wefatherm

Specialist Water Supply Systems

PP-R pipe system

Specification manual

MADE IN GERMANY

Wefatherm specialist water supply systems

Table of Contents

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 Wefathem 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safety and for the proper application of our products at regular intervals if your present Specification Manual has been replaced by a new version.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 followed by 40 followed by 60	2,5 20 25	70	2.5	100	100	Underfloor heating and low temperature radiator connections (70 °C)
5 [b)]	20 followed by 60 followed by 80	14 25 10	90	1	100	100	High temperature radiator connections (80 °C)

Table 1.1 Aplication 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.

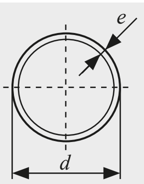
The Maximum Operating Pressure is calculated according to the equation:

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

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.



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

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.

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

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 ISO15874 and DIN8077-8078. 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.

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

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.

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

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

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

- *= 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.	Satured 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	Behaviour at 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	Behaviour at 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
Dioctyl 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	
		20 °C	60 °C
Fruit juice	Work. sol.	S	S
Furfuryl alcohol	Tech. gr.	S	L
Gas, natural, dry	Tech. gr.	S	L
Gas, natural, wet	Tech. gr.	S	-
Gasoline (fuel) (free from aromatics)	Work. sol.	L	NS
Gelatine	Sol.	S	S
Ginger ale	Work. sol.	S	S
Glucose	Sol.	S	S
Glycerine	Tech. gr.	S	S
Glycolic acid	<65%	L	L
Grapefruit juice	Work. sol.	S	S
Heptane	Tech. gr.	L	NS
Hexadecanol	Work. sol.	S	-
Hexane	Tech. gr.	S	L
1-Hexanol	Tech. gr.	S	S
Honey	Work. sol.	S	S
Horseradish	Work. sol.	S	S
Hydrobromic acid	<20%	S	S
	>20 to 50%	S	L
	66%	L	NS
Hydrochloric acid	<25%	S	L
	>25 to 37,5%	L	L
Hydrochloric acid, dry gas	Tech. gr.	S	NS
Hydrochloric acid, wet gas	Tech. gr.	S	NS
Hydrocyanic acid	Tech. gr.	S	NS
Hydrofluoric acid	<40%	S	L
	50%	L	-
	>50 to 70%	L	NS
Hydrofluoric acid, gas	Tech. gr.	NS	-
Hydrogen, gas	Tech. gr.	S	S
Hydrogen peroxide	<10%	S	L
	>30 to 70%	L	L
	70%	L	NS
Hydrogen sulphide aqueous	Sat. sol.	S	S
Hydrogen sulphide, dry gas	Tech. gr.	S	S
Hydroquinone	Sat. sol.	S	L
Hypochlorous acid	<70%	L	NS
Iodine	Sat. sol.	NS	NS
Iodine, in alcohol	Work. sol.	L	L
Isobutyl alcohol	Tech. gr.	S	L
Isobutyronitrile	Tech. gr.	L	NS
Isooctane	Tech. gr.	L	L
Isopropyl acetat	Tech. gr.	S	L
Isopropyl alcohol	Tech. gr.	S	S
Isopropyl ether	Tech. gr.	L	NS
Kerosene	Work. sol.	L	L
Lactic acid	<90%	S	S
	Tech. gr.	S	L
Lanolin	Work. sol.	S	L
Lauryl chloride	Sat. sol.	L	NS
Lead acetate	Dil. sol.	S	S
Lead tetraethyl	Tech. gr.	S	-
Linseed oil	Work. sol.	S	S
Magnesium carbonate	Susp.	S	S
Magnesium chloride	Sat. sol.	S	S
Magnesium hydroxide	Sat. sol.	S	S
Magnesium nitrate	Sat. sol.	S	S
Magnesium sulphate	Sat. sol.	S	S
Maleic acid	Sat. sol.	S	S
Malic acid	Sat. sol.	S	S
Margarine	Work. sol.	S	S
Mayonnaise	Work. sol.	S	S
Mercuric chloride	Sat. sol.	S	S
Mercuric cyanide	Sat. sol.	S	S
Mercurous nitrate	Sat. sol.	S	S
Mercury	Tech. gr.	S	S
Mesityl oxide	Work. sol.	NS	NS
Methane, gas	Tech. gr.	S	L

Flow substance	Concentration	Behaviour at	
		20 °C	60 °C
Methyl acetate	Tech. gr.	S	S
Methyl alcohol	5%	S	L
	Tech. gr.	S	S
Methyl bromide, gas	Tech. gr.	NS	NS
Methyl butyl ketone	Tech. gr.	S	L
Methyl cyclohexanones	Tech. gr.	L	-
Methyl ethyl ketone	Tech. gr.	S	L
Methyl glycol	Work. sol.	S	L
Methyl methacrylate	Tech. gr.	S	S
Methyl sulphate	Work. sol.	L	-
Methyl sulphonic acid	Tech. gr.	L	L
Methylamine	<32%	S	NS
Methylene chloride	Tech. gr.	-	-
Milk	Work. sol.	S	S
Mineral oils (free from aromatics)	Work. sol.	S	L
Molasses	Work. sol.	S	S
Mustard, aqueous	Work. sol.	S	-
Naphtha	Work. sol.	L	NS
Naphthalene	Work. sol.	L	L
Nickel acetate	Sat. sol.	S	S
Nickel chloride	Sat. sol.	S	S
Nickel nitrate	Sat. sol.	S	S
Nickel sulphate	Sat. sol.	S	S
Nicotin acid	Susp.	S	-
Nitric acid	5%	L	L
	>10 to 30%	L	NS
	>35%	NS	NS
Nitric acid (with nitrogen dioxide)	Fuming	NS	NS
Nitrobenzene	Tech. gr.	S	L
Nitromethane	Tech. gr.	S	L
Oleic acid	Tech. gr.	S	L
Oleum		NS	NS
Olive oil	Work. sol.	S	L
Oxalic acid (subl.)	Dil. sol.	S	S
	Sat. sol.	S	L
Oxygen, gas	Tech. gr.	S	L
Ozone, gas	Sat. sol.	NS	NS
Paraffin	Tech. gr.	S	S
Paraffin oil	Tech. gr.	S	L
Peanut oil	Work. sol.	S	L
Pentane	Work. sol.	L	L
Peppermint oil	Work. sol.	S	L
Perchloro- ethylene	Work. sol.	L	NS
Perchloric acid	10%	L	L
	20%	L	NS
	70	L	-
Petrol (aliphatic hydrocarbon / benzene)	80/20%	L	NS
Petroleum ether (ligroin)	Work. sol.	L	L
Phenol	Sol.	S	L
	5%	S	S
	50%	S	-
	90%	S	L
Phenylhydrazine	Tech. gr.	L	L
Phenylhydrazine hydrochloride	Dil. sol.	S	L
	97%	S	NS
Phosphine, gas	Tech. gr.	L	L
Phosphoric acid	<98%	S	S
Phosphorus (III) chloride	Tech. gr.	L	-
Phosphorus oxychloride	Tech. gr.	L	L
Phthalic acid	Susp.	S	S
Picric acid (subl.)	Sat. sol.	S	L
Potassium bicarbonate	Sat. sol.	S	S
Potassium bisulphate	Sat. sol.	S	S
Potassium borate	Sat. sol.	S	S
Potassium bromate	Sat. sol.	S	S

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Material properties and application limitations

Flow substance	Concentration	Behaviour at	
		20 °C	60 °C
Potassium bromide	Sat. sol.	S	S
Potassium carbonate	Sat. sol.	S	S
Potassium chlorate	Sat. sol.	S	L
Potassium chloride	Sat. sol.	S	S
Potassium chlorite	Sat. sol.	S	S
Potassium chromate	Sat. sol.	S	L
Potassium cuprocyanide	Sat. sol.	S	S
Potassium cyanide	Sol.	S	S
Potassium dichromate	Sat. sol.	S	L
Potassium ferricyanide	Sat. sol.	S	S
Potassium fluoride	Sat. sol.	S	S
Potassium hexacyanoferrate (II)	Sat. sol.	S	S
Potassium hydrogen sulphite	Sat. sol.	S	S
Potassium hydroxide	<20%	S	S
	<50%	L	L
Potassium hypochlorite	Sol.	L	-
Potassium iodide	Sat. sol.	S	S
Potassium nitrate	Sat. sol.	S	L
Potassium orthophosphate	Sat. sol.	S	S
Potassium perborate	Sat. sol.	S	S
Potassium perchlorate	10%	S	L
	Sat. sol.	L	L
Potassium permanganate	Sat. sol.	L	L
Potassium persulphate	Sat. sol.	S	S
Potassium sulphate	Sat. sol.	S	S
Potassium sulphide	Sat. sol.	S	S
Potassium sulphite	Sat. sol.	S	S
Potassium, thiosulphate	Sat. sol.	S	S
Propane, gas	Tech. gr.	S	L
Propionic acid	50%	S	L
	Tech. gr.	L	L
Propyl alcohol	Tech. gr.	S	S
Pyridine	Tech. gr.	L	L
Salicylic acid (subl.)	Sat. sol.	S	S
Selenic acid	Sat. sol.	S	S
Silicic acid	Susp.	S	S
Silicone oil	Tech. gr.	S	S
Silver acetate	Sat. sol.	S	S
Silver cyanide	Sat. sol.	S	S
Silver nitrate	Sat. sol.	S	S
Sodium acetate	Sat. sol.	S	S
Sodium antimonite	Sat. sol.	S	S
Sodium arsenite	Sat. sol.	S	S
Sodium benzoate	Up to 50%	S	L
Sodium bicarbonate	Sat. sol.	S	S
Sodium bisulphate	Up to 50%	S	S
Sodium bromide	Up to 50%	S	S
Sodium carbonate	Up to 50%	S	S
Sodium chlorate	Sat. sol.	S	L
Sodium chloride	Sat. sol.	S	S
Sodium chlorite	2%	S	L
	20%	S	L
Sodium chromate	Dil. sol.	S	S
Sodium cyanide	Sat. sol.	S	S
Sodium dichromate	Sat. sol.	S	L
Sodium ferricyanide	Sat. sol.	S	S
Sodium ferrocyanide	Sat. sol.	S	S
Sodium fluoride	Sat. sol.	S	S
Sodium hydrogen sulphite	Sat. sol.	S	S
Sodium hydroxide	Dil. Sol.	S	S
	Sat. sol.	S	L
	<10%	S	S
	>10 to 60%	S	L
Sodium hypochlorite	2% Cl (% of free chlorine)	L	-
	12,5% Cl (% of free chlorine)	L	-

