

Specialist Water Supply Systems

PP-R / PP-RCT pipe system

Specification manual

Wefatherm specialist water supply systems

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PP-R pipe systems d20-315 mm

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Wefatherm disclaimer

Validity

This Specification Manual is dated November 2022 and replaces older versions. The current technical documentation can be downloaded at www.wefatherm.de.

No part of this technical documentation may be used or reproduced without permission. For information please contact the Wefatherm Customer Service.

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.

Wefatherm GmbH does not guarantee the accuracy, suitability for particular applications, or results to be obtained therefrom.

Important information and pictograms

This manual contains pictograms to emphasise important or beneficial information.

 Important information and safety alerts to take into account

 Update actual version

 Conditions

 Consult the Wefatherm Customer Service

 Information on the internet

 Benefit

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safety and for the proper application of our products at regular intervals if your present Specification Manual has been replaced by a new version.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 Customer Service 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 Customer Service
- 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 authorised and trained people
- Allow work on electrical installations or parts only to be performed by specially trained and authorised personnel

General precautions

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

Disclaimer

Work wear



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 tool being used.
- 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 sharp blades. 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 Customer Service.

1 Water supply systems

1.1 Domestic systems

The Wefatherm system can be applied for typical domestic water supply systems such as:

- Drinking water: considered fresh water for drinking and preparing food.
- Hot tap water: heated (drinking) water.
- Sanitary applications: such as flush systems, washing and irrigation.

Domestic water supply systems are used in all kinds of low and high rise buildings. Typical domestic water supply systems are detailed in the following application standard.

1.1.1 ISO 15874 Plastic piping systems for hot and cold water installations - Polypropylene (PP)

This standard describes requirements for a piping system and its components made from polypropylene (PP) intended to be used for hot and cold water installations.

ISO 15874 describes single layer pipes only. Fibre pipes and Stabi pipes are not covered by this standard and are instead covered by ISO 21003 "Multilayer piping systems for hot and cold water installations inside buildings". Standard ISO 21003 is a reference product standard that refers to Standard ISO 15874 for Polypropylene (PP) pipes. Fibre pipes comply to similar but not identical requirements and could be used for same application.

The scope of standard ISO 15874 is hot and cold water installations within buildings for the conveyance of water whether or not intended for human consumption (domestic systems), and for heating systems, under design pressures and temperatures according to the class of application. It covers a range of service conditions (classes of application), design pressures and pipe dimension classes.

The Wefatherm pipe system can be applied for hot and cold water supply according standard ISO 15874, as mentioned in Table 2.10, within the restrictions as given in chapter 2 of this Specification Manual.



It is the responsibility of the purchaser or specifier to make the appropriate selection taking into account particular requirements and any relevant national regulations and installation practices or codes.

Application class	Design temperature T_D °C	Operation time at T_D Year	T_{max} °C	Operation time at T_{max} Year(s)	T_{mal} °C	Operation time at T_{mal} h	Application
1 ^{a)}	60	49	80	1	95	100	Hot water supply (60 °C)
2 ^{a)}	70	49	80	1	95	100	Hot water supply (70 °C)
4 ^{b)}	20	2,5	70	2.5	100	100	Underfloor heating and low temperature radiator connections (70 °C)
	followed by 40	20					
	followed by 60	25					
5 ^{b)}	20	14	90	1	100	100	High temperature radiator connections (80 °C)
	followed by 60	25					
	followed by 80	10					

Table 1.1 Application classes according standard ISO 15874

a) A country may select either class 1 or class 2 in conformity with its national regulations.

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



This standard is not applicable when the values for design temperature T_D , maximum design temperature T_{max} and malfunction temperature T_{mal} are exceeded.

Water supply systems

1.2 Supply systems

When service conditions deviate from conditions as mentioned in standard ISO 15874 (for example in large plants) applications can be covered by standards DIN 8077-8078 and ASTM F2389.

In large plants, water supply systems consist of floor distribution, rising mains and transport lines to rising mains. Such large plants are found in mid-rise and high-rise buildings.

1.2.1 DIN 8077 Polypropylene (PP) pipes - Dimensions DIN 8078 Polypropylene (PP) pipes - General quality requirements and testing.

This standard describes requirements for round seamless polypropylene (PP) pipes, PP-R and PP-RCT, with a minimum safety design factor SF of 1,25.

The scope of this standard is for the conveyance of water and other conveyed media to which PP-R and PP-RCT are chemical resistant.

The Maximum Operating Pressure is calculated according to the equation:

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

Equation 1.1

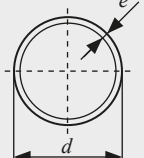
MOP = Maximum Operating Pressure

MRS = Minimum Required Strength for specific operating conditions

SF = Safety (design) Factor

SDR = SDR rating of the pipe

MRS for required temperature and life design cycle can be found in a regression curve. A copy of these regression curves is provided in Appendix A of this Specification Manual.



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

Equation 1.2

Safety factors for applications are specified in application standards, like standard ISO 15874 for hot & cold PP installations and standard ISO 15494 for Industrial plastic piping systems.

Values for maximum operating pressures with safety design factors 1,25 and 1,5 are provided in this standard. A copy of these values is provided in Appendix B of this Specification Manual.

In general a safety design factor of 1,5 is applied for typical domestic water supply systems according standard ISO 15874. Specifiers can consider applying a safety design factor that deviates for specific conditions which may occur in rising mains, or transport lines to rising mains.

The Wefatherm pipe system can be applied for the conveyance of water, and other aqueous solutions to which PP-R and PP-RCT are chemical resistant, intended for hot and cold water supply systems according standard DIN 8077-8078 as mentioned in Table 2.10 within the restrictions as given in chapter 2 of this Specification Manual.

1.2.2 ASTM F2389 Pressure-rated Polypropylene (PP) Piping Systems

This standard describes requirements for polypropylene (PP) piping system components made to metric sizes and IPS schedule 80 sizes, and pressure rated for water service and distribution supply.

The scope of this standard covers the use in water service lines, hot-and-cold water distribution, hydronic heating and irrigation systems.

The values are stated in inch-pound units. Mathematical conversions to SI units are for information only. The pressure ratings shown are based on the ISO 9080 extrapolation criteria as used in standards ISO 15874 and DIN 8077-8078. The pressure rating calculation for the metric series is based on an overall design factor of 1,5.

The calculated values are similar to the calculated values as shown in standard DIN 8077-8078 but not identical.

The Wefatherm pipe system is a metric system that can be applied for pressure rated water service lines and hot-and-cold water distribution according standard DIN 8077-8078 as mentioned in Table 2.10 within the restrictions as given in chapter 2 of this Specification Manual.



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Material properties and application limitations

2 Material properties and application limitations

2.1 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. This includes hot and cold water distribution, under-floor heating, radiator connections or wall cooling and heating systems.



Illustration 2.1



Benefits of PP-R piping systems:

- Lifetime service 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

2.1.1 Chemical resistance of polypropylene

Table 2.1 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 concerned fluid at 20 and 60°C and atmospheric pressure, followed in certain cases by the determination of tensile characteristics.

Scope and field of 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 and 60°C
- in the absence of internal pressure and external mechanical stress (for example flexural stresses, stresses due to thrust, rolling loads etc.)



The information given in Table 2.1 do not offer unconditional guarantee for operational reliability in all circumstances. They should be used as guidance and not be taken as a definitive reference for determining the chemical compatibility of the Wefatherm piping system in a specific application.

Material properties and application limitations

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 tests are acknowledged to be 'satisfactory' by the majority of the countries participating in the evaluation.

L = Limited

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

NS = Not satisfactory

The chemical resistance of polypropylene exposed to the action of a fluid is classified as 'not satisfactory' when the results of tests are acknowledged to be 'not satisfactory' by the majority of the countries participating in the evaluation.

Also classified as 'not satisfactory' are materials for which judgements 'L' and 'NS' are pronounced to an equal extent.

- = No data on the chemical resistance is available

Dil. sol. Dilute aqueous solution at a concentration equal to or lower than 10%
 Sol. Aqueous solution at a concentration higher than 10%, but not saturated
 Sat. sol. Saturated aqueous solution, prepared at 20 °C
 Work.sol. Working solution having the usual concentration for industrial use
 Tech. gr. At least technical grade purity
 Susp. Suspension of solid in a saturated solution at 20 °C

Solution concentrations reported in the text are expressed as a percentage by mass at 20 °C. 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 2.1) 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 Customer Service.

Flow substance	Concentration	Behaviour at	
		20 °C	60 °C
Acetaldehyde	40%	S	L
	Tech. gr.	L	L
Acetamide	5%	S	S
Acetic acid	Up to 10%	S	S
	>10% to 50%	S	L
	60%	L	L
	80%	L	NS
	95%	S	L
Acetic acid, glacial	>96%	S	L
Acetic anhydrid	Tech. gr.	S	L
Acetone	Tech. gr.	S	S
Acetophenone	Tech. gr.	S	L
Acetyl chloride	Tech. gr.	L	-
Acetylene, gas	Tech. gr.	S	L
Acrylonitrile	Tech. gr.	S	L
Adipic acid	Sat. sol.	S	S
Air	Tech. gr.	S	S
Allyl alcohol	Tech. gr.	L	L
Allyl chloride	Sat. sol.	L	NS
Almond oil	Tech. gr.	S	L
Aluminium chloride	Sat. sol.	S	S
Aluminium fluoride	Susp.	S	S
Aluminium hydroxide	Susp.	S	S
Aluminium nitrate	Sat. sol.	S	S
Aluminium chloride oxyde	Susp.	S	S
Aluminium potassium sulphate	Sat. sol.	S	S
Aluminium sulphate	Sat. sol.	S	S
Ammonia, aqueous	Sat. sol.	S	S
Ammonia, dry gas	Tech. gr.	S	L
Ammonia, wet gas	Tech. gr.	S	L
Ammonium acetate	Sat. sol.	S	S

Flow substance	Concentration	Behaviour at	
		20 °C	60 °C
Ammonium bifluoride	Sat. sol.	S	S
Ammonium carbonate	Sat. sol.	S	S
Ammonium chloride	Sat. sol.	S	S
Ammonium fluoride	Sat. sol.	S	S
Ammonium hydrogen carbonate	Sat. sol.	S	S
Ammonium metaphosphate	Sat. sol.	S	S
Ammonium molybdate	Sat. sol.	S	S
Ammonium nitrate	Sat. sol.	S	S
Ammonium persulphate	Sat. sol.	S	S
Ammonium phosphate	Sat. sol.	S	S
Ammonium sulphate	Sat. sol.	S	S
Ammonium sulphide	Sat. sol.	S	S
Ammonium thiocyanate	Sat. sol.	S	S
Amyl acetate	Tech. gr.	L	NS
Amyl alcohol	Tech. gr.	S	S
Amyl chloride	Tech. gr.	NS	NS
Aniline	Tech. gr.	L	L
Aniline hydrochloride	Sat. sol.	L	L
Anisole	Tech. gr.	L	NS
Anthraquinone sulphonic acid	Susp.	S	S
Antimony (III) chloride	Sat. sol.	S	S
Apple juice	Work. sol.	S	S
Aqua regia (HCL/HNO3)	67%/33%	NS	NS
Arsenic acid	Sat. sol.	S	S
Arsenic trioxide	Sol.	L	L
Barium bromide	Sat. sol.	S	S
Barium carbonate	Susp.	S	S
Barium chloride	Sat. sol.	S	S
Barium hydroxide	Sat. sol.	S	S
Barium sulphate	Susp.	S	S

Material properties and application limitations

Flow substance	Concentration	Behaviour at	
		20 °C	60 °C
Barium sulphide	Sat. sol.	S	S
Beer	Work. sol.	S	S
Benzaldehyde	10%	S	S
	Tech. gr.	S	L
Benzene	Tech. gr.	L	NS
Benzoic acid	Sat. sol.	S	S
Benzoyl chloride	Tech. gr.	L	-
Benzyl alcohol	Tech. gr.	S	L
Benzyl chloride	Tech. gr.	L	NS
Bismuth carbonate	Sat. sol.	S	S
Borax	Sol.	S	S
Boric acid	Sat. sol.	S	S
Boron trifluoride	Sat. sol.	S	S
Bromic acid	10%	S	S
	50%	NS	NS
Bromine, gas		L	NS
Bromine, liquid	Tech. gr.	NS	NS
Bromine water	Sat. sol.	L	NS
Bromoethane	Tech. gr.	NS	NS
Butadiene, gas	Tech. gr.	L	NS
Butane, gas	Tech. gr.	S	L
Butanediol	10%	S	L
	Tech. gr.	L	L
n-Butanol	Tech. gr.	S	L
Butyl acetate	Tech. gr.	L	L
Butyl glycol	Tech. gr.	S	L
Butylphenol	Sat. sol.	S	L
Butyl phthalate	Tech. gr.	S	L
Butyric acid	20%	S	L
	Tech. gr.	L	L
Butyryl chloride	Tech. gr.	L	-
Calcium bisulphite	Sat. sol.	S	S
Calcium bromide	Sat. sol.	S	S
Calcium carbonate	Susp.	S	S
Calcium chlorate	Sat. sol.	L	L
Calcium chloride	Sat. sol.	S	S
Calcium hydroxide	Sat. sol.	S	S
Calcium hypochlorite	10%	L	L
Calcium nitrate	Sat. sol.	S	S
Calcium sulphate	Susp.	S	S
Calcium sulphide	Dil. sol.	S	S
Calcium hydrogen sulphide	Sol.	S	S
Camphor oil	Tech. gr.	NS	NS
Carbon dioxide, aqueous sol.	Sat. sol.	S	S
Carbon dioxide, dry gas	Tech. gr.	S	S
Carbon dioxide, wet gas	Tech. gr.	S	S
Carbon disulphide	Tech. gr.	L	NS
Carbon monoxide, gas	Tech. gr.	S	S
Carbon tetrachloride	Tech. gr.	NS	NS
Castor oil	Tech. gr.	S	S
Chlorine, dry gas	Tech. gr.	NS	NS
Chlorine water	Sat. sol.	L	NS
Chlorine, wet gas	Tech. gr.	NS	NS
Chloroacetic acid	Sat. sol.	S	S
Chlorobenzene	Tech. gr.	L	NS
Chlorobromo-methane	Tech. gr.	L	NS
Chloroethanol	Tech. gr.	S	L
Chloroform	Tech. gr.	L	NS
Chloromethane, gas	Tech. gr.	L	NS
Chloropropanes	Tech. gr.	NS	-
Chlorosulphonic acid	50%	NS	NS
Chrome alum	Sat. sol.	S	S
Chromic acid	<25%	L	L
	>30% to 50%	L	NS
Citric acid	Sat. sol.	S	S
Coconut oil	Work. sol.	S	S
Cod. liver oil	Work. sol.	S	S
Copper (II) chloride	Sat. sol.	S	S
Copper (II) cyanide	Sat. sol.	S	S

Flow substance	Concentration	Behaviour at	
		20 °C	60 °C
Copper (II) fluoride	Sat. sol.	S	S
Copper (II) nitrate	50%	S	S
Copper (II) sulphate	Sat. sol.	S	S
Corn oil	Work. sol.	S	L
Cottonseed oil	Work. sol.	S	-
Cresols	Tech. gr.	S	L
Cresylic acid	Sat. sol.	NS	NS
Crotonaldehyde	Sat. sol.	S	L
	Tech. gr.	S	NS
Crude oil (free from aromatics)	Tech. gr.	L	NS
Cyclohexane	Tech. gr.	S	NS
Cyclohexanol	Sat. sol.	S	L
Cyclohexanone	Tech. gr.	L	NS
Cyclohexylamine	Tech. gr.	L	NS
Decalin	Tech. gr.	NS	NS
Dextrin	Sol.	S	S
Dextrose	Sol.	S	S
Diacetone alcohol	Tech. gr.	L	L
Diazonium chloride	Work. sol.	L	-
Dichloroacetic acid	50%	S	L
	Tech. gr.	L	-
Dichlorobenzene	Tech. gr.	L	-
Dichloroethylene	Tech. gr.	NS	NS
Diesel fuel	Work. sol.	L	L
Diethanolamine	Tech. gr.	S	L
Diethylamine	Tech. gr.	S	NS
Diethyl ether	Tech. gr.	L	NS
Diethylene glycol	Tech. gr.	S	S
Diglycolic acid	18%	S	S
	Sat. sol.	S	L
Diisooctyl phthalate	Tech. gr.	S	L
Dimethylamine	30%	S	-
Dimethylamine, gas	Tech. gr.	S	L
Dimethyl- formamide	Tech. gr.	S	S
Diocetyl phthalate	Tech. gr.	L	L
Dioxane	Tech. gr.	S	L
Diphenylamine	Work. sol.	L	NS
Ethanol	Tech. gr.	S	S
Ethanolamine	Tech. gr.	S	L
Ethyl acetate	Tech. gr.	L	NS
Ethyl acrylate	Tech. gr.	L	NS
Ethyl chloride, gas	Tech. gr.	NS	NS
Ethylene bromide	Tech. gr.	L	NS
Ethylene chlorohydrin	Tech. gr.	L	L
1,1 Ethylene dichloride	Tech. gr.	L	L
1,2 Ethylene dichloride	Tech. gr.	L	NS
Ethylene glycol	Tech. gr.	S	S
Ethyl ether	Tech. gr.	L	L
Ethyl glycol	Tech. gr.	S	NS
Ethylene oxide	Tech. gr.	L	NS
Ferric chloride	Sat. sol.	S	S
Ferric nitrate	Sat. sol.	S	S
Ferric sulphate	Sat. sol.	S	S
Ferrous chloride	Sat. sol.	S	S
Ferrous sulphate	Sat. sol.	S	S
Fluoboric acid	Sat. sol.	S	L
Fluorine, dry gas	Tech. gr.	NS	NS
Fluosilicic acid	Sat. sol.	S	L
	>25 to 32%	S	S
	>40%	S	L
Formaldehyde	Dil. sol.	S	NS
	>30 to 50%	S	NS
Formic acid	10%	S	L
	>40 to 50%	L	L
	>85% to tech. gr.	L	NS
Freon 12	Work. sol.	L	NS
Freon 22, gas	Tech. gr.	L	NS
Fructose	Sol.	S	S

Material properties and application limitations

Flow substance	Concentration	Behaviour at		Flow substance	Concentration	Behaviour at	
		20 °C	60 °C			20 °C	60 °C
Fruit juice	Work. sol.	S	S	Methyl acetate	Tech. gr.	S	S
Furfuryl alcohol	Tech. gr.	S	L	Methyl alcohol	5%	S	L
Gas, natural, dry	Tech. gr.	S	L		Tech. gr.	S	S
Gas, natural, wet	Tech. gr.	S	-	Methyl bromide, gas	Tech. gr.	NS	NS
Gasoline (fuel) (free from aromatics)	Work. sol.	L	NS	Methyl butyl ketone	Tech. gr.	S	L
Gelatine	Sol.	S	S	Methyl cyclohexanones	Tech. gr.	L	-
Ginger ale	Work. sol.	S	S	Methyl ethyl ketone	Tech. gr.	S	L
Glucose	Sol.	S	S	Methyl glycol	Work. sol.	S	L
Glycerine	Tech. gr.	S	S	Methyl methacrylate	Tech. gr.	S	S
Glycolic acid	<65%	L	L	Methyl sulphate	Work. sol.	L	-
Grapefruit juice	Work. sol.	S	S	Methyl sulphonic acid	Tech. gr.	L	L
Heptane	Tech. gr.	L	NS	Methylamine	<32%	S	NS
Hexadecanol	Work. sol.	S	-	Methylene chloride	Tech. gr.	-	-
Hexane	Tech. gr.	S	L	Milk	Work. sol.	S	S
1-Hexanol	Tech. gr.	S	S	Mineral oils (free from aromatics)	Work. sol.	S	L
Honey	Work. sol.	S	S	Molasses	Work. sol.	S	S
Horseradish	Work. sol.	S	S	Mustard, aqueous	Work. sol.	S	-
Hydrobromic acid	<20%	S	S	Naphtha	Work. sol.	L	NS
	>20 to 50%	S	L	Naphthalene	Work. sol.	L	L
	66%	L	NS	Nickel acetate	Sat. sol.	S	S
Hydrochloric acid	<25%	S	L	Nickel chloride	Sat. sol.	S	S
	>25 to 37,5%	L	L	Nickel nitrate	Sat. sol.	S	S
Hydrochloric acid, dry gas	Tech. gr.	S	NS	Nickel sulphate	Sat. sol.	S	S
Hydrochloric acid, wet gas	Tech. gr.	S	NS	Nicotin acid	Susp.	S	-
Hydrocyanic acid	Tech. gr.	S	NS	Nitric acid	5%	L	L
Hydrofluoric acid	<40%	S	L		>10 to 30%	L	NS
	50%	L	-		>35%	NS	NS
	>50 to 70%	L	NS	Nitric acid (with nitrogen dioxide)	Fuming	NS	NS
Hydrofluoric acid, gas	Tech. gr.	NS	-	Nitrobenzene	Tech. gr.	S	L
Hydrogen, gas	Tech. gr.	S	S	Nitromethane	Tech. gr.	S	L
Hydrogen peroxide	<10%	S	L	Oleic acid	Tech. gr.	S	L
	>30 to 70%	L	L	Oleum		NS	NS
	70%	L	NS	Olive oil	Work. sol.	S	L
Hydrogen sulphide aqueous	Sat. sol.	S	S	Oxalic acid (subl.)	Dil. sol.	S	S
Hydrogen sulphide, dry gas	Tech. gr.	S	S		Sat. sol.	S	L
Hydroquinone	Sat. sol.	S	L	Oxygen, gas	Tech. gr.	S	L
Hypochlorous acid	<70%	L	NS	Ozone, gas	Sat. sol.	NS	NS
Iodine	Sat. sol.	NS	NS	Paraffin	Tech. gr.	S	S
Iodine, in alcohol	Work. sol.	L	L	Paraffin oil	Tech. gr.	S	L
Isobutyl alcohol	Tech. gr.	S	L	Peanut oil	Work. sol.	S	L
Isobutyronitrile	Tech. gr.	L	NS	Pentane	Work. sol.	L	L
Isooctane	Tech. gr.	L	L	Peppermint oil	Work. sol.	S	L
Isopropyl acetat	Tech. gr.	S	L	Perchloro-ethylene	Work. sol.	L	NS
Isopropyl alcohol	Tech. gr.	S	S	Perchloric acid	10%	L	L
Isopropyl ether	Tech. gr.	L	NS		20%	L	NS
Kerosene	Work. sol.	L	L		70	L	-
Lactic acid	<90%	S	S	Petrol (aliphatic hydrocarbon / benzene)	80/20%	L	NS
	Tech. gr.	S	L	Petroleum ether (ligroin)	Work. sol.	L	L
Lanolin	Work. sol.	S	L	Phenol	Sol.	S	L
Lauryl chloride	Sat. sol.	L	NS		5%	S	S
Lead acetate	Dil. sol.	S	S		50%	S	-
Lead tetraethyl	Tech. gr.	S	-		90%	S	L
Linseed oil	Work. sol.	S	S	Phenylhydrazine	Tech. gr.	L	L
Magnesium carbonate	Susp.	S	S	Phenylhydrazine hydrochloride	Dil. sol.	S	L
Magnesium chloride	Sat. sol.	S	S		97%	S	NS
Magnesium hydroxide	Sat. sol.	S	S	Phosphine, gas	Tech. gr.	L	L
Magnesium nitrate	Sat. sol.	S	S	Phosphoric acid	<98%	S	S
Magnesium sulphate	Sat. sol.	S	S	Phosphorus (III) chloride	Tech. gr.	L	-
Maleic acid	Sat. sol.	S	S	Phosphorus oxychloride	Tech. gr.	L	L
Malic acid	Sat. sol.	S	S	Phthalic acid	Susp.	S	S
Margarine	Work. sol.	S	S	Picric acid (subl.)	Sat. sol.	S	L
Mayonnaise	Work. sol.	S	S	Potassium bicarbonate	Sat. sol.	S	S
Mercuric chloride	Sat. sol.	S	S	Potassium bisulphate	Sat. sol.	S	S
Mercuric cyanide	Sat. sol.	S	S	Potassium borate	Sat. sol.	S	S
Mercurous nitrate	Sat. sol.	S	S	Potassium bromate	Sat. sol.	S	S
Mercury	Tech. gr.	S	S				
Mesityl oxide	Work. sol.	NS	NS				
Methane, gas	Tech. gr.	S	L				

Material properties and application limitations

Flow substance	Concentration	Behaviour at		Flow substance	Concentration	Behaviour at	
		20 °C	60 °C			20 °C	60 °C
Potassium bromide	Sat. sol.	S	S	Sodium metaphosphate	Sol.	S	S
Potassium carbonate	Sat. sol.	S	S	Sodium nitrate	Sat. sol.	S	L
Potassium chlorate	Sat. sol.	S	L	Sodium nitrite	Sat. sol.	S	S
Potassium chloride	Sat. sol.	S	S	Sodium perborate	Sat. sol.	S	S
Potassium chlorite	Sat. sol.	S	S	Sodium phosphate, acid	Sat. sol.	S	S
Potassium chromate	Sat. sol.	S	L	Sodium phosphate, neutral	Sat. sol.	S	S
Potassium cuprocyanide	Sat. sol.	S	S	Sodium silicate	Sat. sol.	S	S
Potassium cyanide	Sol.	S	S	Sodium sulphate	Sat. sol.	S	S
Potassium dichromate	Sat. sol.	S	L	Sodium sulphide	Sat. sol.	S	S
Potassium ferricyanide	Sat. sol.	S	S	Sodium sulphite	40%	S	S
Potassium fluoride	Sat. sol.	S	S	Sodium thiosulphate (hypo-sulphite)	Sat. sol.	S	S
Potassium hexacyanoferrate (II)	Sat. sol.	S	S	Soybean oil	Work. sol.	S	L
Potassium hydrogen sulphite	Sat. sol.	S	S	Stearic acid	Work. sol.	S	L
Potassium hydroxide	<20%	S	S	Stearin	Work. sol.	S	L
	<50%	L	L	Styrene	Sat. sol.	L	NS
Potassium hypochlorite	Sol.	L	-	Sugar, aqueous sol.	Sol.	S	S
Potassium iodide	Sat. sol.	S	S	Sulphur dioxide, dry gas	Work. sol.	S	S
Potassium nitrate	Sat. sol.	S	L	Sulphur dioxide, wet gas	Work. sol.	S	S
Potassium orthophosphate	Sat. sol.	S	S	Sulphur ether (thioether)	Work. sol.	L	NS
Potassium perborate	Sat. sol.	S	S	Sulphuric acid	>10 to 30%	S	S
Potassium perchlorate	10%	S	L		>50 to 70%	S	L
	Sat. sol.	L	L		>80 to 90%	L	NS
Potassium permanganate	Sat. sol.	L	L		>95%	NS	NS
Potassium persulphate	Sat. sol.	S	S		Fuming	NS	NS
Potassium sulphate	Sat. sol.	S	S	Sulphurous acid	Sat. sol.	S	L
Potassium sulphide	Sat. sol.	S	S	Tannic acid	Sat. sol.	S	L
Potassium sulphite	Sat. sol.	S	S	Tartaric acid	Sat. sol.	S	S
Potassium, thiosulphate	Sat. sol.	S	S	Tetrahydrofuran	Tech. gr.	NS	NS
Propane, gas	Tech. gr.	S	L	Tetralin	Tech. gr.	NS	NS
Propionic acid	50%	S	L	Thionyl chloride	Tech. gr.	NS	NS
	Tech. gr.	L	L	Thiophene	Tech. gr.	L	L
Propyl alcohol	Tech. gr.	S	S	Tin (II) chloride	Sat. sol.	S	S
Pyridine	Tech. gr.	L	L	Tin (IV) chloride	Sol.	S	S
Salicylic acid (subl.)	Sat. sol.	S	S	Toluene	Tech. gr.	L	NS
Selenic acid	Sat. sol.	S	S	Tributyl- phosphate	Sat. sol.	S	L
Silicic acid	Susp.	S	S	Trichloroacetic acid	<50%	S	S
Silicone oil	Tech. gr.	S	S	Trichloro- benzene	Work. sol.	NS	NS
Silver acetate	Sat. sol.	S	S	Trichloro- ethylene	Tech. gr.	L	L
Silver cyanide	Sat. sol.	S	S	Triethanolamine	Sol.	S	S
Silver nitrate	Sat. sol.	S	S		Tech. gr.	S	L
Sodium acetate	Sat. sol.	S	S	Triethylene glycol	Sol.	S	S
Sodium antimonite	Sat. sol.	S	S	Trimethylol- propane	<10%	S	S
Sodium arsenite	Sat. sol.	S	S	Turpentine	Tech. gr.	L	NS
Sodium benzoate	Up to 50%	S	L	Urea	Sat. sol.	S	S
Sodium bicarbonate	Sat. sol.	S	S	Uric acid	Work. sol.	S	S
Sodium bisulphate	Up to 50%	S	S	Urine	Work. sol.	S	S
Sodium bromide	Up to 50%	S	S	Vegetable oils	Tech. gr.	S	L
Sodium carbonate	Up to 50%	S	S	Vinegar	Work. sol.	S	S
Sodium chlorate	Sat. sol.	S	L	Vinyl acetate (monomer)	Tech. gr.	S	L
Sodium chloride	Sat. sol.	S	S	Water, distilled	Work. sol.	S	S
Sodium chlorite	2%	S	L	Water, sea	Work. sol.	S	S
	20%	S	L	Whiskey	Work. sol.	S	L
Sodium chromate	Dil. sol.	S	S	Wine	Work. sol.	S	S
Sodium cyanide	Sat. sol.	S	S	Wines and spirits	Work. sol.	S	S
Sodium dichromate	Sat. sol.	S	L	Xylene	Tech. gr.	L	NS
Sodium ferricyanide	Sat. sol.	S	S	Yeast	Susp.	S	-
Sodium ferrocyanide	Sat. sol.	S	S	Zinc carbonate	Sat. sol.	S	S
Sodium fluoride	Sat. sol.	S	S	Zinc chloride	Sat. sol.	S	S
Sodium hydrogen sulphite	Sat. sol.	S	S	Zinc chromate	Sat. sol.	L	L
Sodium hydroxide	Dil. Sol.	S	S	Zinc cyanide	Sat. sol.	S	S
	Sat. sol.	S	L	Zinc nitrate	Sat. sol.	L	L
	<10%	S	S	Zinc oxide	Susp.	S	S
	>10 to 60%	S	L	Zinc stearate	Susp.	S	S
Sodium hypochlorite	2% Cl (% of free chlorine)	L	-	Zinc sulphate	Sat. sol.	S	S
	12,5% Cl (% of free chlorine)	L	-				

Table 2.1 Chemical resistance of polypropylene, not subjected to mechanical stress, to various fluids at 20 and 60 °C (source: ISO/TR 10358)

Material properties and application limitations

2.1.2 Fire behaviour of PP

PP-R pipe systems can be classified:

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

Table 2.2

European standard EN 13501-1

This standard defines a class system for material behaviour for building products and building constructions during a fire. 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 to 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 2.3

Phase 2: smoke generation

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

Table 2.4

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 2.5

Fire safety level of buildings

The level of fire safety of a building is not standardised in every European country. Each member state may determine in its own regulations which fire class is suitable for specific areas inside buildings.

German industry standard DIN 4102

The official fire rating has been regulated in accordance with DIN 4102 (still valid today).

Materials are tested for the degree of flammability and combustibility. DIN 4102 includes the 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 and flammability:

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

Table 2.6

Roughly compared:

Classification EN 13501	Classification DIN 4102
A1	A1
A2	A2
B	
C	B1
D	B2
E	
F	B3

Table 2.7

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

Material properties and application limitations

Emissions from fire

A fire will start when an ignition source (e.g. a 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 that of other plastics, but more intense than that of wood. In oxygen-rich flaming fires, less smoke is generated than when the fire is smouldering. The relative flammability depends not only on the polypropylene material and its burning behaviour, but also on the conditions and the size and shape of the materials involved.

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

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

Emissions from processes (welding)

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

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

2.1.5 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 extent 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 of more than 0,5 mm. 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, stabilisers, absorbers or blockers can be applied. For example, carbon black at around a 2% level in Polyethylene will curtail the degradation process. Wefatherm UV resistant pipes are covered with an outer layer of black Polyethylene.

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

Material properties and application limitations

2.2 PP-R material

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

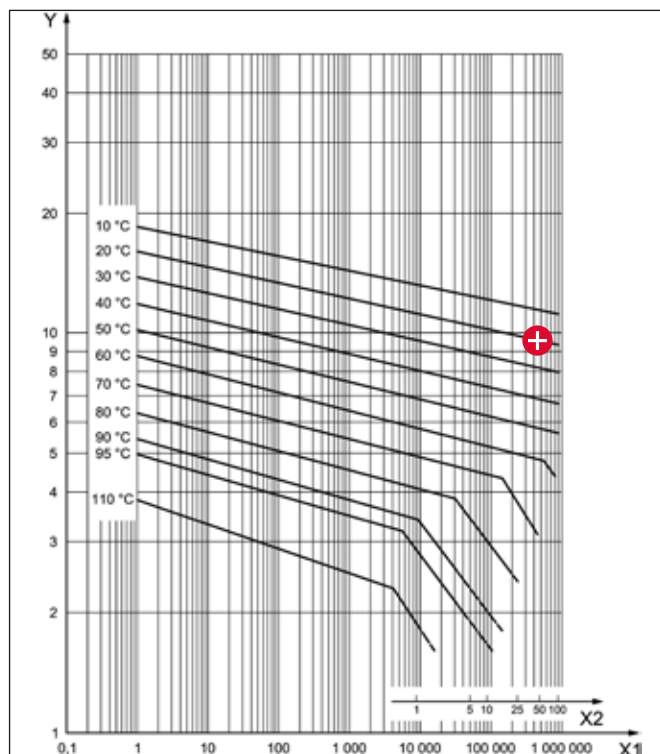


Illustration 2.2

Property	Typical value	Unit	Test method
Density	0,9-1,0	g/cm ³	ISO 1183
Melt flow rate 230 °C/2,16	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
<i>Charpy impact strength, notched</i>			
(23 °C)	20	kJ/m ²	ISO 179/1eA
(0 °C)	3,5	kJ/m ²	ISO 179/1eA
(-20 °C)	2	kJ/m ²	ISO 179/1eA
<i>Charpy impact strength, unnotched</i>			
(23 °C)	No break		ISO 179/1eU
(0 °C)	No break		ISO 179/1eU
(-20 °C)	40	kJ/m ²	ISO 179/1eU
Melt temperature	210-220	°C	

Table 2.8 Physical properties PP-R material Borealis RA130E

Pipes of this material possess pressure resistance, according to ISO 9080 with a proven MRS class of 10 MPa (20 °C, 50 years) and CRS class of 3.2 MPa (70 °C, 50 years).



Graphic 2.1 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



The Wefatherm pipe system can be applied for hot and cold water supply according standard ISO 15874 as mentioned in table 2.10 within the restrictions as given in chapter 2 of this Specification Manual.

Material properties and application limitations

2.3 PP-RCT material

PP-RCT (PolyPropylene-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.

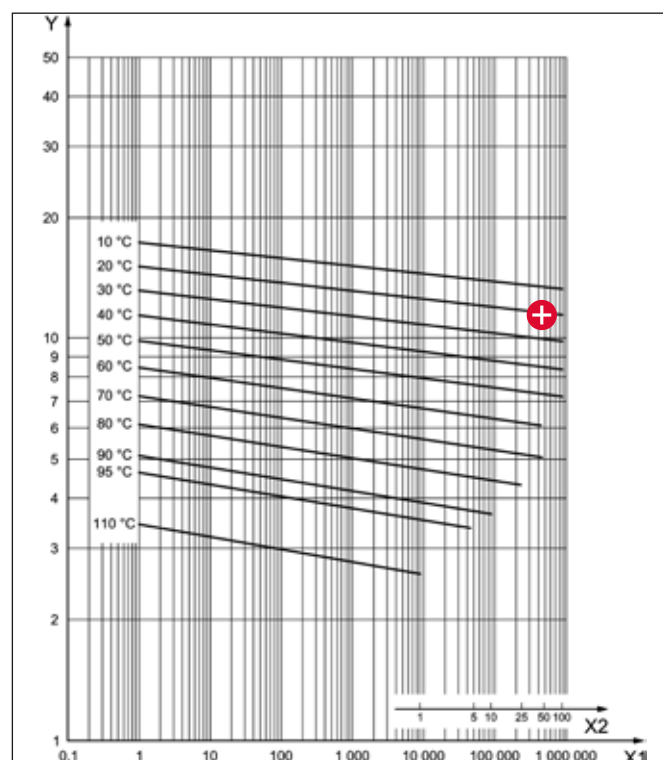


Illustration 2.3

Property	Typical value	Unit	Test method
Density	>0,89	g/cm ³	ISO 1183
Melt flow rate 230 °C/2,16	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
Tensile modulus (1 mm/min)	850	MPa	ISO 527-2
Charpy impact strength, notched (23 °C)	40	kJ/m ²	ISO 179/1eA
(0 °C)	4	kJ/m ²	ISO 179/1eA
(-20 °C)	2	kJ/m ²	ISO 179/1eA
Coefficient of thermal expansion (0 °C/70 °C)	1,5*10E-4	1/K	DIN 53752
Thermal conductivity	0,24	W/(m K)	DIN 52612
Melt temperature	220-230	°C	

Table 2.9 Physical properties PP-RCT material Borealis RA7050

Pipes of this material possess pressure resistance according to ISO 9080 with a proven MRS class of 11,5 MPa (20 °C, 50 years) and CRS class of 5 MPa (70 °C, 50 years).



Graphic 2.2 PP-RCT MRS 11,2 MPa (20 °C, 50 years)

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

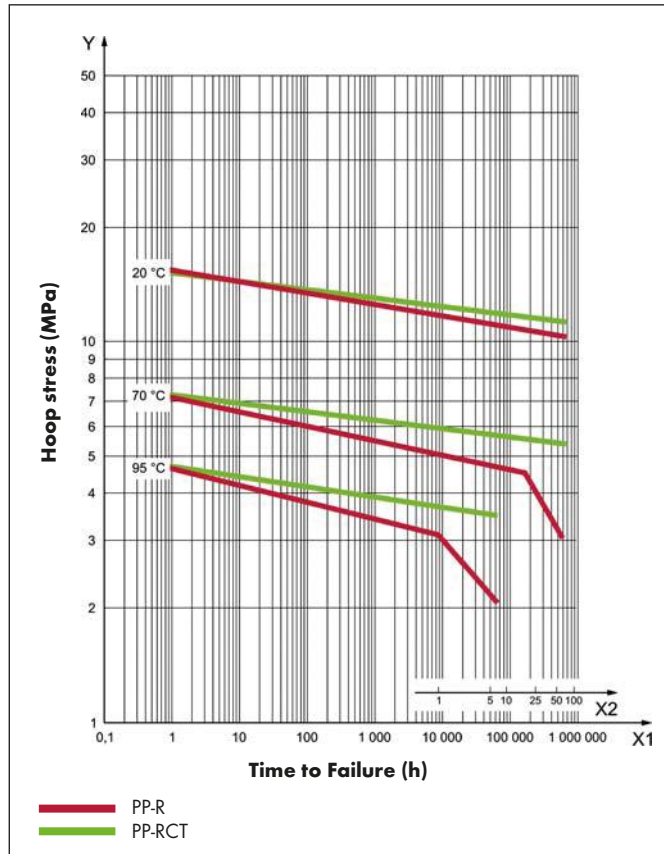
! The Wefatherm pipe system can be applied for hot and cold water supply according standard ISO 15874 as mentioned in table 2.10 within the restrictions as given in chapter 2 of this Specification Manual.

Material properties and application limitations

2.4 Advantages PP-RCT over PP-R

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

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



Graphic 2.3

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.

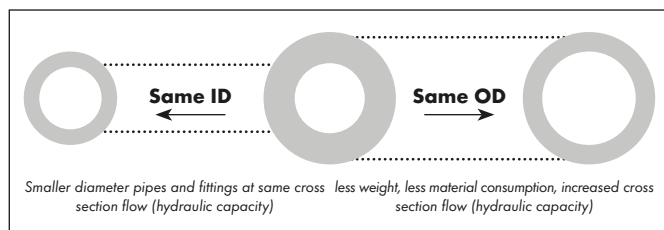


Illustration 2.4

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

Stabilisation package

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

The role of the stabilisation packages is to protect the polymer against oxidation which may occur during the:

- manufacturing step by extrusion or injection where the material is exposed at high temperature i.e. 200°C and 230°C for a short period of time
- long term exposure of the pipe system, under pressure at temperature up to 70°C

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

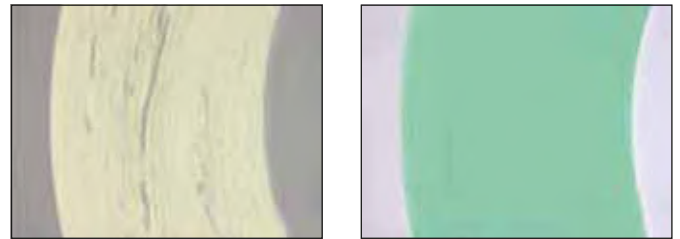


Illustration 2.5 Stereomicroscopic observation of pipe cross sections with poor dispersion and excellent dispersion of pigment and additives

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

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 ($d \geq 160$ 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.

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



Please note 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 please contact the Wefatherm Customer Service.



Each specific application needs to be calculated in detail in the design stage of the project. The real operating temperature and pressure can be determined. If you require additional assistance please contact the Wefatherm Customer Service.

Material properties and application limitations

2.5 Maximum operating pressure pipe ranges

Material Type SDR Colour	PP-RCT Standard 7.4 Green	PP-R Standard 6 Green	PP-RCT Fibre 7.4 Green	PP-R Standard 11 Green	PP-RCT Standard 11 Green	PP-R Fibre 7.4 Green	PP-RCT Fibre 9 Green	PP-RCT Fibre 11 Green	PP-RCT Fibre 11 Grey
									
20	●	●	●	●		●			●
25	●	●	●	●		●			●
32	●	●	●	●		●	●		●
40	●	●	●	●		●	●		●
50	●	●	●	●		●	●		●
63	●	●	●	●		●	●		●
75	●	●	●	●		●	●		●
90	●	●	●	●		●	●		●
110	●	●	●	●		●	●		●
125	●	●	●	●		●	●		●
160			●		●			●	●
200			●		●			●	
250			●		●			●	
315					●				

Maximum Operating Pressure (bar) according standard ISO 15874									
Material Type SDR	PP-RCT Standard 7.4	PP-R Standard 6	PP-R Standard 7.4	PP-R Standard 11	PP-RCT Standard 11	PP-R Fibre 7.4	PP-RCT Fibre 7.4	PP-RCT Fibre 11	PP-RCT Fibre 11
Class 1	10	10	8	-	6	8	10	6	6
Class 2	10	8	6	-	6	6	10	6	6
Class 4	10	10	10	-	6	10	10	6	6
Class 5	8	6	6	-	4	6	8	4	4
20 °C/50 years	10	10	10	10	10	10	10	10	10

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

Maximum Operating Pressure (bar) according standard DIN 8077									
Material Type SDR	PP-RCT Standard 7.4	PP-R Standard 6	PP-R Standard 7.4	PP-R Standard 11	PP-RCT Standard 11	PP-R Fibre 7.4	PP-RCT Fibre 7.4	PP-RCT Fibre 11	PP-RCT Fibre 11
SF 1,50-20 °C	24,3	25,7	20,4	12,9	15,3	20,4	24,3	15,3	15,3
SF 1,50-70 °C	10,7	8,5	6,7	4,2	6,8	6,7	10,7	6,8	6,8
SF 1,25-20 °C	29,2	30,9	24,5	15,4	18,4	24,5	29,2	18,4	18,4
SF 1,25-70 °C	12,9	10,2	8,1	5,1	8,1	8,1	12,9	8,1	8,1

! Standard DIN 8077 provides intermediate and exceeding values for maximum operating temperatures. It is the responsibility of the purchaser or specifier to make the appropriate selection taking into account particular requirements and any relevant national regulations and installation practices or codes.

SF = Safety (Design) Factor - permanent temperature over 50 years Design Lifetime

Table 2.10

Material properties and application limitations

2.6 Brass transitions

2.6.1 Brass

Transition fittings and unions are widely used to connect pipe systems of different materials together. Usually with male and female threaded parts in accordance with the accepted ISO 7/EN 10226 or ISO 228 standards.



Illustration 2.6

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.

! It is the responsibility of the purchaser or specifier to make the appropriate selection taking into account particular requirements and any relevant national regulations and installation practices or codes.

☎ For additional information on brass, please contact the Wefatherm Customer Service.

2.6.2 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

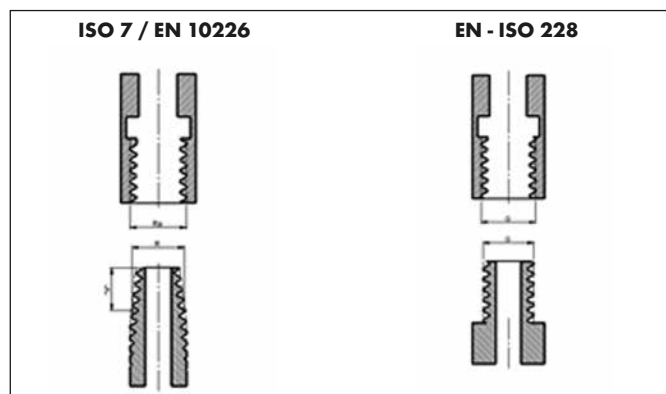


Illustration 2.7

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 2.11

2.6.3 Mixed copper/PP-R systems

In some specific hydraulic conditions (fluid velocity, temperature, chemicals treatment, water quality) copper components can suffer from "flow-accelerated" or "flow-induced" corrosion (also known as "erosion corrosion") which results in the release of dissolved copper into the water (copper ions).

Copper ions have a catalyst effect on the oxidation process of polypropylene materials which may, when other conditions are met, degrade the PP-R over time, leading potentially to premature failure or other adverse effect.

In piping systems which combine copper components with PP-R systems, it is important to limit the conditions which induce "erosion corrosion" and impact the longevity of both the copper and the PP-R materials.

! Limitation mixed copper/PP-R hot water circulation systems

Water temperature	max. 70°C
Medium velocity	max. 0,9 m/sec
Operating pressure	according Table 2.10 of this Specification Manual with max. 8 bar
Dissolved copper	max. 0,1 mg/L

! The dissolved copper level depends on conditions such as water temperature, levels of chlorine, pH, ORP, and dissolved oxygen content. It is recommended to measure this level before use. Water quality can be significantly impacted (positively or adversely) by water treatment. In case of change, the copper ions level should be checked.

When adequate control of water chemistry, water velocities or water temperatures cannot be assured over the lifetime of the plumbing system, it is necessary to avoid mixed-material piping systems by utilising PP-R materials only.

These concerns do not apply to copper alloy materials, such as brass or bronze, or to cold water installations.

☎ For additional information please contact the Wefatherm Customer Service.

Material properties and application limitations

2.7 Rubber gaskets

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



Illustration 2.8

The applied gasket material is EPDM Semperit E633 black. This SVHC-free EPDM material is certified according to KTW-BWGL for gaskets and equipment (P2) with cold and hot water.

- Hardness (Shore A): 70 ± 5
- Density (g/cm^3): 1,11
- Tensile strength (N/mm^2): 11
- Elongation at break (%): 300
- Working temperature range up to 110°C
- Thickness 2.0 mm

Resistance

Medium	Class
Ozone	good resistant
Aging	good resistant
Oils	non resistant
Fuel	non resistant
Acids	resistant
Strong bases	resistant
Abrasion resistance	moderately resistant

Table 2.12 Resistance



For additional information on the chemical resistance of gaskets please contact the Wefatherm Customer Service.

2.8 Backing rings



Illustration 2.9

Profiled flanges, with 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 EN-GJS-500-7, then placed into an injection moulding machine and encapsulated with 30% reinforced polypropylene. This process guarantees a substantial corrosion protection barrier.

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



Advantages

- High corrosion resistance through the polypropylene layer over metallic insert
- "C" shaped section with anti-loosening spring effect, therefore elimination of re-torquing after initial installation
- Weight reduced by 70% compared to normal steel flanges.
- Substantially simplified handling
- 16 bar operating pressure

Re-tightening

The "spring effect" refers to the elastic deformation of the material that allows it to return to its initial shape once the loads are removed. The profile of the backing ring is designed to ensure an antiloosening effect that allows the flange to keep the bolts tightened even in case of wide temperature variations.

The design shape of the flanges is based on FEM calculations (Finite Element Method) whereby special considerations have been given to the thermoplastic stub end. The safety factor applied in design phase indicates that plastic deformation begins, or the material reaches its yield point, at a tightening torque 4 times higher than the recommended one.

For increased temperatures ($>20^\circ\text{C}$) it remains advisable to inspect the flange joint periodical and re-tighten the fasteners if necessary.

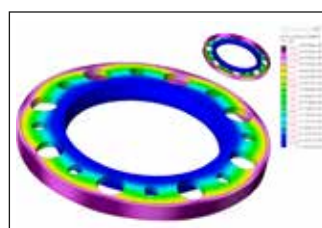


Illustration 2.10 Load distribution



Illustration 2.11 Elastic deformation

Material properties and application limitations

2.9 Legionella prevention & control and Wefatherm PP-R pipe systems

National regulation/guidelines, Germany

Legionella prevention and control is covered by following guidelines:

- DVGW worksheet W551 "Drinking water heating and drinking water piping systems - Technical measures to reduce Legionella growth – Design, construction, operation and rehabilitation of drinking water installations".
- DVGW worksheet W551-3 "Hygiene in Potable Water Installations – Part 3: Cleaning and Disinfection".
- DVGW publication TWIN Nr5 (2009) "Disinfection of drinking water installations to eliminate microbial contamination"

Measures to restrict the growth of Legionella bacteria

The above mentioned worksheets recommend the following key 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 needs to 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 the water temperature to be kept 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 minimise the formation of biofilm:

Measures should be taken to minimise 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 should be noted that plastic pipes offer the benefits of being hardly subject to scaling and are not being corroded by water.

Good practices in design, installation, commissioning, operation and maintenance, as described above and in accordance with recognised technical regulations, generally ensure 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. If flushing or cleaning of the installation has not eliminated 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 on DVGW Worksheets W551 and DVGW W551-3 and publication TWIN Nr5 (2009). These regulations/guidelines define three types of disinfection treatment:

- Thermal disinfection of the system
- Chemical discontinuous disinfection of the system
- Chemical continuous disinfection of drinking water

Pipes, fittings and piping accessories of a drinking water network may be damaged by chemical disinfection procedures, regardless of the materials used. The consequence can be a sometimes severe reduction of the service life of the piping network. Therefore thermal disinfection should always be preferred to a chemical one.

Thermal disinfection of the system

If contamination is suspected, a thermal disinfection as per DVGW worksheet W551 is possible as an urgent measure and sensible. According to the latest technical standards, water temperatures of at least 70 °C are most likely to kill of germs and bacteria, including legionella, found freely in water.

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.



It must be ensured that the allowable operating pressure is not exceeded during thermal disinfection.

Chemical discontinuous disinfection of the system

Contrary to the disinfection of drinking water, the disinfection of a system is a discontinuous measure, comprising a drinking water system from the area of contamination to the tapping point of the consumer. Such disinfection is to be applied temporarily and only in case of a proven contamination.

The chemical "discontinuous 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. Combined thermal-chemical disinfection at temperatures of higher than 25 °C, as well as permanent or regular disinfection cycles (e.g. monthly) are not permitted 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 W551-3 "Shock disinfection" and manufacturers requirements for Wefatherm PP-R pipe systems.

Disinfectant	Chemical formula	Max. application concentration	Max. application duration	Max. temperature in the piping
Chlorine dioxide	ClO ₂	6 mg/l ClO ₂	12 hours	<25 °C
Sodium hypochlorite	NaOCl Cl ₂	50 mg/l Cl ₂	12 hours	<25 °C
Hydrogen peroxide	H ₂ O ₂	150 mg/l H ₂ O ₂	24 hours	<25 °C

Table 2.13 Discontinuous disinfection, active agents and concentrations according to DVGW W551-3



The number of disinfection cycles should not exceed a cumulative 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 occur. This applies to all common materials (plastics, metals, elastomers, etc.) used in modern installation systems.

Material properties and application limitations

Chemical disinfection - "Time limited continuous disinfection" of drinking water

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 method is not a measure for Legionella prevention.

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

Disinfectant	Chemical formula	Max. application concentration	Max. temperature in the piping	Max. application duration (*)
Chlorine dioxide	ClO ₂	not allowed		
Sodium hypochlorite	NaOCl	0,3 mg/l free Cl ₂ (Chlorine)	60 °C	6 months
Chlorine	Cl ₂	0,3 mg/l free Cl ₂ (Chlorine)	60 °C	6 months
Sodium hypochlorite	NaOCl	0,3 mg/l free Cl ₂ (Chlorine)	< 25 °C	18 months
Chlorine	Cl ₂	0,3 mg/l free Cl ₂ (Chlorine)	< 25 °C	18 months

Table 2.14 The concentrations and exposures of chemicals in accordance with "list of treatment substances and disinfection procedure" §20 of Drinking Water Ordinance 2023 (TrinkwV) and manufacturers requirements for Wefatherm PP-R pipe systems.

! (*) The maximum application duration 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 occur, depending upon the pipe work's material.

! The above is only applicable in Germany. Other national papers may specify differently. Check relevant applicable national regulations and with the pipe manufacturer the compatibility of the pipe work. Consult the Wefatherm Customer Service.

 **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.

General information on water supply systems

3 General information on water supply systems

Drinking water is one of our most important elements and is accordingly subject to very strict regulation, and national guidelines on drinking water must be followed. The guidelines mentioned in this Specification Manual are based on the regulations in Germany and the European Union.

Directives on the quality of water intended for human consumption:

- Germany: Drinking water ordinance (Trinkwasserverordnung) TrinkwV
- European Union: Drinking Water Directive 2020/2184

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

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 discomfort like noise
- Prevention from the loss of waste and energy

Substances list

For preparation of water for human consumption only substances may be applied which are recognised by the German ministry of health. With the goal to:

- Remove undesired substances from the water
- Make the water suitable for human consumption
- Kill or inactivate causes of disease at key times:
 - 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 at 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 listed in the German drinking water regulation. An extract of this list is given in table 3.1.

Drinking Water Directive (EU) 2020/2184

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 Commission



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.

Substance	CAS Nr.	EINECS Nr.	Application	Requirement	Max. concentration after treatment
Calciumhypochlorit	7778-54-3	231-908-7	Disinfection	DIN EN 900 Table 1, type 1	max. 0,3 mg/l free Cl ₂ min. 0,1 mg/l free Cl ₂
Chlorine	7782-50-5	231-959-5	Disinfection, production of Chlorinedioxide	DIN EN 937 Table 1	max. 0,3 mg/l free Cl ₂ min. 0,1 mg/l free Cl ₂
Chlorinedioxide	10049-04-4	233-162-8	Disinfection	DIN EN 12671 (EN 937, 901, 939, 899, 938, 12926)	max. 0,2 mg/l free Cl ₂ min. 0,05 mg/l free Cl ₂
Natriumhypochlorite	7681-52-9	231-668-3	Disinfection	DIN EN 901 Table 1, type 1 Limit for impurities with sodium chlorate (NaClO ₃): <5.4% (m/m) of active chlorine	max. 0,3 mg/l free Cl ₂ min. 0,1 mg/l free Cl ₂
Ozone	10028-15-6	233-069-2	Disinfection, oxidation	DIN EN 1278 Attachment A.3.2	0,05 mg/l O ₃

CAS: Chemical Abstracts Service Registry Number

EINECS: European Inventory of Existing Commercial Chemical Substances

Table 3.1 Extract of water treatment substances for disinfection in drinking water, according to Trinkwasserverordnung TrinkwV

General information on water supply systems

3.1 Hygienic reliability

Maintaining the hygienic quality of drinking water within a system requires protection against contamination from:

- *Increased microbiological growth*
Water naturally contains low levels of pathogenic germs which can cause illnesses like legionella and dysentery when the bacteria start to grow and increase. These organisms generally develop at temperature between 20°C and 55°C. So water within a system needs to avoid this temperature range.
- *Contamination from materials*
Drinking water makes contact with the materials used 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, any materials containing elements which could leach from them and accumulate in drinking water at an unacceptable level must be avoided. A known example is the use of lead pipes in drinking water distribution. Also some plasticisers and colour dies used in plastics are potential contaminators. Regulation on drinking water prevents the use of such materials. Multiple Third Party testing confirms that materials used in the Wefatherm system comply with these regulations.
- *Back flow of 'used water' into the system*
When water flushes from a tap, such as in a bath, it can make contact with soap or oils and becomes no longer fit for human consumption. Furthermore, flush systems are sometimes not used every day, and the flush water may be exposed to elevated temperatures with the result that it could contain increased amount of bacteria. So, no fixed connections between bath tubs, flush cisterns, and heating or cooling systems are allowed.

3.2 Long term uninterrupted use

For long term uninterrupted use the system should be protected:

- against fire
- against freezing
- against excessive heating
- against condensation
- against corrosion
- against mechanical damage

Standard	Title
DIN 1988	Codes of practice for drinking water installations – DVGW code of practice
DIN 2000	Central drinking water supply
DIN 4708	Central heat water installations
EN 806	Specifications for installations inside buildings conveying water for human consumption

Table 3.2 Specification for drinking water installations

Standard	Title
W551	Technical measures to reduce legionella growth
W553	Dimensioning of circulation-systems in central drinking water heating systems
VDI 6023	Guideline on how to plan, design, engineer, operate and maintain

Table 3.3 Codes of practice: specification for large scale drinking water installations

- *Protection against fire*
In buildings, fire protection is usually based on zones with barriers to slow down the spread of fire, to limit exposure, and to provide time to extinguish it. Pipe and cable systems must not act as a fuse for the development of a fire, so fire protection sleeves should be applied 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 start leaking as soon as the water melts again. So apply insulation wherever there is a potential risk.
- *Protection against excessive heat*
When cold and hot water systems are close to each other, or at points where they cross, the cold water can become hot with the result that it is no longer fresh. Excessive heat for example from a boiler, might damage the pipe system, resulting in early failure of the material.
- *Protection against condensation*
When warm, moist air comes into contact with a cool surface, it condenses and forms small drops of water. If this persists, areas of dampness can form and funguses can develop. The risk of condensation can be reduced by insulating cold water systems.
- *Protection against corrosion*
Corrosion causes degradation of the pipe material and leads to early failure of systems. The risk of corrosion to metal pipe systems like passivation or insulation are applied to reduce the risk for corrosion.
- *Protection against mechanical damage*
Mechanical damages like scratches or indentations caused by bad handling, lead to weakening of the material. Careless clamping and insufficient expansion compensation leads to additional material stresses. Both can result in early failure of the system.

3.3 Avoid discomfort

Avoid discomfort due to:

- *Noise*
Hearing water flow becomes a discomfort above a noise level 30 dB(a). Apply insulation to prevent noise exceeding this level.
- *Waiting time for availability of warm water*
Waiting for the right temperature becomes a nuisance after a certain time. Apply an application specific pipe diameter to avoid excessive waiting time.

3.4 Waste prevention

Waste prevention against excessive use of:

- *Water*
When excessive time is necessary to wait for the required water temperature, valuable water is wasted. Apply a specific dimension of pipe system to avoid excessive waiting time.
- *Energy*
Reduction of energy consumption in buildings is regarded as a substantial contributor to reaching climate goals. Beside insulation of buildings and modern heating technology, the reduction of energy for the production of hot water is possible. In modern buildings, hot water systems are optimised to ensure that substantially lower energy is required.

General information on water supply systems

3.5 Manufacturers position on Legionella prevention & control

Introduction

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 treatment, not necessarily covered in this statement to cure contamination.

! Considerations about the Legionella bacteria and risk for human health

Legionella Pneumophila is the most prevalent form of legionella and is particularly dangerous to humans. This bacteria is found in minimal, generally non-pathogenic quantities in groundwater and surface water, as well as in drinking water supply systems, and building plumbing drinking water networks.

The bacteria produce a pathological effect, particularly in warm vaporised 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 only die when temperatures exceed 60 °C.

The need to control the Legionella risk is particularly high in buildings where more vulnerable residents may suffer from bacterial exposure (hospitals, retirement homes, schools), in large complex water systems of buildings like hotels, fitness centres and to a great extent in other large commercial buildings.

In such buildings specific measures are usually required and need to be systematically implemented to prevent the occurrence of Legionella growth and to treat the installation whenever levels exceed regulatory thresholds.

Considerations about biofilm

Biofilm provides a favourable substrate for Legionella growth.

! Microbial growth is difficult to predict and is influenced by multiple factors

Key factors are such as pipe work design, the nature and quality of the water, chemicals applied to disinfect the water in the public network, local conditions such as temperature, operation and maintenance, and the presence of scale and corrosion of the pipes make it difficult to develop any predictive model.

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

A biofilm is a collection of microorganisms caused when bacteria attaches itself to surfaces. Even perfectly hygienic drinking water contains bacteria with nutrients fueling their growth. Bacteria attach to any kind of surface, which is why biofilms develop in all water systems, irrespective of the materials used.

Field studies show that 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 such as hospitals, retirement homes and schools, for incidences of Legionella. For the first time, such a study included not only analysis of drinking water, but also biofilm formation in the pipes. The study showed that plastics and non-plastic piping systems behave similarly regarding biofilm development.

"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," said the Öfi conclusion.

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

European standards, applicable to all types of pipe works, regardless of materials used, provide guidance to minimise contamination of the pipe work by such bacteria as Legionella. Advice is given to ensure the proper design and operation of drinking water installations without the use of disinfectants, and describes 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 are not standardised among EU states. They are covered at national level through national standards, regulations and guidelines, which can vary significantly from one European country to the other - in particular with regard to water temperature, allowable chemicals and concentrations.

For example, 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 must be followed.

! Applicable national regulations in the relevant country must be checked and acceptable exposure times clarified with the pipe work's manufacturer. For more information, please consult the Wefatherm Customer Service.

The presence of disinfectant in the public fresh water network should be taken into consideration

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

General information on water supply systems

Important general recommendations

! Chemicals used for disinfection are strong oxidising substances. Chlorine dioxide is the most oxidising and active one. For certain materials they may significantly reduce the lifetime of the piping system. In extreme circumstances, the pipe material (plastic, metal or elastomer) may be damaged after even a single exposure.

The impact of a disinfection procedure on the piping components depends on a number of factors including:

- The type of material used for the various components of the pipe system (pipes, fittings, seal joints and equipment 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 with 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 minimise the risk of damage to the pipe work.

Any disinfection procedure must 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 damage to the piping system (pipes, valves, devices, seals, O-rings, etc.) in which case lifetime performance cannot be guaranteed.

It is strongly recommended that prior to applying a chemical disinfection (shock or continuous), to the building drinking water network relevant information such as applicable regulations and characteristics of the fresh water delivered into the building should be collected. This should be used to seek advice from the manufacturers of the pipe system, of the disinfection chemical, and of the disinfection dosing equipment, 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 service life.

! In case of specific questions concerning mechanical performance, chemical resistance, design, installation, commissioning, operation or maintenance, please contact the Wefatherm Customer Service.

Product quality and certification

4 Product quality and certification

4.1 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 16962: 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

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 4.1 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
Homogeneous material	X	1x month	2x year	6.1.9 Microscope Max 0,02 mm

Table 4.2 General requirements

4.2 Quality management system

The system of monitoring the high quality of the products during the production process is given in illustration 4.1.

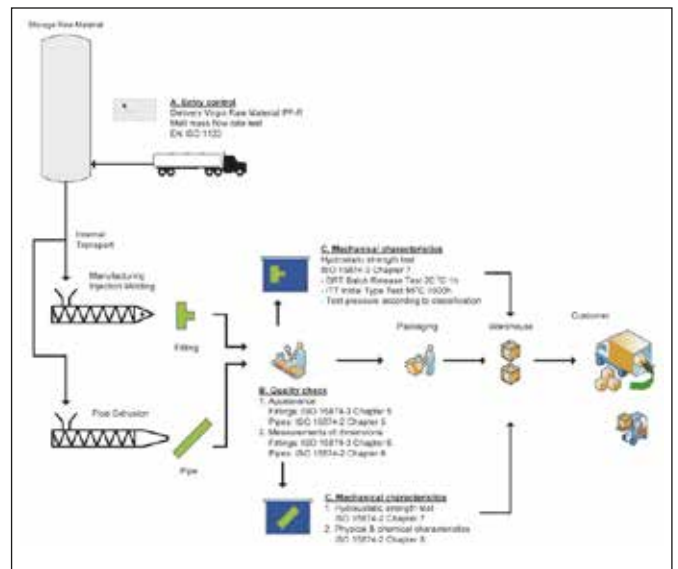


Illustration 4.1 Quality management system

Product quality and certification

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 starts 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.

4.3 Product certification

The Wefatherm pipe system is subjected to multiple internal and external checks. National and international authorities and institutions, the neutrality of which is unquestionable, 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

External monitoring is carried out by the South-German Plastics Centre (SKZ), Würzburg and TZW Karlsruhe. These are authorised 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 with 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 the 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.

4.4 Approvals

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

Illustration 4.2

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



Due to their wall structure fibre pipes and stabi pipes are not covered by standards DIN 8077 and ISO 15874. They are externally monitored by SKZ and are not part of the DVGW certification.

4.5 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 mentioned in table 4.3.

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 4.3

4.6 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.

Product quality and certification

4.7 Manufacturer's guarantee

When these components are correctly installed and used, the Wefatherm pipe system can be expected to provide long-term, trouble-free and satisfactory operation. However, should you have any questions, our after-sales service is ready to help you.

Warranty

The pipes and fittings ('The Products'), which are components of the Wefatherm Pipe System, are warranted against manufacturing defects for a period of 10 years from the date of manufacture marked on them, subject to all the following conditions:

- (i) The warranty shall not apply to defects that were apparent at the time of 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.

4.8 Product liability insurance

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



For additional information contact the Wefatherm Customer Service.

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 experience in application and production techniques. Customers nowadays expect that both the engineering (planning) firm and construction company have 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.

! 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 for 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 programmes 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 four main groups, see illustration 5.1.

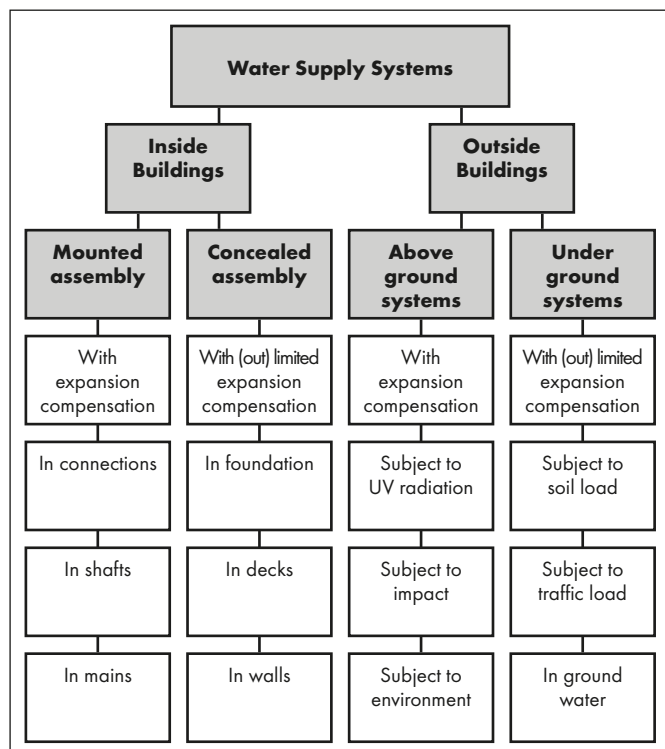


Illustration 5.1

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 concealed systems without (or limited) expansion compensation

Longitudinal expansion does not necessarily have to be taken into account with concealed 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. Concealed 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

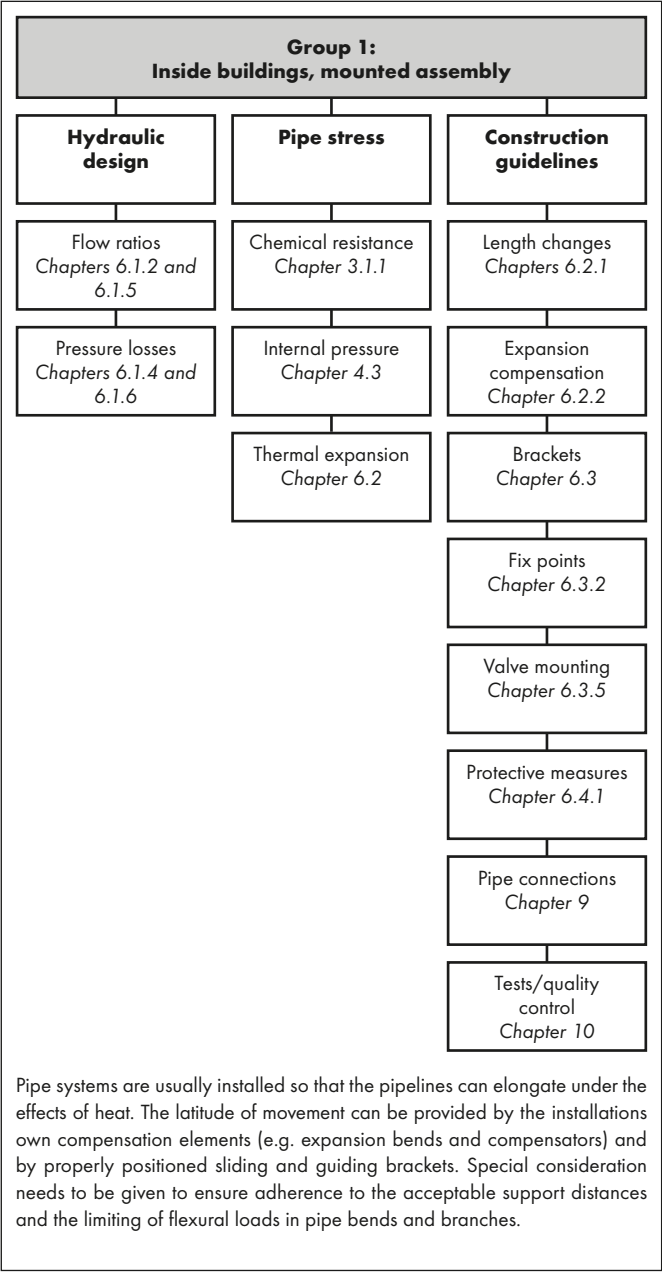


Illustration 5.2 Inside buildings, mounted assembly

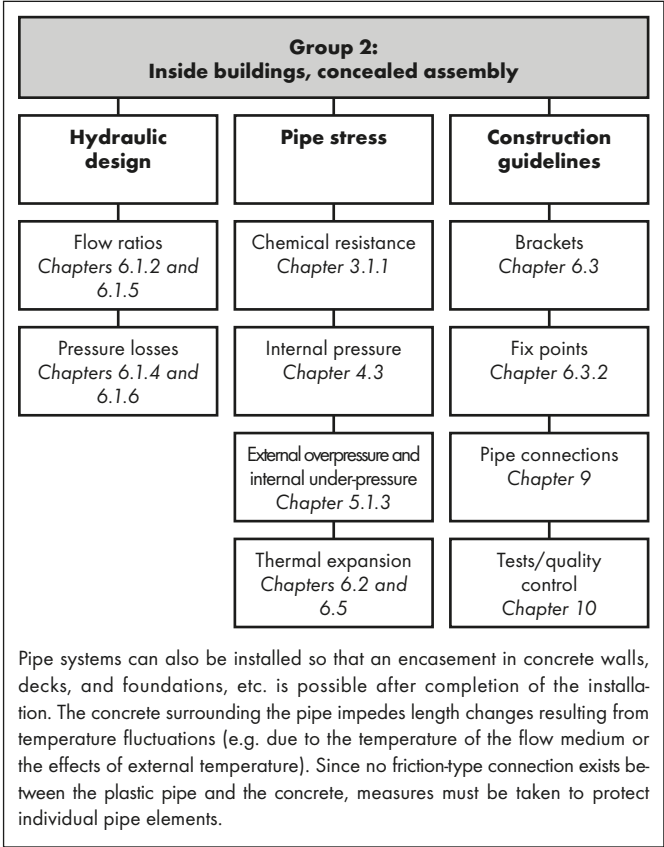
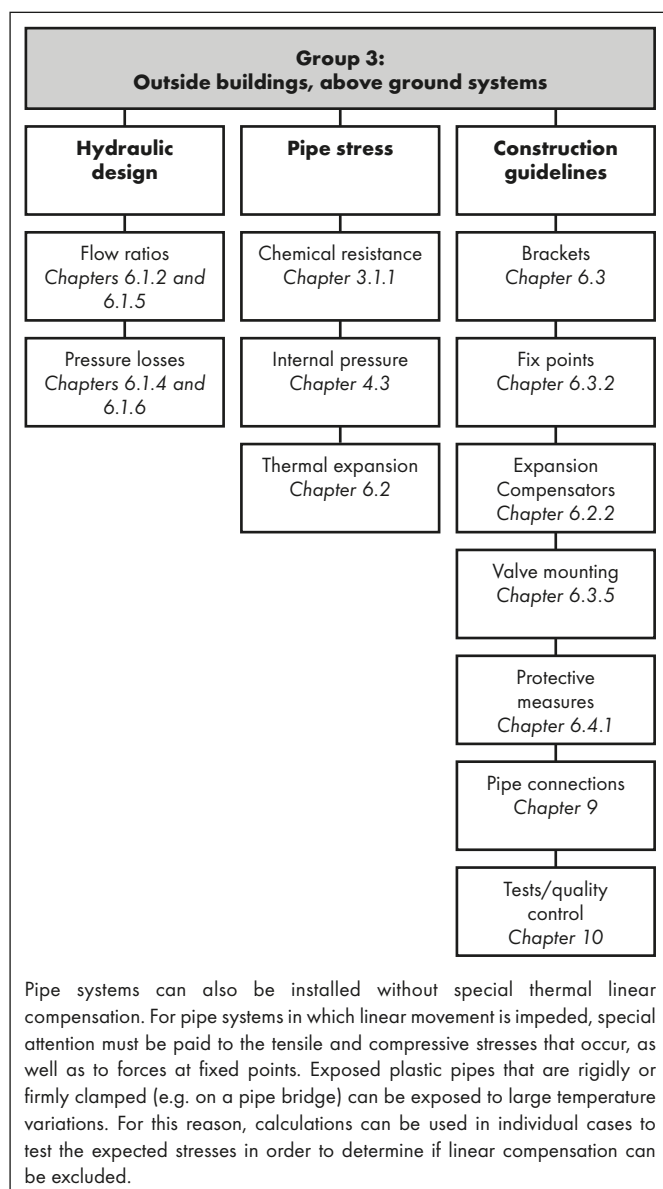
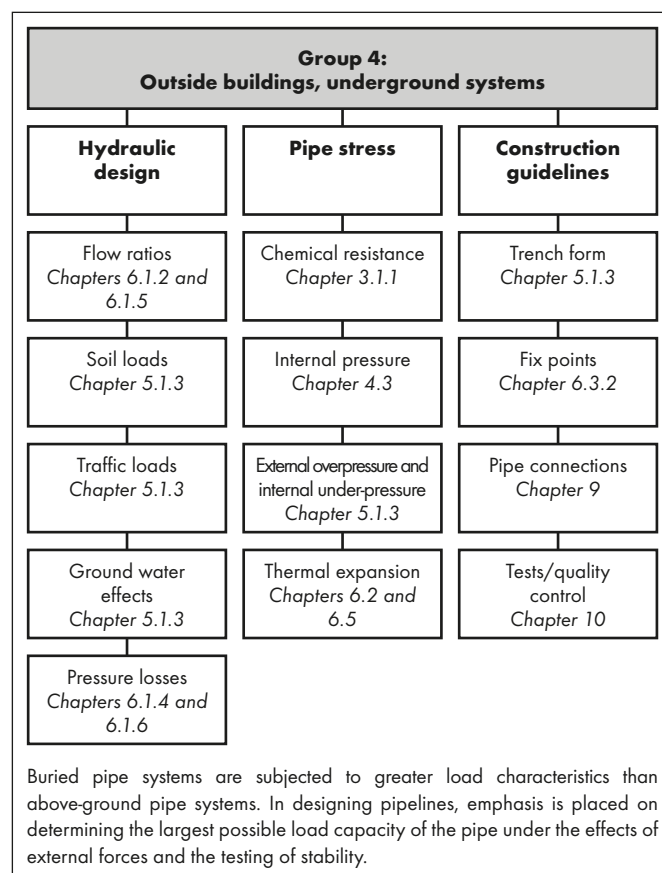


Illustration 5.3 Inside buildings, concealed assembly


Illustration 5.4 Outside buildings, above ground systems

Illustration 5.5 Outside buildings, underground systems

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, and external loads, can occur collectively 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 please contact the Wefatherm Customer Service.