Flow substance	Concentration	Behaviour at	
		20 °C	60 °C
Sodium metaphosphate	Sol.	S	S
Sodium nitrate	Sat. sol.	S	L
Sodium nitrite	Sat. sol.	S	S
Sodium perborate	Sat. sol.	S	S
Sodium phospate, acid	Sat. sol.	S	S
Sodium phospate, neutral	Sat. sol.	S	S
Sodium silicate	Sat. sol.	S	S
Sodium sulphate	Sat. sol.	S	S
Sodium sulphide	Sat. sol.	S	S
Sodium sulphite	40%	S	S
Sodium thiosulphate (hypo-sulphite)	Sat. sol.	S	S
Soybean oil	Work. sol.	S	L
Stearic acid	Work. sol.	S	L
Stearin	Work. sol.	S	L
Styrene	Sat. sol.	L	NS
Sugar, aqueous sol.	Sol.	S	S
Sulphur dioxide, dry gas	Work. sol.	S	S
Sulphur dioxide, wet gas	Work. sol.	S	S
Sulphur ether (thioether)	Work. sol.	L	NS
Sulphuric acid	>10 to 30%	S	S
	>50 to 70%	S	L
	>80 to 90%	L	NS
	>95%	NS	NS
	Fuming	NS	NS
Sulphurous acid	Sat. sol.	S	L
Tannic acid	Sat. sol.	S	L
Tartaric acid	Sat. sol.	S	S
Tetrahydrofuran	Tech. gr.	NS	NS
Tetralin	Tech. gr.	NS	NS
Thionyl chloride	Tech. gr.	NS	NS
Thiophene	Tech. gr.	L	L
Tin (II) chloride	Sat. sol.	S	S
Tin (IV) chloride	Sol.	S	S
Toluene	Tech. gr.	L	NS
Tributyl- phosphate	Sat. sol.	S	L
Trichloroacetic acid	<50%	S	S
Trichloro- benzene	Work. sol.	NS	NS
Trichloro- ethylene	Tech. gr.	L	L
Triethanolamine	Sol.	S	S
	Tech. gr.	S	L
Triethylene glycol	Sol.	S	S
Trimethylol- propane	<10%	S	S
Turpentine	Tech. gr.	L	NS
Urea	Sat. sol.	S	S
Uric acid	Work. sol.	S	S
Urine	Work. sol.	S	S
Vegetable oils	Tech. gr.	S	L
Vinegar	Work. sol.	S	S
Vinyl acetate (monomer)	Tech. gr.	S	L
Water, distilled	Work. sol.	S	S
Water, sea	Work. sol.	S	S
Whiskey	Work. sol.	S	L
Wine	Work. sol.	S	S
Wines and spirits	Work. sol.	S	S
Xylene	Tech. gr.	L	NS
Yeast	Susp.	S	-
Zinc carbonate	Sat. sol.	S	S
Zinc chloride	Sat. sol.	S	S
Zinc chromate	Sat. sol.	L	L
Zinc cyanide	Sat. sol.	S	S
Zinc nitrate	Sat. sol.	L	L
Zinc oxide	Susp.	S	S
Zinc stearate	Susp.	S	S
Zinc sulphate	Sat. sol.	S	S

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

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 (CO_2) 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

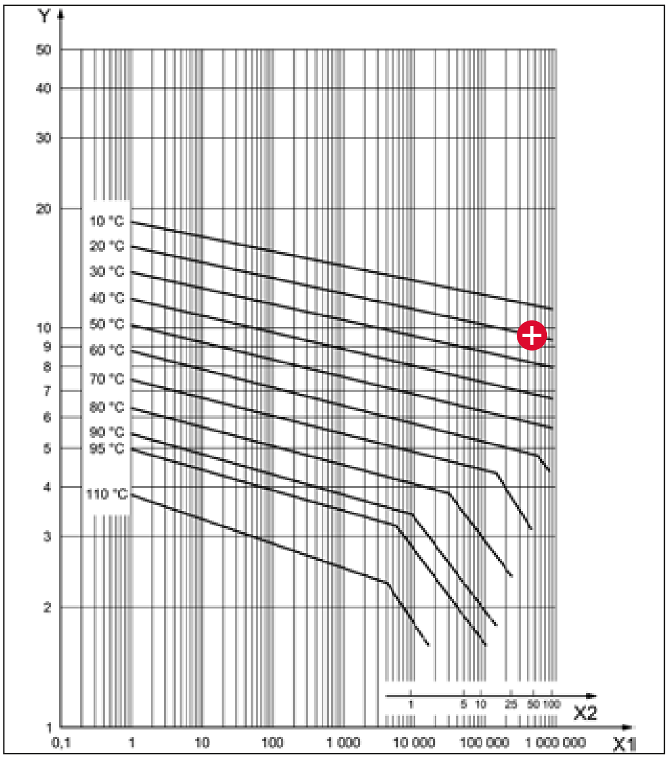
The PP-R material Borealis RA130E has become a leading PP-R grade due to its outstanding performance and quality.

Illustration 2.2

Property	Typical value	Unit	Test method
Density	0,9-1,0	g/cm³	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
Charpy impact strength, notched			
(23°C)	20	kJ/m²	ISO 179/1eA
(0°C)	3,5	kJ/m²	ISO 179/1eA
(-20°C)	2	kJ/m²	ISO 179/1eA
Charpy impact strength, unnotched			
(23°C)	No break		ISO 179/1eU
(0°C)	No break		ISO 179/1eU
(-20°C)	40	kJ/m²	ISO 179/1eU
Melt temperature	210-220	°C	

Table 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.

2.3 PP-RCT material

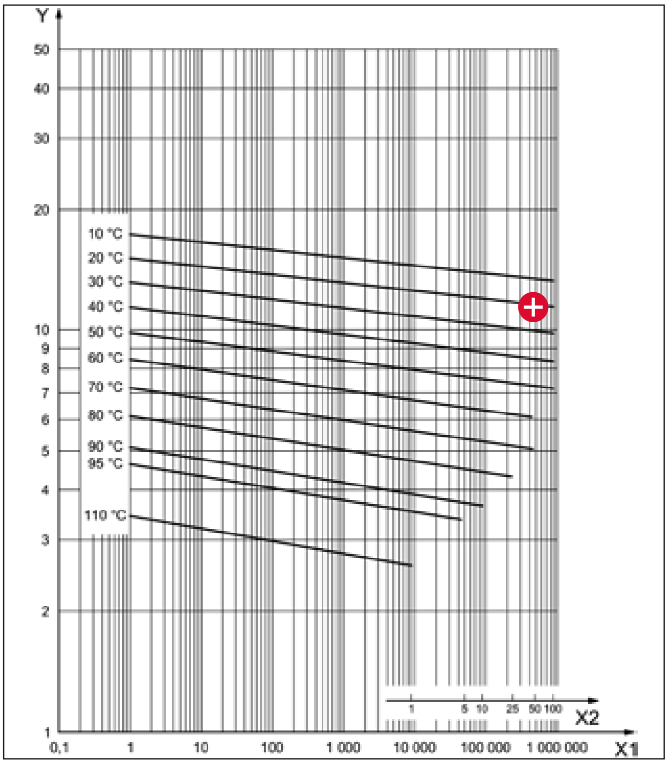
PP-RCT (PolyPropylene-Random Crystallinity Temperature) is a material classification to describe the second generation class of PP-R materials. The Borealis RA7050 PP-RCT material has a special crystallinity which improves the mechanical characteristics of the material, especially at elevated temperatures.

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

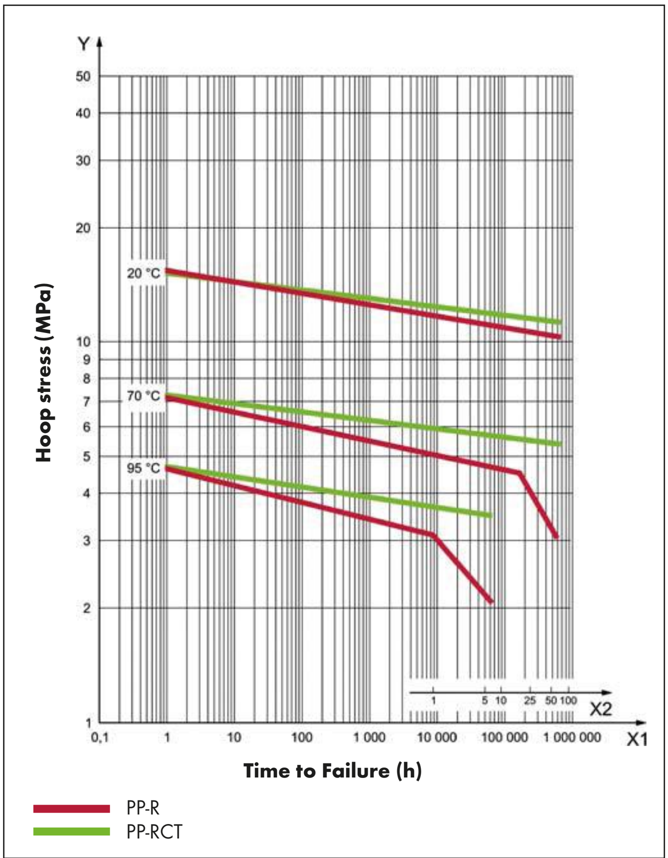
The Wefatherm pipe system can be applied for hot and cold water supply according standard ISO 15874 as mentioned in table 2.10 within the restrictions as given in chapter 2 of this Specification Manual.

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.

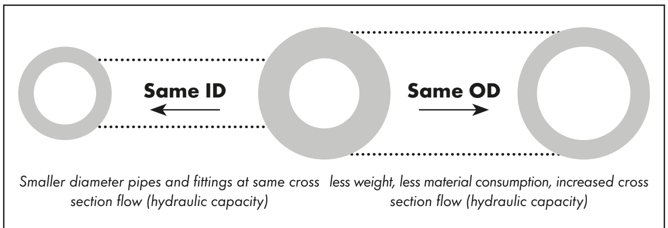


Illustration 2.4

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

> 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.

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.

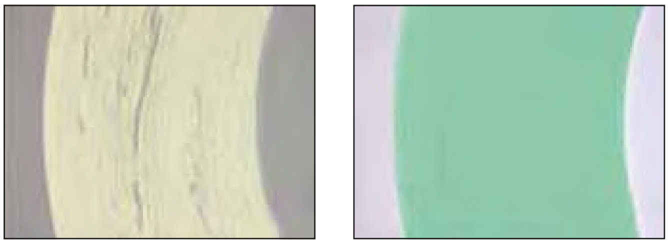


Illustration 2.5 Stereomicroscopic observation of pipe cross sections with poor dispersion and excellent dispersion of pigment and additives

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

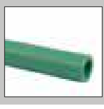
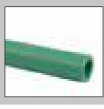
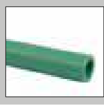
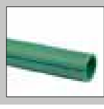
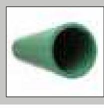
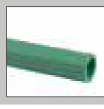
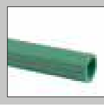
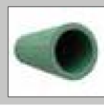
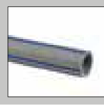
PP-R and PP-RCT can be welded without restriction. Welding PP-RCT onto PP-R components can also be performed unrestricted. The welding processes (socket welding, butt-welding and electrofusion) of polypropylene are described in The German Welders Association guideline DVS 2207-11.

For butt-welding (d ≧ 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.

2.5 Maximum operating pressure pipe ranges

Material Type SDR Colour	PP-RCT Standard 7.4 Green	PP-R Standard 6 Green	PP-R Standard 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 9**	**PP-RCT Fibre 11**	**PP-RCT Fibre 11**
Class 1	10	10	8	-	6	8	8	6	6
Class 2	10	8	6	-	6	6	6	6	6
Class 4	10	10	10	-	6	10	8	6	6
Class 5	8	6	6	-	4	6	6	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 9**	**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	19,3	15,3	15,3
SF 1,50-70°C	10,7	8,5	6,7	4,2	6,8	6,7	8,5	6,8	6,8
SF 1,25-20°C	29,2	30,9	24,5	15,4	18,4	24,5	23,1	18,4	18,4
SF 1,25-70°C	12,9	10,2	8,1	5,1	8,1	8,1	10,2	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

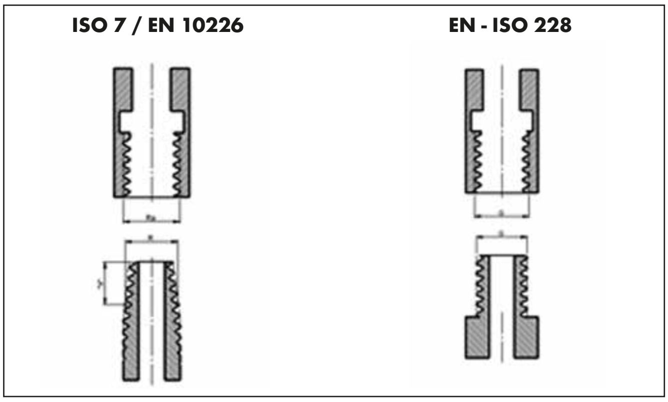


Illustration 2.7

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.

2.7 Rubber gaskets

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

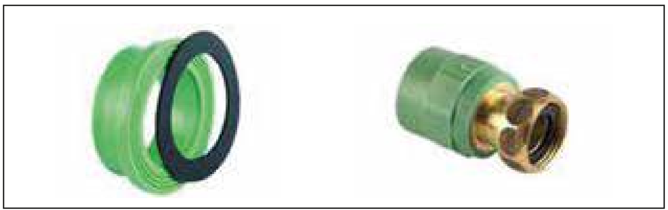


Illustration 2.8

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/cm³): 1,11
- Tensile strength (N/mm²): 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-torqueing 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 °C) it remains advisable to inspect the flange joint periodical and re-tighten the fasteners if necessary.

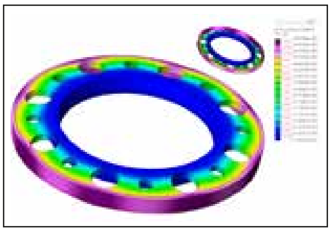


Illustration 2.10 Load distribution

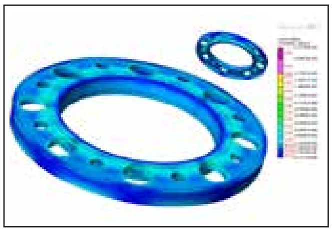


Illustration 2.11 Elastic deformation

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	50 mg/l Cl_2	12 hours	<25 °C
Hydrogen peroxide	H_2O_2	150 mg/l H_2O_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.

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.

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:
a. Remove undesired substances from the water
b. Make the water suitable for human consumption
c. 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 Trinkwasserverordung TrinkwV

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 unaccepted 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.

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.

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
Homogeneousness 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.

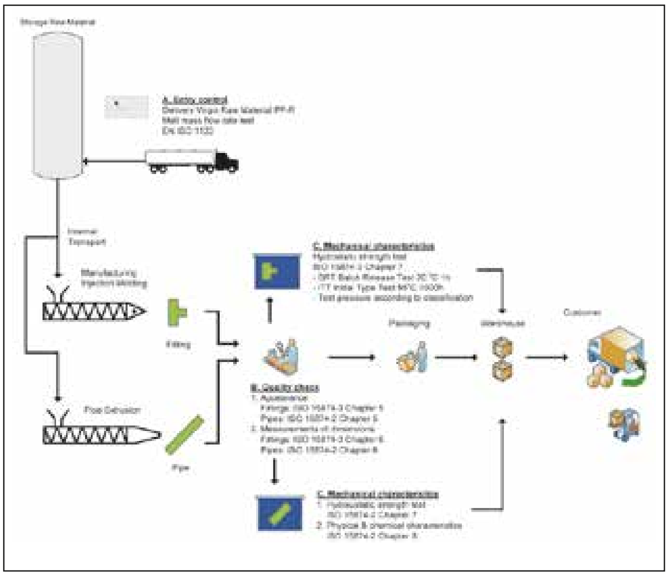


Illustration 4.1 Quality management system

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.

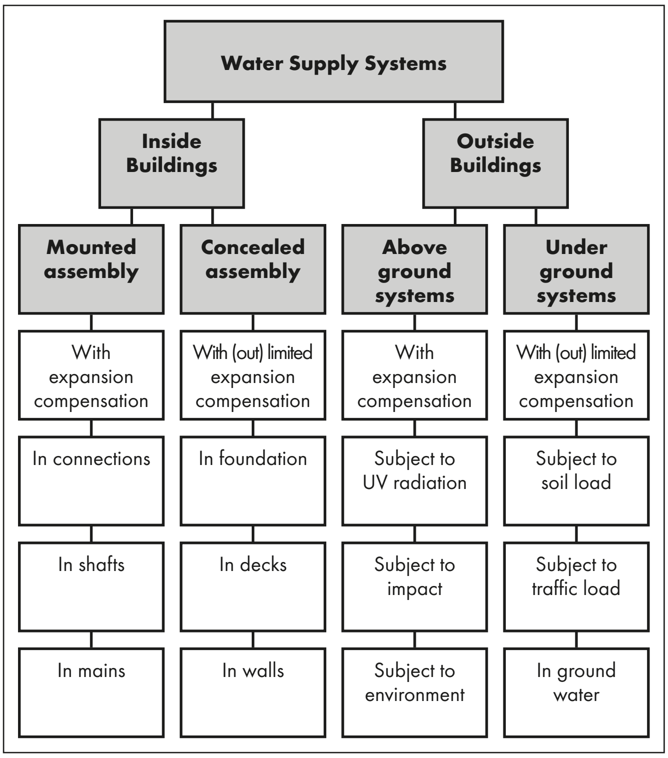


Illustration 5.1

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.

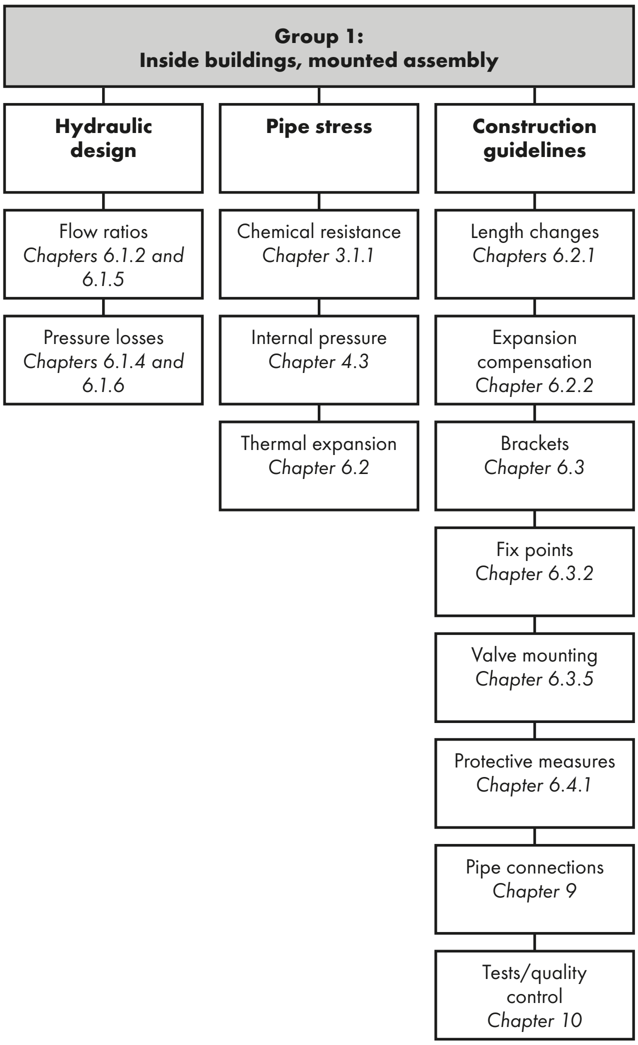
Group 3: Outside buildings above ground systems with expansion compensation

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

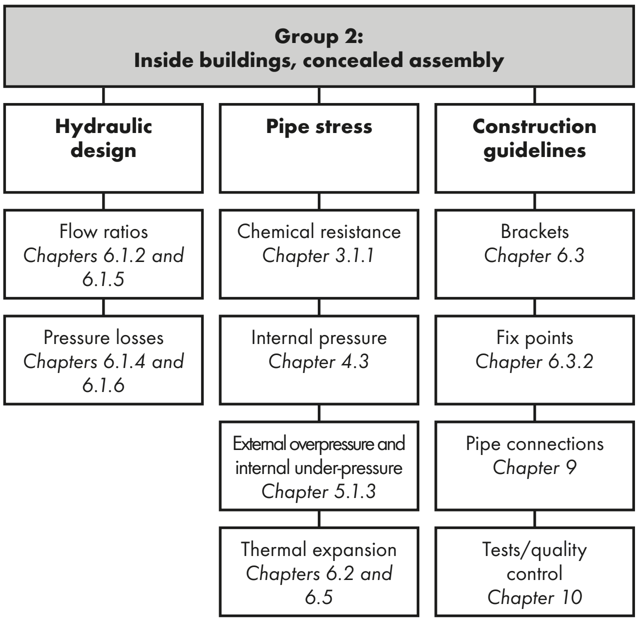
Fundamentally it will always be possible to lay an underground polypropylene network. Longitudinal expansion does not necessarily have to be taken into account because problems resulting from longitudinal expansion generally do not arise. For hot water systems the material strength decreases in the course 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



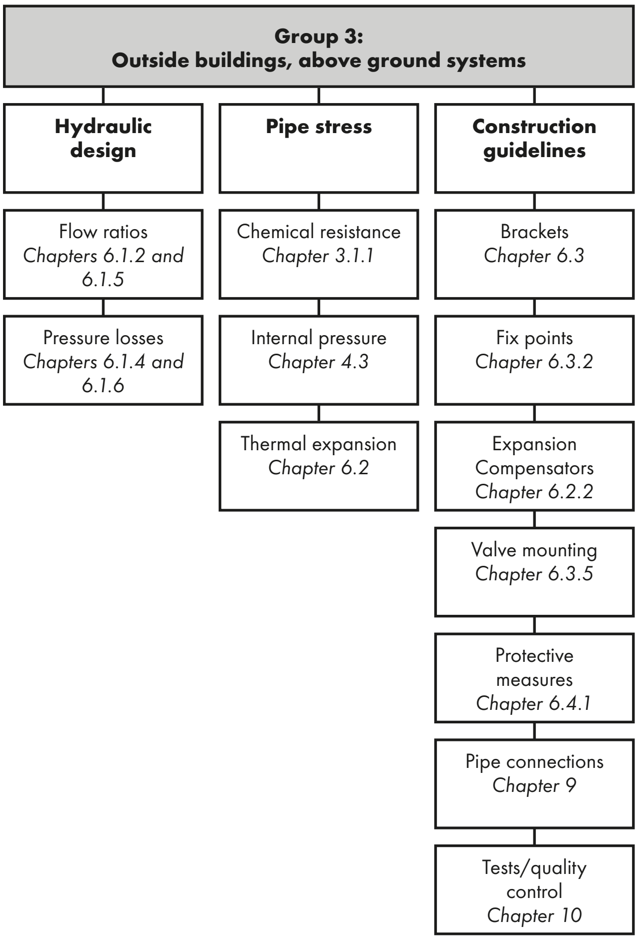
Pipe systems are usually installed so that the pipelines can elongate under the effects of heat. The latitude of movement can be provided by the installations own compensation elements (e.g. expansion bends and compensators) and by properly positioned sliding and guiding brackets. Special consideration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

Illustration 5.2 Inside buildings, mounted assembly



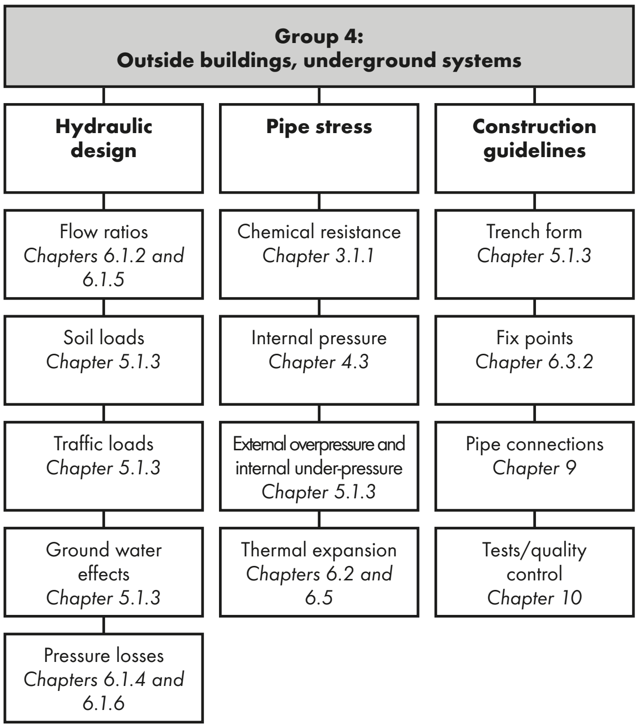
Pipe systems can also be installed so that an encasement in concrete walls, decks, and foundations, etc. is possible after completion of the installation. The concrete surrounding the pipe impedes length changes resulting from temperature fluctuations (e.g. due to the temperature of the flow medium or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

Illustration 5.3 Inside buildings, concealed assembly



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

Illustration 5.4 Outside buildings, above ground systems



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

Illustration 5.5 Outside buildings, underground systems

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), Wurzburg.