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. Therefore, the testing for stress has 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 relevant 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 compactible 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 stresses (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 actual 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. Owners of an installation are obliged to reduce risk based on a risk analysis and maintenance plan.

Risk analyses

Buildings requiring risk analyses and maintenance plans of collective drinking water installations include:

- Medical care facilities
- Rehabilitation and recover centres
- Care and shelter centres
- Hotels
- Swimming pools and wellness centres
- Buildings which have a lodging function and/or shower facilities

Maintenance plan

The maintenance plan details the measures for periodic management of risk and for the monitoring of water quality. It also stipulates action to be taken when requirements are not met.

Samples are first taken and analysed for the initial risk analysis and then repeated every six months. The plan also specifies the number of samples to be taken, related to the number of tap points.

Management measures

Management measures include:

- Flushing of less frequently operated tap points
- Measuring temperatures
- Checking non-return valves
- Taking water samples
- Flushing boilers and storage tanks



It is essential to follow the applicable laws, standards, guidelines, regulations and instructions for environmental protection, as well as advice from professional associations and the local utility companies.

5.3 Pipe selection

5.3.1 Pipe wall configurations

Wefatherm pipes are available in two 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 colour for hot and cold water
purple colour for reused water
- Mono layer = PP-R/PP-RCT

The international product certification applies on this pipe wall type.



Illustration 5.6

Fibre pipe

This is a three-layer pipe of which the middle layer is enforced with glass fibre. The production of these pipes is externally monitored by the South German Plastics Centre (SKZ), Würzburg.

- PP-R available in SDR 7,4
- PP-RCT available in SDR 9 - 11 - SDR 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

Standards

5.3.2 Pipe wall selection

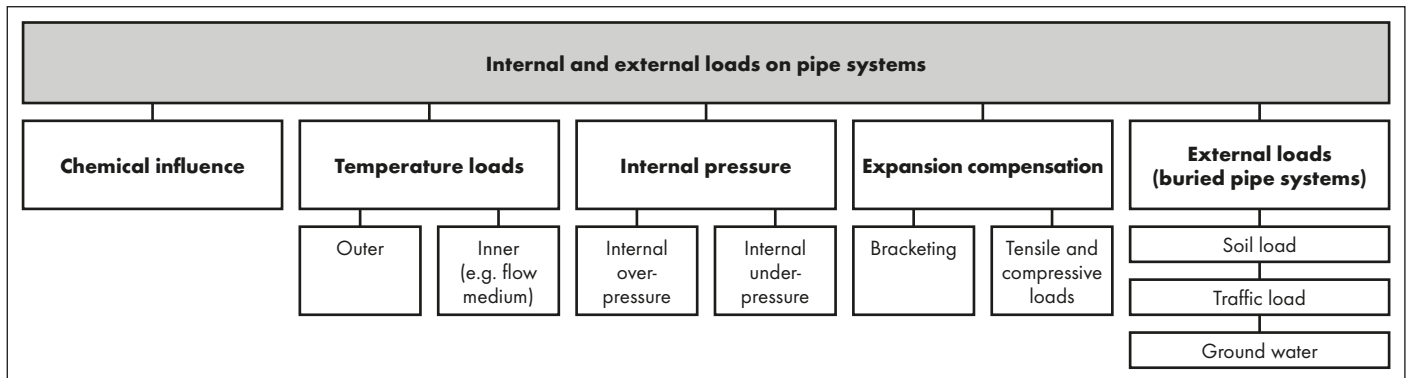


Illustration 5.9

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 provided in chapter 3.

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

! In hot tap water systems, the potentially amount of dissolved chlorine can be higher due to secondary (preventive and corrective) disinfection water treatment. Limitations must be respected, particularly in recirculating hot water systems with water temperatures above 70 °C. See restrictions in chapter 2 of this Specification Manual

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

The required SDR value is determined by the temperature load and internal pressure. The requirements for temperature load and internal pressure are specified in national guidelines.

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

Table 2.10 of this Specification Manual shows the maximum operating pressures of the Wefatherm pipe ranges.

! It is the responsibility of the purchaser or specifier to make the appropriate selection taking into account specific requirements, any relevant national regulations and installation practices or codes.

Temperature load and internal overpressure

An overload of pressure in a pipe system due to internal overpressure, especially in association with additional heat effects, results in a continuous expansion of the pipe until it breaks. The danger of an expansion arises as a result of insufficient wall thicknesses. In the case of heat expansion, a wall thickness enlargement also increases the reactive forces on the pipe's fixed points. The engineer must ensure that the wall thickness is designed to meet requirements whilst the pipe remains elastic enough to respond to any length changes that might occur. A sudden change in structural operating conditions, due to internal pressure, leads to pressure surges. The distinctive elasticity of a 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 properly tested for any foreseeable effects of pressure surges.

5.3.3 Pipe diameter selection

In order to select the correct pipe diameters, 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 required in order to calculate the correct diameters for a pipe network. The following data is needed:

- 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, and water treatment units.
- 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

Tables providing the relevant information (pipe friction resistances, loss coefficients for fittings and connection units) are provided in appendix B of this Specification Manual.

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

! If you require assistance for the design and calculation of water supply systems, contact the Wefatherm Customer Service.

6 Engineering

6.1 Basis for calculation of drinking water systems

Drinking water installations must be planned, designed and operated with particular accuracy according to EN 806 and DIN 1988. The determining of the pipe diameter is based on the calculation of the pressure loss in pipes.

Beside the diameter, the pressure loss depends on the length of the pipe, the pipe material and on the flow rate, dependent on the quantity and size of the water points to which the pipe is connected.

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 in accordance with the German standard DIN 1988-300, are given in tables 6.1 and 6.2. Ensure the values are applied according to 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]	Type of drinking water removal point		Calculation flow rate with the removal of:		
			Mixed water		Only cold or only hot water
			$V_{R,cold}$ [l/s]	$V_{R,hot}$ [l/s]	V_R [l/s]
0,5	Outlet valves without aeration ^{a)}	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
0,5	Filling valve for flushing tank to DIN EN 14124	DN 15	-	-	0,13
1,0	Flushing valve (manual) for urinal to DIN EN 12541	DN 15	-	-	0,30
1,0	Flushing valve (electronic) for urinal to DIN EN 15091	DN 15	-	-	0,30
1,2	Flushing valve for toilet	DN 20	-	-	1,00
0,5	Corner valves for urinal basins	DN 15	-	-	0,30
0,5	Domestic dishwashing machine to DIN EN 50242	DN 15	-	-	0,07
0,5	Domestic washing machine to DIN EN 60456	DN 15	-	-	0,15
1,0	Mixing battery ^{b), c)} for 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	-

a) Without connected appliances (e. g. lawn sprinkler).

b) The design flow rate must be calculated for the cold and hot water connection.

c) Angle valves, e. g. for basin fittings and S connections for e. g. shower and bathtub fittings must be considered as individual resistances or in the minimum flow pressure of the tapping fitting.

Tapping fittings not included in the table and appliances of the same type with larger fitting flow rates or minimum flow pressures than indicated must be considered according to manufacturer information when determining the pipe diameters.

Table 6.1 Minimum flow pressure and design flow rates according to DIN 1988-300



Manufacturers must indicate the minimum flow pressure and the design flow rates on the cold and hot water side (with mixer taps). Generally, manufacturer's specifications, which can deviate significantly from the values indicated in the table, must be observed when dimensioning pipe diameters. Proceed as follows:

There are two options if the manufacturer's specifications regarding minimum flow pressure and design flow rate are below those specified in the table:

- If the drinking water installation is designed for lower values due to reasons

of hygiene or efficiency, this procedure must be agreed with the owner and the design conditions for the tapping points (minimum flow rate, design flow rate) must be included in the calculation.

- If the drinking water installation is not dimensioned for lower values, the values specified in the table must be considered.

If the manufacturer's specifications are above the values specified in the table, the drinking water installation must be dimensioned according to the manufacturer's specifications.

Engineering

6.1.2 Flow speed and maximum flow rate

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

When determining the pipe diameter, not only the available pressure must be considered, but also the maximum flow rate in the sections. Table 6.2 gives an overview of the maximum calculated flow velocities in the sections according to DIN 1988-300. A distinction is made here as to whether permanent consumers are present or not. Through the use of low-pressure-loss fittings, e.g. g. angle seat valves, consumption lines can be subjected to a higher maximum flow rate of up to 5 m/s. This results in the advantage that the pipelines can be made smaller.

Pipework section	Max. computed flow speed at flow duration of	
	< 15 min. m/s	≥ 15 min. m/s
Connection lines	2	2
Consumer lines: Part sections with resistance coefficient of fittings $\zeta < 2,5$ *)	5	2
Consumer lines: Part sections with resistance coefficient of fittings $\zeta \geq 2,5$ **)	2.5	2
Recirculating hot water systems	0.9	0.9

*) e.g. ball valve, angle seat valve

**) e.g. straight seat valve

Table 6.2 Flow speeds for drinking water applications acc. to DIN 1988-300



National regulations may require lower flow rates to avoid water hammers and noise.

6.1.3 Resistance coefficients

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

6.1.4 Maximum flow rate

Maximum flow rates are given in Appendix B of this Specification Manual.

6.1.5 Pipe friction gradients

Pipe friction gradient R and calculated flow speed in dependence of circulation are given in Appendix B of this Specification Manual.

6.1.6 Pressure losses from individual resistance

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

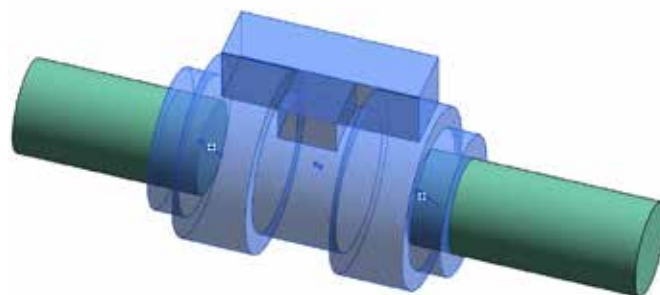
Computed flow speed v m/s	Pressure loss Z for $\zeta = 1$ mbar	Computed flow speed v m/s	Pressure loss Z for $\zeta = 1$ mbar
0,1	0,1	2,6	33,8
0,2	0,2	2,7	36,5
0,3	0,5	2,8	39,2
0,4	0,8	2,9	42,1
0,5	1,3	3,0	45
0,6	1,8	3,1	48
0,7	2,5	3,2	51
0,8	3,2	3,3	55
0,9	4,1	3,4	58
1,0	5,0	3,5	61
1,1	6,1	3,6	65
1,2	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 $\zeta = 1$ (at $\vartheta = 10^\circ\text{C}$ and $Q = 999,7 \text{ kg/m}^3$) and flow speed ($z = 5v^2 \cdot \sum \zeta$)

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



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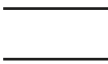
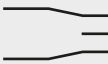
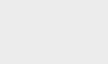
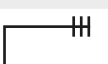
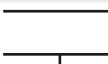
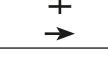
Nr.	Individual resistance	Graphical symbol	Resistance coefficient
1	Socket		0,25
2	Reduction up to 2 dimensions		0,55
2a	Reduction from 3 dimensions		0,85
3	Elbow 90°		2,0
3a	Elbow 90° i./a.		1,2
4	Elbow 45°		0,6
4a	Elbow 45° i./a.		0,5
5	Tee (separation)		1,8
5a	Tee (reduced)		3,6
6	Tee (combination)		1,3
6a	Tee (reduced)		2,6
7	Tee (counter-flow)		4,2
7a	Tee (reduced)		9,0
8	Tee (counter-flow)		2,2
8a	Tee (reduced)		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		9,5
	20 mm		8,5
	25 mm		7,6
	32 mm		5,7
	40 mm		
15	Inclined seat valve		5,0
	20 mm		4,4
	25 mm		3,8
	32 mm		3,2
	40 mm		
16	KFR valve		5,0
	20 mm		4,4
	25 mm		3,8
	32 mm		3,2
	40 mm		
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 fibre pipe is considerably less than is experienced with 100% plastic pipe. The method for theroretically calculating the longitudinal expansion is illustrated in the example. For practical use, the longitudinal expansion to be expected with three different materials is shown in the 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 as to whether any of the possible measures to compensate it should be taken.

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.

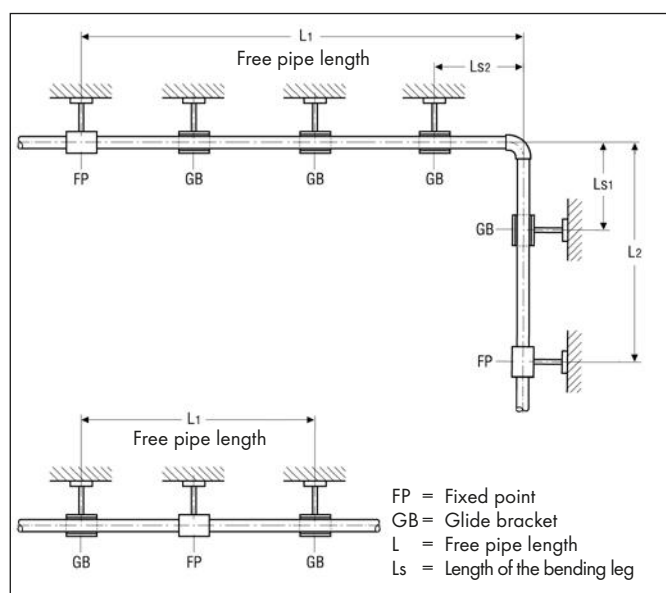


Illustration 6.1 Longitudinal expansion

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:

$$\Delta L = \alpha \times L \times \Delta t$$

ΔL = Longitudinal expansion in mm
 α = linear expansion factor
 for Wefatherm standard pipe 0,150 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

Wefatherm Standard pipes

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

Equation 6.2

Pipe length (m)	Longitudinal expansion Temperature difference Δt (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

Wefatherm Fiber pipes

$$\alpha = 0,035 \text{ mm/m} \cdot \text{K}$$

Equation 6.3

Pipe length	Longitudinal expansion Temperature difference Δt (K)							
(m)	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 6.7

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.

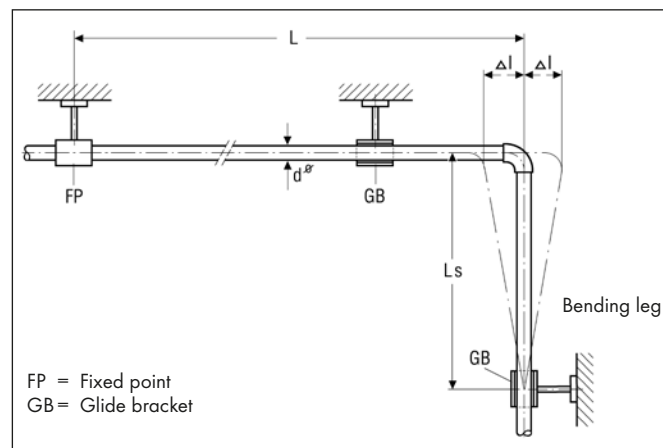


Illustration 6.2

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:

$$L_s = K \times \sqrt{d \cdot \Delta L}$$

L_s = length of the bending leg in mm

K = constant for the material, for Wefatherm pipes = 15

d = external diameter Wefatherm pipe in mm

ΔL = longitudinal expansion in mm

1. Calculation of the longitudinal expansion ΔL

For a temperature difference of Δt 40 K between the hot water temperature and the ambient temperature.

Given:

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

$$L = 10,0 \text{ m}$$

$$\Delta t = 40 \text{ K (}^\circ\text{C)}$$

To be calculated: ΔL

$$\alpha \times L \times \Delta t = \Delta L$$

$$0,15 \times 10,0 \times 40 = 60 \text{ mm}$$

2. Calculation of the minimum length of L_s of the bending leg

Given:

$$K = 15$$

$$d = 40 \text{ mm}$$

$$\Delta L = 60 \text{ mm}$$

To be calculated: L_s

$$K \times \sqrt{d \times \Delta L} = L_s$$

$$15 \times \sqrt{40 \times 60} = 735 \text{ mm}$$

Equation 6.5

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 need to be calculated.

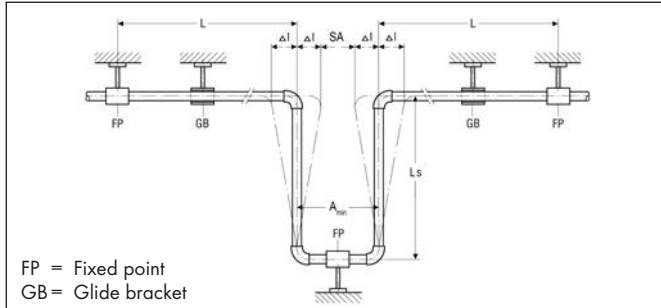


Illustration 6.3

Calculation example of expansion bow width A_{min} :

The width of the expansion bow A_{min} is calculated using the following formula:

$$A_{min} = 2 \times \Delta L + SA$$

A_{min} = Width of expansion bow
SA = Safety distance
 ΔL = Longitudinal expansion

Given: $\Delta L = 60 \text{ mm}$
SA = 150 mm

To be calculated: A_{min}
 $2 \times \Delta L + SA = A_{min}$
 $2 \times 60 + 150 = 270 \text{ mm}$

Equation 6.6

Pre-stressing

By pre-stressing a bending leg, the length of the leg can be shortened with a narrow space. When carefully planned and carried out, preload assemblies offer an optically perfect finish as expansion movement is not visible. The calculated ΔL is negatively pre-stressed while being installed. After initial operation of a pipe system, a correct 90° angle will be achieved.

Example of calculating the length of bending legs with pre-stressing:

The length of the bending leg with pre-stressing is calculated in accordance with the following formula (U-shape):

$$K \times \sqrt{d \times \frac{\Delta L}{2}} = L_{SV}$$

L_{SV} = Length of the bending leg with pre-stressing
K = Material-specific constant for Wefatherm pipes
d = External diameter Wefatherm pipes
 ΔL = Longitudinal expansion

Given: K = 15
d = 40 mm
 $\Delta L = 60 \text{ mm}$

To be calculated: L_{SV}
 $K \times \sqrt{d \times \frac{\Delta L}{2}} = L_{SV}$
 $15 \times \sqrt{40 \times \frac{60}{2}} = 520 \text{ mm}$

Equation 6.7

6.3 Mounting and bracketing

6.3.1 Techniques for mounting pipework

When considering techniques for mounting pipe work, it is necessary to differentiate between fixed point mountings (referred to as fixed points) and loose or sliding point mountings (referred to as sliding points). By definition, the fixed point or fixed clamp holds the pipe in a fixed manner, in contrast to a sliding point which will permit the pipe to move in an axial direction. An optimal 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 point and ensure the required guiding and holding of the pipe.

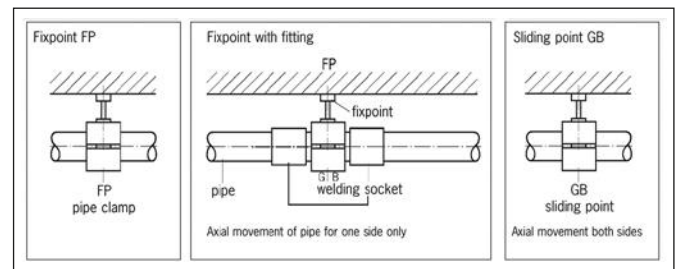


Illustration 6.4

6.3.2 Fix points

Fixed point mountings (fixed points) divide a pipe network into sections. The free lengths from a fixed point must be measured with an allowance made for possible longitudinal expansion. 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. In such cases the clamps may 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 branching pipe 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 affected by loose or sliding point mountings. The clamps should have suitable inserts (e.g. rubber) to prevent the pipe surface from being damaged and to allow movement. Fittings must be at a sufficient distance from the sliding point clamps, otherwise they will act as fixed points.

6.3.4 Principles for the layout and construction of fixed points

- Fixed points should be arranged so that direction changes of the pipe can be used to absorb length changes.
- They should also be designed to take into account 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 distortion 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, thus creating predominantly compressive stresses when heated (operating state).
- If flange connections are used 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 impede the pipe system should be provided with an additional support structure. Supporting valves not only serve to bear weight, but also prevent the transfer of forces on 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 should be given to the implications of the restricted length change.

6.3.6 Spans LA at pipe wall temperature T_R

Wefatherm PP-R pipe

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

Table 6.8

Wefatherm fiber pipes

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

Table 6.9

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) should include insulation against loss of heat or cooling, changes in ambient temperature and UV light effects. They need to be protected to avoid such effects as a reduction in length. In establishing the bracket distances, the weight of the insulation should be taken into account. Protective measures that broaden the range of internal pressure loads for which the pipes are suitable should also be considered.



Energy-saving is environmental protection. The legal regulations and requirements of specific countries must be followed.

6.4.2 Insulating warm water lines

In spite of the high level of insulation of PP-R pipe systems, warm and hot water lines should be further insulated to protect against physical contact with hot surfaces, to reduce noise discomfort, and to reduce loss of heat from the water. In hot water circulation systems, temperature loss needs to be minimised to avoid conditions which may induce legionella. The minimum return flow temperature needs to be maintained at 60°C. This is done by raising the boiler temperature, but this requires additional energy and can cause additional stress on the (plastic) pipe work. At water temperatures above 70°C, a possible reduction in the life expectancy of PP needs to be taken into account. Depending on the operating conditions, the life expectancy may be reduced significantly. However, with proper insulation, boiler temperatures can be lowered and the PP-R's excellent material properties fully maintained.

Mounting situation	Insulating layer thickness at $\lambda = 0,040 \text{ W (mK)}$
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 masonry slit rising main	
Pipework laid in wall recess next to heated pipe lines	13 mm
Pipework laid on cement floor	4 mm

Table 6.10 Guideline values for minimum thicknesses of insulation for insulating drinking water systems (cold)

Engineering

6.4.3 Insulating cold water lines

Condensation is formed by the precipitation of water vapour on a surface that is cooler than its environment. This causes the water vapour to condense and to form water droplets. Whether water vapour condenses to water on piping depends on the insulation and humidity.

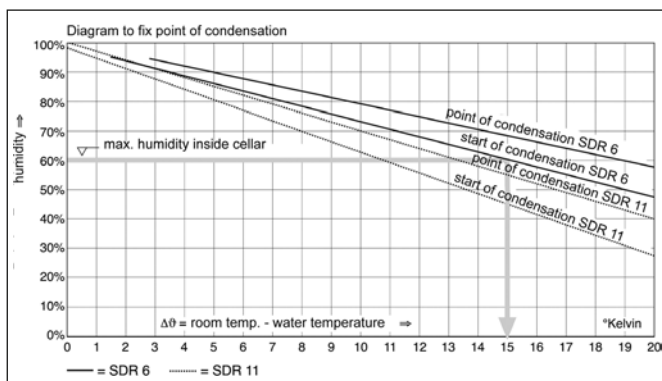


Illustration 6.5 Condensation on cold water lines

6.4.4 Condensation point

- A typical case occurs in a cellar, buried to two thirds of the wall height in the earth, and that has no ventilation from doors and windows.
- Such a 'typical case' occurs even in summer after strong rain in cellars with 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.
- In southern regions, these temperatures are sometimes exceeded and the water temperature is often higher than 10°C.
- For cellars and all rooms, it should be determined, on a case-by-case basis, whether the maximum room temperature might be 15°C higher than the water temperature.
- For SDR 11 pipes, the allowed temperature difference is 11 °C.

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



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. These instructions may be applied to other similar circumstances.

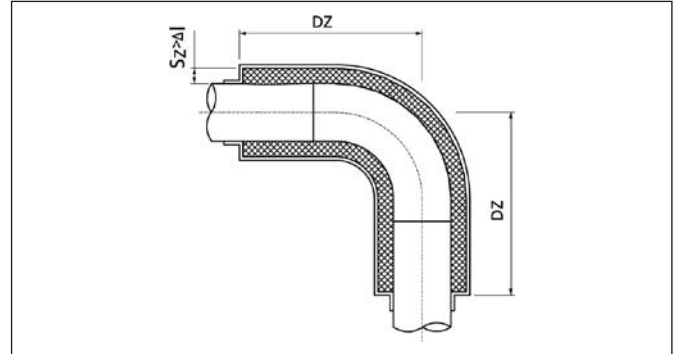


Illustration 6.6 Expansion zones in pipe bends

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 could 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 is often concentrated on tee sections, as additional 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.

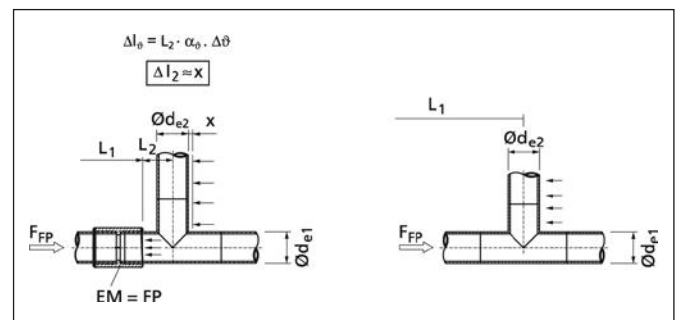


Illustration 6.7 Shear and fixed point forces on tees and 45° branches

6.6 Testing and Commissioning

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 (usually water) and the pipe work material are at the same temperature. The test medium should have a temperature that is as constant as possible. The pressure test is divided into three parts: 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 10 minutes within a period of 30 minutes. After the pressure has been restored a second time, the test pressure should not fall by more than 0,6 bar within the next 30 minutes. No leakage must occur.

Main test

The main test starts immediately after the completion of the initial test and lasts two hours. During this period the pressure must 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 needs to be depressurised. Leakage must not occur at any point in the network being tested.

Measuring devices

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

Test memorandum

The tests have to be documented in a memorandum which needs to be signed by the client and contractor and should state 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 to ensure 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 must be flushed out.

Suitable processes are:

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

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 $P_{perm} = 10 \text{ bar} / \text{ } ______ \text{ bar}$ (if greater) Water temperature $\vartheta_w = \text{ } ______ \text{ }^\circ\text{C}$ Ambient temperature $\vartheta_u = \text{ } ______ \text{ }^\circ\text{C}$ $\Delta\vartheta = \vartheta_u - \vartheta_w = \text{ } ______ \text{ K}$	
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

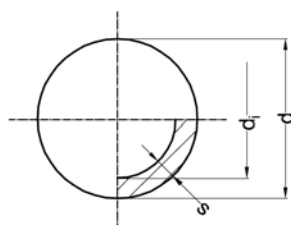
Pipe SDR 6 PP-R

PP-R
SDR 6
green

length of pipes = 4 m



d	Item Code	s	d _i	l/m	DN	kg
20	5155 20002	3,4	13,2	0,137	12	0,724
25	5155 20003	4,2	16,6	0,216	15	1,116
32	5155 20004	5,4	21,2	0,353	20	1,824
40	5155 20005	6,7	26,6	0,556	25	2,820
50	5155 20006	8,3	33,2	0,876	32	4,388
63	5155 20007	10,5	42,0	1,385	40	6,660
75	5155 20008	12,5	50,0	1,963	50	9,816
90	5155 20009	15,0	60,0	2,827	-	14,104
110	5155 20010	18,3	73,2	4,231	65	21,068
125	5155 20011	20,8	83,4	5,463	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.

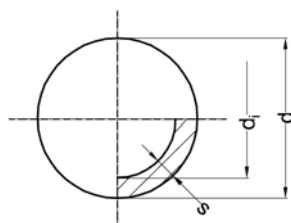
Pipe fiber SDR 7,4 PP-RCT

PP-RCT
SDR 7,4
green

length of pipes = 4 m



d	Item Code	s	d _i	l/m	DN	kg
20	5152 25201	2,8	14,4	0,163	15	0,624
25	5152 25202	3,5	18,0	0,254	20	0,968
32	5152 25203	4,4	23,2	0,423	25	1,564
40	5152 25204	5,5	29,0	0,661	32	2,432
50	5152 25205	6,9	36,2	1,029	40	3,760
63	5152 25206	8,6	45,8	1,647	50	5,936
75	5152 25207	10,3	54,4	2,324	-	8,444
90	5152 25209	12,3	65,4	3,359	65	12,124
110	5152 25211	15,1	79,8	5,001	80	18,072
125	5152 25212	17,1	90,8	6,447	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 20°C/20bar, 70°C/10 bar.

PP-R pipe system d20-315 mm

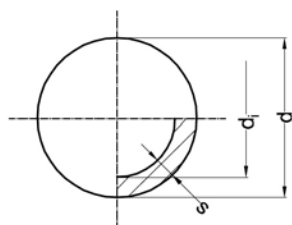
Pipe SDR 7,4 PP-R

PP-R
SDR 7,4
green

length of pipes = 4 m



d	Item Code	s	d _i	l/m	DN	kg
20	5155 20101	2,8	14,4	0,163	15	0,624
25	5155 20102	3,5	18,0	0,254	20	0,968
32	5155 20103	4,4	23,2	0,423	25	1,564
40	5155 20104	5,5	29,0	0,661	32	2,432
50	5155 20105	6,9	36,2	1,029	40	3,760
63	5155 20106	8,6	45,8	1,647	50	5,936
75	5155 20107	10,3	54,4	2,321	-	8,444
90	5155 20108	12,3	65,4	3,359	65	12,124
110	5155 20109	15,1	79,8	5,001	80	18,072
125	5155 20110	17,1	90,8	6,475	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.

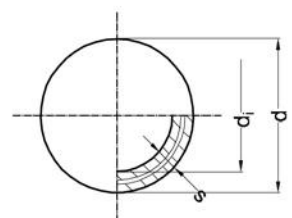
Pipe fiber SDR 7,4 PP-R

PP-R
SDR 7,4
green

length of pipes = 4 m



d	Item Code	s	d _i	l/m	DN	kg
20	5155 20150	2,8	14,4	0,163	15	0,608
25	5155 20151	3,5	18,0	0,254	20	0,944
32	5155 20152	4,4	23,2	0,423	25	1,532
40	5155 20153	5,5	29,0	0,661	32	2,376
50	5155 20154	6,9	36,2	1,029	40	3,716
63	5155 20155	8,6	45,8	1,647	50	5,816
75	5155 20156	10,3	54,4	2,324	-	8,284
90	5155 20157	12,3	65,4	3,359	65	11,908
110	5155 20158	15,1	79,8	5,001	80	17,816
125	5155 20159	17,1	90,8	6,475	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.

PP-R pipe system d20-315 mm

Pipe fiber SDR 9 PP-RCT

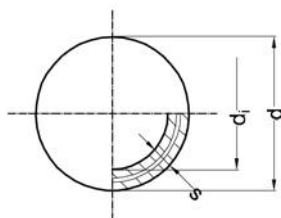
PP-RCT
SDR 9
green

length of pipes = 4 m



d	Item Code	s	d _i	l/m	DN	kg
32	5152 27303	3,6	24,8	0,483	25	1,1631
40	5152 27304	4,5	31,0	0,755	32	1,817
50	5152 27305	5,6	38,8	1,182	40	2,828
63	5152 27306	7,1	48,8	1,870	50	4,514
75	5152 27307	8,4	58,2	2,660	-	6,362
90	5152 27309	10,1	69,8	3,826	65	9,177
110	5152 27311	12,3	85,4	5,728	80	13,666
125	5152 27312	14,0	97,0	7,390	100	17,672

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



Pipe SDR 11 PP-R

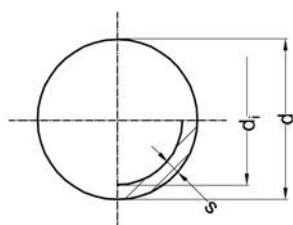
PP-R
SDR 11
green

length of pipes = 4 m



d	Item Code	s	d _i	l/m	DN	kg
20	5155 20050	1,9	16,2	0,205	15	0,452
25	5155 20051	2,3	20,4	0,328	20	0,688
32	5155 20052	2,9	26,2	0,531	25	1,120
40	5155 20053	3,7	32,6	0,834	32	1,728
50	5155 20054	4,6	40,8	1,307	40	2,676
63	5155 20055	5,8	51,4	2,075	50	4,224
75	5155 20056	6,8	61,4	2,941	-	5,964
90	5155 20057	8,2	73,6	4,254	65	8,528
110	5155 20058	10,0	90,0	6,362	80	12,680
125	5155 20059	11,4	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

PP-RCT

SDR 11

length of pipes = 4 m

green

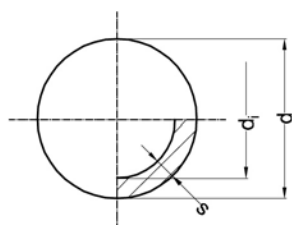


d	Item Code	s	d _i	l/m	DN	kg
160	5152 25016	14,6	130,8	13,4	125	25,320
200	5152 25020	18,2	163,6	21,0	150	39,232
250	5152 25025 ¹⁾	22,7	204,6	32,9	200	61,156
315	5152 25031 ¹⁾	28,6	257,8	52,2	250	69,156

¹⁾ L = 5,8 m.

Suitable for hot and cold water and sanitary installations.

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



Pipe fiber SDR 7,4 PP-RCT

PP-RCT

SDR 7,4

length of pipes = 4 m

green



d	Item Code	s	d _i	l/m	DN	kg
160	5152 27016	21,9	116,2	10,6	100	38,56
200	5152 27020 ¹⁾	27,4	145,2	16,6	125	60,32
250	5152 27025 ¹⁾	34,2	181,6	25,9	180	94,12

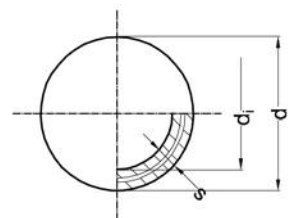
¹⁾ L = 5,8 m.

Suitable for hot and cold water, central heating and air conditioning.

ISO 15874 class 1/6, 2/6, 4/6, 5/4 bar.

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

Striped.