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

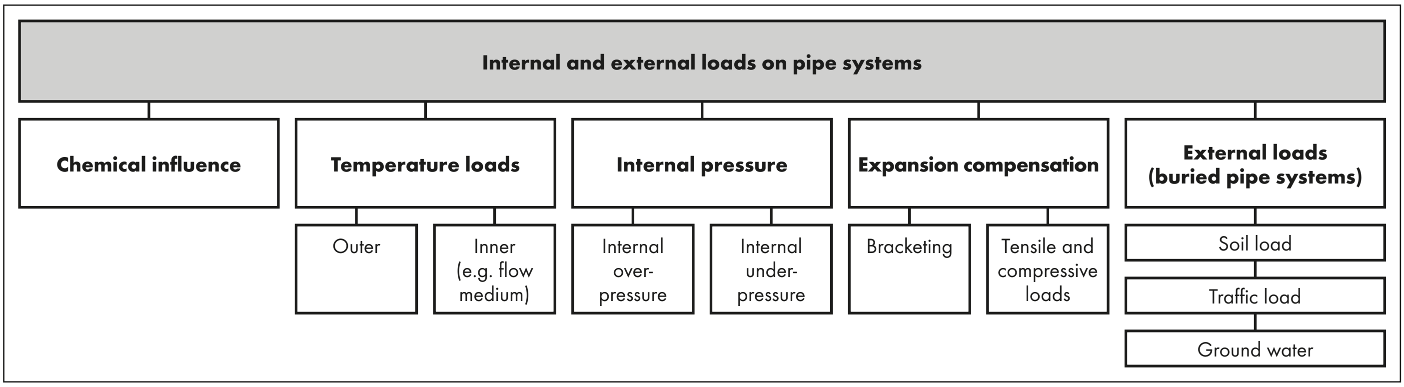


Illustration 5.9

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_{minFL} [bar]	Type of drinking water removal point		Calculation flow rate with the removal of: Mixed water $V_{R,cold}$ [l/s]	Mixed water $V_{R,hot}$ [l/s]	Only cold or only hot water 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
	Mixing battery[b), c)] for				
1,0	shower tubs	DN 15	0,15	0,15	-
1,0	bath tubs	DN 15	0,15	0,15	-
1,0	kitchen sinks	DN 15	0,07	0,07	-
1,0	wash stands	DN 15	0,07	0,07	-
1,0	bidets	DN 15	0,07	0,07	-

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.	≥ 15 min.
	m/s	m/s
Connection lines	2	2
Consumer lines: Part sections with resistance coefficient of fittings ζ < 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

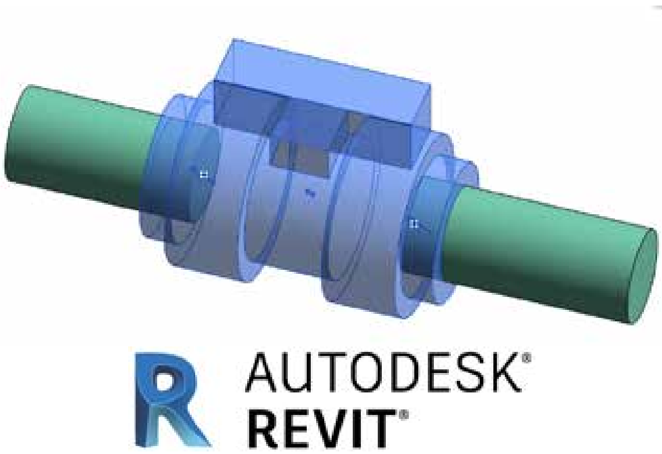
Pressure losses from individual resistances Z as a function of the flow speed.

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

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

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

Please visit www.wefatherm.de/solutions/bim to download the up-to-date BIM content.



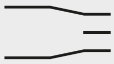
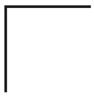
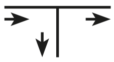
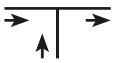
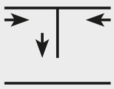
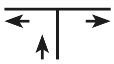
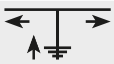
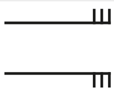
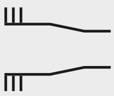
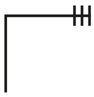
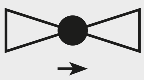
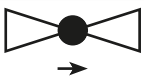
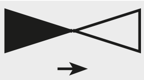
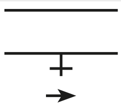
Nr.	Individual resistance		Graphical symbol	Resistance coefficient
1	Socket			0,25
2 2a	Reduction up to 2 dimensions Reduction from 3 dimensions			0,55 0,85
3 3a	Elbow 90° Elbow 90° i./a.			2,0 1,2
4 4a	Elbow 45° Elbow 45° i./a.			0,6 0,5
5 5a	Tee (separation) Tee (reduced)			1,8 3,6
6 6a	Tee (combination)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

Table 6.4

Engineering

6.2 Mechanical parameters

6.2.1 Longitudinal expansion

Polypropylene pipe systems extend when subjected to heat in accordance with their material characteristics. The longitudinal expansion of the Wefatherm stabi pipe or Wefatherm 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.

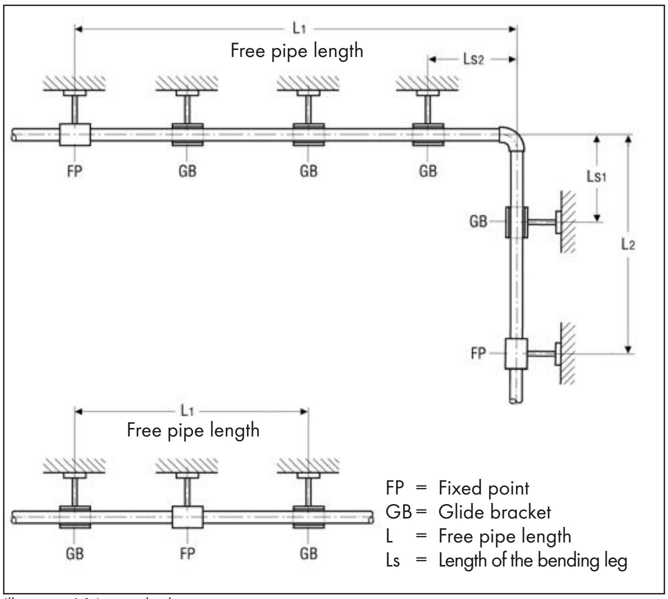


Illustration 6.1 Longitudinal expansion

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

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

Equation 6.2

Pipe length	Longitudinal expansion Temperature difference Δ_t (K)							
(m)	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

α **= 0,035 mm/m . K**

Equation 6.3

Pipe length	Longitudinal expansion Temperature difference Δ_t (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.

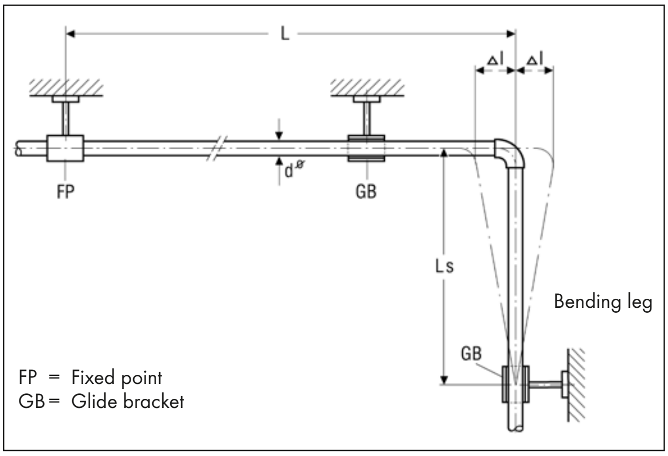


Illustration 6.2

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:

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

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:
   α = 0,15 mm/m . K
   L = 10,0 m
   Δt = 40 K (°C)

   To be calculated: ΔL
   $\alpha \times L \times \Delta t = \Delta L$
   0.15 x 10,0 x 40 = 60 mm

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

   Given:
   K = 15
   d = 40 mm
   ΔL = 60 mm

   To be calculated: L_s
   $K \times \sqrt{d \times \Delta L} = L_S$
   $15 \times \sqrt{40 \times 60} = 735$ mm

Equation 6.5

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.

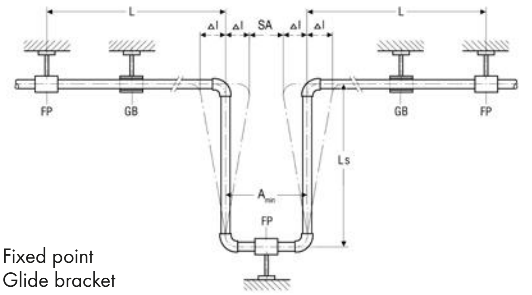


Illustration 6.3

Calculation example of expansion bow width Amin:

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:
ΔL = 60 mm
SA = 150 mm

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

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

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
ΔL = 60 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.

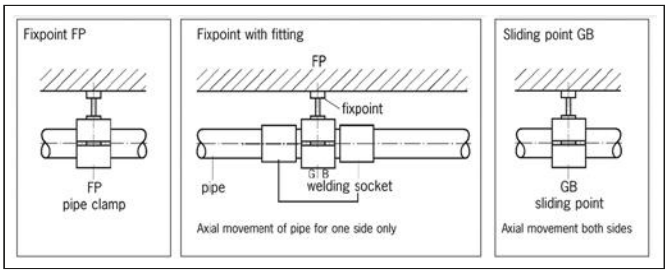


Illustration 6.4

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.	Pipe diameter (mm)									
TR (°C)	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.	Pipe diameter (mm)									
TR (°C)	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 λ = 0,040 W (mK)
Pipework laid exposed in unheated room (e.g. basement)	4 mm
Pipework laid exposed in heated room	9 mm
Pipework laid in channel with additional heated pipe lines	4 mm
Pipework laid in channel next to heated pipe lines	13 mm
Pipework laid in masonry slit rising main	
Pipework laid in wall recess next to heated pipe lines	13 mm
Pipework laid on cement floor 4 mm	4 mm

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

Engineering

6.4.3 Insulating cold water lines

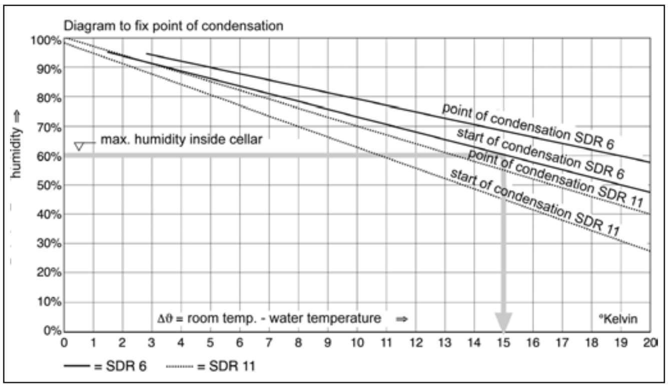
Condensation is formed by the precipitation of water vapour on a surface that is cooler than its environment. This causes the water vapour to condense and to form water droplets. Whether water vapour condenses to water on piping depends on the insulation and humidity.

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.

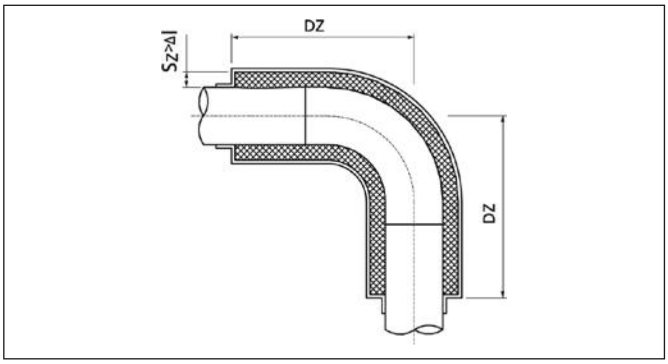


Illustration 6.6 Expansion zones in pipe bends

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.

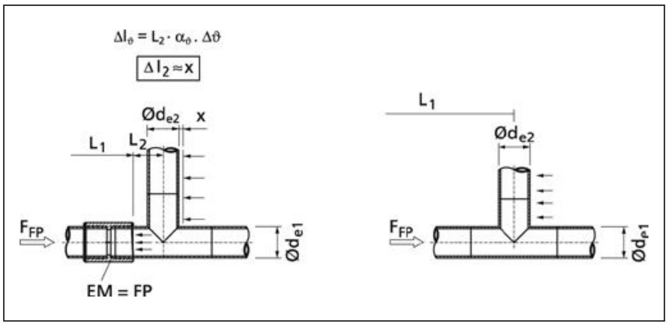


Illustration 6.7 Shear and fixed point forces on tees and 45° branches

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.

Name of project:

Client represented by:

Contractor/responsible expert

represented by:

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

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

Water temperature ϑw = ______________ °C

Ambient temperature ϑu = ______________ °C

Δϑ = ϑu-ϑw = ______________ 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

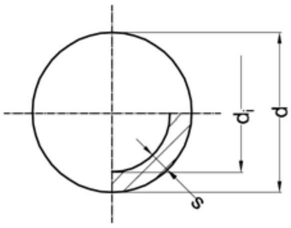
PP-R pipe system d20-315 mm

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



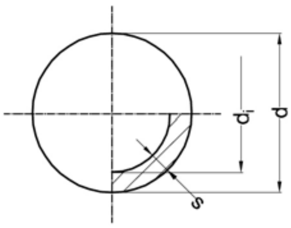
Suitable for hot and cold water, central heating and air conditioning.
ISO 15874 class 1/10, 2/8, 4/10, 5/6 bar.
DIN 8077/8078 20°C/20 bar, 70°C/10 bar.

Pipe 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.

wefatherm

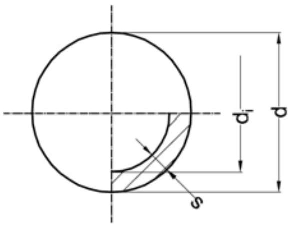
PP-R pipe system d20-315 mm

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



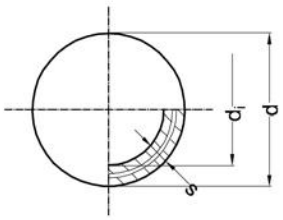
Suitable for hot and cold water, central heating and air conditioning.
ISO 15874 class 1/8, 2/6, 4/10, 5/6 bar.
DIN 8077/8078 20 °C/16 bar, 70 °C/8 bar.

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



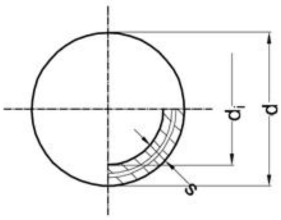
Recognizable by four red stripes.
Suitable for hot and cold water and central heating.
ISO 15874 class 1/8, 2/6, 4/10, 5/6 bar.
DIN 8077/8078 20 °C/16 bar, 70 °C/8 bar.

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



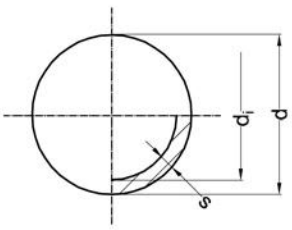
Recognizable by four red stripes.
Suitable for hot and cold water and central heating.
ISO 15874 class 1/8, 2/6, 4/8, 5/6 bar.
DIN 8077/8078 20°/20 bar, 70°/8 bar.

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.

wefatherm

PP-R pipe system d20-315 mm

Pipe SDR 11 PP-RCT

PP-RCT
SDR 11
green

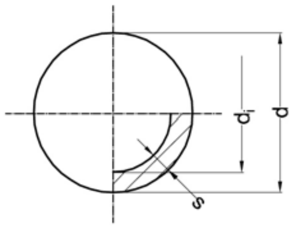
length of pipes = 4 m

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 11 PP-RCT

PP-RCT
SDR 11
green

length of pipes = 4 m

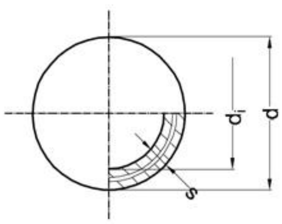
d	Item Code	s	d_i	l/m	DN	kg
160	**5152 27016**	**14,6**	130,8	13,4	125	27,100
200	**5152 27020** 1)	**18,2**	163,6	21,0	150	42,560
250	**5152 27025** 1)	**22,7**	204,6	32,9	200	66,440

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.

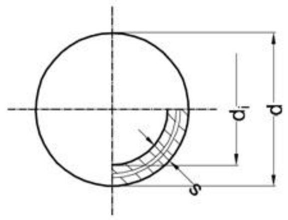


PP-R pipe system d20-315 mm

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

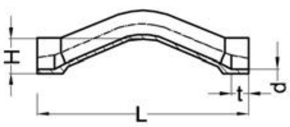
PP-R
SDR 6
green

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

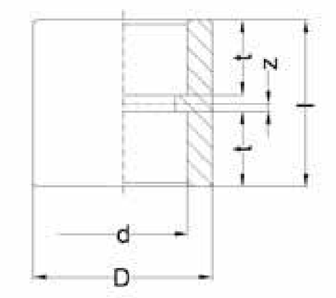
PP-R
SDR 6
green

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



Socket

PP-R
SDR 6
green

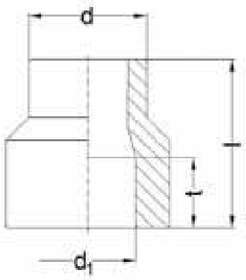


d	Item Code	D	l	z	t	kg
20	**5155 27002**	29,5	32	1,5	14,5	0,011
25	**5155 27003**	34,0	35	1,5	16,0	0,014
32	**5155 27004**	43,0	40	1,9	18,0	0,026
40	**5155 27005**	53,5	44	1,5	20,5	0,042
50	**5155 27006**	68,5	50	1,5	23,5	0,083
63	**5155 27007**	88,0	59	2,1	27,5	0,159
75	**5155 27008**	105,0	67	2,5	32,0	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

PP-R pipe system d20-315 mm

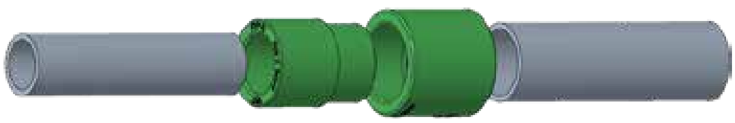
Reducer PP-R

PP-R
SDR 6
green



$d_1$xd	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

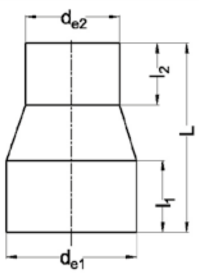
For each reducer, an additional socket with the dimension "d" is necessary.



Reducer PP-RCT

for butt-welding and electrofusion

PP-RCT
SDR 11
green

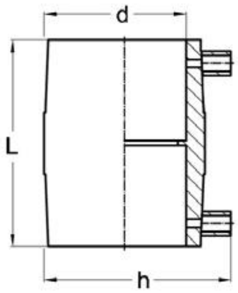


d_{e1}xd_{e2}	Item Code		L	l_1	l_2	kg
160x110	**5152 41830**		260	110	93	1,150
160x125	**5152 41831**		260	110	95	1,120
200x160	**5152 41934**	1)	151	50	40	1,330
200x160	**5152 41834**		280	122	115	2,600
250x160	**5152 41936**	1)	194	60	40	2,370
250x160	**5152 41836**		345	145	115	3,900
250x200	**5152 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*

Electrofusion coupler

PP-RCT
SDR 7,4
green

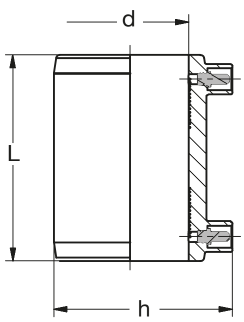


d	Item Code		L	h	kg
20	5152 50201		70	52	0,054
25	5152 50202		70	58	0,056
32	5155 50103	1)	70	65	0,071
40	5152 50204		85	75	0,111
50	5152 50205		88	87	0,149
63	5155 50106	1)	100	100	0,180
75	5152 50207		125	114	0,354
90	5152 50209		146	130	0,497
110	5155 50109	1) 2)	155	144	0,684
125	5152 50112	2)	166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

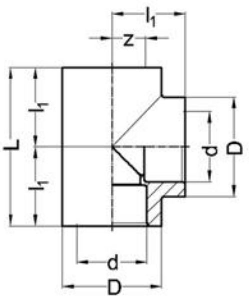
1) *SDR 11*

![wefatherm]

PP-R pipe system d20-315 mm

Tee 90° PP-R

PP-R
SDR 6
green



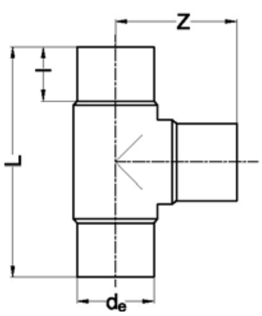
d	Item Code		D	L	l_1	z	kg
20	5155 24002		29,5	50,6	25,3	10,8	0,023
25	5155 24003		34,0	60,0	30,0	14,0	0,033
32	5155 24004		44,0	69,0	34,5	16,4	0,062
40	5155 24005		53,5	85,6	42,8	22,3	0,105
50	5155 24006		68,0	120,0	60,0	36,5	0,188
63	5155 24007		85,0	118,0	59,0	31,5	0,372
75	5152 41507	1)	99,5	140,6	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

for butt-welding and electrofusion

PP-RCT
SDR 11
green

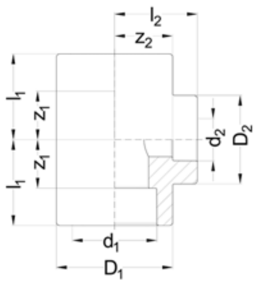


d_e	Item Code		L	Z	l	kg
160	5152 41616	1)	350	160	40	2,920
160	5152 41516		440	220	110	4,000
200	5152 41620	1)	430	215	64	6,470
200	5152 41520		520	260	127	7,400
250	5152 41625	1)	550	275	86	12,650
250	5152 41525		628	314	148	13,800
315	5152 41631	1)	700	350	111	25,700
315	5152 41531		700	350	157	27,600

1) *short version, suitable for butt-welding only*

Tee reduced 90°

PP-R
SDR 6
green



d_1xd_2xd_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*

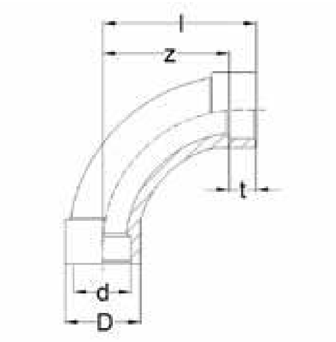
PP-R pipe system d20-315 mm

Bend 90°

PP-R
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

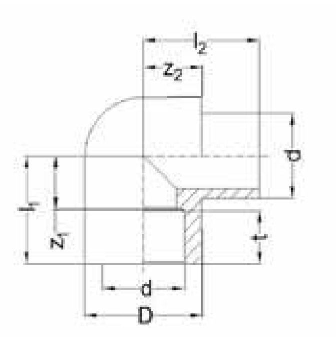
R ≈ 2 x d.