PP-R pipe system d20-315 mm

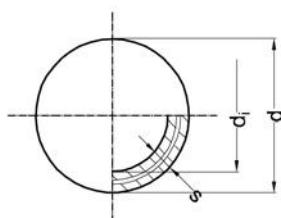
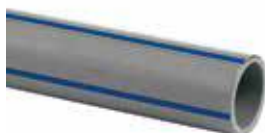
Pipe Wefaklim fiber SDR 11 - grey PP-RCT

PP-RCT

SDR 11

grey

length of pipes = 4 m



d	Item Code	s	d _i	l/m	DN	kg
20	5150 20130 ¹⁾	2,8	14,4	0,163	15	0,608
25	5150 20131 ¹⁾	3,5	18,0	0,254	20	0,944
32	5150 20132	2,9	26,2	0,539	25	1,544
40	5150 20133	3,7	32,6	0,835	32	2,440
50	5150 20134	4,6	40,8	1,307	40	3,696
63	5150 20135	5,8	51,4	2,075	50	4,224
75	5150 20136	6,8	61,4	2,961	60	5,848
90	5150 20137	8,2	73,6	4,254	65	8,640
110	5150 20138	10,0	90,0	6,362	80	12,744
125	5150 20139	11,4	102,2	8,203	100	16,396
160	5150 20140	14,6	130,8	13,437	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.

PP-R pipe system d20-315 mm

Bridge m/m

PP-R
SDR 6
green



d	Item 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



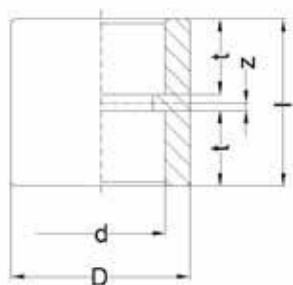
d	Item Code	L	t	H	kg
20	5155 70201	160	16	27	0,041
25	5155 70202	200	18	32	0,077



pipe system d20-315 mm

Socket

PP-RCT
SDR 6
green

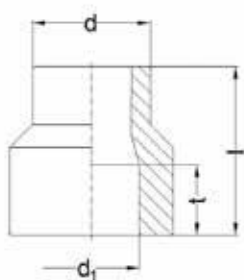


d	Item Code	D	l	z	t	kg
20	5155 27002	29,5	32	1,5	14,5	0,011
25	5155 27003	34,0	35	1,5	16,0	0,014
32	5155 27004	43,0	40	1,9	18,0	0,026
40	5155 27005	53,5	44	1,5	20,5	0,042
50	5155 27006	68,5	50	1,5	23,5	0,083
63	5155 27007	88,0	59	2,1	27,5	0,159
75	5155 27008	105,0	67	2,5	32,0	0,239
90	5155 27009	125,0	71	2,5	33,0	0,376
110	5155 27010	146,5	80	2,0	38,0	0,530
125	5155 27011	165,0	85	1,5	41,0	0,692

pipe system d20-315 mm

Reducer PP-RCT

PP-RCT
SDR 6
green



d ₁ x d	Item Code	t	l	kg
25x20	5155 26003	17,1	41,8	0,014
32x20	5155 26004	15,2	47,6	0,029
32x25	5155 26005	20,4	47,4	0,022
40x20	5155 26006	-	40,7	0,025
40x25	5155 26007	16,3	41,1	0,023
40x32	5155 26008	19,8	53,3	0,033
50x20	5155 26009	-	55,1	0,046
50x25	5155 26010	-	54,9	0,047
50x32	5155 26011	18,5	56,9	0,057
50x40	5155 26012	21,8	59,5	0,058
63x25	5155 26014	-	65,0	0,080
63x32	5155 26015	-	64,6	0,089
63x40	5155 26013	20,5	64,5	0,095
63x50	5155 26016	23,7	68,7	0,128
75x50	5155 26017	23,6	67,7	0,143
75x63	5155 26018	28,4	74,5	0,203
90x63	5155 26019	28,2	78,0	0,171
90x75	5155 26020	29,6	80,0	0,228
110x90	5155 26025	33,9	92,9	0,450
125x110	5155 26026	37,2	96,0	0,595

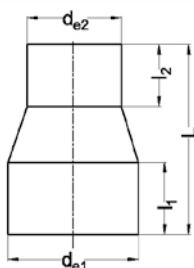
For each reducer, an additional socket with the dimension "d" is necessary.



Reducer PP-RCT

PP-RCT
SDR 11
green

for butt-welding and electrofusion



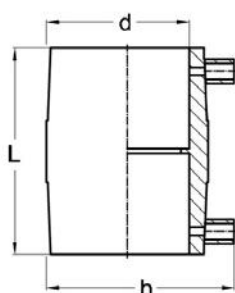
d _{e1} x d _{e2}	Item Code	L	l ₁	l ₂	kg
160x110	5152 41830	260	110	93	1,150
160x125	5152 41831	260	110	95	1,120
200x160	5152 41934 ¹⁾	151	50	40	1,330
200x160	5152 41834	280	122	115	2,600
250x160	5152 41936 ¹⁾	194	60	40	2,370
250x160	5152 41836	345	145	115	3,900
250x200	5152 41937 ¹⁾	182	60	50	2,400
250x200	5152 41837	345	145	125	4,500
315x250	5152 41840	400	160	145	8,000

¹⁾ short version suitable for butt-welding only

pipe system d20-315 mm

Electrofusion coupler

PP-RCT
SDR 7,4
green



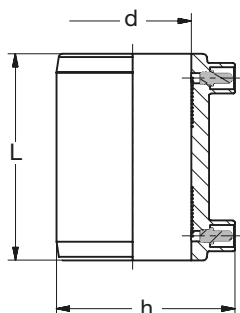
d	Item Code	L	h	kg
20	5152 50201	70	52	0,054
25	5152 50202	70	58	0,056
32	5155 50103 ¹⁾	70	65	0,071
40	5152 50204	85	75	0,111
50	5152 50205	88	87	0,149
63	5155 50106 ¹⁾	100	100	0,180
75	5152 50207	125	114	0,354
90	5152 50209	146	130	0,497
110	5155 50109 ^{1) 2)}	155	144	0,684
125	5152 50112 ²⁾	166	167	0,993

¹⁾ PP-R

²⁾ SDR 11

Electrofusion coupler

PP-RCT
SDR 7,4
green



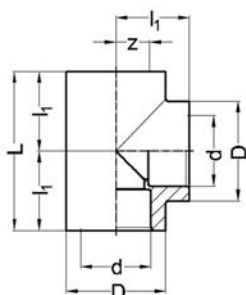
d	Item Code	L	h	kg
160	5152 50216	172	205	1,300
200	5152 50220	203	245	1,900
250	5152 50225	244	315	4,500
315	5152 50131 ¹⁾	284	375	10,800

¹⁾ SDR 11

pipe system d20-315 mm

Tee 90° PP-RCT

PP-RCT
SDR 6
green



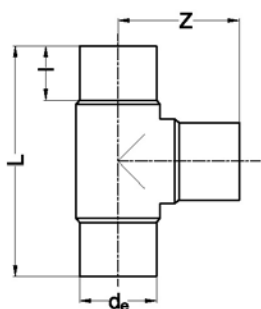
d	Item Code	D	L	I ₁	z	kg
20	5155 24002	29,5	50,6	25,3	10,8	0,023
25	5155 24003	34,0	60,0	30,0	14,0	0,033
32	5155 24004	44,0	69,0	34,5	16,4	0,062
40	5155 24005	53,5	85,6	42,8	22,3	0,105
50	5155 24006	68,0	120,0	60,0	36,5	0,188
63	5155 24007	85,0	118,0	59,0	31,5	0,372
75	5152 41507 ¹⁾	99,5	140,6	70,3	39,3	0,557
90	5152 41509 ¹⁾	119,0	160,0	80,0	44,5	0,956
110	5152 41511 ¹⁾	144,5	197,6	98,8	57,3	1,745
125	5152 41512 ¹⁾	164,5	245,6	122,8	82,8	2,780

¹⁾ PP-RCT

Tee 90° PP-RCT

PP-RCT
SDR 7.4/ 11
green

for butt-welding and electrofusion



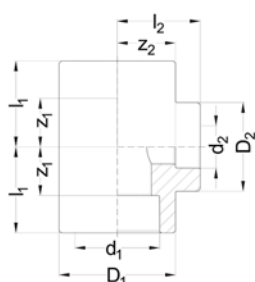
d _e	Item Code	L	Z	I	kg
160	5152 41616 ¹⁾	350	160	40	2,920
160	5152 41516	440	220	110	4,000
200	5152 41620 ¹⁾	430	215	64	6,470
200	5152 41520	520	260	127	7,400
250	5152 41625 ¹⁾	550	275	86	12,650
250	5152 41525	628	314	148	13,800
315	5152 41631 ¹⁾	700	350	111	25,700
315	5152 41531	700	350	157	27,600

¹⁾ short version, suitable for butt-welding only

pipe system d20-315 mm

Tee reduced 90°

PP-RCT
SDR 6
green



d ₁ x d ₂ x d ₃	Item Code	D ₁	l ₁	z ₁	D ₂	l ₂	z ₂	kg
20x 25x 25	5155 25025	34,0	31,3	15,3	30,0	30,0	14,0	0,039
25x 20x 20	5155 25024	34,0	31,3	15,3	30,0	30,0	15,5	0,037
25x 20x 25	5155 25003	34,0	31,3	15,3	30,0	30,0	15,5	0,032
32x 20x 25	5155 25026	44,0	35,5	17,4	44,0	34,5	20,0	0,075
32x 20x 32	5155 25004	44,0	35,8	17,7	44,0	34,5	20,0	0,070
32x 25x 25	5155 25028	44,0	35,5	17,4	44,0	34,5	18,5	0,071
32x 25x 32	5155 25005	44,0	35,8	17,7	44,0	34,5	18,5	0,066
32x 32x 25	5155 25023	43,5	35,5	17,4	43,5	34,8	16,7	0,066
40x 20x 40	5155 25006	52,0	42,0	21,5	36,0	41,5	27,0	0,089
40x 25x 40	5155 25007	52,4	44,0	23,5	34,9	38,8	22,8	0,085
40x 32x 40	5155 25008	53,5	44,0	23,5	53,5	42,3	24,2	0,116
50x 20x 50	5155 25029	68,0	50,0	26,5	43,0	44,1	29,6	0,180
50x 25x 50	5155 25009	65,4	52,0	28,5	34,5	47,3	31,3	0,175
50x 32x 50	5155 25010	65,4	52,0	28,5	43,0	47,3	29,2	0,169
50x 40x 50	5155 25011	68,0	52,0	28,5	68,0	50,0	29,5	0,207
63x 20x 63	5155 25012	85,0	63,0	35,5	46,5	60,5	46,0	0,375
63x 25x 63	5155 25013	85,0	63,0	35,5	46,5	60,5	44,5	0,368
63x 32x 63	5155 25014	85,0	63,0	35,5	65,0	60,5	42,4	0,404
63x 40x 63	5155 25015	85,0	63,0	35,5	65,0	60,5	40,0	0,392
63x 50x 63	5155 25016	85,0	63,0	35,5	85,0	60,5	37,0	0,417
75x 20x 75	5152 41720	¹⁾ 100,0	71,0	41,0	29,0	71,0	57,0	0,512
75x 25x 75	5152 41721	¹⁾ 100,0	71,0	41,0	34,0	71,0	55,0	0,512
75x 32x 75	5152 41722	¹⁾ 100,0	71,0	41,0	43,0	71,0	53,0	0,514
75x 40x 75	5152 41723	¹⁾ 100,0	71,0	41,0	52,0	71,0	51,0	0,529
75x 50x 75	5152 41724	¹⁾ 100,0	71,0	41,0	65,0	71,0	48,0	0,506
75x 63x 75	5152 41725	¹⁾ 100,0	71,0	41,0	85,0	71,0	44,0	0,600
90x 63x 90	5152 41728	¹⁾ 120,0	83,0	50,0	85,0	83,0	53,0	0,917
90x 75x 90	5152 41729	¹⁾ 120,0	83,0	50,0	100,0	83,0	53,0	0,916
110x 63x110	5152 41731	¹⁾ 147,0	100,0	59,0	85,0	100,0	69,0	1,674
110x 75x110	5152 41732	¹⁾ 147,0	100,0	59,0	100,0	100,0	66,0	1,717
110x 90x110	5152 41733	¹⁾ 147,0	100,0	59,0	120,0	100,0	63,0	1,770
125x 75x125	5152 41735	¹⁾ 165,0	124,0	84,0	100,0	104,0	74,0	2,630
125x 90x125	5152 41736	¹⁾ 165,0	124,0	84,0	120,0	106,0	73,0	2,610
125x110x125	5152 41737	¹⁾ 165,0	124,0	84,0	148,0	110,0	87,0	2,540

¹⁾ PP-RCT

pipe system d20-315 mm

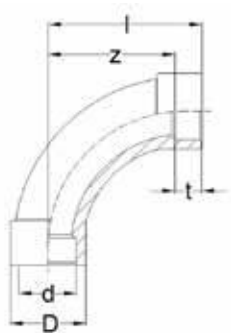
Bend 90°

PP-RCT
SDR 11
green



d	Item Code	D	l	z	t	kg
20	5155 21101	28	56	42	14,5	0,030
25	5155 21102	34	69	53	16,0	0,052
32	5155 21103	42	86	68	18,0	0,088
40	5155 21104	52	106	86	20,5	0,164

$R \approx 2 \times d$.

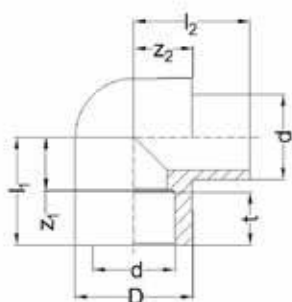


Elbow 90° s/m

PP-RCT
SDR 6
green



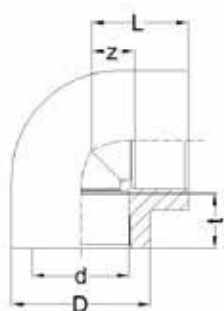
d	Item Code	D	l ₁	z ₁	l ₂	z ₂	t	kg
20	5155 22001	30,0	24,5	10,0	29,5	15,0	14,5	0,016
25	5155 22002	34,8	31,8	15,8	34,2	17,3	16,0	0,029
32	5155 22003	44,0	34,3	16,2	39,6	22,0	18,0	0,049



pipe system d20-315 mm

Elbow 90°

PP-RCT
SDR 6
green

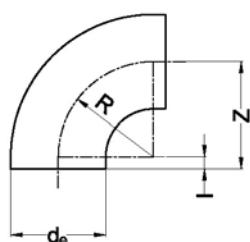


d	Item Code	D	L	z	t	kg
20	5155 21002	29,5	25,8	11,3	14,5	0,018
25	5155 21003	34,2	29,9	13,9	16,0	0,024
32	5155 21004	44,0	34,0	15,9	18,0	0,048
40	5155 21005	53,0	43,5	23,0	20,5	0,081
50	5155 21006	70,0	49,0	25,5	23,5	0,167
63	5155 21007	86,5	60,8	33,4	27,5	0,275
75	5155 21008	102,5	67,3	36,3	30,0	0,472
90	5155 21009	120,5	78,3	42,8	33,0	0,748
110	5155 21010	148,0	99,0	62,0	37,0	1,437
125	5155 21011	165,0	124,0	84,0	40,0	2,340

Bend 90° short

PP-RCT
SDR 11
green

for butt-welding



d _e	Item Code	Z	I	R	kg
160	5152 41116	175	15	160	2,380
200	5152 41120	215	15	200	3,605
250	5152 41125	275	25	250	7,210
315	5152 41131	350	35	315	13,970

$$R \approx 1 \times d_e$$

pipe system d20-315 mm

Elbow 90° long

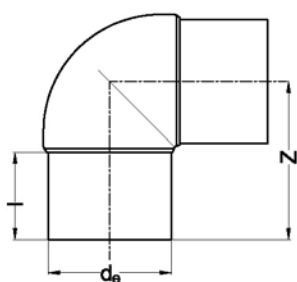
PP-RCT
SDR 7,4

for butt-welding and electrofusion

green



d ₆	Item Code	Z	l	kg
160	5152 41016	200	115	3,100
200	5152 41020	250	128	5,500
250	5152 41025	305	145	9,600
315	5152 41031	350	164	18,000

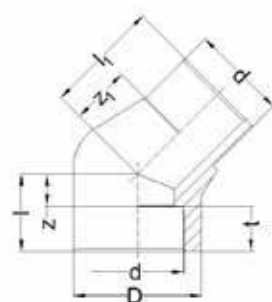


Elbow 45° s/m

PP-RCT
SDR 6
green



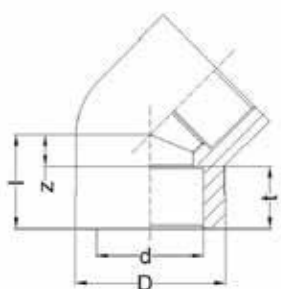
d	Item Code	D	l	z	l ₁	z ₁	t	kg
20	5155 22100	29,0	20	5	28	13,0	14,5	0,013
25	5155 22101	34,0	22	6	34	17,0	16,0	0,022
32	5155 22102	43,0	26	8	39	20,0	18,0	0,040



pipe system d20-315 mm

Elbow 45°

PP-RCT
SDR 6
green

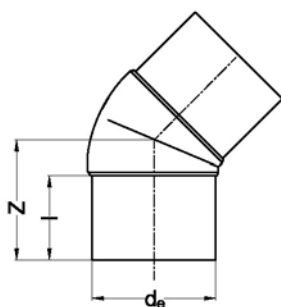


d	Item Code	D	l	z	t	kg
20	5155 23002	30,0	21,6	7,1	14,5	0,016
25	5155 23003	34,5	24,8	8,8	16,0	0,021
32	5155 23004	44,0	27,6	9,5	18,0	0,039
40	5155 23005	52,0	32,0	11,0	20,5	0,060
50	5155 23006	65,0	37,0	13,0	23,5	0,095
63	5155 23007	82,0	44,0	16,0	27,5	0,210
75	5155 23008	100,0	50,0	20,0	30,0	0,336
90	5155 23009	120,0	58,0	25,0	33,0	0,582
110	5155 23010	148,0	69,0	32,0	37,0	1,064
125	5155 23011	165,0	77,0	37,0	40,0	1,520

Elbow 45° long

PP-RCT
SDR 7,4
green

for butt-welding and electrofusion



d _e	Item Code	Z	l	kg
160	5152 41316	170	107	2,400
200	5152 41320	201	127	4,400
250	5152 41325	225	155	8,000
315	5152 41331	280	161	15,000

pipe system d20-315 mm

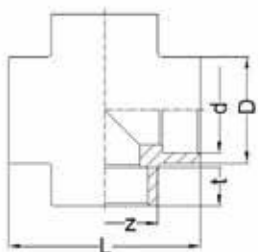
Cross

PP-RCT
SDR 7,4
green



d	Item Code		D	L	z	t	kg
32	5152 42403 ¹⁾		40	77	34	18,0	0,058
40	5155 25102		51	93	42	20,5	0,111
50	5155 25103		63	112	66	23,5	0,212
63	5152 42406 ¹⁾		76	137	84	27,5	0,355

¹⁾ PP-RCT

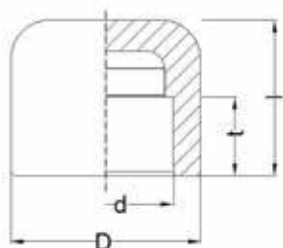


End cap

PP-RCT
SDR 6
green



d	Item Code		D	l	t	kg
20	5155 28002		29,5	28,8	14,5	0,011
25	5155 28003		34,5	30,0	16,0	0,015
32	5155 28004		43,5	35,7	18,0	0,028
40	5155 28005		52,5	40,0	20,5	0,040
50	5155 28006		64,0	45,0	23,5	0,061
63	5155 28007		85,5	54,0	27,5	0,136
75	5155 28008		101,0	65,0	30,0	0,235
90	5155 28009		119,0	76,0	33,0	0,332
110	5155 28010		148,0	79,0	37,0	0,616
125	5155 28011		165,0	87,0	40,0	0,780



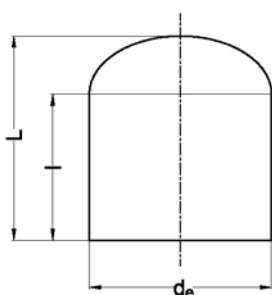
pipe system d20-315 mm

End cap long

PP-RCT
SDR 7,4

for butt-welding and electrofusion

green

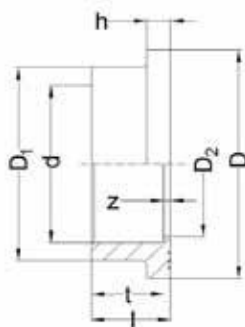


d _e	Item Code	L	I	kg
160	5152 42216	140	100	0,950
200	5152 42220	185	145	2,100
250	5152 42225	218	170	3,200
315	5152 42231	250	192	6,000

Flange sleeve

with EPDM gasket

PP-RCT
SDR 6
green



d	Item Code	D	D ₁	D ₂	h	l	z	t	kg
32	5155 28020	50	41	28,0	7	21,0	4	18,0	0,017
40	5155 28021	61	50	36,5	8	23,5	4	20,5	0,027
50	5155 28022	74	61	44,5	8	27,0	4	23,5	0,040
63	5155 28023	90	76	57,0	9	30,0	4	27,5	0,065
75	5155 28024	106	90	69,5	10	33,0	5	30,0	0,095
90	5155 28025	138	109	84,0	13	40,0	8	33,0	0,198
110	5155 28026	158	131	112,0	14	42,0	8	37,0	0,251
125	5155 28027	162	147	100,0	25	53,0	15	42,0	0,390

With grooved sealing surface.

Gasket with KTW-BWGL certification for potable water application.

pipe system d20-315 mm

Stub end

without gasket

for butt-welding and electrofusion

PP-RCT

SDR 7,4

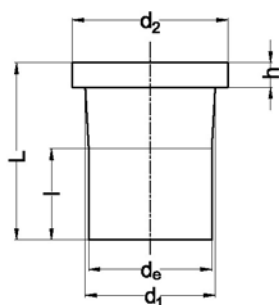
green



d_e	Item Code		h	l	d_1	d_2	L	kg
160	5152 42116	¹⁾	18	30	175	210	80	0,875
160	5152 42016		25	134	175	212	190	1,570
200	5152 42120	¹⁾	18	40	232	268	100	1,875
200	5152 42020		32	129	232	268	205	3,900
250	5152 42125	¹⁾	20	40	285	320	100	2,825
250	5152 42025		35	156	285	320	235	5,000
315	5152 42131	¹⁾	20	40	335	370	100	3,475
315	5152 42031		35	185	335	370	262	7,700

¹⁾ short version, suitable for butt-welding only

With grooved sealing surface.
For profile gaskets with steel core please see section "Complementary products".



pipe system d20-315 mm

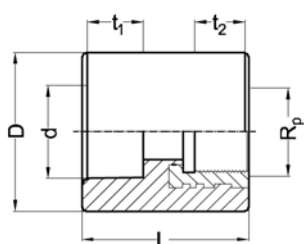
Transition round female

PP-RCT/brass
SDR 6
green



$d \times R_p$	Item Code	L	t_1	t_2	D	kg
20x $\frac{1}{2}$ "	5155 28101	42	15	17	41	0,072
20x $\frac{3}{4}$ "	5155 28102	44	15	17	47	0,100
25x $\frac{1}{2}$ "	5155 28103	44	16	17	41	0,076
25x $\frac{3}{4}$ "	5155 28104	44	16	17	47	0,095
32x $\frac{3}{4}$ "	5155 28105	44	18	17	43	0,105

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



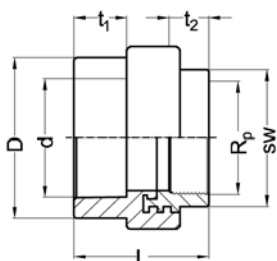
Transition hexagon female

PP-RCT/brass
SDR 6
green



$d \times R_p$	Item Code	L	t_1	t_2	D	SW	kg
32x 1"	5155 28204	60	18	22	61	39	0,240
40x1 $\frac{1}{4}$ "	5155 28205	63	21	22	72	47	0,347
50x1 $\frac{1}{2}$ "	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.



pipe system d20-315 mm

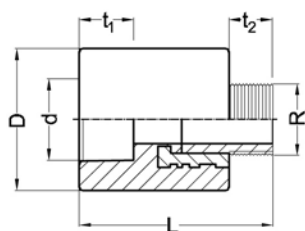
Transition round male

PP-RCT/brass
SDR 6
green



dxR	Item Code	L	t ₁	t ₂	D	kg
20x 1/2"	5155 29101	56	15	13	41	0,098
20x 3/4"	5155 29102	61	15	17	47	0,164
25x 1/2"	5155 29103	56	16	13	41	0,101
25x 3/4"	5155 29104	61	16	17	47	0,161

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



Transition hexagon male

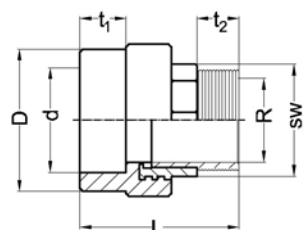
PP-RCT/brass
SDR 6
green



dxR	Item Code	L	t ₁	t ₂	D	SW	kg
32x 1"	5155 29204	79	18	20	53	32	0,240
40x 1 1/4"	5155 29205	80	20,5	21	67	44	0,438
50x 1 1/2"	5155 29206	85	24	21	74	48	0,498
63x 2"	5155 29207	95	28	24	90	60	0,711
75x 2 1/2"	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"	5152 44621 ¹⁾	170	40	42	208	149	4,380

¹⁾ PP-RCT

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



PP-R pipe system d20-315 mm

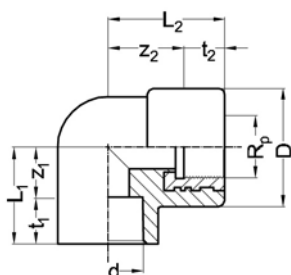
Transition elbow 90° female

PP-RCT/brass
SDR 6
green



$d \times R_p$	Item Code	D	L_1	t_1	z_1	t_2	z_2	L_2	kg
20x1/2"	5155 28301	40	33	15	18	17	22	39	0,084
20x3/4"	5155 28302	44	33	15	18	17	22	39	0,110
25x1/2"	5155 28303	40	33	16	17	17	22	39	0,088
25x3/4"	5155 28304	44	33	16	17	17	22	59	0,107
32x3/4"	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.



PP-R pipe system d20-315 mm

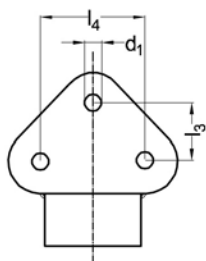
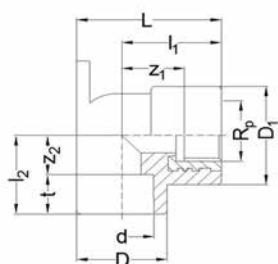
Back plate elbow female

PP-R/brass
SDR 6
green



$d \times R_p$	Item Code	D	D_1	d_1	L	l_1	l_2	l_3	l_4	z_1	z_2	t	kg
20x1/2"	5155 29002	30,0	39	5,5	53,0	38,0	32	19,5	40	24,0	17,5	14,50	0,090
20x3/4"	5155 29003	34,0	44	5,5	57,5	40,5	32	19,5	40	26,5	17,5	14,50	0,116
25x1/2"	5155 29004	34,0	40	5,5	54,5	37,5	32	19,5	40	23,5	16,0	16,00	0,095
25x3/4"	5155 29005	34,5	44	5,5	57,5	40,3	32	19,5	40	26,5	16,0	16,00	0,013

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



PP-R pipe system d20-315 mm

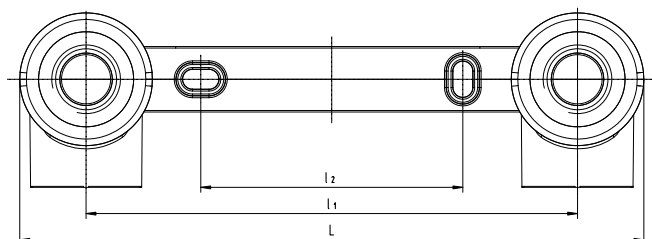
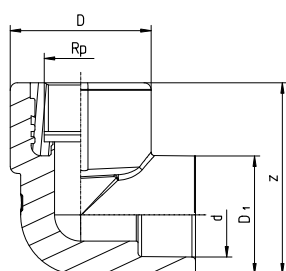
Double elbow tap connector

PP-R/brass
SDR 6
green

dxR	Item Code	D	D ₁	d	z	L	l ₁	l ₂	kg
20x1/2"	5155 29902	40,5	34	20	55	190	150	80	0,205
25x1/2"	5155 29904	40,5	34	25	55	190	150	80	0,202



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



PP-R pipe system d20-315 mm

Transition elbow 90° male

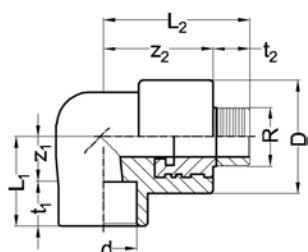
PP-RCT/brass
SDR 6
green



dxR	Item Code	D	L ₁	t ₁	z ₁	t ₂	Z ₂	L ₂	kg
20x1/2"	5155 28401	40	32	15	17	12	41	53	0,117
20x3/4"	5155 28402	44	32	15	17	15	43	58	0,175
25x1/2"	5155 28403	40	32	16	16	12	41	53	0,114
25x3/4"	5155 28404	44	32	16	16	15	43	58	0,173
32x3/4"	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

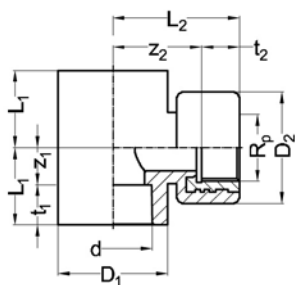
PP-RCT/brass
SDR 6
green



dxR _p	Item Code	L ₁	t ₁	z ₁	L ₂	t ₂	Z ₂	D ₁	D ₂	kg
20x1/2"	5155 29301	64	15	17	37	15	22	30	38	0,087
20x3/4"	5155 29302	79	15	24	37	15	22	34	46	0,129
25x1/2"	5155 29303	65	16	16	38	15	23	34	38	0,098
25x3/4"	5155 29304	79	16	24	37	15	22	34	46	0,120
32x3/4"	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.

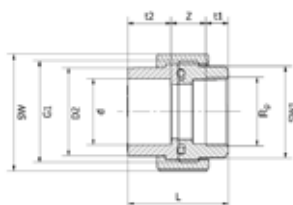


PP-R pipe system d20-315 mm

Union brass female

PP-RCT/brass

green



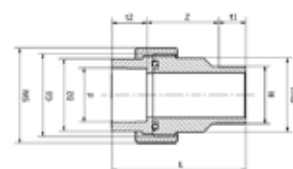
dxR _p	Item Code	G ₁	D ₂	t ₁	t ₂	z	L	SW	SW ₁	kg
20 x 1/2"	5152 45402	1"	27	15	16	11,5	42,5	37	26	0,146
25 x 3/4"	5152 45405	1 1/4"	36	16,5	18	12,5	47	47	32	0,251
32 x 1"	5152 45408	1 1/2"	41	19,1	20	13,4	52,5	55	38	0,341
40 x 1 1/4"	5152 45411	2"	52,5	21,5	22	14	57,5	66	47	0,520
50 x 1 1/2"	5152 45413	2 1/4"	59	21,5	25	14,5	61	72	53	0,609
63 x 2"	5152 45415	2 3/4"	73,5	25,7	29	13,8	68,5	87	67	0,930

ISO 15874 Class 1/10, 2/10, 4/10, 5/8 bar.
DIN 8077/8078 20°C/10 bar, 70°C/10 bar.
Thread according to EN 10226 (ISO 7).
For sealing we recommend PTFE tape.

Union brass male

PP-RCT/brass

green



dxR	Item Code	G ₁	D ₂	t ₁	t ₂	z	L	SW	SW ₁	kg
20 x 1/2"	5152 45302	1"	27	15	16	24,5	55,5	37	26	0,180
25 x 3/4"	5152 45305	1 1/4"	36	16,5	18	36	70,5	47	32	0,330
32 x 1"	5152 45308	1 1/2"	41	19,5	20	37	76,5	55	38	0,480
40 x 1 1/4"	5152 45311	2"	52,5	21,5	22	36	79,5	66	47	0,680
50 x 1 1/2"	5152 45313	2 1/4"	59	21,5	25	44	90,5	72	53	0,859
63 x 2"	5152 45315	2 3/4"	73,5	26	29	46,5	101,5	87	67	1,363

ISO 15874 Class 1/10, 2/10, 4/10, 5/8 bar.
DIN 8077/8078 20°C/10 bar, 70°C/10 bar.
Thread according to EN 10226 (ISO 7).
For sealing we recommend PTFE tape.

PP-R pipe system d20-315 mm

Union brass nut

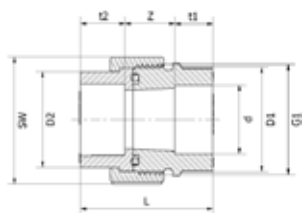
PP-RCT/brass

green



d	Item Code	G ₁	D ₁	D ₂	t ₁	t ₂	Z	L	SW	kg
20	5152 45601	1"	31	27	16	16	18,5	50,5	37	0,090
25	5152 45602	1 1/4"	36	36	18	18	18,5	54,5	47	0,150
32	5152 45603	1 1/2"	45,5	41	20	20	19,5	59,5	55	0,210
40	5152 45604	2"	56	52,5	22	22	22,5	66,5	66	0,320
50	5152 45605	2 1/4"	66	59	25	25	23,5	73,5	72	0,367
63	5152 45606	2 3/4"	81,5	73,5	29	29	24,5	82,5	87	0,490

ISO 15874 Class 1/10, 2/10, 4/10, 5/8 bar.
DIN 8077/8078 20°C/10 bar, 70°C/10 bar.



Pipe union brass female

PP-RCT/brass
SDR 6

green

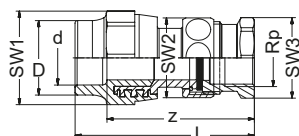


dxR _p	Item Code	G	D	L	z	SW ₁	SW ₂	SW ₃	kg
20x 3/4"	5155 29602	¹⁾ 1	29	102	86	44	37	34	0,289
25x 1/2"	5155 29603	¹⁾ 3/4	34	94	78	36	30	27	0,202
32x 3/4"	5155 29606	¹⁾ 1	43	105	87	44	37	34	0,298
63x 2"	5155 29609	¹⁾ 2 3/8	79	142	114	85	74	70	1,298
75x2 1/2"	5152 45017	²⁾ 2 3/4	99	169	139	113	90	90	2,400

¹⁾ Discontinued, as long as stock lasts

²⁾ PP-RCT

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



PP-R pipe system d20-315 mm

Pipe union brass male

PP-RCT/brass
SDR 6
green

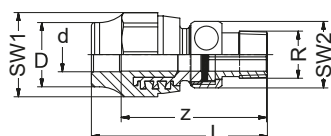


dxR	Item Code	G	D	L	z	SW ₁	SW ₂	kg
20x 3/4"	5155 29702 ¹⁾	1	29	86	72	44	37	0,273
63x 2"	5155 29709 ¹⁾	2 ³ / ₈	79	137	109	85	74	1,275
75x2 1/2"	5152 45117 ²⁾	2 ³ / ₄	99	163	133	113	90	2,290

¹⁾ Discontinued, as long as stock lasts

²⁾ PP-RCT

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



Pipe connection brass nut female

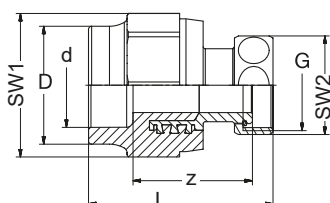
PP-RCT/brass
SDR 6
green



dxG	Item Code	D	L	z	SW ₁	SW ₂	kg
20x 3/4"	5155 29801	29	66	44	36	30	0,130
20x 1"	5155 29802	29	72	48	44	37	0,234
25x 3/4"	5155 29803	34	67	44	44	30	0,128
25x 1"	5155 29804	34	72	47	44	37	0,218
32x 1"	5155 29805	43	74	47	51	37	0,191
32x1 1/4"	5155 29806	43	80	53	51	46	0,398
40x1 1/2"	5155 29807	55	90	58	63	52	0,477
50x1 3/4"	5155 29808	64	98	61	70	59	0,558
63x2 3/8"	5155 29809	79	114	72	85	74	0,926
75x2 3/4"	5152 45217 ¹⁾	99	137	86	112	90	1,910

¹⁾ PP-RCT

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



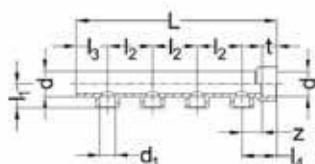
PP-R pipe system d20-315 mm

Distributor manifold 4x

PP-RCT
SDR 6
green



$dx d_1$	Item Code	Z	L	l_1	l_2	l_3	l_4	t	kg
32/20	5152 42603	18	246	30	43	37	56	18	0,100



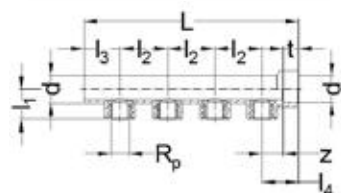
Distributor manifold 4x female

PP-R/brass
SDR 6
green



$dx R_p$	Item Code	Z	L	l_1	l_2	l_3	l_4	t	kg
32/1/2"	5152 42703 ¹⁾	18,0	250	35	43	41	56	18,00	0,341
40/1/2"	5155 20606	20,5	250	38	43	41	56	20,50	0,396

¹⁾ PP-RCT



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

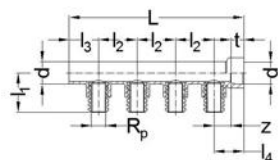
Distributor manifold 4x male

PP-R/brass
SDR 6
green



$dx R$	Item Code	Z	Z_1	L	l_1	l_2	l_3	l_4	t	kg
32/1/2"	5155 20608	18,0	15	250	50	43	41	56	18,00	0,413
40/1/2"	5155 20610	20,5	15	250	50	43	41	56	20,50	0,495

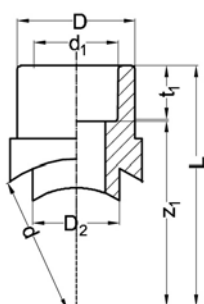
Thread according to EN 10226 (ISO 7).
For sealing we recommend PTFE tape.