Elbow 90° s/m

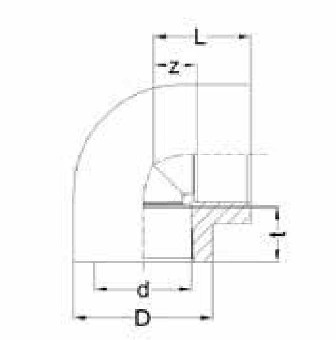
PP-R
SDR 6
green

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



Elbow 90°

PP-R
SDR 6
green

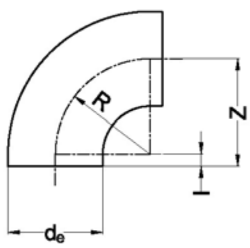


d	Item Code	D	L	z	t	kg
20	**5155 21002**	29,5	25,8	11,3	14,5	0,018
25	**5155 21003**	34,2	29,9	13,9	16,0	0,024
32	**5155 21004**	44,0	34,0	15,9	18,0	0,048
40	**5155 21005**	53,0	43,5	23,0	20,5	0,081
50	**5155 21006**	70,0	49,0	25,5	23,5	0,167
63	**5155 21007**	86,5	60,8	33,4	27,5	0,275
75	**5155 21008**	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

for butt-welding

PP-RCT
SDR 11
green



d_e	Item Code	Z	l	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

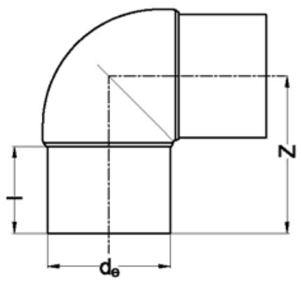
$R \approx 1 \times d_e$.

PP-R pipe system d20-315 mm

Elbow 90° long PP-RCT
SDR 11

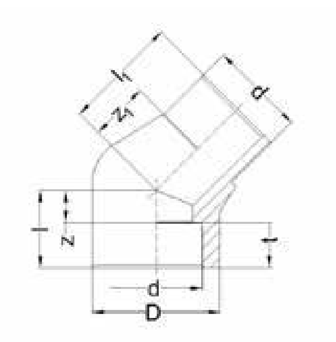
for butt-welding and electrofusion green

d_e	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



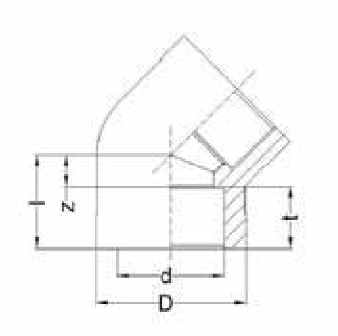
Elbow 45° s/m PP-R
SDR 6
green

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



Elbow 45°

PP-R
SDR 6
green

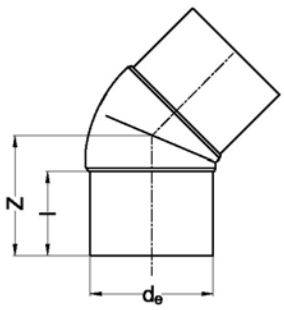


d	Item Code	D	l	z	t	kg
20	**5155 23002**	30,0	21,6	7,1	14,5	0,016
25	**5155 23003**	34,5	24,8	8,8	16,0	0,021
32	**5155 23004**	44,0	27,6	9,5	18,0	0,039
40	**5155 23005**	52,0	32,0	11,0	20,5	0,060
50	**5155 23006**	65,0	37,0	13,0	23,5	0,095
63	**5155 23007**	82,0	44,0	16,0	27,5	0,210
75	**5155 23008**	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

for butt-welding and electrofusion

PP-RCT
SDR 11
green

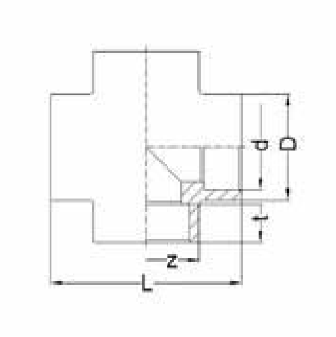


d_e	Item Code	Z	l	kg
160	**5152 41316**	170	107	2,400
200	**5152 41320**	201	127	4,400
250	**5152 41325**	225	155	8,000
315	**5152 41331**	280	161	15,000

PP-R pipe system d20-315 mm

Cross

PP-R
SDR 11
green

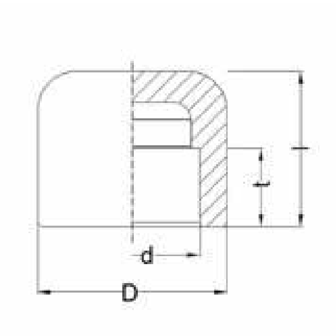


d	Item Code		D	L	z	t	kg
32	**5152 42403**	1)	40	77	34	18,0	0,058
40	**5155 25102**		51	93	42	20,5	0,111
50	**5155 25103**		63	112	66	23,5	0,212
63	**5152 42406**	1)	76	137	84	27,5	0,355

1) *PP-RCT*

End cap

PP-R
SDR 6
green



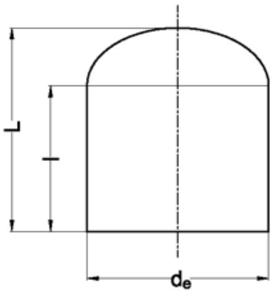
d	Item Code	D	l	t	kg
20	**5155 28002**	29,5	28,8	14,5	0,011
25	**5155 28003**	34,5	30,0	16,0	0,015
32	**5155 28004**	43,5	35,7	18,0	0,028
40	**5155 28005**	52,5	40,0	20,5	0,040
50	**5155 28006**	64,0	45,0	23,5	0,061
63	**5155 28007**	85,5	54,0	27,5	0,136
75	**5155 28008**	101,0	65,0	30,0	0,235
90	**5155 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

End cap long

for butt-welding and electrofusion

PP-RCT
SDR 11
green

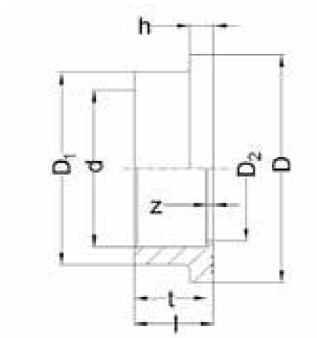
d_e	Item Code	L	l	kg
160	**5152 42216**	140	100	0,950
200	**5152 42220**	185	145	2,100
250	**5152 42225**	218	170	3,200
315	**5152 42231**	250	192	6,000



Flange sleeve
with EPDM gasket

PP-R
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



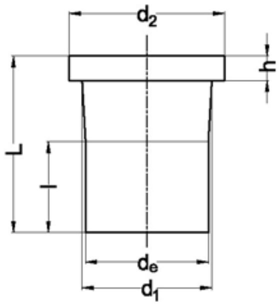
With grooved sealing surface.

Gasket with KTW-BWGL certification for potable water application.

PP-R pipe system d20-315 mm

Stub end
without gasket
for butt-welding and electrofusion

PP-RCT
SDR 11
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*

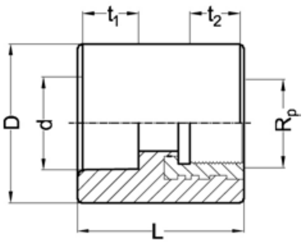
With grooved sealing surface.
For profile gaskets with steel core please see section “Complementary products”.

Transition round female

PP-R/brass
SDR 6
green

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

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

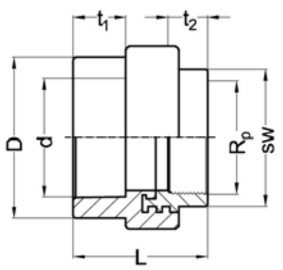


Transition hexagon female

PP-R/brass
SDR 6
green

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

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



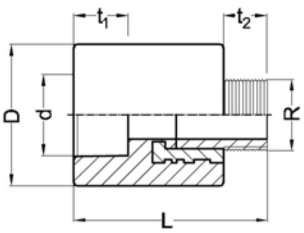
PP-R pipe system d20-315 mm

Transition round male

PP-R/brass
SDR 6
green

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

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

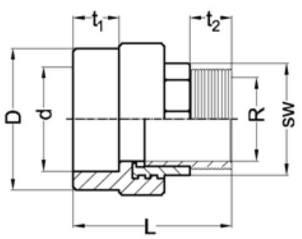


Transition hexagon male

PP-R/brass
SDR 6
green

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

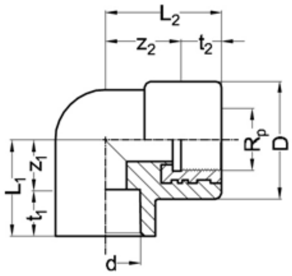
PP-R pipe system d20-315 mm

Transition elbow 90° female

PP-R/brass
SDR 6
green

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

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



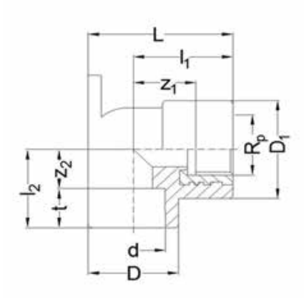
PP-R pipe system d20-315 mm

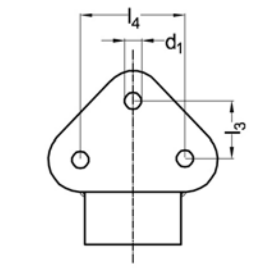
Back plate elbow female

PP-R/brass
SDR 6
green

dxR_p	Item Code	D	D_1	d_1	L	l_1	l_2	l_3	l_4	z_1	z_2	t	kg
20x½"	**5155 29002**	30,0	39	5,5	53,0	38,0	32	19,5	40	24,0	17,5	14,50	0,090
20x¾"	**5155 29003**	34,0	44	5,5	57,5	40,5	32	19,5	40	26,5	17,5	14,50	0,116
25x½"	**5155 29004**	34,0	40	5,5	54,5	37,5	32	19,5	40	23,5	16,0	16,00	0,095
25x¾"	**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.