PP-R pipe system d20-315 mm

Weld-in saddle PP-R

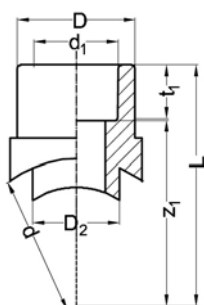
PP-R
SDR 6
green



d/d ₁	Item 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

Weld-in saddle PP-RCT

PP-RCT
SDR 6
green



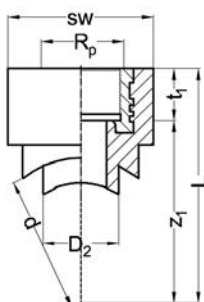
d/d ₁	Item Code	D	D ₂	t ₁	z ₁	L	SW	kg
63-125/32	5152 43007	51	32	20	9	-	38	0,035
75-125/32	5152 43010 ¹⁾	51	32	20	9	-	51	0,035
75-125/40	5152 43011	63	40	22	16	-	63	0,083
90-125/50	5152 43015	70	50	39	14	-	70	0,098
110-125/63	5152 43024	85	63	30	15	-	85	0,163
160-250/20	5152 43026	38	16	29	13	-	38	0,027
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
315/32	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

¹⁾ Discontinued, as long as stock lasts

PP-R pipe system d20-315 mm

Weld-in saddle female PP-R

PP-R/brass
SDR 6
green

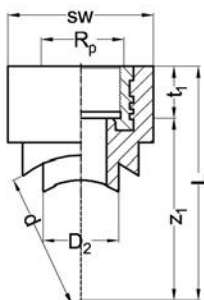


$d \times R_p$	Item Code	D_2	t_1	z_1	L	SW	kg
40x 1/2"	5155 28071	25	15	35	50	38	0,067
50x 1/2"	5155 28072	25	15	34	49	46	0,067
63x 1/2"	5155 28073	25	15	39	54	38	0,068
75x 1/2"	5155 28074	25	15	39	54	46	0,066
90x 1/2"	5155 28075	25	15	45	60	38	0,061
110x 1/2"	5155 28076	25	15	46	61	46	0,070
125x 1/2"	5155 28077	25	15	52	67	38	0,070
40x 3/4"	5155 28171	25	15	59	74	38	0,094
50x 3/4"	5155 28172	25	15	59	74	46	0,096
63x 3/4"	5155 28173	25	15	69	84	36	0,094
75x 3/4"	5155 28174	25	15	69	84	46	0,094
90x 3/4"	5155 28175	25	15	77	92	38	0,095
110x 3/4"	5155 28176	25	15	77	92	46	0,095
125x 3/4"	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



$d \times R_p$	Item Code	D_2	t_1	z_1	L	SW	kg
75-125x 1"	5152 43110	40	22	16	-	63	0,170
90-125x 1 1/4"	5152 43114	50	22	17	-	70	0,250
90-125x 1 1/2"	5152 43115	50	20	39	-	85	0,220
110-125x 1 1/2"	5152 43118 ¹⁾	50	20	19	-	70	0,292
110-125x 2"	5152 43124	63	25	20	-	85	0,485
160-250x 1/2"	5152 43126	25	17	12	-	38	0,071
160-250x 3/4"	5152 43127	32	17	12	-	51	0,112
160-250x 1"	5152 43128	40	22	16	-	63	0,197
160-250x 1 1/4"	5152 43129	50	22	17	-	70	0,213
160-250x 1 1/2"	5152 43130	50	20	19	-	70	0,240
160-250x 2"	5152 43131	63	25	20	-	85	0,490
315x 3/4"	5152 43138	32	17	12	-	51	0,240
315x 1"	5152 43139	40	22	16	-	63	0,240
315x 1 1/4"	5152 43140	50	22	17	-	70	0,247
315x 1 1/2"	5152 43141	50	20	19	-	70	0,242
315x 2"	5152 43142	63	25	20	-	85	0,484

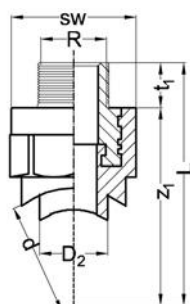
¹⁾ Discontinued, as long as stock lasts

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

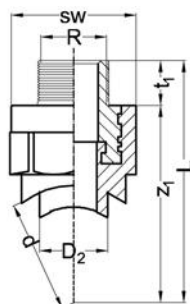


dxR	Item Code	D ₂	t ₁	z ₁	L	SW	kg
40x 1/2"	5155 28081	25	13	49	62	38	0,085
50x 1/2"	5155 28082	25	17	49	66	46	0,091
63x 1/2"	5155 28083	25	13	54	67	38	0,083
75x 1/2"	5155 28084	25	17	54	71	46	0,083
90x 1/2"	5155 28085	25	13	61	74	38	0,083
110x 1/2"	5155 28086	25	17	60	77	46	0,084
125x 1/2"	5155 28087	25	13	66	79	38	0,096
40x 3/4"	5155 28181	25	17	66	83	46	0,160
50x 3/4"	5155 28182	25	13	74	87	36	0,158
63x 3/4"	5155 28183	25	17	74	91	46	0,159
75x 3/4"	5155 28184	25	13	83	96	36	0,159
90x 3/4"	5155 28185	25	17	84	101	46	0,161
110x 3/4"	5155 28186	25	13	92	105	38	0,158
125x 3/4"	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	Item Code	D ₂	t ₁	z ₁	SW	kg
75-125x 1"	5152 43210	40	20	18	63	0,210
90-125x 1 1/4"	5152 43214	50	21	17	70	0,340
90-125x 1 1/2"	5152 43215	50	21	18	70	0,350
110-125x 1 1/2"	5152 43218 ¹⁾	50	21	18	85	0,553
110-125x 2"	5152 43224	63	24	21	85	0,650
160-250x 1/2"	5152 43226	25	13	20	38	0,091
160-250x 3/4"	5152 43227	32	17	26	51	0,133
160-250x 1"	5152 43228	40	20	36	63	0,234
160-250x 1 1/4"	5152 43229	50	21	38	70	0,334
160-250x 1 1/2"	5152 43230	50	21	38	70	0,353
160-250x 2"	5152 43231	63	24	46	85	0,730
315x 3/4"	5152 43238	32	17	26	38	0,183
315x 1"	5152 43239	40	20	36	63	0,239
315x 1 1/4"	5152 43240	50	21	38	70	0,342
315x 1 1/2"	5152 43241	50	21	38	70	0,353
315x 2"	5152 43242	63	24	46	85	0,648

¹⁾ Discontinued, as long as stock lasts

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

PP-R pipe system d20-315 mm

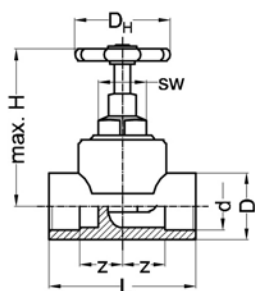
Stop valve surface assembly

for surface installation

PP-R
SDR 6
green



d	Item 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

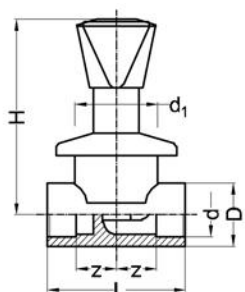
for concealed installation

PP-R/chrome plated
SDR 6
green



d	Item 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	0,413
32	5155 29512	97	30	44	90	25	0,478

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



PP-R pipe system d20-315 mm

Stop valve concealed assembly - extended

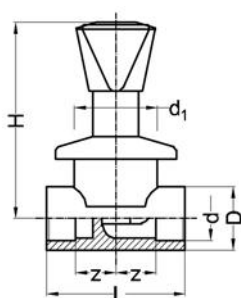
PP-R/chrome plated
SDR 6
green

for concealed installation



d	Item 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

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



Stop valve concealed assembly (tamper resistant)

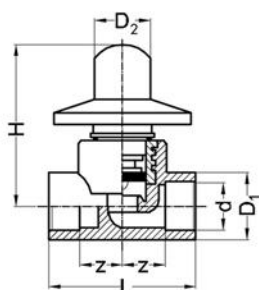
PP-R/chrome plated
SDR 6
green

for concealed installation



d	Item 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

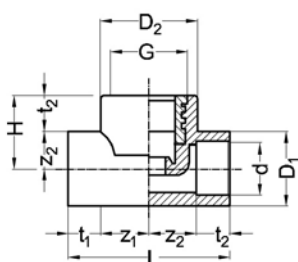
Stop valve body

PP-R
SDR 6
green



dxG	Item 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.



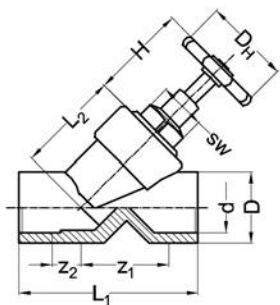
Y-valve

PP-R
SDR 6
green



d	Item 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	5152 61203 ¹⁾	94	60	34	64	55	28	60	0,540
40	5155 29542	113	90	40	77	55	28	60	0,773

¹⁾ PP-RCT



PP-R pipe system d20-315 mm

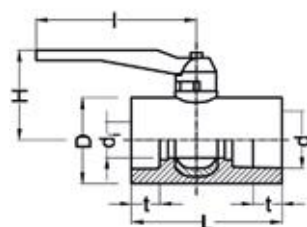
Ball valve

PP-RCT
SDR 6
green



d	Item Code	L	t	H	I	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.



Double union ball valve – Dual Block®

2-way ball valve with female ends for socket welding

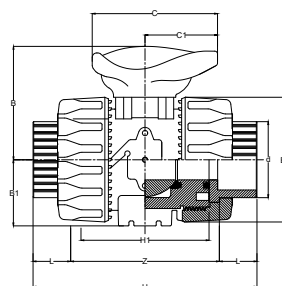
PP-RCT

green



d	Item Code	B	B1	C	C1	E	H	H1	Z	L	kg
20	5152 65101	54	29	67	40	54	103	65	3	16	0,143
25	5152 65102	65	35	85	49	65	114	70	4	18	0,238
32	5152 65103	70	39	85	49	73	126	78	4	20	0,312
40	5152 65104	83	46	108	64	86	142	88	5	22	0,480
50	5152 65105	89	52	108	64	98	164	93	11	25	0,638
63	5152 65106	108	62	134	76	122	199	111	15	29	1,115

ISO 16135 20 °C/10bar.
Ball and stem: PP-H.
Handle: PVC.
Seats: PTFE.
O-rings: EPDM.



Complementary products

Extension 95 mm
for concealed valves

chromium plated



Item Code	l	d	kg
5150 29520	95	24	0,139

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

Extension set 30 mm
for concealed valves

brass



Item 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 3/4" thread, code 5155 29510, 5155 29511, 5155 29525 and 5155 29526

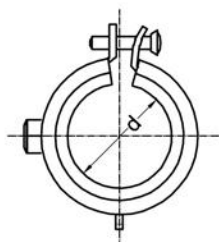
Pipe clamp

for sliding and fixed position mounting



d	Item Code	kg
20	5150 34201 ¹⁾	0,047
25	5150 34202 ¹⁾	0,051
32	5150 34203 ¹⁾	0,058
40	5150 34204 ¹⁾	0,068
50	5150 34205 ¹⁾	0,076
63	5150 34206 ¹⁾	0,091
75	5150 34207 ¹⁾	0,228
90	5150 34208 ¹⁾	0,281
110	5150 34209 ¹⁾	0,360
125	5150 34210 ¹⁾	0,413

¹⁾ Discontinued, as long as stock lasts.



Complementary products

Profile backing ring PP d32-125

EN 1092 - PN 10/PN16 bolt hole pattern
for flange sleeve (socket-welding connection)



d _e /DN	Item Code	bar	d ₁	D	k	b	d	n	M	r	kg
32/25	5150 28040	16	42	122	85	17	14	4	M12	3	0,4
40/32	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

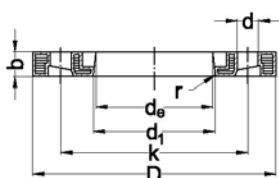
¹⁾ variant with flat design

With ductile iron core. External coating in glass-fiber reinforced polypropylene.

n = number of bolts.

bar = maximum operating pressure.

"PN10" refers to the bolt hole pattern, not to the pressure class of the backing ring.



Profile backing ring PP d160-315

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



d _e /DN	Item Code	bar	d ₁	D	k	b	d	n	M	r	kg
160/150	5152 52016 ¹⁾	16	178	291	240	28	22	8	M20	3	3,000
200/200	5152 52020	16	238	346	295	32	22	8	M20	4	3,800
250/250	5152 52025	16	288	405	350	36	22	12	M20	4	4,900
315/300	5152 52031	16	337	456	400	42	22	12	M20	4	6,400

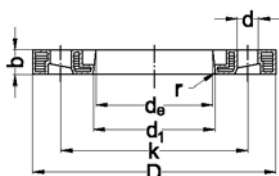
¹⁾ PN 10/PN16 bolt hole pattern

With ductile iron core. External coating in glass-fiber reinforced polypropylene.

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 gasket NBR

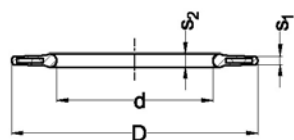
with steel core

for stub ends SDR 11



d _e /DN	Item 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-BWGL certification for potable water application.



Pin for pipe repair

PP-R

green

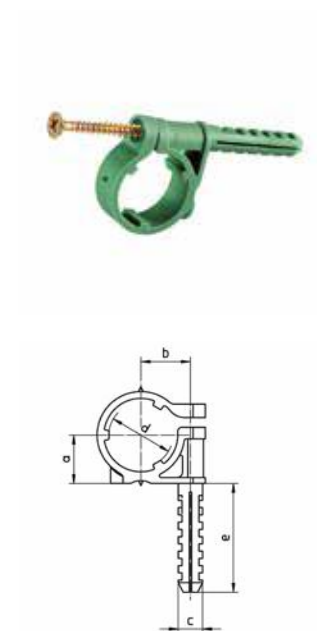


d	Item Code	kg
7/11	5155 28030	0,004

To repair point damage.

Complementary products

Pipe clip



d	Item 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

Mounting plate

galvanized steel



Item Code	kg
5150 34000	0,276

Plug

for pressure test
1x male



d	Item Code	Colour	kg
1/2"	5150 36100	red	0,016
1/2"	5150 36101	blue	0,016

Complementary products

Welding tool

for socket-welding



d	Item 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	Item 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
75-125/63	5150 30062	1,046
160-250/25	5150 30065	0,170
160-250/32	5150 30066	0,226
160-250/40	5150 30067	0,358
160-250/50	5150 30068	0,650
160-250/63	5150 30069	1,044
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	Item Code	kg
7	5150 30080	0,095
11	5150 30081	0,098

Drill for weld-in saddles



d	Item 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

Profi-cut pipe cutter 0-42 mm



d	Item Code	kg
0-42	5150 32002	0,408

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

Complementary products

Pipe cutter 50-110 mm



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

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

Manual welding device d16-25



d	Item Code	kg
16-25	5150 31002	5,000

Manual welding device for one tool. Suitable for the socket fusion of pipes and fittings up to d25.

- Socket welder with aluminum heating plate and heat-insulated plastic handle.
- Including fork support, allen wrench, pin for sockets and spigots.
- Max. power consumption 500 W.

Welding tools are not included, they should be ordered separately.
With transport case.

Manual welding device d16-63



d	Item Code	kg
16-63	5150 31000	6,200

Manual welding device for up to two tools. Suitable for the socket fusion of pipes and fittings up to d63.

- Socket welder with aluminum heating plate and heat-insulated plastic handle.
- Including fork support, bench vice, allen wrench, pin for sockets and spigots.
- Max. power consumption 800 W.

Welding tools are not included, they should be ordered separately.
With transport case.

Complementary products

Manual welding device d16-125



d	Item Code	kg
16-125	5150 31005	9,750

Manual welding device for up to five tools. Suitable for the socket fusion of pipes and fittings up to d125.

- Socket welder with aluminum heating plate and heat-insulated plastic handle.
- Including fork support, bench vice, allen wrench, pin for sockets and spigots.
- Max. power consumption 1400 W.

Welding tools are not included, they should be ordered separately.
With transport case.

Socket welding machine d25-125



d	Item Code	kg
25-125	5150 31003	100,00

Suitable for the socket fusion of pipes and fittings up to d125.

- Machine body featuring a selector for the welding depths of the different diameters.
- Four self-centering steel clamps for locking pipes and fittings.
- Self-centring socket welder with electronic temperature control
- Pipe support tripod
- Sliding trolley

Welding tools are not included, they should be ordered separately.

Butt-welding machine



d	Item Code	kg
160-250	5150 31008	160,00
160-315	5150 31004	166,00

Self-aligning hydraulic butt fusion machine. Suitable for the socket fusion of pipes and fittings up to d315.

- Machine body built with a supporting frame, four clamps and two hydraulic cylinders with fast non-drip coupling connections.
- Teflon-coated (PTFE) heating plate with a built-in independent thermometer.
- Extractable electric milling cutter to face the heads of the pipes and/or fittings.
- Electro-hydraulic gearcase protected from crashes and atmospheric corrosion by a plastic box.
- Milling cutter/ heating plate support.
- Inserts for pipes d160-250 or d160-315.
- Max. power consumption 4500 W.

With transport case.

Complementary products

Electrofusion welding machine

Universal fusion unit without documentation function



Item Code	kg
5150 31011	12,800

- For diameter up to d1200.
- Converter technology with active cooling.
- High-resolution, bright 4,3" TFT display.
- With reader wand.
- Mains cable 5 m, fusion cable 4 m with socket contacts Ø 4 mm.
- Robust casing IP 54, protection class I.
- Welding voltage 8 - 48 V.
- With USB interface to install software updates.

Delivered in practical aluminium transport box.

Pipe scraper tool d20-63

Cross-dimensional scraper tool



d	Item Code	kg
20-63	5150 31020	2,600

For safe removal of the oxide layer from PP-R(CT) pipes.

- Universal scraper areas from d20-63, no dimensional adjustment required.
- Scraper blade made from wear-resistant carbide.
- Replacement blade with second cutting edge for double tool life.
- Automatic compensation of pipe ovalities and tolerances
- Uniform chip removal by spring-mounted scraper blade and automatic feed.

Delivered in practical aluminium transport box.

Pipe scraper tool d75-225

Cross-dimensional scraper tool



d	Item Code	kg
75-225	5150 31021	4,835

For safe removal of the oxide layer from PP-R(CT) pipes.

- Universal scraper areas from d75-225, no dimensional adjustment required.
- Replacement blade with 2 cutting edges for twice the service life.
- With quick adjustment of the scraping length.
- Automatic compensation of pipe ovalities and tolerances
- Uniform chip removal by spring-mounted scraper blade and automatic feed.

Delivered in practical aluminium transport box.

Complementary products

Scraper - manual



Item Code	kg
5150 31030	0,300

For removal of oxide skin on PP-R pipes.

Depth gauge



Item Code	kg
5199 99971	0,010

Complementary products

8 Transport and storage

8.1 Packaging

8.1.1 Pipes

Pipes are packed in bundles, and 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, and 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 the 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 fluctuating temperatures. However, 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 must 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 from sunlight.

Suggestions for the correct treatment of pipe systems

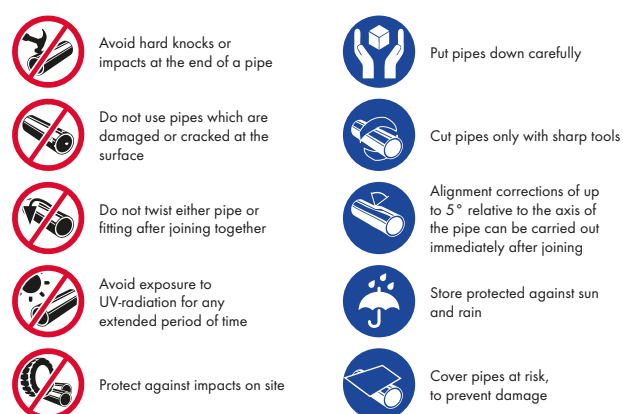


Illustration 8.3

8.3 Disposal of waste materials

Separate waste materials for disposal according to 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 regulations on drinking water for human consumption prevents the use of recycled material in the production of components for water supply systems.



Illustration 8.2 Pipe marking example

Joining techniques

9 Joining 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

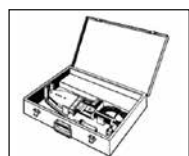
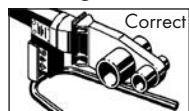
9.2 Socket welding

9.2.1 Socket welding - manual

This joining 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)	Insertion depth (mm)	Heating-up time (sec)	Processing time (sec)	Cooling-down time (min)
20	14	5	4	2
25	15	7	4	2
32	16,5	8	6	4
40	18	12	6	4
50	20	18	6	4
63	24	24	8	6
75	26	30	8	6
90	29	40	8	6
110	32,5	50	10	8
125	35	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.

Joining techniques

9.2.2 Socket welding - mechanical

This joining technique is suitable for d75-125 mm.

The described process is according guidelines DVS 2207 Part 11.

Welding device



Illustration 9.1

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.

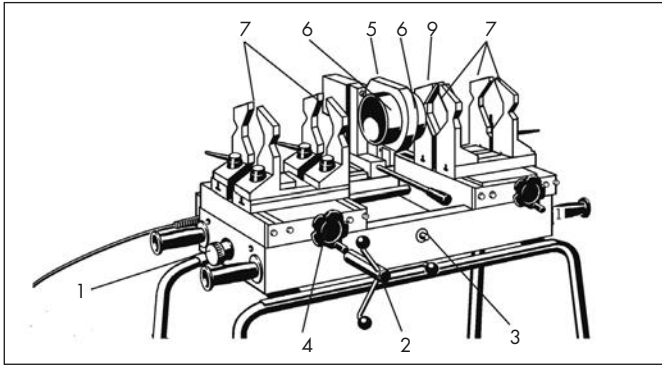


Illustration 9.2

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)	Insertion depth (mm)	Heating-up time (sec)	Processing time (sec)	Cooling-down time (min)
20	14	5	4	2
25	15	7	4	2
32	16,5	8	6	4
40	18	12	6	4
50	20	18	6	4
63	24	24	8	6
75	26	30	8	6
90	29	40	8	6
110	32,5	50	10	8
125	35	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%.

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.

Joining techniques

9.3 Butt-welding

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

Butt-welding is a very economical and reliable joining 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).

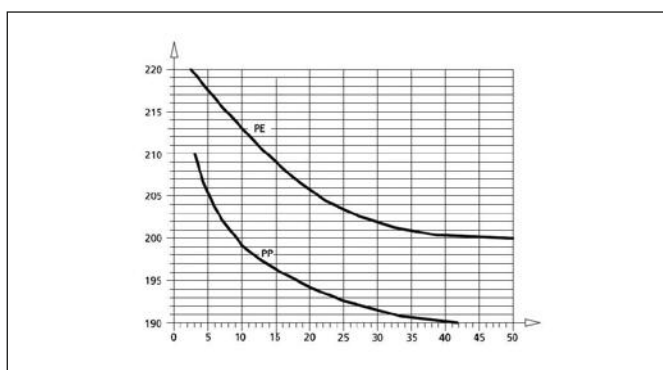


Illustration 9.3 Heating temperature as function of PP pipe wall thickness

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.

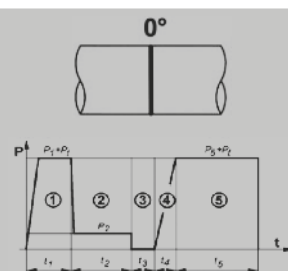
Delta 250B DVS 2207-11 PP					  						
D (mm)	s (mm)	SDR = D/s	T (°C)	*P1 (bar)	1 	2 P ₂ (bar)	3 t ₂ (sec)	4 t _{3 max} (sec)	5 t ₄ (sec)	*P ₅ (bar)	t ₅ (min)
160	14,6	11	210	11	1,0	1	277	8	13	11	24
160	17,8	9	210	13	1,0	1	315	9	16	13	28
160	21,9	7,4	210	16	1,5	2	359	10	19	16	34
160	26,6	6	210	19	2,0	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

9.4 Electrofusion welding

This joining 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.



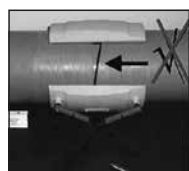
2. Prepare the pipe surface in the welding area. Remove the oxidation layer in the welding area, depth of the coupler + 0,5 cm processing surcharge. Use a rotary scraper tool. Remove the chips without touching the pipe surface.



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 allowed operating pressure.

d (mm)	Cooling time (min)
20 - 40	10
50 - 63	15
75 - 125	20
160 - 315	30

Table 9.4

Joining techniques

9.5 Flange jointing

This paragraph contains requirements 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.

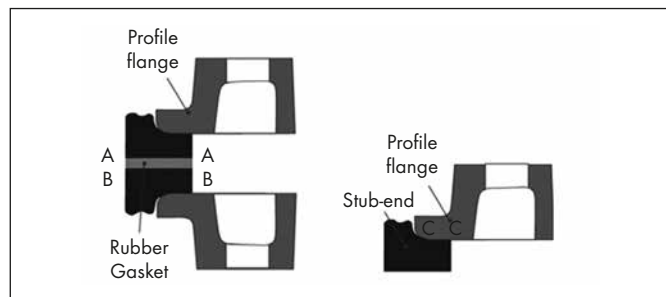


Illustration 9.4

Bolt tightening

The length of the screws has to be chosen to ensure that the screw thread-length overlap with at least two threads. To distribute the force of the screw head and the nut over a larger area, flat-washers have to be used on both sides.

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 9.6, 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).

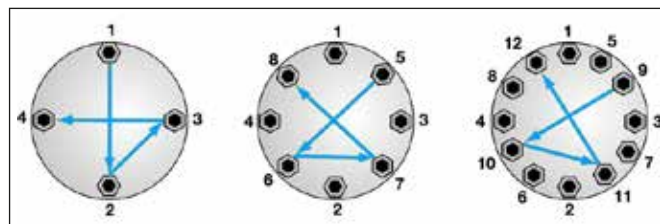


Illustration 9.5



Always use the crisscross pattern!

The order in which the bolts and nuts are tightened has a significant influence on the distribution of forces acting on the gasket (surface pressure). Improper tightening leads to a high dispersion of the preloading forces and can result in falling short of the required minimum surface pressure to the point of leakage.

Temperature	Preload
between -50 °C and -5 °C	minimum
between -5 °C and +30 °C	normal (values between min. and max. preload indicated on Table 9.6)
between +30 °C and +60 °C	maximum

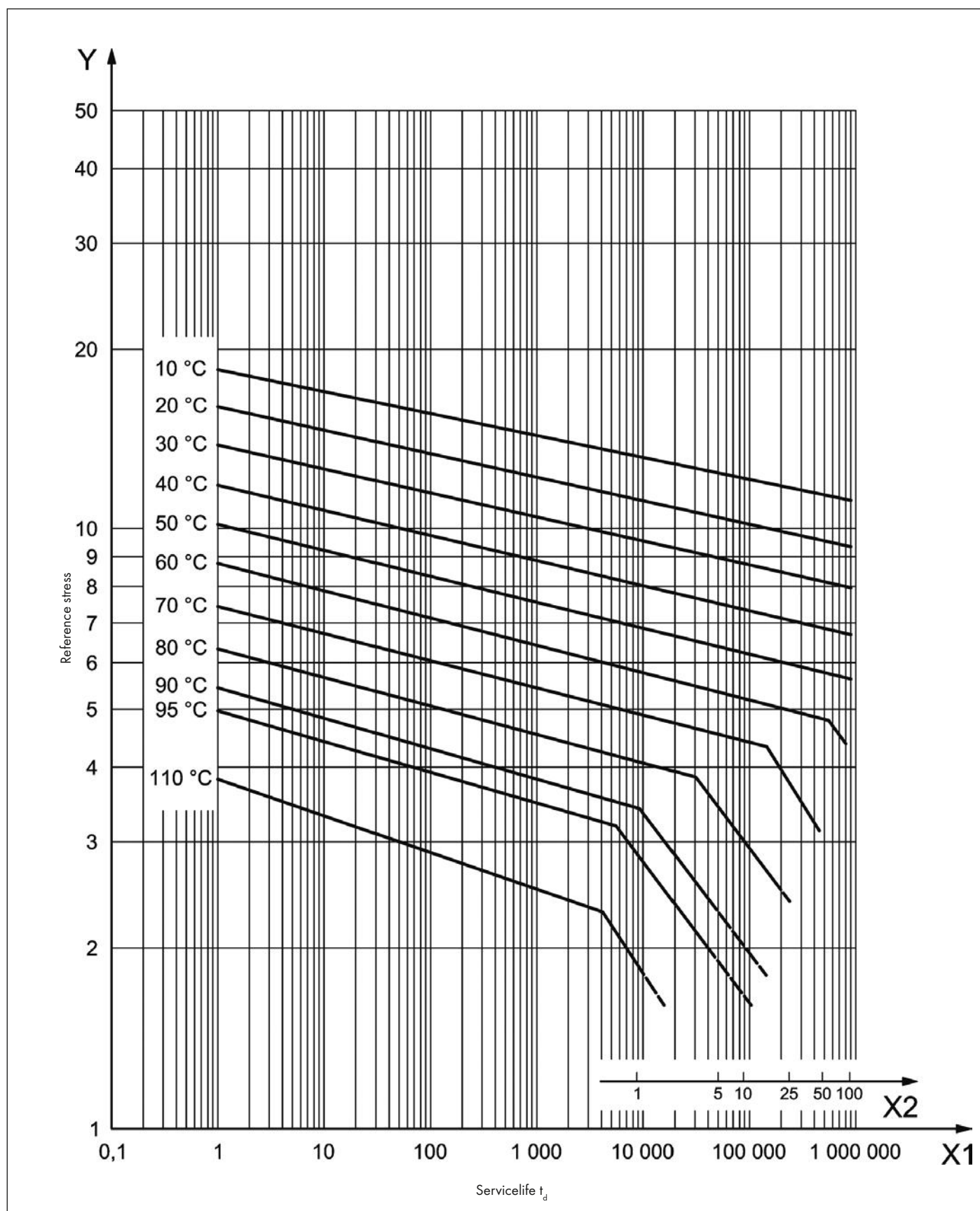
Tabelle 9.5 Tightening depending on temperature

d ₂ (mm)	DN	Hole distance (mm)	Hole diameter (mm)	Number of holes	Bolts	Minimum preload (Nm)	Maximum preload (Nm)
32	25	85	14	4	M12	15	20
40	32	100	18	4	M16	15	25
50	40	110	18	4	M16	20	30
63	50	125	18	4	M16	30	40
75	65	145	18	4	M16	40	50
90	80	160	18	8	M16	40	50
110	100	180	18	8	M16	40	60
125	100	180	18	8	M16	50	70
160	150	240	22	8	M20	60	80
200	200	295	22	8	M20	80	90
250	250	350	22	12	M20	80	100
315	300	400	22	12	M20	90	120

Table 9.6 Tightening torque according to manufacturer's instructions

Appendix A

Appendix A1 References for PP-R



Appendix A2

Polypropylene

RA130E-6017

Product Safety Information

1. Identification of the substance/mixture and of the company/undertaking

Trade name: RA130E-6017

Material use: Raw material for plastics industry

Manufacturer: Borealis AG

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

2. Hazards identification

Classification of the substance or mixture: The product is not classified as hazardous according to Regulation (EC) No 1272/2008 and its amendments.

Label elements: Not a hazardous substance or mixture.

Other hazards: The product burns, but is not classified as flammable. Dust from the product gives a potential risk for dust explosion. This substance/mixture contains no components considered to be either persistent, bioaccumulative and toxic (PBT), or very persistent and very bioaccumulative (vPvB) at levels of 0.1% or higher.

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

If inhaled: Move to fresh air in case of accidental inhalation of vapours or decomposition products.

In case of skin contact: If molten material comes in contact with the skin, cool with plenty of water. DO NOT remove solidified product, as removal could result in severe tissue damage. Obtain medical attention.

Most important symptoms and effects, both acute and delayed: 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.

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. Recycle or dispose loose material properly. Do not flush into surface water or sanitary sewer system. Should not be released into the environment.

It is recommended to implement systems and practices (such as Operation Clean Sweep®) to prevent accidental release of plastics in to the environment.

7. Handling and storage

Advice on safe handling: During processing and thermal treatment of the product, small amounts of volatile hydrocarbons may be released. Avoid inhalation of dust and decomposition fumes. Provide adequate ventilation. Local exhaust ventilation or additional personal protective equipment (PPE) may be necessary.

Advice on protection against fire and explosion: Dust from the product represents a risk for dust explosions when dispersed with air in a sufficient concentration and with the presence of an ignition source. All equipment shall be grounded. Routine

housekeeping will also contribute in preventing risks of dust explosions.

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

8. Exposure controls/personal protection

Do not eat, drink or smoke when using this product. Wash hands before breaks and at the end of workday.

Appropriate personal protective equipment (PPE) shall be worn in accordance with Regulation (EU) 2016/425.

Provide adequate ventilation. Local exhaust ventilation may be necessary.

9. Physical and chemical properties

Appearance: pellets, 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 to human health.

12. Ecological information

The product is not considered hazardous for the environment. Not readily biodegradable. Does not accumulate in organisms. Avoid release to 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

None known to apply.

16. Other information

Product does not require Safety Data Sheet in accordance with Article 31 of Regulation (EC) No 1907/2006, and its amendments.

Issuer: Borealis, Group Product Stewardship 12.04.2023 Ed.4.