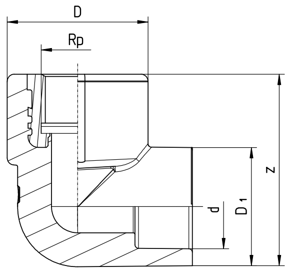


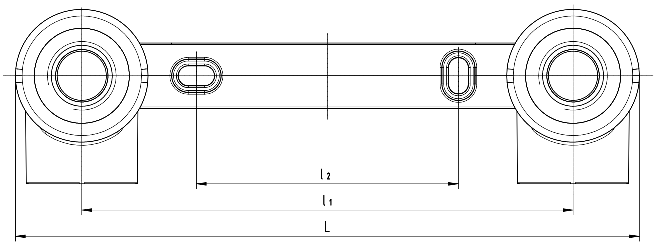
Double elbow tap connector

PP-R/brass
SDR 6
green

dxR	Item Code	D	D_1	d	z	L	l_1	l_2	kg
20x½"	**5155 29902**	40,5	34	20	55	190	150	80	0,205
25x½"	**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.



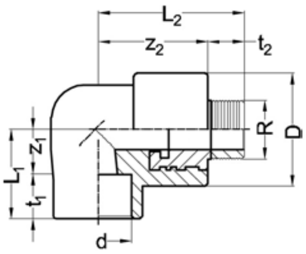


wefatherm

PP-R pipe system d20-315 mm

Transition elbow 90° male

PP-R/brass
SDR 6
green



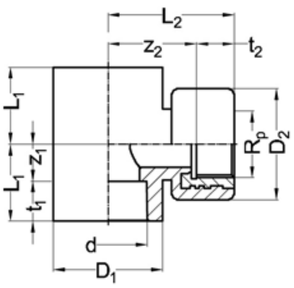
dxR	Item Code		D	L_1	t_1	z_1	t_2	Z_2	L_2	kg
20x½"	**5155 28401**		40	32	15	17	12	41	53	0,117
20x¾"	**5155 28402**		44	32	15	17	15	43	58	0,175
25x½"	**5155 28403**		40	32	16	16	12	41	53	0,114
25x¾"	**5155 28404**		44	32	16	16	15	43	58	0,173
32x¾"	**5155 28405**		44	30	18	12	15	52	67	0,179
32x 1"	**5155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

1) *with hexagon for wrench*

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

Transition tee female

PP-R/brass
SDR 6
green



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

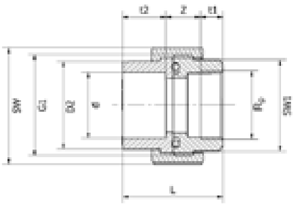
1) *with hexagon for wrench*

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

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 ½"	**5152 45402**	1"	27	15	16	11,5	42,5	37	26	0,146
25 x ¾"	**5152 45405**	1 ¼"	36	16,5	18	12,5	47	47	32	0,251
32 x 1"	**5152 45408**	1 ½"	41	19,1	20	13,4	52,5	55	38	0,341
40 x 1¼"	**5152 45411**	2"	52,5	21,5	22	14	57,5	66	47	0,520
50 x 1½"	**5152 45413**	2 ¼"	59	21,5	25	14,5	61	72	53	0,609
63 x 2"	**5152 45415**	2 ¾"	73,5	25,7	29	13,8	68,5	87	67	0,930

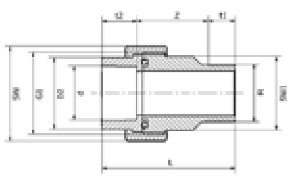


ISO 15874 Class 1/10, 2/10, 4/10, 5/8 bar.
DIN 8077/8078 20°C/10 bar, 70°C/10 bar.
Thread according to EN 10226 (ISO 7).
For sealing we recommend PTFE tape.

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 ½"	**5152 45302**	1"	27	15	16	24,5	55,5	37	26	0,180
25 x ¾"	**5152 45305**	1¼"	36	16,5	18	36	70,5	47	32	0,330
32 x 1"	**5152 45308**	1½"	41	19,5	20	37	76,5	55	38	0,480
40 x 1¼"	**5152 45311**	2"	52,5	21,5	22	36	79,5	66	47	0,680
50 x 1½"	**5152 45313**	2¼"	59	21,5	25	44	90,5	72	53	0,859
63 x 2"	**5152 45315**	2¾"	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.

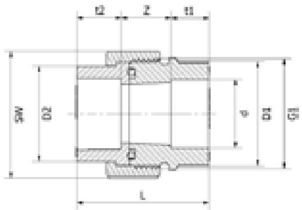
PP-R pipe system d20-315 mm

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**	1¼"	36	36	18	18	18,5	54,5	47	0,150
32	**5152 45603**	1½"	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**	2¼"	66	59	25	25	23,5	73,5	72	0,367
63	**5152 45606**	2¾"	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

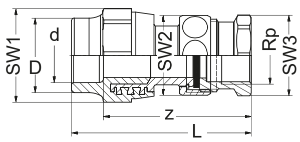
PP-R/brass
SDR 6
green

dxR_p	Item Code		G	D	L	z	SW_1	SW_2	SW_3	kg
20x ¾"	**5155 29602**	1)	1	29	102	86	44	37	34	0,289
25x ½"	**5155 29603**	1)	¾	34	94	78	36	30	27	0,202
32x ¾"	**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
75x2½"	**5152 45017**	2)	2¾	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.



Pipe union brass male

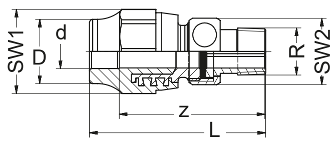
PP-R/brass
SDR 6
green

dxR	Item Code		G	D	L	z	SW_1	SW_2	kg
20x ¾"	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
75x2½"	5152 45117	2)	2¾	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.



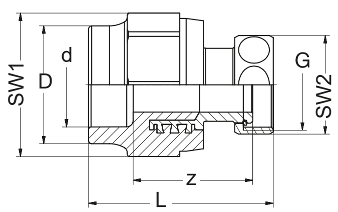
Pipe connection brass nut female

PP-R/brass
SDR 6
green

dxG	Item Code		D	L	z	SW_1	SW_2	kg
20x ¾"	5155 29801		29	66	44	36	30	0,130
20x 1"	5155 29802		29	72	48	44	37	0,234
25x ¾"	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
32x1¼"	5155 29806		43	80	53	51	46	0,398
40x1½"	5155 29807		55	90	58	63	52	0,477
50x1¾"	5155 29808		64	98	61	70	59	0,558
63x2⅜"	5155 29809		79	114	72	85	74	0,926
75x2¾"	5152 45217	1)	99	137	86	112	90	1,910

1) *PP-RCT*

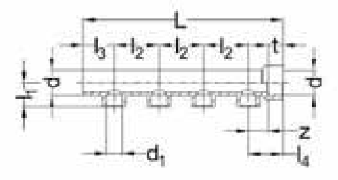
For the connection to ancillary equipment such as water meters.
Thread according to ISO 228-1.



PP-R pipe system d20-315 mm

Distributor manifold 4x

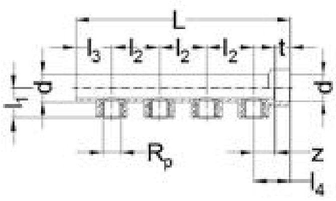
PP-RCT
SDR 6
green



dxd_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



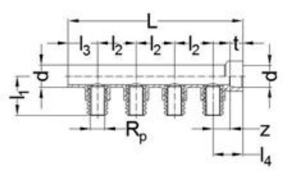
dxR_p	Item Code	z	L	l_1	l_2	l_3	l_4	t	kg
32/½"	**5152 42703** [1]	18,0	250	35	43	41	56	18,00	0,341
40/½"	**5155 20606**	20,5	250	38	43	41	56	20,50	0,396

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

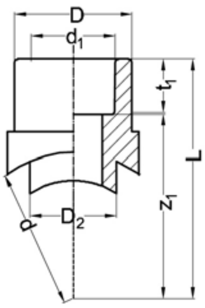


dxR	Item Code	z	z_1	L	l_1	l_2	l_3	l_4	t	kg
32/½"	**5155 20608**	18,0	15	250	50	43	41	56	18,00	0,413
40/½"	**5155 20610**	20,5	15	250	50	43	41	56	20,50	0,495

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

Weld-in saddle PP-R

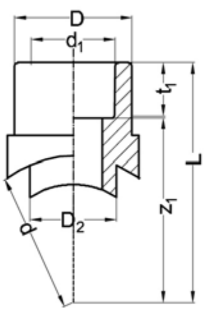
PP-R
SDR 6
green



d/d1	Item Code	D	D2	t1	z1	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



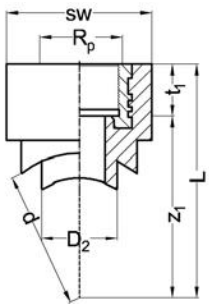
d/d1	Item Code	D	D2	t1	z1	L	SW	kg
63-125/32	**5152 43007**	51	32	20	9	-	38	0,035
75-125/32	**5152 43010** [1]	51	32	20	9	-	51	0,035
75-125/40	**5152 43011**	63	40	22	16	-	63	0,083
90-125/50	**5152 43015**	70	50	39	14	-	70	0,098
110-125/63	**5152 43024**	85	63	30	15	-	85	0,163
160-250/20	**5152 43026**	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

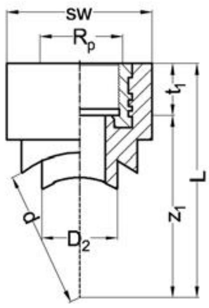


dxR_p	Item Code	D_2	t_1	z_1	L	SW	kg
40x ½"	**5155 28071**	25	15	35	50	38	0,067
50x ½"	**5155 28072**	25	15	34	49	46	0,067
63x ½"	**5155 28073**	25	15	39	54	38	0,068
75x ½"	**5155 28074**	25	15	39	54	46	0,066
90x ½"	**5155 28075**	25	15	45	60	38	0,061
110x ½"	**5155 28076**	25	15	46	61	46	0,070
125x ½"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

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

Weld-in saddle female PP-RCT

PP-RCT/brass
SDR 6
green



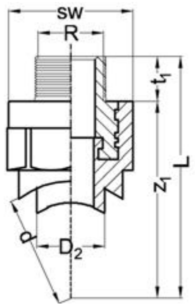
dxR_p	Item Code	D_2	t_1	z_1	L	SW	kg
75-125x 1"	**5152 43110**	40	22	16	-	63	0,170
90-125x1¼"	**5152 43114**	50	22	17	-	70	0,250
90-125x1½"	**5152 43115**	50	20	39	-	85	0,220
110-125x1½"	**5152 43118** 1)	50	20	19	-	70	0,292
110-125x 2"	**5152 43124**	63	25	20	-	85	0,485
160-250x ½"	**5152 43126**	25	17	12	-	38	0,071
160-250x ¾"	**5152 43127**	32	17	12	-	51	0,112
160-250x 1"	**5152 43128**	40	22	16		63	0,197
160-250x1¼"	**5152 43129**	50	22	17	-	70	0,213
160-250x1½"	**5152 43130**	50	20	19	-	70	0,240
160-250x 2"	**5152 43131**	63	25	20	-	85	0,490
315x ¾"	**5152 43138**	32	17	12	-	51	0,240
315x 1"	**5152 43139**	40	22	16	-	63	0,240
315x1¼"	**5152 43140**	50	22	17	-	70	0,247
315x1½"	**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.