Appendix A

Appendix A3 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 - Restrictions on the manufacturing, placing on the market and use of certain dangerous substances, mixtures and articles
- Annex XIV of the REACH Regulation 1907/2006/EC - List of substances subject to authorisation
- 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) - Annex VII - No ingredients used which require selective waste treatment
- Proposition 65 list of chemicals known to the State of California to cause cancer or reproductive toxicity - no warning labels are required for this product
- Regulation 1005/2009/EC (Substances that deplete the ozone layer)
- 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 (EU) 2019/1021 on persistent organic pollutants (POPs), repealing 850/2004/EC
- 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:

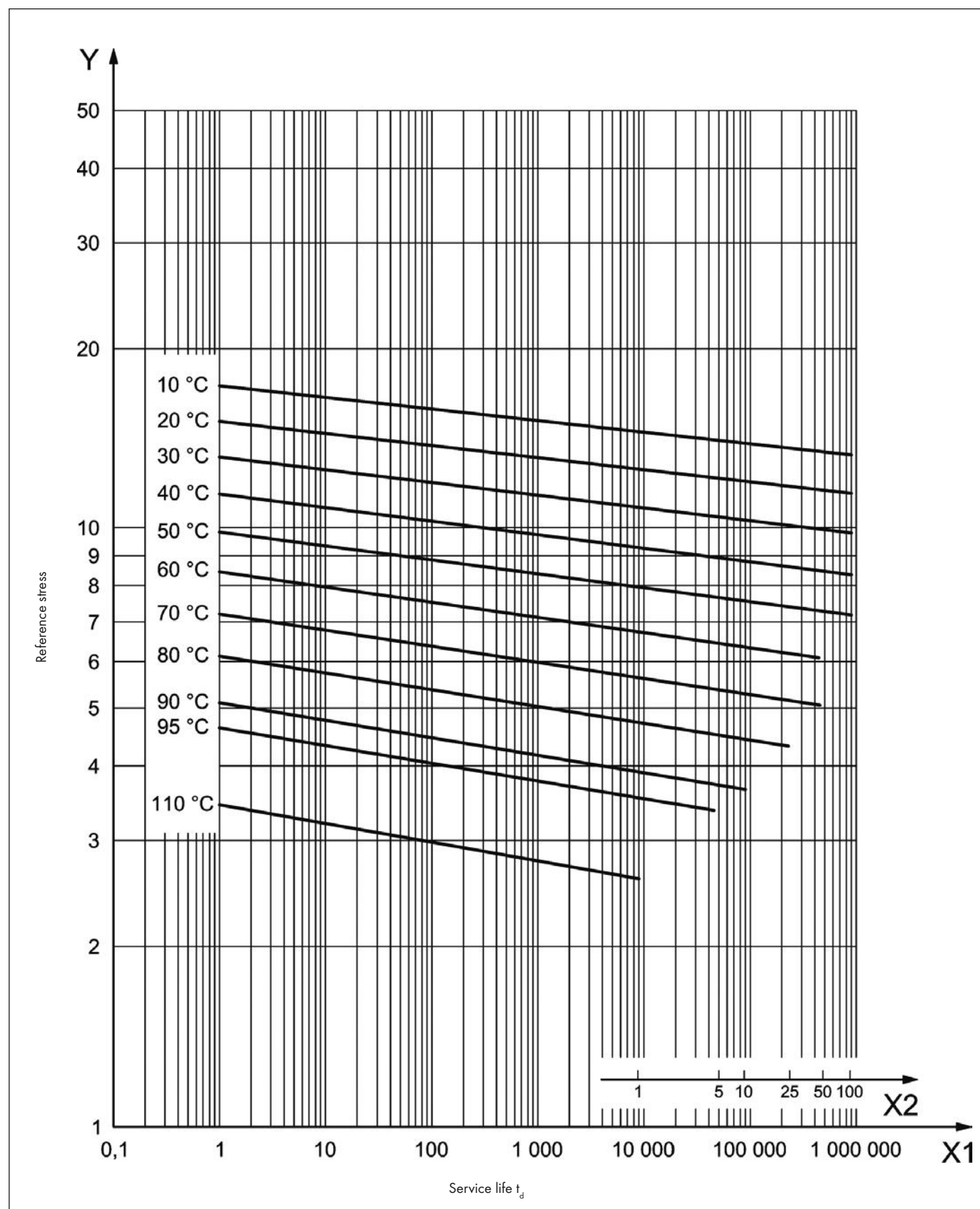
Acrylamide
Aromatic Amines (restricted in Regulation 1907/2006/EC, Annex XVII)
Artificial Musk
Asbestos
Azocolorants (restricted in Regulation 1907/2006/EC, Annex XVII) Azodicarboxamide, semicarbazide
Benzophenones (e.g. 4-MBP, 4-HBP, 2,2'-Dimethoxy-2-phenylacetophenone)
Biocides (Pesti-, Herbi-, Insecti-, Fungi-, Bactericides)
CFC, HCFC
CMR substances Categories 1A, 1B according to Regulation 1272/2008/EC *
Colophony (rosin)
4,4'-Diaminodiphenylmethane (MDA)
Di-2-ethyl-hexyl maleate (DEHM)
Dimethylfumarate (DMF), Dibutylfumarate
1,4-Dioxane
Elements: Arsenic, Beryllium, Bismuth, Gold, Indium, Palladium, Selenium, Silver, Tellurium, Thorium, Tin, Tantalum, Tungsten
Heavy metals: Cadmium, Chromium (VI), Lead, Mercury 2-Ethylhexanoic acid, Ethoxyquin, ITX, Thiurams Flame retardants (halogenated or phosphorus based)
Formaldehyde
Fragrances
Furfural
Glyoxal
Mechanically recycled materials
Melamine, Cyanuric acid
Natural rubbers, Latex Nitrosamines, Nitrates, Nitrites
Octyl- and Nonylphenols and Octyl- or Nonylphenoethoxylates; TNPP
Organotin compounds
Oxo-degradable additives
Parabens
PBT and vPvB substances according to EC Regulation No.1907/2006 (REACH)
PFAS (e.g. PFOA, PFOS)
Plasticisers (e.g. Adipates, ESBO, Phthalates*)
Polychlorinated Bi-, Terphenyls and Naphthalenes
Polychlorinated dibenzodioxins and dibenzofurans
Polycyclic aromatic hydrocarbons (PAH) as restricted in Regulation 1907/2006/EC, Annex XVII
Quaternary ammonium compounds
Radioactive substances
Styrene, Polystyrene
SVHC on "Candidate List of Substances of Very High Concern for Authorisation" **
Thiuram mix
Tri-tert-butylphenol
UV-hardeners (e.g. ITX, Titanyl-acetylacetone)
Vinylchloride, Vinylidenechloride, PVC, CPVC 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. 22.

Appendix A4

References for PP-RCT



Appendix A

Appendix A5 Polypropylene RA7050-GN Product Safety Information

1. Identification of the substance/mixture and of the company/undertaking

Trade name: RA7050-GN

Material use: Raw material for plastics industry

Manufacturer: Borealis AG

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

2. Hazards identification

Classification of the substance or mixture: The product is not classified as hazardous according to Regulation (EC) No 1272/2008 and its amendments.

Label elements: Not a hazardous substance or mixture.

Other hazards: The product burns, but is not classified as flammable. Dust from the product gives a potential risk for dust explosion. This substance/mixture contains no components considered to be either persistent, bioaccumulative and toxic (PBT), or very persistent and very bioaccumulative (vPvB) at levels of 0.1% or higher.

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

If inhaled: Move to fresh air in case of accidental inhalation of vapours or decomposition products.

In case of skin contact: If molten material comes in contact with the skin, cool with plenty of water. DO NOT remove solidified product, as removal could result in severe tissue damage. Obtain medical attention.

Most important symptoms and effects, both acute and delayed: 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.

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. Recycle or dispose loose material properly. Do not flush into surface water or sanitary sewer system. Should not be released into the environment.

It is recommended to implement systems and practices (such as Operation Clean Sweep®) to prevent accidental release of plastics in to the environment.

7. Handling and storage

Advice on safe handling: During processing and thermal treatment of the product, small amounts of volatile hydrocarbons may be released. Avoid inhalation of dust and decomposition fumes. Provide adequate ventilation. Local exhaust ventilation or additional personal protective equipment (PPE) may be necessary.

Advice on protection against fire and explosion: Dust from the product represents a risk for dust explosions when dispersed with air in a sufficient concentration and with the presence of an ignition source. All equipment shall be grounded. Routine

housekeeping will also contribute in preventing risks of dust explosions.

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

8. Exposure controls/personal protection

Do not eat, drink or smoke when using this product. Wash hands before breaks and at the end of workday.

Appropriate personal protective equipment (PPE) shall be worn in accordance with Regulation (EU) 2016/425.

Provide adequate ventilation. Local exhaust ventilation may be necessary.

9. Physical and chemical properties

Appearance: pellets, green

Odour: odourless

Melting point/range: 130–170 °C

Density: 0,9–1,0 g/cm³

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 to human health.

12. Ecological information

The product is not considered hazardous for the environment. Not readily biodegradable. Does not accumulate in organisms. Avoid release to 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

None known to apply.

16. Other information

Product does not require Safety Data Sheet in accordance with Article 31 of Regulation (EC) No 1907/2006, and its amendments.

Issuer: Borealis Group Product Stewardship 12.04.2023 Ed.4.

Appendix A6

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 - Restrictions on the manufacturing, placing on the market and use of certain dangerous substances, mixtures and articles
- Annex XIV of the REACH Regulation 1907/2006/EC - List of substances subject to authorisation
- 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) - Annex VII - No ingredients used which require selective waste treatment
- Proposition 65 list of chemicals known to the State of California to cause cancer or reproductive toxicity - no warning labels are required for this product
- Regulation 1005/2009/EC (Substances that deplete the ozone layer)
- 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 (EU) 2019/1021 on persistent organic pollutants (POPs), repealing 850/2004/EC
- 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)
 Artificial Musk
 Asbestos
 Azocolorants (restricted in Regulation 1907/2006/EC, Annex XVII) Azodicar-bonamide, semicarbazide
 Benzophenones (e.g. 4-MBP, 4-HBP, 2,2'-Dimethoxy-2-phenylacetophenone)
 Biocides (Pesti-, Herbi-, Insecti-, Fungi-, Bactericides)
 CFC, HCFC
 CMR substances Categories 1A, 1B according to Regulation 1272/2008/EC *
 Colophony (rosin)
 4,4'- Diaminodiphenylmethane (MDA)
 Di-2-ethyl-hexyl maleate (DEHM)
 Dimethylfumarate (DMF), Dibutylfumarate
 1,4-Dioxane
 Elements: Arsenic, Beryllium, Bismuth, Gold, Indium, Palladium, Selenium, Silver, Tellurium, Thorium, Tin, Tantalum, Tungsten
 Heavy metals: Cadmium, Chromium (VI), Lead, Mercury 2-Ethylhexanoic acid, Ethoxyquin, ITX, Thiurams Flame retardants (halogenated or phosphorus based)
 Formaldehyde
 Fragrances
 Furfural
 Glyoxal
 Mechanically recycled materials
 Melamine, Cyanuric acid
 Natural rubbers, Latex Nitrosamines, Nitrates, Nitrites
 Octyl- and Nonylphenols and Octyl- or Nonylphenoethoxylates; TNPP
 Organotin compounds
 Oxo-degradable additives
 Parabens
 PBT and vPvB substances according to EC Regulation No.1907/2006 (REACH)
 PFAS (e.g. PFOA, PFOS)
 Plasticisers (e.g. Adipates, ESBO, Phthalates*)
 Polychlorinated Bi-, Terphenyls and Naphthalenes
 Polychlorinated dibenzodioxins and dibenzofurans
 Polycyclic aromatic hydrocarbons (PAH) as restricted in Regulation 1907/2006/EC, Annex XVII
 Quaternary ammonium compounds
 Radioactive substances
 Styrene, Polystyrene
 SVHC on "Candidate List of Substances of Very High Concern for Authorisation" *
 Thiuram mix
 Tri-tert-butylphenol
 UV-hardeners (e.g. ITX, Titanium-acetylacetone)
 Vinylchloride, Vinylidenechloride, PVC, CPVC 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. 22.

Appendix B

Appendix B1

Maximum Operating Pressure

Values for maximum operating pressures MOP provided in standard DIN 8077. Material PP-R, for water Safety factor (SF) = 1,25.

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
20	100	17,8	28,2	35,5	44,7
	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
30	50	15,4	24,5	30,9	38,9
	100	15,0	23,9	30,2	37,8
	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
40	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
	1	13,0	20,6	25,9	32,6
	5	12,1	19,2	24,2	30,5
50	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
	1	11,0	17,4	21,9	27,6
60	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
70	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
80	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
95	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
	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.

Provided maximum operating pressures do not apply for pipes exposed to UV radiation, nor for pipes exposed to conveyed media to which PP-R and PP-RCT are not chemical resistant. When handled improperly with associated risk, apply an additional Safety (design) Factor.

Appendix B2

Maximum Operating Pressure

Values for maximum operating pressures MOP provided in standard DIN 8077. Material PP-R, for water Safety factor (SF) = 1,5.

Temperature °C	Operating years	Maximum Operating Pressure			
		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
20	100	14,8	23,5	29,6	37,2
	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
30	50	12,9	20,4	25,7	32,4
	100	12,5	19,9	25,0	31,5
	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
40	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
	1	10,8	17,1	21,6	27,2
	5	10,1	16,0	20,2	25,4
50	10	9,8	15,5	19,6	24,7
	25	9,4	15,0	18,8	23,8
	50	9,2	14,5	18,3	23,1
	100	8,9	14,1	17,8	22,4
	1	9,1	14,5	18,2	23,0
60	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
70	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
80	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
95	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
	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.

Provided maximum operating pressures do not apply for pipes exposed to UV radiation, nor for pipes exposed to conveyed media to which PP-R and PP-RCT are not chemical resistant. When handled improperly with associated risk, apply an additional Safety (design) Factor.

Appendix B

Appendix B3

Maximum Operating Pressure

Values for maximum operating pressures MOP provided in standard DIN 8077. Material PP-RCT, for water Safety factor (SF) = 1,25.

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
	100	9,5	12,0	15,2	19,0	24,1
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
	100	7,9	10,0	12,7	15,9	20,1
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
	50	6,7	8,4	10,7	13,4	16,9
	100	6,5	8,2	10,5	13,1	16,5
95	1	5,6	7,1	8,9	11,2	14,2
	5	5,3	6,7	8,5	10,7	13,5
	10	5,1	6,4	8,2	10,2	12,9
	25	4,9	6,1	7,9	9,9	12,5
	50	4,7	5,9	7,7	9,7	12,1
	100	4,5	5,7	7,5	9,5	11,7
(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.

Provided maximum operating pressures do not apply for pipes exposed to UV radiation, nor for pipes exposed to conveyed media to which PP-R and PP-RCT are not chemical resistant. When handled improperly with associated risk, apply an additional Safety (design) Factor.

Appendix B4

Maximum Operating Pressure

Values for maximum operating pressures MOP provided in standard DIN 8077. Material PP-RCT, for water Safety factor (SF) = 1,5.

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
	100	7,9	10,0	12,6	15,9	20,0
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
	100	6,6	8,3	10,5	13,2	16,6
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
	50	5,6	7,1	9,0	11,2	14,0
	100	5,4	6,9	8,8	11,0	13,6
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	5,4	7,0	8,7	10,9
	25	4,1	5,2	6,8	8,5	10,6
	50	4,0	5,1	6,7	8,4	10,4
	100	3,9	5,0	6,6	8,3	10,2
(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.

Provided maximum operating pressures do not apply for pipes exposed to UV radiation, nor for pipes exposed to conveyed media to which PP-R and PP-RCT are not chemical resistant. When handled improperly with associated risk, apply an additional Safety (design) Factor.

Appendix B

Appendix B7-1

Maximum flow rate

Determination of the maximum flowrate V_s from the flow ΣV_R for buildings according to DIN 1988 Part 3 - $V_s = 0,682 \cdot (\Sigma V_R)^{0,45} - 0,14$ (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 V_s from the flow ΣV_R for buildings according to DIN 1988 Part 3 - $V_s = 1,7 \cdot (\Sigma V_R)^{0,21} - 0,7$ (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 flow rate $\dot{V}$.

Pipe roughness: $K = 0,007 \text{ mm}$ $\dot{V}$ = flow rate (l/s)
 Density: $\rho = 998,2 \text{ kg/m}^3$ R = pressure gradient (mbar/m)
 Temperature: $t = 20^\circ\text{C}$ v = flow speed (m/s)
 Kinematic viscosity: $\nu = 1,003 \times 10^{-6} \text{ m}^2/\text{s}$

$d \times s$		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
$\dot{V}$	d_i	13,2 mm	16,6 mm	21,2 mm	26,6 mm	33,4 mm	42,0 mm	50,0 mm	60,0 mm	73,4 mm	83,4 mm
0,01	R	0,14	-	-	-	-	-	-	-	-	-
	v	0,07	-	-	-	-	-	-	-	-	-
0,02	R	0,42	-	-	-	-	-	-	-	-	-
	v	0,15	-	-	-	-	-	-	-	-	-
0,03	R	0,84	-	-	-	-	-	-	-	-	-
	v	0,22	-	-	-	-	-	-	-	-	-
0,04	R	1,36	-	-	-	-	-	-	-	-	-
	v	0,29	-	-	-	-	-	-	-	-	-
0,05	R	1,97	0,67	-	-	-	-	-	-	-	-
	v	0,37	0,23	-	-	-	-	-	-	-	-
0,06	R	2,69	0,90	-	-	-	-	-	-	-	-
	v	0,44	0,28	-	-	-	-	-	-	-	-
0,07	R	3,46	1,20	0,37	-	-	-	-	-	-	-
	v	0,51	0,32	0,20	-	-	-	-	-	-	-
0,08	R	4,39	1,48	0,47	-	-	-	-	-	-	-
	v	0,58	0,37	0,23	-	-	-	-	-	-	-
0,09	R	5,40	1,82	0,57	-	-	-	-	-	-	-
	v	0,66	0,42	0,25	-	-	-	-	-	-	-
0,10	R	6,46	2,18	0,68	-	-	-	-	-	-	-
	v	0,73	0,46	0,28	-	-	-	-	-	-	-
0,12	R	9,01	2,96	0,93	0,32	-	-	-	-	-	-
	v	0,88	0,55	0,34	0,22	-	-	-	-	-	-
0,14	R	11,87	3,90	1,22	0,42	-	-	-	-	-	-
	v	1,02	0,65	0,40	0,25	-	-	-	-	-	-
0,16	R	14,99	4,93	1,55	0,53	-	-	-	-	-	-
	v	1,17	0,74	0,45	0,29	-	-	-	-	-	-
0,18	R	18,32	6,03	1,90	0,65	-	-	-	-	-	-
	v	1,32	0,83	0,51	0,32	-	-	-	-	-	-
0,20	R	21,81	7,45	2,27	0,78	-	-	-	-	-	-
	v	1,46	0,92	0,57	0,36	-	-	-	-	-	-
0,30	R	45,43	15,02	4,59	1,59	0,53	-	-	-	-	-
	v	2,19	1,39	0,85	0,54	0,34	-	-	-	-	-
0,40	R	77,53	25,68	7,86	2,62	0,87	0,30	0,13	-	-	-
	v	2,92	1,85	1,13	0,72	0,46	0,29	0,20	-	-	-
0,50	R	116,09	36,91	11,34	3,80	1,31	0,43	0,19	-	-	-
	v	3,65	2,31	1,42	0,90	0,57	0,36	0,25	-	-	-
0,60	R	159,91	53,15	15,64	5,25	1,82	0,60	0,26	0,11	-	-
	v	4,38	2,77	1,70	1,08	0,68	0,43	0,31	0,21	-	-
0,70	R	-	69,20	21,29	7,15	2,38	0,79	0,34	0,14	-	-
	v	-	3,23	1,98	1,26	0,80	0,51	0,36	0,25	-	-
0,80	R	-	90,38	26,60	8,94	2,99	0,99	0,43	0,18	-	-
	v	-	3,70	2,27	1,44	0,91	0,58	0,41	0,28	-	-
0,90	R	-	109,19	33,67	10,83	3,63	1,20	0,52	0,22	0,09	-
	v	-	4,16	2,55	1,62	1,03	0,65	0,46	0,32	0,21	-
1,00	R	-	134,80	39,68	13,37	4,48	1,49	0,65	0,27	0,10	-
	v	-	4,62	2,83	1,80	1,14	0,72	0,51	0,35	0,24	-

Appendix B8-2

Pipe friction gradient/flow speed of Wefatherm pipes SDR 6

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

Pipe roughness: $K = 0,007 \text{ mm}$ $\dot{V} = \text{flow rate (l/s)}$

Density: $\rho = 998,2 \text{ kg/m}^3$ $R = \text{pressure gradient (mbar/m)}$

Temperature: $t = 20^\circ\text{C}$ $v = \text{flow speed (m/s)}$

Kinematic viscosity: $\nu = 1,003 \times 10^{-6} \text{ m}^2/\text{s}$

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

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 flow rate $\dot{V}$.

Pipe roughness: $K = 0,007 \text{ mm}$ $\dot{V}$ = flow rate (l/s)
 Density: $\rho = 998,2 \text{ kg/m}^3$ R = pressure gradient (mbar/m)
 Temperature: $t = 20^\circ\text{C}$ v = flow speed (m/s)
 Kinematic viscosity: $\nu = 1,003 \times 10^{-6} \text{ m}^2/\text{s}$

$d \times s$		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
$\dot{V}$	d_i	13,2 mm	16,6 mm	21,2 mm	26,6 mm	33,4 mm	42,0 mm	50,0 mm	60,0 mm	73,4 mm	83,4 mm
5,80	R	-	-	-	-	-	35,41	14,81	6,30	2,30	1,28
	v	-	-	-	-	-	4,19	2,95	2,05	1,37	1,06
6,00	R	-	-	-	-	-	37,89	15,85	6,74	2,46	1,37
	v	-	-	-	-	-	4,33	3,06	2,12	1,42	1,10
6,20	R	-	-	-	-	-	40,46	16,92	7,20	2,63	1,46
	v	-	-	-	-	-	4,48	3,16	2,19	1,47	1,13
6,40	R	-	-	-	-	-	43,11	18,03	7,67	2,80	1,48
	v	-	-	-	-	-	4,62	3,26	2,26	1,51	1,17
6,60	R	-	-	-	-	-	45,85	19,17	7,71	2,98	1,57
	v	-	-	-	-	-	4,76	3,36	2,33	1,56	1,21
6,80	R	-	-	-	-	-	-	20,35	8,18	3,16	1,67
	v	-	-	-	-	-	-	3,46	2,41	1,61	1,24
7,00	R	-	-	-	-	-	-	21,57	8,67	3,35	1,77
	v	-	-	-	-	-	-	3,57	2,48	1,65	1,28
7,20	R	-	-	-	-	-	-	22,82	9,17	3,54	1,87
	v	-	-	-	-	-	-	3,67	2,55	1,70	1,32
7,40	R	-	-	-	-	-	-	24,10	9,69	3,74	1,98
	v	-	-	-	-	-	-	3,77	2,62	1,75	1,35
7,60	R	-	-	-	-	-	-	25,42	10,22	3,95	2,08
	v	-	-	-	-	-	-	3,87	2,69	1,80	1,39
7,80	R	-	-	-	-	-	-	26,78	10,76	3,93	2,20
	v	-	-	-	-	-	-	3,97	2,76	1,84	1,43
8,00	R	-	-	-	-	-	-	28,17	11,32	4,13	2,31
	v	-	-	-	-	-	-	4,07	2,83	1,89	1,46
8,20	R	-	-	-	-	-	-	29,60	11,89	4,34	2,43
	v	-	-	-	-	-	-	4,18	2,90	1,94	1,50
8,40	R	-	-	-	-	-	-	31,06	12,48	4,56	2,55
	v	-	-	-	-	-	-	4,28	2,97	1,99	1,54
8,60	R	-	-	-	-	-	-	30,64	13,08	4,77	2,52
	v	-	-	-	-	-	-	4,38	3,04	2,03	1,57
8,80	R	-	-	-	-	-	-	32,08	13,70	5,00	2,64
	v	-	-	-	-	-	-	4,48	3,11	2,08	1,61
9,00	R	-	-	-	-	-	-	33,56	14,33	5,23	2,76
	v	-	-	-	-	-	-	4,58	3,18	2,13	1,65
9,20	R	-	-	-	-	-	-	35,06	14,97	5,46	2,89
	v	-	-	-	-	-	-	4,69	3,25	2,17	1,68
9,40	R	-	-	-	-	-	-	36,60	15,63	5,70	3,01
	v	-	-	-	-	-	-	4,79	3,32	2,22	1,72
9,60	R	-	-	-	-	-	-	-	15,34	5,95	3,14
	v	-	-	-	-	-	-	-	3,40	2,27	1,76
9,80	R	-	-	-	-	-	-	-	15,99	6,20	3,27
	v	-	-	-	-	-	-	-	3,47	2,32	1,79
10,00	R	-	-	-	-	-	-	-	16,65	6,46	3,41
	v	-	-	-	-	-	-	-	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 flow rate $\dot{V}$.

Pipe roughness: $K = 0,007 \text{ mm}$ $\dot{V} = \text{flow rate (l/s)}$

Density: $\rho = 983,2 \text{ kg/m}^3$ $R = \text{pressure gradient (mbar/m)}$

Temperature: $t = 60^\circ\text{C}$ $v = \text{flow speed (m/s)}$

Kinematic viscosity: $\nu = 0,47 \times 10^{-6} \text{ m}^2/\text{s}$

d x s		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
$\dot{V}$	d_i	13,2 mm	16,6 mm	21,2 mm	26,6 mm	33,4 mm	42,0 mm	50,0 mm	60,0 mm	73,4 mm	83,4 mm
0,01	R	0,10	-	-	-	-	-	-	-	-	-
	v	0,07	-	-	-	-	-	-	-	-	-
0,02	R	0,33	-	-	-	-	-	-	-	-	-
	v	0,15	-	-	-	-	-	-	-	-	-
0,03	R	0,64	-	-	-	-	-	-	-	-	-
	v	0,22	-	-	-	-	-	-	-	-	-
0,04	R	1,08	-	-	-	-	-	-	-	-	-
	v	0,29	-	-	-	-	-	-	-	-	-
0,05	R	1,59	0,54	-	-	-	-	-	-	-	-
	v	0,37	0,23	-	-	-	-	-	-	-	-
0,06	R	2,15	0,73	-	-	-	-	-	-	-	-
	v	0,44	0,28	-	-	-	-	-	-	-	-
0,07	R	2,83	0,96	0,30	-	-	-	-	-	-	-
	v	0,51	0,32	0,20	-	-	-	-	-	-	-
0,08	R	3,56	1,21	0,37	-	-	-	-	-	-	-
	v	0,58	0,37	0,23	-	-	-	-	-	-	-
0,09	R	4,51	1,49	0,45	-	-	-	-	-	-	-
	v	0,66	0,42	0,25	-	-	-	-	-	-	-
0,10	R	5,37	1,77	0,56	-	-	-	-	-	-	-
	v	0,73	0,46	0,28	-	-	-	-	-	-	-
0,12	R	7,45	2,46	0,75	0,26	-	-	-	-	-	-
	v	0,88	0,55	0,34	0,22	-	-	-	-	-	-
0,14	R	9,74	3,22	0,98	0,34	-	-	-	-	-	-
	v	1,02	0,65	0,40	0,25	-	-	-	-	-	-
0,16	R	12,73	4,05	1,29	0,43	-	-	-	-	-	-
	v	1,17	0,74	0,45	0,29	-	-	-	-	-	-
0,18	R	15,46	5,12	1,57	0,52	-	-	-	-	-	-
	v	1,32	0,83	0,51	0,32	-	-	-	-	-	-
0,20	R	19,09	6,07	1,86	0,62	-	-	-	-	-	-
	v	1,46	0,92	0,57	0,36	-	-	-	-	-	-
0,30	R	39,38	12,52	3,85	1,29	0,43	-	-	-	-	-
	v	2,19	1,39	0,85	0,54	0,34	-	-	-	-	-
0,40	R	66,82	21,24	6,55	2,20	0,74	0,24	0,11	-	-	-
	v	2,92	1,85	1,13	0,72	0,46	0,29	0,20	-	-	-
0,50	R	104,41	33,19	9,77	3,29	1,10	0,37	0,15	-	-	-
	v	3,65	2,31	1,42	0,90	0,57	0,36	0,25	-	-	-
0,60	R	143,18	45,52	13,40	4,52	1,52	0,50	0,21	0,09	-	-
	v	4,38	2,77	1,70	1,08	0,68	0,43	0,31	0,21	-	-
0,70	R	-	61,96	18,24	5,86	1,97	0,66	0,29	0,12	-	-
	v	-	3,23	1,98	1,26	0,80	0,51	0,36	0,25	-	-
0,80	R	-	76,88	23,82	7,66	2,58	0,82	0,36	0,15	-	-
	v	-	3,70	2,27	1,44	0,91	0,58	0,41	0,28	-	-
0,90	R	-	97,30	28,64	9,69	3,11	1,04	0,43	0,18	0,07	-
	v	-	4,16	2,55	1,62	1,03	0,65	0,46	0,32	0,21	-
1,00	R	-	120,13	35,36	11,37	3,83	1,22	0,54	0,23	0,09	-
	v	-	4,62	2,83	1,80	1,14	0,72	0,51	0,35	0,24	-

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 flow rate $\dot{V}$.

Pipe roughness: $K = 0,007 \text{ mm}$ $\dot{V}$ = flow rate (l/s)
 Density: $\rho = 983,2 \text{ kg/m}^3$ R = pressure gradient (mbar/m)
 Temperature: $t = 60^\circ\text{C}$ v = flow speed (m/s)
 Kinematic viscosity: $\nu = 0,47 \times 10^{-6} \text{ m}^2/\text{s}$

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

Appendix B8-6

Pipe friction gradient/flow speed of Wefatherm pipes SDR 6

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

Pipe roughness: $K = 0,007 \text{ mm}$ $\dot{V} = \text{flow rate (l/s)}$

Density: $\rho = 983,2 \text{ kg/m}^3$ $R = \text{pressure gradient (mbar/m)}$

Temperature: $t = 60^\circ\text{C}$ $v = \text{flow speed (m/s)}$

Kinematic viscosity: $\nu = 0,47 \times 10^{-6} \text{ m}^2/\text{s}$

d x s		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
$\dot{V}$	d_i	13,2 mm	16,6 mm	21,2 mm	26,6 mm	33,4 mm	42,0 mm	50,0 mm	60,0 mm	73,4 mm	83,4 mm
5,80	R	-	-	-	-	-	32,82	13,73	5,52	2,01	1,06
	v	-	-	-	-	-	4,19	2,95	2,05	1,37	1,06
6,00	R	-	-	-	-	-	35,12	14,69	5,90	2,15	1,14
	v	-	-	-	-	-	4,33	3,06	2,12	1,42	1,10
6,20	R	-	-	-	-	-	37,50	15,69	6,30	2,30	1,21
	v	-	-	-	-	-	4,48	3,16	2,19	1,47	1,13
6,40	R	-	-	-	-	-	37,47	16,71	6,72	2,45	1,29
	v	-	-	-	-	-	4,62	3,26	2,26	1,51	1,17
6,60	R	-	-	-	-	-	39,84	16,66	7,14	2,61	1,38
	v	-	-	-	-	-	4,76	3,36	2,33	1,56	1,21
6,80	R	-	-	-	-	-	-	17,69	7,58	2,77	1,46
	v	-	-	-	-	-	-	3,46	2,41	1,61	1,24
7,00	R	-	-	-	-	-	-	18,74	8,04	2,93	1,55
	v	-	-	-	-	-	-	3,57	2,48	1,65	1,28
7,20	R	-	-	-	-	-	-	19,83	7,97	3,10	1,64
	v	-	-	-	-	-	-	3,67	2,55	1,70	1,32
7,40	R	-	-	-	-	-	-	20,95	8,42	3,28	1,73
	v	-	-	-	-	-	-	3,77	2,62	1,75	1,35
7,60	R	-	-	-	-	-	-	22,10	8,88	3,46	1,83
	v	-	-	-	-	-	-	3,87	2,69	1,80	1,39
7,80	R	-	-	-	-	-	-	23,27	9,35	3,64	1,92
	v	-	-	-	-	-	-	3,97	2,76	1,84	1,43
8,00	R	-	-	-	-	-	-	24,48	9,84	3,59	2,02
	v	-	-	-	-	-	-	4,07	2,83	1,89	1,46
8,20	R	-	-	-	-	-	-	25,72	10,34	3,77	2,12
	v	-	-	-	-	-	-	4,18	2,90	1,94	1,50
8,40	R	-	-	-	-	-	-	26,99	10,85	3,96	2,23
	v	-	-	-	-	-	-	4,28	2,97	1,99	1,54
8,60	R	-	-	-	-	-	-	28,29	11,37	4,15	2,19
	v	-	-	-	-	-	-	4,38	3,04	2,03	1,57
8,80	R	-	-	-	-	-	-	29,62	11,91	4,35	2,29
	v	-	-	-	-	-	-	4,48	3,11	2,08	1,61
9,00	R	-	-	-	-	-	-	30,99	12,45	4,54	2,40
	v	-	-	-	-	-	-	4,58	3,18	2,13	1,65
9,20	R	-	-	-	-	-	-	32,38	13,01	4,75	2,51
	v	-	-	-	-	-	-	4,69	3,25	2,17	1,68
9,40	R	-	-	-	-	-	-	33,80	13,58	4,96	2,62
	v	-	-	-	-	-	-	4,79	3,32	2,22	1,72
9,60	R	-	-	-	-	-	-	-	14,17	5,17	2,73
	v	-	-	-	-	-	-	-	3,40	2,27	1,76
9,80	R	-	-	-	-	-	-	-	14,76	5,39	2,85
	v	-	-	-	-	-	-	-	3,47	2,32	1,79
10,00	R	-	-	-	-	-	-	-	15,37	5,61	2,96
	v	-	-	-	-	-	-	-	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 flow rate $\dot{V}$.

Pipe roughness: $K = 0,007 \text{ mm}$ $\dot{V}$ = flow rate (l/s)
 Density: $\rho = 998,2 \text{ kg/m}^3$ R = pressure gradient (mbar/m)
 Temperature: $t = 20^\circ\text{C}$ v = flow speed (m/s)
 Kinematic viscosity: $\nu = 1,003 \times 10^{-6} \text{ m}^2/\text{s}$

$d \times s$		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
$\dot{V}$	d_i	14,4 mm	18,0 mm	23,2 mm	29,0 mm	36,2 mm	45,8 mm	54,4 mm	65,4 mm	79,8 mm	90,8 mm
0,01	R	0,09	-	-	-	-	-	-	-	-	-
	v	0,06	-	-	-	-	-	-	-	-	-
0,02	R	0,28	-	-	-	-	-	-	-	-	-
	v	0,12	-	-	-	-	-	-	-	-	-
0,03	R	0,55	-	-	-	-	-	-	-	-	-
	v	0,18	-	-	-	-	-	-	-	-	-
0,04	R	0,90	-	-	-	-	-	-	-	-	-
	v	0,25	-	-	-	-	-	-	-	-	-
0,05	R	1,31	0,46	-	-	-	-	-	-	-	-
	v	0,31	0,20	-	-	-	-	-	-	-	-
0,06	R	1,79	0,62	-	-	-	-	-	-	-	-
	v	0,37	0,24	-	-	-	-	-	-	-	-
0,07	R	2,31	0,80	-	-	-	-	-	-	-	-
	v	0,43	0,28	-	-	-	-	-	-	-	-
0,08	R	2,93	1,01	-	-	-	-	-	-	-	-
	v	0,49	0,31	-	-	-	-	-	-	-	-
0,09	R	3,60	1,25	0,37	-	-	-	-	-	-	-
	v	0,55	0,35	0,21	-	-	-	-	-	-	-
0,10	R	4,31	1,50	0,45	-	-	-	-	-	-	-
	v	0,61	0,39	0,24	-	-	-	-	-	-	-
0,12	R	5,83	2,03	0,61	-	-	-	-	-	-	-
	v	0,74	0,47	0,28	-	-	-	-	-	-	-
0,14	R	7,68	2,69	0,80	0,28	-	-	-	-	-	-
	v	0,86	0,55	0,33	0,21	-	-	-	-	-	-
0,16	R	9,70	3,40	1,02	0,35	-	-	-	-	-	-
	v	0,98	0,63	0,38	0,24	-	-	-	-	-	-
0,18	R	11,85	4,16	1,25	0,42	-	-	-	-	-	-
	v	1,11	0,71	0,43	0,27	-	-	-	-	-	-
0,20	R	14,64	4,97	1,49	0,52	-	-	-	-	-	-
	v	1,23	0,79	0,47	0,30	-	-	-	-	-	-
0,30	R	29,40	10,02	3,03	1,03	0,36	-	-	-	-	-
	v	1,84	1,18	0,71	0,45	0,29	-	-	-	-	-
0,40	R	50,18	17,13	5,01	1,70	0,60	0,19	-	-	-	-
	v	2,46	1,57	0,95	0,61	0,39	0,24	-	-	-	-
0,50	R	75,14	25,69	7,52	2,56	0,88	0,29	0,13	-	-	-
	v	3,07	1,96	1,18	0,76	0,49	0,30	0,22	-	-	-
0,60	R	103,50	35,45	10,40	3,55	1,22	0,39	0,18	-	-	-
	v	3,68	2,36	1,42	0,91	0,58	0,36	0,26	-	-	-
0,70	R	140,87	46,16	13,57	4,64	1,59	0,51	0,22	0,10	-	-
	v	4,30	2,75	1,66	1,06	0,68	0,42	0,30	0,21	-	-
0,80	R	175,63	60,29	16,95	5,81	2,00	0,67	0,29	0,12	-	-
	v	4,91	3,14	1,89	1,21	0,78	0,49	0,34	0,24	-	-
0,90	R	-	72,84	21,45	7,35	2,53	0,81	0,36	0,15	-	-
	v	-	3,54	2,13	1,36	0,87	0,55	0,39	0,27	-	-
1,00	R	-	89,92	26,48	8,68	2,99	0,96	0,42	0,18	0,07	-
	v	-	3,93	2,37	1,51	0,97	0,61	0,43	0,30	0,20	-

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 flow rate $\dot{V}$.

Pipe roughness: $K = 0,007 \text{ mm}$ $\dot{V} = \text{flow rate (l/s)}$

Density: $\rho = 998,2 \text{ kg/m}^3$ $R = \text{pressure gradient (mbar/m)}$

Temperature: $t = 20^\circ\text{C}$ $v = \text{flow speed (m/s)}$

Kinematic viscosity: $\nu = 1,003 \times 10^{-6} \text{ m}^2/\text{s}$

d x s		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
$\dot{V}$	d_i	14,4 mm	18,0 mm	23,2 mm	29,0 mm	36,2 mm	45,8 mm	54,4 mm	65,4 mm	79,8 mm	90,8 mm
1,20	R	-	123,32	36,40	12,50	4,12	1,33	0,59	0,24	0,09	-
	v	-	4,72	2,84	1,82	1,17	0,73	0,52	0,36	0,24	-
1,40	R	-	-	47,19	16,24	5,61	1,81	0,77	0,32	0,12	0,07
	v	-	-	3,31	2,12	1,36	0,85	0,60	0,42	0,28	0,22
1,60	R	-	-	61,64	20,20	7,00	2,26	1,00	0,42	0,16	0,08
	v	-	-	3,78	2,42	1,55	0,97	0,69	0,48	0,32	0,25
1,80	R	-	-	78,01	25,56	8,86	2,73	1,21	0,50	0,19	0,11
	v	-	-	4,26	2,73	1,75	1,09	0,77	0,54	0,36	0,28
2,00	R	-	-	91,49	31,56	10,41	3,37	1,49	0,60	0,23	0,13
	v	-	-	4,73	3,03	1,94	1,21	0,86	0,60	0,40	0,31
2,20	R	-	-	-	36,28	12,60	4,08	1,73	0,72	0,28	0,15
	v	-	-	-	3,33	2,14	1,34	0,95	0,65	0,44	0,34
2,40	R	-	-	-	43,17	14,99	4,63	2,05	0,86	0,32	0,17
	v	-	-	-	3,63	2,33	1,46	1,03	0,71	0,48	0,37
2,60	R	-	-	-	50,67	16,72	5,43	2,30	0,96	0,37	0,20
	v	-	-	-	3,94	2,53	1,58	1,12	0,77	0,52	0,40
2,80	R	-	-	-	58,76	19,39	6,30	2,66	1,11	0,43	0,23
	v	-	-	-	4,24	2,72	1,70	1,20	0,83	0,56	0,43
3,00	R	-	-	-	63,90	22,26	6,87	3,06	1,28	0,47	0,26
	v	-	-	-	4,54	2,91	1,82	1,29	0,89	0,60	0,46
3,20	R	-	-	-	72,71	25,32	7,81	3,48	1,38	0,54	0,30
	v	-	-	-	4,84	3,11	1,94	1,38	0,95	0,64	0,49
3,40	R	-	-	-	-	27,08	8,82	3,73	1,56	0,61	0,32
	v	-	-	-	-	3,30	2,06	1,46	1,01	0,68	0,53
3,60	R	-	-	-	-	30,36	9,89	4,18	1,75	0,68	0,36
	v	-	-	-	-	3,50	2,19	1,55	1,07	0,72	0,56
3,80	R	-	-	-	-	33,83	11,02	4,66	1,95	0,72	0,40
	v	-	-	-	-	3,69	2,31	1,63	1,13	0,76	0,59
4,00	R	-	-	-	-	37,48	11,56	5,16	2,06	0,80	0,44
	v	-	-	-	-	3,89	2,43	1,72	1,19	0,80	0,62
4,20	R	-	-	-	-	41,33	12,75	5,69	2,27	0,88	0,46
	v	-	-	-	-	4,08	2,55	1,81	1,25	0,84	0,65
4,40	R	-	-	-	-	45,36	13,99	6,25	2,49	0,97	0,51
	v	-	-	-	-	4,28	2,67	1,89	1,31	0,88	0,68
4,60	R	-	-	-	-	49,57	15,29	6,47	2,72	1,06	0,55
	v	-	-	-	-	4,47	2,79	1,98	1,37	0,92	0,71
4,80	R	-	-	-	-	50,98	16,65	7,04	2,96	1,09	0,60
	v	-	-	-	-	4,66	2,91	2,07	1,43	0,96	0,74
5,00	R	-	-	-	-	55,32	18,07	7,64	3,21	1,19	0,66
	v	-	-	-	-	4,86	3,03	2,15	1,49	1,00	0,77
5,20	R	-	-	-	-	-	19,54	8,27	3,29	1,28	0,71
	v	-	-	-	-	-	3,16	2,24	1,55	1,04	0,80
5,40	R	-	-	-	-	-	21,07	8,91	3,55	1,39	0,73
	v	-	-	-	-	-	3,28	2,32	1,61	1,08	0,83
5,60	R	-	-	-	-	-	21,40	9,59	3,82	1,49	0,78
	v	-	-	-	-	-	3,40	2,41	1,67	1,12	0,86

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 flow rate $\dot{V}$.

Pipe roughness: $K = 0,007 \text{ mm}$ $\dot{V}$ = flow rate (l/s)
 Density: $\rho = 998,2 \text{ kg/m}^3$ R = pressure gradient (mbar/m)
 Temperature: $t = 20^\circ\text{C}$ v = flow speed (m/s)
 Kinematic viscosity: $\nu = 1,003 \times 10^{-6} \text{ m}^2/\text{s}$

$d \times s$		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
$\dot{V}$	d_i	14,4 mm	18,0 mm	23,2 mm	29,0 mm	36,2 mm	45,8 mm	54,4 mm	65,4 mm	79,8 mm	90,8 mm
5,80	R	-	-	-	-	-	22,96	10,28	4,09	1,60	0,84
	v	-	-	-	-	-	3,52	2,50	1,73	1,16	0,90
6,00	R	-	-	-	-	-	24,57	11,00	4,38	1,71	0,90
	v	-	-	-	-	-	3,64	2,58	1,79	1,20	0,93
6,20	R	-	-	-	-	-	26,24	11,10	4,68	1,73	0,96
	v	-	-	-	-	-	3,76	2,67	1,85	1,24	0,96
6,40	R	-	-	-	-	-	27,96	11,83	4,99	1,84	1,02
	v	-	-	-	-	-	3,88	2,75	1,91	1,28	0,99
6,60	R	-	-	-	-	-	29,73	12,58	5,30	1,96	1,08
	v	-	-	-	-	-	4,01	2,84	1,96	1,32	1,02
6,80	R	-	-	-	-	-	31,56	13,35	5,63	2,08	1,09
	v	-	-	-	-	-	4,13	2,93	2,02	1,36	1,05
7,00	R	-	-	-	-	-	33,44	14,15	5,96	2,21	1,16
	v	-	-	-	-	-	4,25	3,01	2,08	1,40	1,08
7,20	R	-	-	-	-	-	35,38	14,97	5,96	2,33	1,22
	v	-	-	-	-	-	4,37	3,10	2,14	1,44	1,11
7,40	R	-	-	-	-	-	37,38	15,81	6,30	2,46	1,29
	v	-	-	-	-	-	4,49	3,18	2,20	1,48	1,14
7,60	R	-	-	-	-	-	39,42	16,68	6,64	2,60	1,36
	v	-	-	-	-	-	4,61	3,27	2,26	1,52	1,17
7,80	R	-	-	-	-	-	41,53	17,57	6,99	2,74	1,44
	v	-	-	-	-	-	4,73	3,36	2,32	1,56	1,20
8,00	R	-	-	-	-	-	43,68	18,48	7,36	2,88	1,51
	v	-	-	-	-	-	4,86	3,44	2,38	1,60	1,24
8,20	R	-	-	-	-	-	-	19,41	7,73	3,03	1,59
	v	-	-	-	-	-	-	3,53	2,44	1,64	1,27
8,40	R	-	-	-	-	-	-	20,37	8,11	3,00	1,66
	v	-	-	-	-	-	-	3,61	2,50	1,68	1,30
8,60	R	-	-	-	-	-	-	21,35	8,50	3,14	1,75
	v	-	-	-	-	-	-	3,70	2,56	1,72	1,33
8,80	R	-	-	-	-	-	-	22,36	8,90	3,29	1,83
	v	-	-	-	-	-	-	3,79	2,62	1,76	1,36
9,00	R	-	-	-	-	-	-	22,01	9,31	3,44	1,91
	v	-	-	-	-	-	-	3,87	2,68	1,80	1,39
9,20	R	-	-	-	-	-	-	23,00	9,73	3,60	1,89
	v	-	-	-	-	-	-	3,96	2,74	1,84	1,42
9,40	R	-	-	-	-	-	-	24,01	10,16	3,76	1,97
	v	-	-	-	-	-	-	4,04	2,80	1,88	1,45
9,60	R	-	-	-	-	-	-	25,04	10,60	3,92	2,05
	v	-	-	-	-	-	-	4,13	2,86	1,92	1,48
9,80	R	-	-	-	-	-	-	26,10	11,04	4,08	2,14
	v	-	-	-	-	-	-	4,22	2,92	1,96	1,51
10,00	R	-	-	-	-	-	-	27,17	11,50	4,25	2,23
	v	-	-	-	-	-	-	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 flow rate $\dot{V}$.

Pipe roughness: $K = 0,007 \text{ mm}$ $\dot{V} = \text{flow rate (l/s)}$

Density: $\rho = 983,2 \text{ kg/m}^3$ $R = \text{pressure gradient (mbar/m)}$

Temperature: $t = 60^\circ\text{C}$ $v = \text{flow speed (m/s)}$

Kinematic viscosity: $\nu = 0,47 \times 10^{-6} \text{ m}^2/\text{s}$

d x s		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
$\dot{V}$	d_i	14,4 mm	18,0 mm	23,2 mm	29,0 mm	36,2 mm	45,8 mm	54,4 mm	65,4 mm	79,8 mm	90,8 mm
0,01	R	0,07	-	-	-	-	-	-	-	-	-
	v	0,06	-	-	-	-	-	-	-	-	-
0,02	R	0,22	-	-	-	-	-	-	-	-	-
	v	0,12	-	-	-	-	-	-	-	-	-
0,03	R	0,43	-	-	-	-	-	-	-	-	-
	v	0,18	-	-	-	-	-	-	-	-	-
0,04	R	0,70	-	-	-	-	-	-	-	-	-
	v	0,25	-	-	-	-	-	-	-	-	-
0,05	R	1,03	0,36	-	-	-	-	-	-	-	-
	v	0,31	0,20	-	-	-	-	-	-	-	-
0,06	R	1,44	0,50	-	-	-	-	-	-	-	-
	v	0,37	0,24	-	-	-	-	-	-	-	-
0,07	R	1,89	0,64	-	-	-	-	-	-	-	-
	v	0,43	0,28	-	-	-	-	-	-	-	-
0,08	R	2,39	0,81	-	-	-	-	-	-	-	-
	v	0,49	0,31	-	-	-	-	-	-	-	-
0,09	R	2,92	0,99	0,30	-	-	-	-	-	-	-
	v	0,55	0,35	0,21	-	-	-	-	-	-	-
0,10	R	3,48	1,22	0,36	-	-	-	-	-	-	-
	v	0,61	0,39	0,24	-	-	-	-	-	-	-
0,12	R	4,82	1,64	0,50	-	-	-	-	-	-	-
	v	0,74	0,47	0,28	-	-	-	-	-	-	-
0,14	R	6,31	2,15	0,65	0,22	-	-	-	-	-	-
	v	0,86	0,55	0,33	0,21	-	-	-	-	-	-
0,16	R	8,24	2,81	0,82	0,28	-	-	-	-	-	-
	v	0,98	0,63	0,38	0,24	-	-	-	-	-	-
0,18	R	10,01	3,42	1,00	0,35	-	-	-	-	-	-
	v	1,11	0,71	0,43	0,27	-	-	-	-	-	-
0,20	R	12,36	4,22	1,23	0,42	-	-	-	-	-	-
	v	1,23	0,79	0,47	0,30	-	-	-	-	-	-
0,30	R	25,49	8,73	2,56	0,87	0,30	-	-	-	-	-
	v	1,84	1,18	0,71	0,45	0,29	-	-	-	-	-
0,40	R	43,25	14,85	4,17	1,43	0,49	0,16	-	-	-	-
	v	2,46	1,57	0,95	0,61	0,39	0,24	-	-	-	-
0,50	R	67,57	22,14	6,23	2,14	0,74	0,24	0,10	-	-	-
	v	3,07	1,96	1,18	0,76	0,49	0,30	0,22	-	-	-
0,60	R	92,67	30,37	8,96	2,94	1,02	0,33	0,14	-	-	-
	v	3,68	2,36	1,42	0,91	0,58	0,36	0,26	-	-	-
0,70	R	126,14	41,33	11,62	4,00	1,32	0,43	0,19	0,08	-	-
	v	4,30	2,75	1,66	1,06	0,68	0,42	0,30	0,21	-	-
0,80	R	156,51	51,29	15,18	4,97	1,72	0,56	0,24	0,10	-	-
	v	4,91	3,14	1,89	1,21	0,78	0,49	0,34	0,24	-	-
0,90	R	-	64,91	18,25	6,29	2,08	0,67	0,30	0,12	-	-
	v	-	3,54	2,13	1,36	0,87	0,55	0,39	0,27	-	-
1,00	R	-	80,14	22,53	7,38	2,56	0,83	0,35	0,15	0,06	-
	v	-	3,93	2,37	1,51	0,97	0,61	0,43	0,30	0,20	-

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 flow rate $\dot{V}$.

Pipe roughness: $K = 0,007 \text{ mm}$ $\dot{V}$ = flow rate (l/s)
 Density: $\rho = 983,2 \text{ kg/m}^3$ R = pressure gradient (mbar/m)
 Temperature: $t = 60^\circ\text{C}$ v = flow speed (m/s)
 Kinematic viscosity: $\nu = 0,47 \times 10^{-6} \text{ m}^2/\text{s}$

$d \times s$		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
$\dot{V}$	d_i	14,4 mm	18,0 mm	23,2 mm	29,0 mm	36,2 mm	45,8 mm	54,4 mm	65,4 mm	79,8 mm	90,8 mm
1,20	R	-	115,39	32,44	10,63	3,51	1,14	0,51	0,20	0,08	-
	v	-	4,72	2,84	1,82	1,17	0,73	0,52	0,36	0,24	-
1,40	R	-	-	41,83	13,71	4,77	1,47	0,66	0,27	0,10	0,06
	v	-	-	3,31	2,12	1,36	0,85	0,60	0,42	0,28	0,22
1,60	R	-	-	54,64	17,90	5,91	1,92	0,81	0,34	0,13	0,07
	v	-	-	3,78	2,42	1,55	0,97	0,69	0,48	0,32	0,25
1,80	R	-	-	69,15	22,66	7,48	2,43	1,03	0,43	0,16	0,09
	v	-	-	4,26	2,73	1,75	1,09	0,77	0,54	0,36	0,28
2,00	R	-	-	85,37	27,98	9,23	2,85	1,27	0,51	0,20	0,10
	v	-	-	4,73	3,03	1,94	1,21	0,86	0,60	0,40	0,31
2,20	R	-	-	-	31,97	11,17	3,45	1,46	0,61	0,23	0,12
	v	-	-	-	3,33	2,14	1,34	0,95	0,65	0,44	0,34
2,40	R	-	-	-	38,05	12,55	4,10	1,73	0,73	0,27	0,15
	v	-	-	-	3,63	2,33	1,46	1,03	0,71	0,48	0,37
2,60	R	-	-	-	44,65	14,73	4,54	2,04	0,81	0,32	0,17
	v	-	-	-	3,94	2,53	1,58	1,12	0,77	0,52	0,40
2,80	R	-	-	-	51,79	17,09	5,27	2,36	0,94	0,37	0,19
	v	-	-	-	4,24	2,72	1,70	1,20	0,83	0,56	0,43
3,00	R	-	-	-	59,45	19,61	6,05	2,56	1,08	0,40	0,22
	v	-	-	-	4,54	2,91	1,82	1,29	0,89	0,60	0,46
3,20	R	-	-	-	67,64	22,32	6,88	2,91	1,23	0,45	0,25
	v	-	-	-	4,84	3,11	1,94	1,38	0,95	0,64	0,49
3,40	R	-	-	-	-	25,19	7,77	3,29	1,31	0,51	0,27
	v	-	-	-	-	3,30	2,06	1,46	1,01	0,68	0,53
3,60	R	-	-	-	-	26,58	8,71	3,69	1,47	0,57	0,30
	v	-	-	-	-	3,50	2,19	1,55	1,07	0,72	0,56
3,80	R	-	-	-	-	29,62	9,71	4,11	1,64	0,64	0,34
	v	-	-	-	-	3,69	2,31	1,63	1,13	0,76	0,59
4,00	R	-	-	-	-	32,82	10,12	4,55	1,81	0,67	0,37
	v	-	-	-	-	3,89	2,43	1,72	1,19	0,80	0,62
4,20	R	-	-	-	-	36,18	11,16	5,02	2,00	0,74	0,41
	v	-	-	-	-	4,08	2,55	1,81	1,25	0,84	0,65
4,40	R	-	-	-	-	39,71	12,25	5,18	2,19	0,81	0,42
	v	-	-	-	-	4,28	2,67	1,89	1,31	0,88	0,68
4,60	R	-	-	-	-	43,40	13,39	5,66	2,40	0,89	0,46
	v	-	-	-	-	4,47	2,79	1,98	1,37	0,92	0,71
4,80	R	-	-	-	-	47,26	14,58	6,17	2,46	0,96	0,51
	v	-	-	-	-	4,66	2,91	2,07	1,43	0,96	0,74
5,00	R	-	-	-	-	51,28	15,82	6,69	2,66	1,05	0,55
	v	-	-	-	-	4,86	3,03	2,15	1,49	1,00	0,77
5,20	R	-	-	-	-	-	17,11	7,24	2,88	1,13	0,59
	v	-	-	-	-	-	3,16	2,24	1,55	1,04	0,80
5,40	R	-	-	-	-	-	18,45	7,80	3,11	1,22	0,64
	v	-	-	-	-	-	3,28	2,32	1,61	1,08	0,83
5,60	R	-	-	-	-	-	19,84	8,39	3,34	1,24	0,69
	v	-	-	-	-	-	3,40	2,41	1,67	1,12	0,86

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 flow rate $\dot{V}$.

Pipe roughness: $K = 0,007 \text{ mm}$ $\dot{V} = \text{flow rate (l/s)}$

Density: $\rho = 983,2 \text{ kg/m}^3$ $R = \text{pressure gradient (mbar/m)}$

Temperature: $t = 60^\circ\text{C}$ $v = \text{flow speed (m/s)}$

Kinematic viscosity: $\nu = 0,47 \times 10^{-6} \text{ m}^2/\text{s}$

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

Appendix B

Appendix B8-13

Pipe friction gradient/flow speed of Wefatherm pipes SDR 9

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

Pipe roughness: $K = 0,007 \text{ mm}$ $\dot{V}$ = flow rate (l/s)
 Density: $\rho = 998,2 \text{ kg/m}^3$ R = pressure gradient (mbar/m)
 Temperature: $t = 20^\circ\text{C}$ v = flow speed (m/s)
 Kinematic viscosity: $\nu = 1,003 \times 10^{-6} \text{ m}^2/\text{s}$

$d \times s$		20 x 2,3	25 x 2,8	32 x 3,6	40 x 4,5	50 x 5,6	63 x 7,1	75 x 8,4	90 x 10,1	110 x 12,3	125 x 14,0
$\dot{V}$	d_i	15,4 mm	19,4 mm	24,8 mm	31,0 mm	38,8 mm	48,8 mm	58,2 mm	69,8 mm	85,4 mm	97,0 mm
0,01	R	0,07	-	-	-	-	-	-	-	-	-
	v	0,05	-	-	-	-	-	-	-	-	-
0,02	R	0,21	-	-	-	-	-	-	-	-	-
	v	0,11	-	-	-	-	-	-	-	-	-
0,03	R	0,40	-	-	-	-	-	-	-	-	-
	v	0,16	-	-	-	-	-	-	-	-	-
0,04	R	0,66	-	-	-	-	-	-	-	-	-
	v	0,21	-	-	-	-	-	-	-	-	-
0,05	R	0,96	-	-	-	-	-	-	-	-	-
	v	0,27	0,17	-	-	-	-	-	-	-	-
0,06	R	1,31	0,43	-	-	-	-	-	-	-	-
	v	0,32	0,20	-	-	-	-	-	-	-	-
0,07	R	1,69	0,56	-	-	-	-	-	-	-	-
	v	0,38	0,24	-	-	-	-	-	-	-	-
0,08	R	2,15	0,72	-	-	-	-	-	-	-	-
	v	0,43	0,27	-	-	-	-	-	-	-	-
0,09	R	2,57	0,88	-	-	-	-	-	-	-	-
	v	0,48	0,30	-	-	-	-	-	-	-	-
0,10	R	3,08	1,03	0,33	-	-	-	-	-	-	-
	v	0,54	0,34	0,21	-	-	-	-	-	-	-
0,12	R	4,30	1,44	0,45	-	-	-	-	-	-	-
	v	0,64	0,41	0,25	-	-	-	-	-	-	-
0,14	R	5,68	1,85	0,57	-	-	-	-	-	-	-
	v	0,75	0,47	0,29	-	-	-	-	-	-	-
0,16	R	7,17	2,34	0,73	0,25	-	-	-	-	-	-
	v	0,86	0,54	0,33	0,21	-	-	-	-	-	-
0,18	R	8,78	2,86	0,89	0,31	-	-	-	-	-	-
	v	0,97	0,61	0,37	0,24	-	-	-	-	-	-
0,20	R	10,46	3,53	1,07	0,37	-	-	-	-	-	-
	v	1,07	0,68	0,41	0,26	-	-	-	-	-	-
0,30	R	21,86	7,15	2,17	0,76	0,26	-	-	-	-	-
	v	1,61	1,01	0,62	0,40	0,25	-	-	-	-	-
0,40	R	35,87	11,78	3,59	1,27	0,43	0,15	-	-	-	-
	v	2,15	1,35	0,83	0,53	0,34	0,21	-	-	-	-
0,50	R	53,71	17,67	5,39	1,84	0,64	0,21	-	-	-	-
	v	2,68	1,69	1,04	0,66	0,42	0,27	-	-	-	-
0,60	R	77,35	24,38	7,45	2,54	0,86	0,29	0,13	-	-	-
	v	3,22	2,03	1,24	0,79	0,51	0,32	0,23	-	-	-
0,70	R	100,70	31,74	9,72	3,32	1,13	0,39	0,17	-	-	-
	v	3,76	2,37	1,45	0,93	0,59	0,37	0,26	-	-	-
0,80	R	125,55	41,46	12,70	4,34	1,47	0,49	0,21	0,09	-	-
	v	4,29	2,71	1,66	1,06	0,68	0,43	0,30	0,21	-	-
0,90	R	158,89	52,47	15,37	5,27	1,79	0,59	0,26	0,11	-	-
	v	4,83	3,04	1,86	1,19	0,76	0,48	0,34	0,24	-	-
1,00	R	-	61,83	18,97	6,50	2,12	0,73	0,32	0,13	-	-
	v	-	3,38	2,07	1,32	0,85	0,53	0,38	0,26	-	-

Appendix B8-14

Pipe friction gradient/flow speed of Wefatherm pipes SDR 9

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

Pipe roughness: $K = 0,007 \text{ mm}$ $\dot{V} = \text{flow rate (l/s)}$

Density: $\rho = 998,2 \text{ kg/m}^3$ $R = \text{pressure gradient (mbar/m)}$

Temperature: $t = 20^\circ\text{C}$ $v = \text{flow speed (m/s)}$

Kinematic viscosity: $\nu = 1,003 \times 10^{-6} \text{ m}^2/\text{s}$

d x s		20 x 2,3	25 x 2,8	32 x 3,6	40 x 4,5	50 x 5,6	63 x 7,1	75 x 8,4	90 x 10,1	110 x 12,3	125 x 14,0
$\dot{V}$	d_i	15,4 mm	19,4 mm	24,8 mm	31,0 mm	38,8 mm	48,8 mm	58,2 mm	69,8 mm	85,4 mm	97,0 mm
1,20	R	-	89,04	26,08	8,95	3,05	1,01	0,42	0,18	-	-
	v	-	4,06	2,48	1,59	1,01	0,64	0,45	0,31	-	-
1,40	R	-	115,42	33,81	11,63	3,97	1,32	0,57	0,24	0,09	-
	v	-	4,74	2,90	1,85	1,18	0,75	0,53	0,37	0,24	-
1,60	R	-	-	44,16	15,19	4,95	1,65	0,71	0,30	0,11	0,06
	v	-	-	3,31	2,12	1,35	0,86	0,60	0,42	0,28	0,22
1,80	R	-	-	55,89	18,31	6,26	2,08	0,86	0,36	0,14	0,08
	v	-	-	3,73	2,38	1,52	0,96	0,68	0,47	0,31	0,24
2,00	R	-	-	65,55	22,61	7,36	2,46	1,07	0,45	0,17	0,09
	v	-	-	4,14	2,65	1,69	1,07	0,75	0,52	0,35	0,27
2,20	R	-	-	79,31	25,99	8,91	2,97	1,23	0,52	0,20	0,11
	v	-	-	4,55	2,91	1,86	1,18	0,83	0,57	0,38	0,30
2,40	R	-	-	-	30,93	10,60	3,37	1,47	0,62	0,24	0,12
	v	-	-	-	3,18	2,03	1,28	0,90	0,63	0,42	0,32
2,60	R	-	-	-	36,30	11,82	3,95	1,72	0,69	0,26	0,15
	v	-	-	-	3,44	2,20	1,39	0,98	0,68	0,45	0,35
2,80	R	-	-	-	42,10	13,71	4,58	1,90	0,80	0,31	0,17
	v	-	-	-	3,71	2,37	1,50	1,05	0,73	0,49	0,38
3,00	R	-	-	-	48,33	15,73	5,26	2,18	0,92	0,35	0,19
	v	-	-	-	3,97	2,54	1,60	1,13	0,78	0,52	0,41
3,20	R	-	-	-	52,09	17,90	5,69	2,48	1,05	0,38	0,21
	v	-	-	-	4,24	2,71	1,71	1,20	0,84	0,56	0,43
3,40	R	-	-	-	58,81	20,21	6,42	2,80	1,13	0,43	0,24
	v	-	-	-	4,50	2,88	1,82	1,28	0,89	0,59	0,46
3,60	R	-	-	-	65,93	21,46	7,20	2,98	1,27	0,48	0,26
	v	-	-	-	4,77	3,04	1,92	1,35	0,94	0,63	0,49
3,80	R	-	-	-	-	23,92	8,02	3,32	1,41	0,54	0,29
	v	-	-	-	-	3,21	2,03	1,43	0,99	0,66	0,51
4,00	R	-	-	-	-	26,50	8,89	3,68	1,56	0,57	0,32
	v	-	-	-	-	3,38	2,14	1,50	1,05	0,70	0,54
4,20	R	-	-	-	-	29,22	9,28	4,06	1,64	0,63	0,35
	v	-	-	-	-	3,55	2,25	1,58	1,10	0,73	0,57
4,40	R	-	-	-	-	32,06	10,19	4,46	1,80	0,69	0,36
	v	-	-	-	-	3,72	2,35	1,65	1,15	0,77	0,60
4,60	R	-	-	-	-	35,05	11,14	4,87	1,96	0,75	0,40
	v	-	-	-	-	3,89	2,46	1,73	1,20	0,80	0,62
4,80	R	-	-	-	-	38,16	12,12	5,03	2,14	0,82	0,43
	v	-	-	-	-	4,06	2,57	1,80	1,25	0,84	0,65
5,00	R	-	-	-	-	39,11	13,16	5,45	2,32	0,85	0,47
	v	-	-	-	-	4,23	2,67	1,88	1,31	0,87	0,68
5,20	R	-	-	-	-	42,30	14,23	5,90	2,51	0,92	0,51
	v	-	-	-	-	4,40	2,78	1,95	1,36	0,91	0,70
5,40	R	-	-	-	-	45,61	15,35	6,36	2,71	0,99	0,55
	v	-	-	-	-	4,57	2,89	2,03	1,41	0,94	0,73
5,60	R	-	-	-	-	49,05	16,50	6,84	2,76	1,06	0,56
	v	-	-	-	-	4,74	2,99	2,11	1,46	0,98	0,76

Appendix B

Appendix B8-15

Pipe friction gradient/flow speed of Wefatherm pipes SDR 9

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

Pipe roughness: $K = 0,007 \text{ mm}$ $\dot{V}$ = flow rate (l/s)
 Density: $\rho = 998,2 \text{ kg/m}^3$ R = pressure gradient (mbar/m)
 Temperature: $t = 20^\circ\text{C}$ v = flow speed (m/s)
 Kinematic viscosity: $\nu = 1,003 \times 10^{-6} \text{ m}^2/\text{s}$

$d \times s$		20 x 2,3	25 x 2,8	32 x 3,6	40 x 4,5	50 x 5,6	63 x 7,1	75 x 8,4	90 x 10,1	110 x 12,3	125 x 14,0
$\dot{V}$	d_i	15,4 mm	19,4 mm	24,8 mm	31,0 mm	38,8 mm	48,8 mm	58,2 mm	69,8 mm	85,4 mm	97,0 mm
5,80	R	-	-	-	-	-	16,72	7,34	2,96	1,14	0,60
	v	-	-	-	-	-	3,10	2,18	1,52	1,01	0,78
6,00	R	-	-	-	-	-	17,89	7,85	3,16	1,22	0,64
	v	-	-	-	-	-	3,21	2,26	1,57	1,05	0,81
6,20	R	-	-	-	-	-	19,10	8,38	3,38	1,30	0,69
	v	-	-	-	-	-	3,31	2,33	1,62	1,08	0,84
6,40	R	-	-	-	-	-	20,36	8,93	3,60	1,39	0,73
	v	-	-	-	-	-	3,42	2,41	1,67	1,12	0,87
6,60	R	-	-	-	-	-	21,65	8,97	3,83	1,40	0,78
	v	-	-	-	-	-	3,53	2,48	1,72	1,15	0,89
6,80	R	-	-	-	-	-	22,98	9,52	4,06	1,48	0,83
	v	-	-	-	-	-	3,64	2,56	1,78	1,19	0,92
7,00	R	-	-	-	-	-	24,35	10,09	4,31	1,57	0,88
	v	-	-	-	-	-	3,74	2,63	1,83	1,22	0,95
7,20	R	-	-	-	-	-	25,76	10,68	4,56	1,66	0,93
	v	-	-	-	-	-	3,85	2,71	1,88	1,26	0,97
7,40	R	-	-	-	-	-	27,22	11,28	4,55	1,76	0,93
	v	-	-	-	-	-	3,96	2,78	1,93	1,29	1,00
7,60	R	-	-	-	-	-	28,71	11,90	4,80	1,85	0,98
	v	-	-	-	-	-	4,06	2,86	1,99	1,33	1,03
7,80	R	-	-	-	-	-	30,24	12,53	5,05	1,95	1,03
	v	-	-	-	-	-	4,17	2,93	2,04	1,36	1,06
8,00	R	-	-	-	-	-	31,81	13,18	5,31	2,05	1,09
	v	-	-	-	-	-	4,28	3,01	2,09	1,40	1,08
8,20	R	-	-	-	-	-	33,42	13,85	5,58	2,16	1,14
	v	-	-	-	-	-	4,38	3,08	2,14	1,43	1,11
8,40	R	-	-	-	-	-	35,07	14,53	5,86	2,26	1,20
	v	-	-	-	-	-	4,49	3,16	2,20	1,47	1,14
8,60	R	-	-	-	-	-	34,60	15,23	6,14	2,37	1,25
	v	-	-	-	-	-	4,60	3,23	2,25	1,50	1,16
8,80	R	-	-	-	-	-	36,22	15,95	6,43	2,34	1,31
	v	-	-	-	-	-	4,70	3,31	2,30	1,54	1,19
9,00	R	-	-	-	-	-	-	16,69	6,72	2,45	1,37
	v	-	-	-	-	-	-	3,38	2,35	1,57	1,22
9,20	R	-	-	-	-	-	-	17,43	7,03	2,56	1,44
	v	-	-	-	-	-	-	3,46	2,40	1,61	1,24
9,40	R	-	-	-	-	-	-	17,13	7,34	2,68	1,50
	v	-	-	-	-	-	-	3,53	2,46	1,64	1,27
9,60	R	-	-	-	-	-	-	17,87	7,65	2,79	1,56
	v	-	-	-	-	-	-	3,61	2,51	1,68	1,30
9,80	R	-	-	-	-	-	-	18,62	7,97	2,91	1,54
	v	-	-	-	-	-	-	3,68	2,56	1,71	1,33
10,00	R	-	-	-	-	-	-	19,39	8,30	3,03	1,60
	v	-	-	-	-	-	-	3,76	2,61	1,75	1,35

Appendix B8-16

Pipe friction gradient/flow speed of Wefatherm pipes SDR 9

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

Pipe roughness: $K = 0,007 \text{ mm}$ $\dot{V}$ = flow rate (l/s)

Density: $\rho = 983,3 \text{ kg/m}^3$ R = pressure gradient (mbar/m)

Temperature: $t = 60^\circ\text{C}$ v = flow speed (m/s)

Kinematic viscosity: $\nu = 0,478 \times 10^{-6} \text{ m}^2/\text{s}$

d x s		20 x 2,3	25 x 2,8	32 x 3,6	40 x 4,5	50 x 5,6	63 x 7,1	75 x 8,4	90 x 10,1	110 x 12,3	125 x 14,0
$\dot{V}$	d_i	15,4 mm	19,4 mm	24,8 mm	31,0 mm	38,8 mm	48,8 mm	58,2 mm	69,8 mm	85,4 mm	97,0 mm
0,01	R	0,05	-	-	-	-	-	-	-	-	-
	v	0,05	-	-	-	-	-	-	-	-	-
0,02	R	0,16	-	-	-	-	-	-	-	-	-
	v	0,11	-	-	-	-	-	-	-	-	-
0,03	R	0,31	-	-	-	-	-	-	-	-	-
	v	0,16	-	-	-	-	-	-	-	-	-
0,04	R	0,52	-	-	-	-	-	-	-	-	-
	v	0,21	-	-	-	-	-	-	-	-	-
0,05	R	0,76	-	-	-	-	-	-	-	-	-
	v	0,27	0,17	-	-	-	-	-	-	-	-
0,06	R	1,03	0,34	-	-	-	-	-	-	-	-
	v	0,32	0,20	-	-	-	-	-	-	-	-
0,07	R	1,35	0,45	-	-	-	-	-	-	-	-
	v	0,38	0,24	-	-	-	-	-	-	-	-
0,08	R	1,71	0,58	-	-	-	-	-	-	-	-
	v	0,43	0,27	-	-	-	-	-	-	-	-
0,09	R	2,09	0,70	-	-	-	-	-	-	-	-
	v	0,48	0,30	-	-	-	-	-	-	-	-
0,10	R	2,58	0,84	0,26	-	-	-	-	-	-	-
	v	0,54	0,34	0,21	-	-	-	-	-	-	-
0,12	R	3,58	1,17	0,35	-	-	-	-	-	-	-
	v	0,64	0,41	0,25	-	-	-	-	-	-	-
0,14	R	4,69	1,53	0,47	-	-	-	-	-	-	-
	v	0,75	0,47	0,29	-	-	-	-	-	-	-
0,16	R	5,89	1,93	0,59	0,21	-	-	-	-	-	-
	v	0,86	0,54	0,33	0,21	-	-	-	-	-	-
0,18	R	7,15	2,35	0,74	0,25	-	-	-	-	-	-
	v	0,97	0,61	0,37	0,24	-	-	-	-	-	-
0,20	R	8,83	2,90	0,88	0,30	-	-	-	-	-	-
	v	1,07	0,68	0,41	0,26	-	-	-	-	-	-
0,30	R	18,22	6,00	1,83	0,63	0,21	-	-	-	-	-
	v	1,61	1,01	0,62	0,40	0,25	-	-	-	-	-
0,40	R	30,91	10,21	2,99	1,02	0,35	0,12	-	-	-	-
	v	2,15	1,35	0,83	0,53	0,34	0,21	-	-	-	-
0,50	R	48,30	15,23	4,67	1,53	0,52	0,17	-	-	-	-
	v	2,68	1,69	1,04	0,66	0,42	0,27	-	-	-	-
0,60	R	66,25	20,88	6,42	2,10	0,72	0,24	0,10	-	-	-
	v	3,22	2,03	1,24	0,79	0,51	0,32	0,23	-	-	-
0,70	R	90,17	28,42	8,33	2,86	0,98	0,32	0,13	-	-	-
	v	3,76	2,37	1,45	0,93	0,59	0,37	0,26	-	-	-
0,80	R	111,88	37,12	10,87	3,56	1,22	0,41	0,18	0,07	-	-
	v	4,29	2,71	1,66	1,06	0,68	0,43	0,30	0,21	-	-
0,90	R	141,60	44,63	13,07	4,51	1,54	0,49	0,21	0,09	-	-
	v	4,83	3,04	1,86	1,19	0,76	0,48	0,34	0,24	-	-
1,00	R	-	55,10	16,14	5,57	1,81	0,60	0,26	0,11	-	-
	v	-	3,38	2,07	1,32	0,85	0,53	0,38	0,26	-	-

Appendix B

Appendix B8-17

Pipe friction gradient/flow speed of Wefatherm pipes SDR 9

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

Pipe roughness: $K = 0,007 \text{ mm}$ $\dot{V}$ = flow rate (l/s)
 Density: $\rho = 983,3 \text{ kg/m}^3$ R = pressure gradient (mbar/m)
 Temperature: $t = 60^\circ\text{C}$ v = flow speed (m/s)
 Kinematic viscosity: $\nu = 0,478 \times 10^{-6} \text{ m}^2/\text{s}$

$d \times s$		20 x 2,3	25 x 2,8	32 x 3,6	40 x 4,5	50 x 5,6	63 x 7,1	75 x 8,4	90 x 10,1	110 x 12,3	125 x 14,0
$\dot{V}$	d_i	15,4 mm	19,4 mm	24,8 mm	31,0 mm	38,8 mm	48,8 mm	58,2 mm	69,8 mm	85,4 mm	97,0 mm
1,20	R	-	79,35	23,24	7,62	2,61	0,83	0,36	0,15	-	-
	v	-	4,06	2,48	1,59	1,01	0,64	0,45	0,31	-	-
1,40	R	-	102,32	29,97	10,37	3,38	1,13	0,47	0,20	0,08	-
	v	-	4,74	2,90	1,85	1,18	0,75	0,53	0,37	0,24	-
1,60	R	-	-	39,15	12,83	4,41	1,40	0,61	0,25	0,09	0,05
	v	-	-	3,31	2,12	1,35	0,86	0,60	0,42	0,28	0,22
1,80	R	-	-	49,54	16,23	5,29	1,77	0,73	0,31	0,12	0,06
	v	-	-	3,73	2,38	1,52	0,96	0,68	0,47	0,31	0,24
2,00	R	-	-	61,17	20,04	6,53	2,07	0,91	0,37	0,14	0,08
	v	-	-	4,14	2,65	1,69	1,07	0,75	0,52	0,35	0,27
2,20	R	-	-	69,90	22,90	7,90	2,51	1,10	0,44	0,17	0,09
	v	-	-	4,55	2,91	1,86	1,18	0,83	0,57	0,38	0,30
2,40	R	-	-	-	27,26	8,87	2,99	1,24	0,53	0,19	0,11
	v	-	-	-	3,18	2,03	1,28	0,90	0,63	0,42	0,32
2,60	R	-	-	-	31,99	10,42	3,50	1,45	0,59	0,23	0,13
	v	-	-	-	3,44	2,20	1,39	0,98	0,68	0,45	0,35
2,80	R	-	-	-	37,10	12,08	3,84	1,68	0,68	0,26	0,14
	v	-	-	-	3,71	2,37	1,50	1,05	0,73	0,49	0,38
3,00	R	-	-	-	42,59	13,87	4,41	1,93	0,78	0,30	0,16
	v	-	-	-	3,97	2,54	1,60	1,13	0,78	0,52	0,41
3,20	R	-	-	-	48,46	15,78	5,01	2,08	0,89	0,32	0,18
	v	-	-	-	4,24	2,71	1,71	1,20	0,84	0,56	0,43
3,40	R	-	-	-	54,71	17,81	5,66	2,35	1,00	0,37	0,20
	v	-	-	-	4,50	2,88	1,82	1,28	0,89	0,59	0,46
3,60	R	-	-	-	57,72	19,97	6,34	2,63	1,06	0,41	0,22
	v	-	-	-	4,77	3,04	1,92	1,35	0,94	0,63	0,49
3,80	R	-	-	-	-	20,94	7,07	2,93	1,18	0,46	0,24
	v	-	-	-	-	3,21	2,03	1,43	0,99	0,66	0,51
4,00	R	-	-	-	-	23,20	7,37	3,25	1,31	0,51	0,27
	v	-	-	-	-	3,38	2,14	1,50	1,05	0,70	0,54
4,20	R	-	-	-	-	25,58	8,13	3,58	1,44	0,53	0,29
	v	-	-	-	-	3,55	2,25	1,58	1,10	0,73	0,57
4,40	R	-	-	-	-	28,07	8,92	3,93	1,58	0,58	0,32
	v	-	-	-	-	3,72	2,35	1,65	1,15	0,77	0,60
4,60	R	-	-	-	-	30,68	9,75	4,04	1,73	0,63	0,33
	v	-	-	-	-	3,89	2,46	1,73	1,20	0,80	0,62
4,80	R	-	-	-	-	33,41	10,62	4,40	1,88	0,69	0,36
	v	-	-	-	-	4,06	2,57	1,80	1,25	0,84	0,65
5,00	R	-	-	-	-	36,25	11,52	4,77	1,92	0,75	0,39
	v	-	-	-	-	4,23	2,67	1,88	1,31	0,87	0,68
5,20	R	-	-	-	-	39,21	12,46	5,16	2,08	0,81	0,43
	v	-	-	-	-	4,40	2,78	1,95	1,36	0,91	0,70
5,40	R	-	-	-	-	42,28	13,44	5,57	2,24	0,87	0,46
	v	-	-	-	-	4,57	2,89	2,03	1,41	0,94	0,73
5,60	R	-	-	-	-	45,47	14,45	5,99	2,41	0,94	0,49
	v	-	-	-	-	4,74	2,99	2,11	1,46	0,98	0,76

Appendix B8-18

Pipe friction gradient/flow speed of Wefatherm pipes SDR 9

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

Pipe roughness: $K = 0,007 \text{ mm}$ $\dot{V}$ = flow rate (l/s)

Density: $\rho = 983,3 \text{ kg/m}^3$ R = pressure gradient (mbar/m)

Temperature: $t = 60^\circ\text{C}$ v = flow speed (m/s)

Kinematic viscosity: $\nu = 0,478 \times 10^{-6} \text{ m}^2/\text{s}$

d x s		20 x 2,3	25 x 2,8	32 x 3,6	40 x 4,5	50 x 5,6	63 x 7,1	75 x 8,4	90 x 10,1	110 x 12,3	125 x 14,0
$\dot{V}$	d_i	15,4 mm	19,4 mm	24,8 mm	31,0 mm	38,8 mm	48,8 mm	58,2 mm	69,8 mm	85,4 mm	97,0 mm
5,80	R	-	-	-	-	-	15,50	6,42	2,59	0,94	0,53
	v	-	-	-	-	-	3,10	2,18	1,52	1,01	0,78
6,00	R	-	-	-	-	-	16,59	6,87	2,77	1,01	0,57
	v	-	-	-	-	-	3,21	2,26	1,57	1,05	0,81
6,20	R	-	-	-	-	-	17,71	7,34	2,96	1,08	0,61
	v	-	-	-	-	-	3,31	2,33	1,62	1,08	0,84
6,40	R	-	-	-	-	-	18,87	7,82	3,15	1,15	0,61
	v	-	-	-	-	-	3,42	2,41	1,67	1,12	0,87
6,60	R	-	-	-	-	-	18,82	8,32	3,35	1,22	0,65
	v	-	-	-	-	-	3,53	2,48	1,72	1,15	0,89
6,80	R	-	-	-	-	-	19,97	8,83	3,56	1,30	0,69
	v	-	-	-	-	-	3,64	2,56	1,78	1,19	0,92
7,00	R	-	-	-	-	-	21,17	8,77	3,77	1,38	0,73
	v	-	-	-	-	-	3,74	2,63	1,83	1,22	0,95
7,20	R	-	-	-	-	-	22,39	9,28	3,99	1,46	0,77
	v	-	-	-	-	-	3,85	2,71	1,88	1,26	0,97
7,40	R	-	-	-	-	-	23,65	9,80	4,21	1,54	0,81
	v	-	-	-	-	-	3,96	2,78	1,93	1,29	1,00
7,60	R	-	-	-	-	-	24,95	10,34	4,17	1,62	0,86
	v	-	-	-	-	-	4,06	2,86	1,99	1,33	1,03
7,80	R	-	-	-	-	-	26,28	10,89	4,39	1,71	0,90
	v	-	-	-	-	-	4,17	2,93	2,04	1,36	1,06
8,00	R	-	-	-	-	-	27,64	11,46	4,62	1,80	0,95
	v	-	-	-	-	-	4,28	3,01	2,09	1,40	1,08
8,20	R	-	-	-	-	-	29,04	12,04	4,85	1,89	1,00
	v	-	-	-	-	-	4,38	3,08	2,14	1,43	1,11
8,40	R	-	-	-	-	-	30,48	12,63	5,09	1,98	1,05
	v	-	-	-	-	-	4,49	3,16	2,20	1,47	1,14
8,60	R	-	-	-	-	-	31,95	13,24	5,34	1,95	1,10
	v	-	-	-	-	-	4,60	3,23	2,25	1,50	1,16
8,80	R	-	-	-	-	-	33,45	13,86	5,59	2,04	1,15
	v	-	-	-	-	-	4,70	3,31	2,30	1,54	1,19
9,00	R	-	-	-	-	-	-	14,50	5,84	2,13	1,20
	v	-	-	-	-	-	-	3,38	2,35	1,57	1,22
9,20	R	-	-	-	-	-	-	15,15	6,11	2,23	1,26
	v	-	-	-	-	-	-	3,46	2,40	1,61	1,24
9,40	R	-	-	-	-	-	-	15,82	6,38	2,33	1,23
	v	-	-	-	-	-	-	3,53	2,46	1,64	1,27
9,60	R	-	-	-	-	-	-	16,50	6,65	2,43	1,28
	v	-	-	-	-	-	-	3,61	2,51	1,68	1,30
9,80	R	-	-	-	-	-	-	17,19	6,93	2,53	1,34
	v	-	-	-	-	-	-	3,68	2,56	1,71	1,33
10,00	R	-	-	-	-	-	-	17,90	7,22	2,63	1,39
	v	-	-	-	-	-	-	3,76	2,61	1,75	1,35

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 flow rate $\dot{V}$.

Pipe roughness: $K = 0,007 \text{ mm}$ $\dot{V}$ = flow rate (l/s)
 Density: $\rho = 998,2 \text{ kg/m}^3$ R = pressure gradient (mbar/m)
 Temperature: $t = 20^\circ\text{C}$ v = flow speed (m/s)
 Kinematic viscosity: $\nu = 1,003 \times 10^{-6} \text{ m}^2/\text{s}$

$d \times s$		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
0,01	R	0,05	0,02	-	-	-	-	-	-	-	-
	v	0,05	0,03	-	-	-	-	-	-	-	-
0,02	R	0,16	0,06	-	-	-	-	-	-	-	-
	v	0,10	0,06	-	-	-	-	-	-	-	-
0,03	R	0,32	0,11	-	-	-	-	-	-	-	-
	v	0,15	0,09	-	-	-	-	-	-	-	-
0,04	R	0,51	0,18	-	-	-	-	-	-	-	-
	v	0,19	0,12	-	-	-	-	-	-	-	-
0,05	R	0,74	0,25	-	-	-	-	-	-	-	-
	v	0,24	0,15	-	-	-	-	-	-	-	-
0,06	R	1,02	0,35	-	-	-	-	-	-	-	-
	v	0,29	0,18	-	-	-	-	-	-	-	-
0,07	R	1,31	0,45	-	-	-	-	-	-	-	-
	v	0,34	0,21	-	-	-	-	-	-	-	-
0,08	R	1,67	0,56	-	-	-	-	-	-	-	-
	v	0,39	0,24	-	-	-	-	-	-	-	-
0,09	R	2,06	0,69	-	-	-	-	-	-	-	-
	v	0,44	0,28	-	-	-	-	-	-	-	-
0,10	R	2,47	0,82	-	-	-	-	-	-	-	-
	v	0,49	0,31	-	-	-	-	-	-	-	-
0,12	R	3,34	1,12	0,35	-	-	-	-	-	-	-
	v	0,58	0,37	0,22	-	-	-	-	-	-	-
0,14	R	4,41	1,48	0,45	-	-	-	-	-	-	-
	v	0,68	0,43	0,26	-	-	-	-	-	-	-
0,16	R	5,57	1,88	0,57	-	-	-	-	-	-	-
	v	0,78	0,49	0,30	-	-	-	-	-	-	-
0,18	R	6,81	2,30	0,70	0,25	-	-	-	-	-	-
	v	0,87	0,55	0,33	0,22	-	-	-	-	-	-
0,20	R	8,12	2,75	0,84	0,30	-	-	-	-	-	-
	v	0,97	0,61	0,37	0,24	-	-	-	-	-	-
0,30	R	16,97	5,56	1,71	0,59	0,21	-	-	-	-	-
	v	1,46	0,92	0,56	0,36	0,23	-	-	-	-	-
0,40	R	27,85	9,16	2,83	0,98	0,34	-	-	-	-	-
	v	1,94	1,22	0,74	0,48	0,31	-	-	-	-	-
0,50	R	41,70	13,74	4,10	1,48	0,50	0,17	-	-	-	-
	v	2,43	1,53	0,93	0,60	0,38	0,24	-	-	-	-
0,60	R	60,04	18,96	5,66	1,98	0,70	0,23	0,10	-	-	-
	v	2,91	1,84	1,11	0,72	0,46	0,29	0,20	-	-	-
0,70	R	78,17	25,81	7,71	2,69	0,91	0,30	0,13	-	-	-
	v	3,40	2,14	1,30	0,84	0,54	0,34	0,24	-	-	-
0,80	R	102,10	32,24	9,65	3,38	1,15	0,38	0,16	-	-	-
	v	3,88	2,45	1,48	0,96	0,61	0,39	0,27	-	-	-
0,90	R	123,35	40,81	11,68	4,09	1,39	0,47	0,20	0,08	-	-
	v	4,37	2,75	1,67	1,08	0,69	0,43	0,30	0,21	-	-
1,00	R	152,28	48,09	14,42	5,05	1,72	0,56	0,24	0,10	-	-
	v	4,85	3,06	1,85	1,20	0,76	0,48	0,34	0,24	-	-

Appendix B8-20
Pipe friction gradient/flow speed of Wefatherm pipes SDR 11

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

Pipe roughness: $K = 0,007 \text{ mm}$ $\dot{V}$ = flow rate (l/s)

Density: $\rho = 998,2 \text{ kg/m}^3$ R = pressure gradient (mbar/m)

Temperature: $t = 20^\circ\text{C}$ v = flow speed (m/s)

Kinematic viscosity: $\nu = 1,003 \times 10^{-6} \text{ m}^2/\text{s}$

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
1,20	R	-	69,25	19,82	6,96	2,37	0,78	0,33	0,14	-	-
	v	-	3,67	2,23	1,44	0,92	0,58	0,41	0,28	-	-
1,40	R	-	89,77	26,98	9,04	3,09	1,02	0,44	0,18	0,07	-
	v	-	4,28	2,60	1,68	1,07	0,67	0,47	0,33	0,22	-
1,60	R	-	117,25	33,56	11,81	3,85	1,27	0,55	0,23	0,09	0,05
	v	-	4,90	2,97	1,92	1,22	0,77	0,54	0,38	0,25	0,20
1,80	R	-	-	42,47	14,24	4,87	1,61	0,69	0,28	0,11	0,06
	v	-	-	3,34	2,16	1,38	0,87	0,61	0,42	0,28	0,22
2,00	R	-	-	49,81	17,58	6,01	1,89	0,82	0,34	0,13	0,07
	v	-	-	3,71	2,40	1,53	0,96	0,68	0,47	0,31	0,24
2,20	R	-	-	60,27	21,27	6,93	2,29	0,99	0,40	0,15	0,08
	v	-	-	4,08	2,64	1,68	1,06	0,74	0,52	0,35	0,27
2,40	R	-	-	71,73	24,05	8,24	2,73	1,12	0,47	0,18	0,10
	v	-	-	4,45	2,88	1,84	1,16	0,81	0,56	0,38	0,29
2,60	R	-	-	84,18	28,22	9,68	3,05	1,32	0,56	0,21	0,11
	v	-	-	4,82	3,11	1,99	1,25	0,88	0,61	0,41	0,32
2,80	R	-	-	-	32,73	10,66	3,54	1,53	0,62	0,24	0,13
	v	-	-	-	3,35	2,14	1,35	0,95	0,66	0,44	0,34
3,00	R	-	-	-	37,58	12,24	4,06	1,67	0,71	0,27	0,14
	v	-	-	-	3,59	2,29	1,45	1,01	0,71	0,47	0,37
3,20	R	-	-	-	40,50	13,92	4,39	1,90	0,81	0,31	0,16
	v	-	-	-	3,83	2,45	1,54	1,08	0,75	0,50	0,39
3,40	R	-	-	-	45,72	15,72	4,95	2,14	0,87	0,33	0,18
	v	-	-	-	4,07	2,60	1,64	1,15	0,80	0,53	0,41
3,60	R	-	-	-	51,26	16,69	5,55	2,40	0,97	0,37	0,21
	v	-	-	-	4,31	2,75	1,73	1,22	0,85	0,57	0,44
3,80	R	-	-	-	57,12	18,60	6,19	2,54	1,08	0,42	0,22
	v	-	-	-	4,55	2,91	1,83	1,28	0,89	0,60	0,46
4,00	R	-	-	-	63,29	20,61	6,86	2,82	1,20	0,46	0,24
	v	-	-	-	4,79	3,06	1,93	1,35	0,94	0,63	0,49
4,20	R	-	-	-	-	22,72	7,56	3,11	1,32	0,48	0,27
	v	-	-	-	-	3,21	2,02	1,42	0,99	0,66	0,51
4,40	R	-	-	-	-	24,94	7,86	3,41	1,38	0,53	0,30
	v	-	-	-	-	3,37	2,12	1,49	1,03	0,69	0,54
4,60	R	-	-	-	-	27,26	8,59	3,73	1,51	0,58	0,31
	v	-	-	-	-	3,52	2,22	1,55	1,08	0,72	0,56
4,80	R	-	-	-	-	29,68	9,35	4,06	1,64	0,63	0,33
	v	-	-	-	-	3,67	2,31	1,62	1,13	0,75	0,59
5,00	R	-	-	-	-	32,20	10,15	4,17	1,78	0,69	0,36
	v	-	-	-	-	3,82	2,41	1,69	1,18	0,79	0,61
5,20	R	-	-	-	-	32,90	10,98	4,51	1,92	0,70	0,39
	v	-	-	-	-	3,98	2,51	1,76	1,22	0,82	0,63
5,40	R	-	-	-	-	35,48	11,84	4,87	2,08	0,76	0,42
	v	-	-	-	-	4,13	2,60	1,82	1,27	0,85	0,66
5,60	R	-	-	-	-	38,15	12,73	5,23	2,23	0,82	0,46
	v	-	-	-	-	4,28	2,70	1,89	1,32	0,88	0,68

Appendix B

Appendix B8-21

Pipe friction gradient/flow speed of Wefatherm pipes SDR 11

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

Pipe roughness: $K = 0,007 \text{ mm}$ $\dot{V}$ = flow rate (l/s)
 Density: $\rho = 998,2 \text{ kg/m}^3$ R = pressure gradient (mbar/m)
 Temperature: $t = 20^\circ\text{C}$ v = flow speed (m/s)
 Kinematic viscosity: $\nu = 1,003 \times 10^{-6} \text{ m}^2/\text{s}$

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

Appendix B8-22

Pipe friction gradient/flow speed of Wefatherm pipes SDR 11

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

Pipe roughness: $K = 0,007 \text{ mm}$ $\dot{V}$ = flow rate (l/s)
 Density: $\rho = 983,2 \text{ kg/m}^3$ R = pressure gradient (mbar/m)
 Temperature: $t = 60^\circ\text{C}$ v = flow speed (m/s)
 Kinematic viscosity: $\nu = 0,47 \times 10^{-6} \text{ m}^2/\text{s}$

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
0,01	R	0,04	0,01	-	-	-	-	-	-	-	-
	v	0,05	0,03	-	-	-	-	-	-	-	-
0,02	R	0,13	0,04	-	-	-	-	-	-	-	-
	v	0,10	0,06	-	-	-	-	-	-	-	-
0,03	R	0,24	0,08	-	-	-	-	-	-	-	-
	v	0,15	0,09	-	-	-	-	-	-	-	-
0,04	R	0,40	0,14	-	-	-	-	-	-	-	-
	v	0,19	0,12	-	-	-	-	-	-	-	-
0,05	R	0,59	0,20	-	-	-	-	-	-	-	-
	v	0,24	0,15	-	-	-	-	-	-	-	-
0,06	R	0,82	0,28	-	-	-	-	-	-	-	-
	v	0,29	0,18	-	-	-	-	-	-	-	-
0,07	R	1,08	0,35	-	-	-	-	-	-	-	-
	v	0,34	0,21	-	-	-	-	-	-	-	-
0,08	R	1,37	0,45	-	-	-	-	-	-	-	-
	v	0,39	0,24	-	-	-	-	-	-	-	-
0,09	R	1,68	0,55	-	-	-	-	-	-	-	-
	v	0,44	0,28	-	-	-	-	-	-	-	-
0,10	R	2,00	0,65	-	-	-	-	-	-	-	-
	v	0,49	0,31	-	-	-	-	-	-	-	-
0,12	R	2,78	0,91	0,28	-	-	-	-	-	-	-
	v	0,58	0,37	0,22	-	-	-	-	-	-	-
0,14	R	3,64	1,19	0,37	-	-	-	-	-	-	-
	v	0,68	0,43	0,26	-	-	-	-	-	-	-
0,16	R	4,57	1,50	0,46	-	-	-	-	-	-	-
	v	0,78	0,49	0,30	-	-	-	-	-	-	-
0,18	R	5,79	1,90	0,56	0,20	-	-	-	-	-	-
	v	0,87	0,55	0,33	0,22	-	-	-	-	-	-
0,20	R	6,86	2,26	0,67	0,24	-	-	-	-	-	-
	v	0,97	0,61	0,37	0,24	-	-	-	-	-	-
0,30	R	14,14	4,67	1,39	0,49	0,16	-	-	-	-	-
	v	1,46	0,92	0,56	0,36	0,23	-	-	-	-	-
0,40	R	24,00	7,94	2,38	0,83	0,28	-	-	-	-	-
	v	1,94	1,22	0,74	0,48	0,31	-	-	-	-	-
0,50	R	37,50	11,84	3,55	1,19	0,41	0,14	-	-	-	-
	v	2,43	1,53	0,93	0,60	0,38	0,24	-	-	-	-
0,60	R	51,43	16,24	4,88	1,71	0,58	0,19	0,08	-	-	-
	v	2,91	1,84	1,11	0,72	0,46	0,29	0,20	-	-	-
0,70	R	70,00	22,11	6,33	2,23	0,76	0,25	0,11	-	-	-
	v	3,40	2,14	1,30	0,84	0,54	0,34	0,24	-	-	-
0,80	R	86,85	28,87	8,26	2,91	0,95	0,31	0,13	-	-	-
	v	3,88	2,45	1,48	0,96	0,61	0,39	0,27	-	-	-
0,90	R	109,92	34,72	10,46	3,51	1,20	0,40	0,16	0,07	-	-
	v	4,37	2,75	1,67	1,08	0,69	0,43	0,30	0,21	-	-
1,00	R	135,71	42,86	12,27	4,33	1,41	0,47	0,20	0,08	-	-
	v	4,85	3,06	1,85	1,20	0,76	0,48	0,34	0,24	-	-

Appendix B

Appendix B8-23

Pipe friction gradient/flow speed of Wefatherm pipes SDR 11

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

Pipe roughness: $K = 0,007 \text{ mm}$ $\dot{V}$ = flow rate (l/s)
 Density: $\rho = 983,2 \text{ kg/m}^3$ R = pressure gradient (mbar/m)
 Temperature: $t = 60^\circ\text{C}$ v = flow speed (m/s)
 Kinematic viscosity: $\nu = 0,47 \times 10^{-6} \text{ m}^2/\text{s}$

$d \times s$		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
1,20	R	-	61,72	17,66	5,92	2,03	0,64	0,28	0,12	-	-
	v	-	3,67	2,23	1,44	0,92	0,58	0,41	0,28	-	-
1,40	R	-	79,58	22,77	8,06	2,63	0,87	0,36	0,15	0,06	-
	v	-	4,28	2,60	1,68	1,07	0,67	0,47	0,33	0,22	-
1,60	R	-	103,94	29,75	9,97	3,43	1,08	0,47	0,19	0,07	0,04
	v	-	4,90	2,97	1,92	1,22	0,77	0,54	0,38	0,25	0,20
1,80	R	-	-	37,65	12,62	4,11	1,37	0,56	0,24	0,09	0,05
	v	-	-	3,34	2,16	1,38	0,87	0,61	0,42	0,28	0,22
2,00	R	-	-	46,48	15,58	5,08	1,69	0,69	0,30	0,11	0,06
	v	-	-	3,71	2,40	1,53	0,96	0,68	0,47	0,31	0,24
2,20	R	-	-	53,12	17,81	6,14	1,94	0,84	0,34	0,13	0,07
	v	-	-	4,08	2,64	1,68	1,06	0,74	0,52	0,35	0,27
2,40	R	-	-	63,21	21,19	7,31	2,30	0,95	0,40	0,16	0,08
	v	-	-	4,45	2,88	1,84	1,16	0,81	0,56	0,38	0,29
2,60	R	-	-	74,19	24,87	8,10	2,70	1,11	0,47	0,17	0,10
	v	-	-	4,82	3,11	1,99	1,25	0,88	0,61	0,41	0,32
2,80	R	-	-	-	28,85	9,39	2,96	1,29	0,52	0,20	0,11
	v	-	-	-	3,35	2,14	1,35	0,95	0,66	0,44	0,34
3,00	R	-	-	-	33,12	10,79	3,40	1,48	0,60	0,23	0,12
	v	-	-	-	3,59	2,29	1,45	1,01	0,71	0,47	0,37
3,20	R	-	-	-	37,68	12,27	3,87	1,59	0,68	0,25	0,14
	v	-	-	-	3,83	2,45	1,54	1,08	0,75	0,50	0,39
3,40	R	-	-	-	42,54	13,85	4,37	1,79	0,77	0,28	0,16
	v	-	-	-	4,07	2,60	1,64	1,15	0,80	0,53	0,41
3,60	R	-	-	-	44,88	15,53	4,89	2,01	0,86	0,31	0,17
	v	-	-	-	4,31	2,75	1,73	1,22	0,85	0,57	0,44
3,80	R	-	-	-	50,01	16,29	5,45	2,24	0,91	0,35	0,19
	v	-	-	-	4,55	2,91	1,83	1,28	0,89	0,60	0,46
4,00	R	-	-	-	55,41	18,05	6,04	2,48	1,00	0,39	0,21
	v	-	-	-	4,79	3,06	1,93	1,35	0,94	0,63	0,49
4,20	R	-	-	-	-	19,90	6,27	2,74	1,11	0,43	0,23
	v	-	-	-	-	3,21	2,02	1,42	0,99	0,66	0,51
4,40	R	-	-	-	-	21,84	6,88	3,01	1,21	0,44	0,25
	v	-	-	-	-	3,37	2,12	1,49	1,03	0,69	0,54
4,60	R	-	-	-	-	23,87	7,52	3,09	1,33	0,49	0,27
	v	-	-	-	-	3,52	2,22	1,55	1,08	0,72	0,56
4,80	R	-	-	-	-	25,99	8,19	3,37	1,45	0,53	0,28
	v	-	-	-	-	3,67	2,31	1,62	1,13	0,75	0,59
5,00	R	-	-	-	-	28,20	8,89	3,65	1,57	0,57	0,30
	v	-	-	-	-	3,82	2,41	1,69	1,18	0,79	0,61
5,20	R	-	-	-	-	30,50	9,61	3,95	1,60	0,62	0,33
	v	-	-	-	-	3,98	2,51	1,76	1,22	0,82	0,63
5,40	R	-	-	-	-	32,89	10,36	4,26	1,72	0,67	0,35
	v	-	-	-	-	4,13	2,60	1,82	1,27	0,85	0,66
5,60	R	-	-	-	-	35,37	11,15	4,58	1,85	0,72	0,38
	v	-	-	-	-	4,28	2,70	1,89	1,32	0,88	0,68

Appendix B8-24

Pipe friction gradient/flow speed of Wefatherm pipes SDR 11

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

Pipe roughness: $K = 0,007 \text{ mm}$ $\dot{V}$ = flow rate (l/s)

Density: $\rho = 983,2 \text{ kg/m}^3$ R = pressure gradient (mbar/m)

Temperature: $t = 60^\circ\text{C}$ v = flow speed (m/s)

Kinematic viscosity: $\nu = 0,47 \times 10^{-6} \text{ m}^2/\text{s}$

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

Appendix B

Appendix B8-25

Pipe friction gradient/flow speed of Wefatherm pipes SDR 11

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

$\dot{V}$ = flow rate (l/s)

R = pressure gradient (mbar/m)

v = flow speed (m/s)

Pipe roughness: K = 0,007 mm

Density: ρ = 998 kg/m³

Temperature: t = 20 °C

Kinematic viscosity: ν = 1,02 x 10⁻⁶ m²/s

Pipe roughness: K = 0,007 mm

Density: ρ = 977,8 kg/m³

Temperature: t = 70 °C

Kinematic viscosity: ν = 0,414 x 10⁻⁶ m²/s

$\dot{V}$ l/s	$\dot{V}$ l/min	$\dot{V}$ m ³ /h	d_e s di	160 14,6 130,8	200 18,2 163,6	250 22,7 204,6	315 28,6 257,8	160 14,6 130,8	200 18,2 163,6	250 22,7 204,6	315 28,6 257,8
5	300	18	R	0,11	0,04	-	-	0,09	0,03	-	-
			v	0,37	0,24	-	-	0,37	0,24	-	-
6	360	22	R	0,15	0,05	-	-	0,13	0,04	-	-
			v	0,45	0,29	-	-	0,45	0,29	-	-
7	420	25	R	0,21	0,07	0,02	-	0,17	0,06	0,02	-
			v	0,52	0,33	0,21	-	0,52	0,33	0,21	-
8	480	29	R	0,26	0,09	0,03	-	0,21	0,07	0,02	-
			v	0,60	0,38	0,24	-	0,60	0,38	0,24	-
9	540	32	R	0,33	0,11	0,04	-	0,27	0,09	0,03	-
			v	0,67	0,43	0,27	-	0,67	0,43	0,27	-
10	600	36	R	0,38	0,13	0,05	-	0,33	0,11	0,04	-
			v	0,74	0,48	0,30	-	0,74	0,48	0,30	-
12	720	43	R	0,55	0,18	0,06	0,02	0,45	0,16	0,05	0,02
			v	0,89	0,57	0,36	0,23	0,89	0,57	0,36	0,23
14	840	50	R	0,70	0,24	0,08	0,03	0,61	0,20	0,07	0,02
			v	1,04	0,67	0,43	0,27	1,04	0,67	0,43	0,27
16	960	58	R	0,92	0,30	0,10	0,03	0,74	0,26	0,08	0,03
			v	1,19	0,76	0,49	0,31	1,19	0,76	0,49	0,31
18	1080	65	R	1,10	0,38	0,13	0,04	0,94	0,33	0,11	0,04
			v	1,34	0,86	0,55	0,34	1,34	0,86	0,55	0,34
20	1200	72	R	1,35	0,47	0,15	0,05	1,16	0,38	0,13	0,04
			v	1,49	0,95	0,61	0,38	1,49	0,95	0,61	0,38
22	1320	79	R	1,64	0,53	0,19	0,06	1,40	0,46	0,16	0,05
			v	1,64	1,05	0,67	0,42	1,64	1,05	0,67	0,42
24	1440	87	R	1,95	0,64	0,22	0,07	1,67	0,55	0,18	0,06
			v	1,79	1,14	0,73	0,46	1,79	1,14	0,73	0,46
26	1560	93,6	R	2,14	0,75	0,24	0,08	1,96	0,64	0,21	0,07
			v	1,93	1,24	0,79	0,50	1,93	1,24	0,79	0,50
28	1680	101	R	2,49	0,87	0,28	0,09	2,11	0,74	0,24	0,08
			v	2,08	1,33	0,85	0,54	2,08	1,33	0,85	0,54
30	1800	108	R	2,85	0,99	0,32	0,11	2,42	0,85	0,28	0,09
			v	2,23	1,43	0,91	0,57	2,23	1,43	0,91	0,57
32	1920	115	R	3,25	1,06	0,37	0,12	2,76	0,90	0,32	0,10
			v	2,38	1,52	0,97	0,61	2,38	1,52	0,97	0,61
34	2040	122	R	3,66	1,20	0,42	0,13	3,11	1,02	0,36	0,11
			v	2,53	1,62	1,03	0,65	2,53	1,62	1,03	0,65
36	2160	130	R	4,11	1,34	0,47	0,15	3,49	1,14	0,37	0,13
			v	2,68	1,71	1,09	0,69	2,68	1,71	1,09	0,69
38	2280	137	R	4,58	1,50	0,49	0,16	3,89	1,27	0,41	0,14
			v	2,83	1,81	1,16	0,73	2,83	1,81	1,16	0,73
40	2400	144	R	4,73	1,66	0,54	0,18	4,31	1,41	0,46	0,16
			v	2,98	1,90	1,22	0,77	2,98	1,90	1,22	0,77
42	2520	151	R	5,22	1,83	0,60	0,20	4,75	1,55	0,51	0,17
			v	3,13	2,00	1,28	0,80	3,13	2,00	1,28	0,80
44	2640	158	R	5,73	2,00	0,66	0,22	5,21	1,70	0,56	0,18
			v	3,27	2,09	1,34	0,84	3,27	2,09	1,34	0,84

Appendix B8-26

Pipe friction gradient/flow speed of Wefatherm pipes SDR 11

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

$\dot{V}$ = flow rate (l/s)

R = pressure gradient (mbar/m)

v = flow speed (m/s)

Pipe roughness: K = 0,007 mm

Density: ρ = 998,2 kg/m³

Temperature: t = 20 °C

Kinematic viscosity: ν = 1,003 x 10⁻⁶ m²/s

Pipe roughness: K = 0,007 mm

Density: ρ = 977,8 kg/m³

Temperature: t = 70 °C

Kinematic viscosity: ν = 0,414 x 10⁻⁶ m²/s

$\dot{V}$ l/s	$\dot{V}$ l/min	$\dot{V}$ m ³ /h	d_e s di	160 14,6 130,8	200 18,2 163,6	250 22,7 204,6	315 28,6 257,8	160 14,6 130,8	200 18,2 163,6	250 22,7 204,6	315 28,6 257,8
46	2760	166	R	6,26	2,05	0,72	0,23	5,69	1,86	0,61	0,19
			v	3,42	2,19	1,40	0,88	3,42	2,19	1,40	0,88
48	2880	173	R	6,82	2,23	0,78	0,25	6,20	2,03	0,66	0,21
			v	3,57	2,28	1,46	0,92	3,57	2,28	1,46	0,92
50	3000	180	R	7,40	2,42	0,85	0,27	6,73	2,20	0,72	0,23
			v	3,72	2,38	1,52	0,96	3,72	2,38	1,52	0,96
55	3300	198	R	8,95	2,92	0,96	0,32	7,51	2,66	0,87	0,27
			v	4,09	2,62	1,67	1,05	4,09	2,62	1,67	1,05
60	3600	216	R	10,65	3,48	1,14	0,38	8,94	2,92	1,03	0,33
			v	4,47	2,85	1,82	1,15	4,47	2,85	1,82	1,15
65	3900	234	R	11,61	4,08	1,33	0,45	10,50	3,43	1,12	0,38
			v	4,84	3,09	1,98	1,25	4,84	3,09	1,98	1,25
70	4200	252	R	13,46	4,74	1,55	0,49	12,17	3,98	1,30	0,44
			v	5,21	3,33	2,13	1,34	5,21	3,33	2,13	1,34
75	4500	270	R	15,45	5,05	1,78	0,56	13,97	4,56	1,49	0,47
			v	5,58	3,57	2,28	1,44	5,58	3,57	2,28	1,44
80	4800	288	R	17,58	5,74	2,02	0,64	15,90	5,19	1,70	0,53
			v	5,95	3,81	2,43	1,53	5,95	3,81	2,43	1,53
85	5100	306	R	-	6,48	2,28	0,72	-	5,86	1,92	0,60
			v	-	4,04	2,59	1,63	-	4,04	2,59	1,63
90	5400	324	R	-	7,27	2,38	0,81	-	6,57	2,15	0,68
			v	-	4,28	2,74	1,72	-	4,28	2,74	1,72
95	5700	342	R	-	8,10	2,65	0,90	-	7,32	2,39	0,75
			v	-	4,52	2,89	1,82	-	4,52	2,89	1,82
100	6000	360	R	-	8,98	2,93	0,99	-	8,12	2,65	0,84
			v	-	4,76	3,04	1,92	-	4,76	3,04	1,92
110	6600	396	R	-	10,86	3,55	1,12	-	9,82	3,21	1,01
			v	-	5,23	3,35	2,11	-	5,23	3,35	2,11
120	7200	432	R	-	12,92	4,22	1,33	-	11,69	3,82	1,20
			v	-	5,71	3,65	2,30	-	5,71	3,65	2,30
130	7800	468	R	-	-	4,96	1,56	-	-	4,48	1,41
			v	-	-	3,95	2,49	-	-	3,95	2,49
140	8400	504	R	-	-	5,75	1,81	-	-	4,77	1,50
			v	-	-	4,26	2,68	-	-	4,26	2,68
150	9000	540	R	-	-	6,09	2,08	-	-	5,47	1,72
			v	-	-	4,56	2,87	-	-	4,56	2,87
160	9600	576	R	-	-	6,93	2,36	-	-	6,23	1,96
			v	-	-	4,87	3,07	-	-	4,87	3,07
170	10200	612	R	-	-	7,83	2,67	-	-	7,03	2,21
			v	-	-	5,17	3,26	-	-	5,17	3,26
180	10800	648	R	-	-	8,77	2,76	-	-	7,88	2,48
			v	-	-	5,47	3,45	-	-	5,47	3,45
190	11400	684	R	-	-	9,78	3,08	-	-	8,78	2,76
			v	-	-	5,78	3,64	-	-	5,78	3,64
200	12000	720	R	-	-	-	3,41	-	-	-	3,06
			v	-	-	-	3,83	-	-	-	3,83