Weld-in saddle male PP-R

PP-R/brass
SDR 6
green

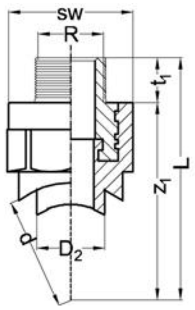


dxR	Item Code	D_2	t_1	z_1	L	SW	kg
40x ½"	**5155 28081**	25	13	49	62	38	0,085
50x ½"	**5155 28082**	25	17	49	66	46	0,091
63x ½"	**5155 28083**	25	13	54	67	38	0,083
75x ½"	**5155 28084**	25	17	54	71	46	0,083
90x ½"	**5155 28085**	25	13	61	74	38	0,083
110x ½"	**5155 28086**	25	17	60	77	46	0,084
125x ½"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

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

Weld-in saddle male PP-RCT

PP-RCT/brass
SDR 6
green



dxR	Item Code	D_2	t_1	z_1	SW	kg
75-125x 1"	**5152 43210**	40	20	18	63	0,210
90-125x1¼"	**5152 43214**	50	21	17	70	0,340
90-125x1½"	**5152 43215**	50	21	18	70	0,350
110-125x1½"	**5152 43218** [1]	50	21	18	85	0,553
110-125x 2"	**5152 43224**	63	24	21	85	0,650
160-250x ½"	**5152 43226**	25	13	20	38	0,091
160-250x ¾"	**5152 43227**	32	17	26	51	0,133
160-250x 1"	**5152 43228**	40	20	36	63	0,234
160-250x1¼"	**5152 43229**	50	21	38	70	0,334
160-250x1½"	**5152 43230**	50	21	38	70	0,353
160-250x 2"	**5152 43231**	63	24	46	85	0,730
315x ¾"	**5152 43238**	32	17	26	38	0,183
315x 1"	**5152 43239**	40	20	36	63	0,239
315x1¼"	**5152 43240**	50	21	38	70	0,342
315x1½"	**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.

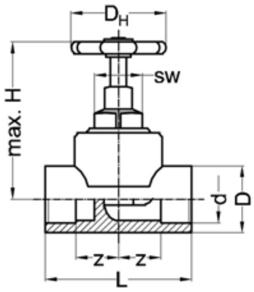
PP-R pipe system d20-315 mm

Stop valve surface assembly

PP-R
SDR 6
green

for surface installation

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



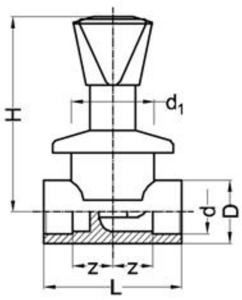
Stop valve concealed assembly

PP-R/chrome plated
SDR 6
green

for concealed installation

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.



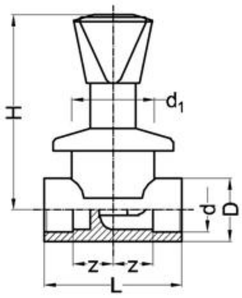
Stop valve concealed assembly - extended

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.



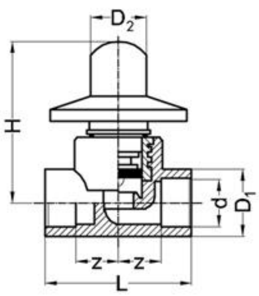
Stop valve concealed assembly (tamper resistant)

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.



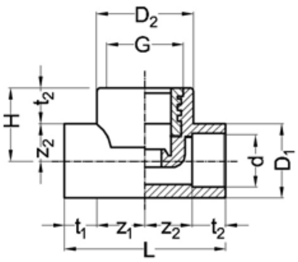
PP-R pipe system d20-315 mm

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.

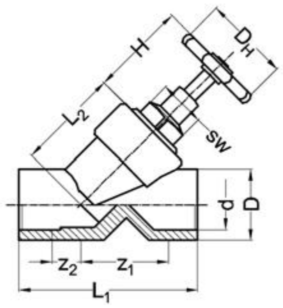


Y-valve

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

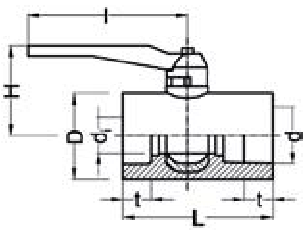


Ball valve

PP-R
SDR 6
green

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

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



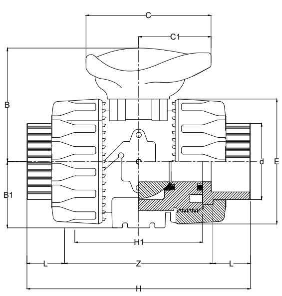
Double union ball valve – Dual Block®

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

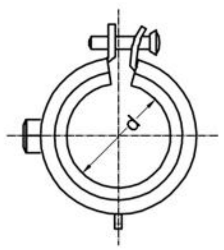
brass

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 ¾" 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

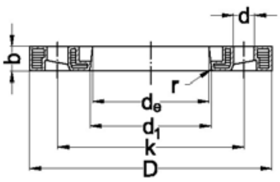
1) *Discontinued, as long as stock lasts.*

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.

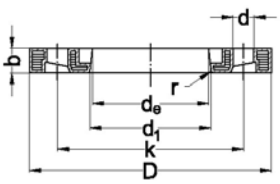


Profile backing ring PP d160-315
EN 1092 - PN10 bolt hole pattern
for stub end (butt-welding connection)

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.

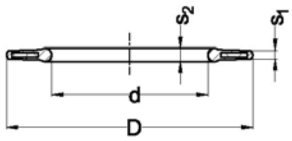


Complementary products

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

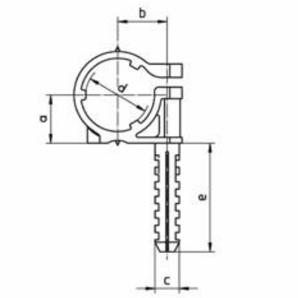
d	Item Code	kg
7/11	**5155 28030**	0,004

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
½"	**5150 36100**	red	0,016
½"	**5150 36101**	blue	0,016

wefatherm

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

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 PE-X 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 PE-X 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.

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 pratical 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 pratical aluminium transport box.

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.

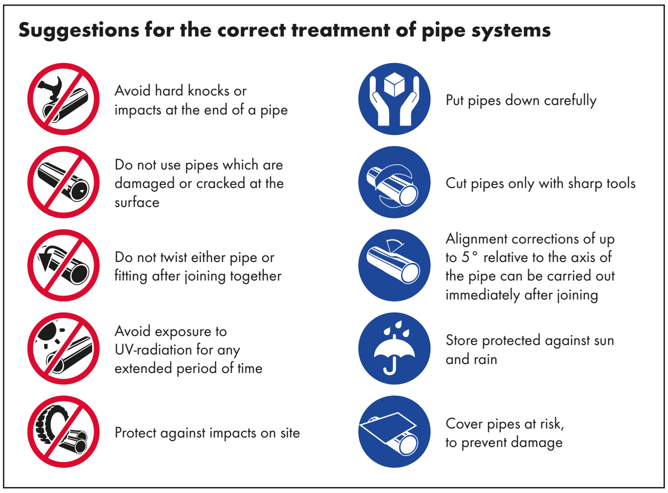


Illustration 8.3

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

9 Jointing techniques

9.1 Health and safety regulations

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

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

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

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

Wear suitable work clothing

Wear a safety helmet

Wear safety shoes

Wear safety glasses

Wear hearing protection

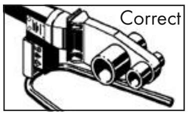
Improper use can cause severe cuts, bruising or dismemberment

9.2 Socket welding

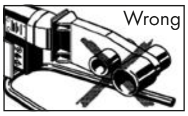
9.2.1 Socket welding - manual

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

Welding device



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



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

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

Pipe outside diameter (mm)	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.

Jointing techniques

9.2.2 Socket welding - mechanical

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

Welding device

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

Illustration 9.1

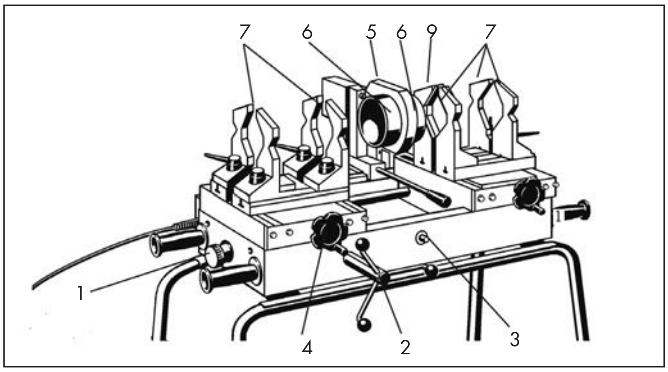


Illustration 9.2

Setting up the welding machine

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

Aligning the welding machine

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

Socket welding - machined process

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

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

Maintenance

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

Pipe outside diameter (mm)	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.

Jointing techniques

9.3 Butt-welding

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

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

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

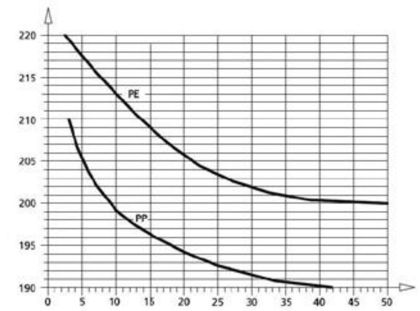
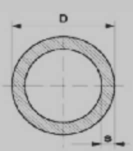
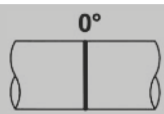


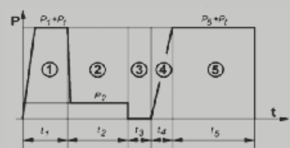
Illustration 9.3 Heating temperature as function of PP pipe wall thickness

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

Delta 250B
DVS 2207-11
PP







						1	2	3	4	5	
D (mm)	**s (mm)**	**SDR = D/s**	**T (ºC)**	***P1 (bar)**		**P_2 (bar)**	**t_2 (sec)**	**$t_{3\,max}$ (sec)**	**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

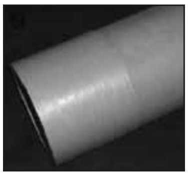
*Table 9.3 *Add to this value the drag pressure of the welding machine*

9.4 Electrofusion welding

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

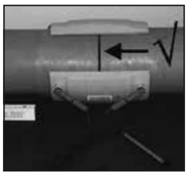
Installation

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



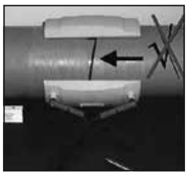
2. Prepare the pipe surface in the welding area. Remove the oxidation layer in the welding area, depth of the coupler + 0,5 cm processing surcharge. Use a rotary scraper tool. Remove the chips without touching the pipe surface.

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



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

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



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

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

Table 9.4

Jointing 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.

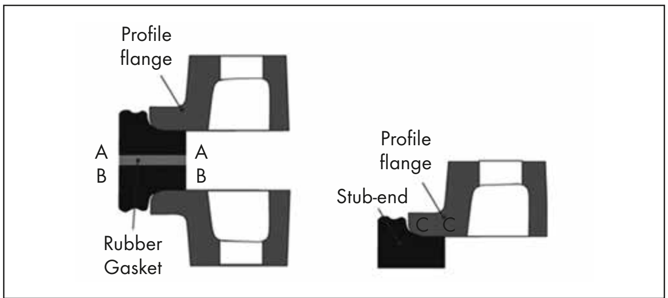


Illustration 9.4

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).

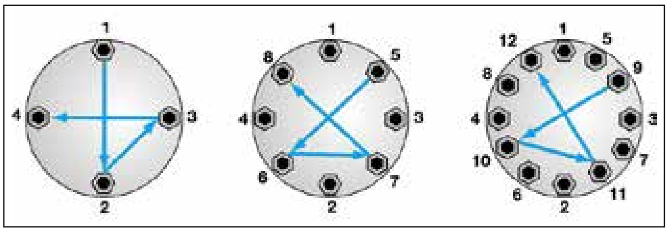


Illustration 9.5

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

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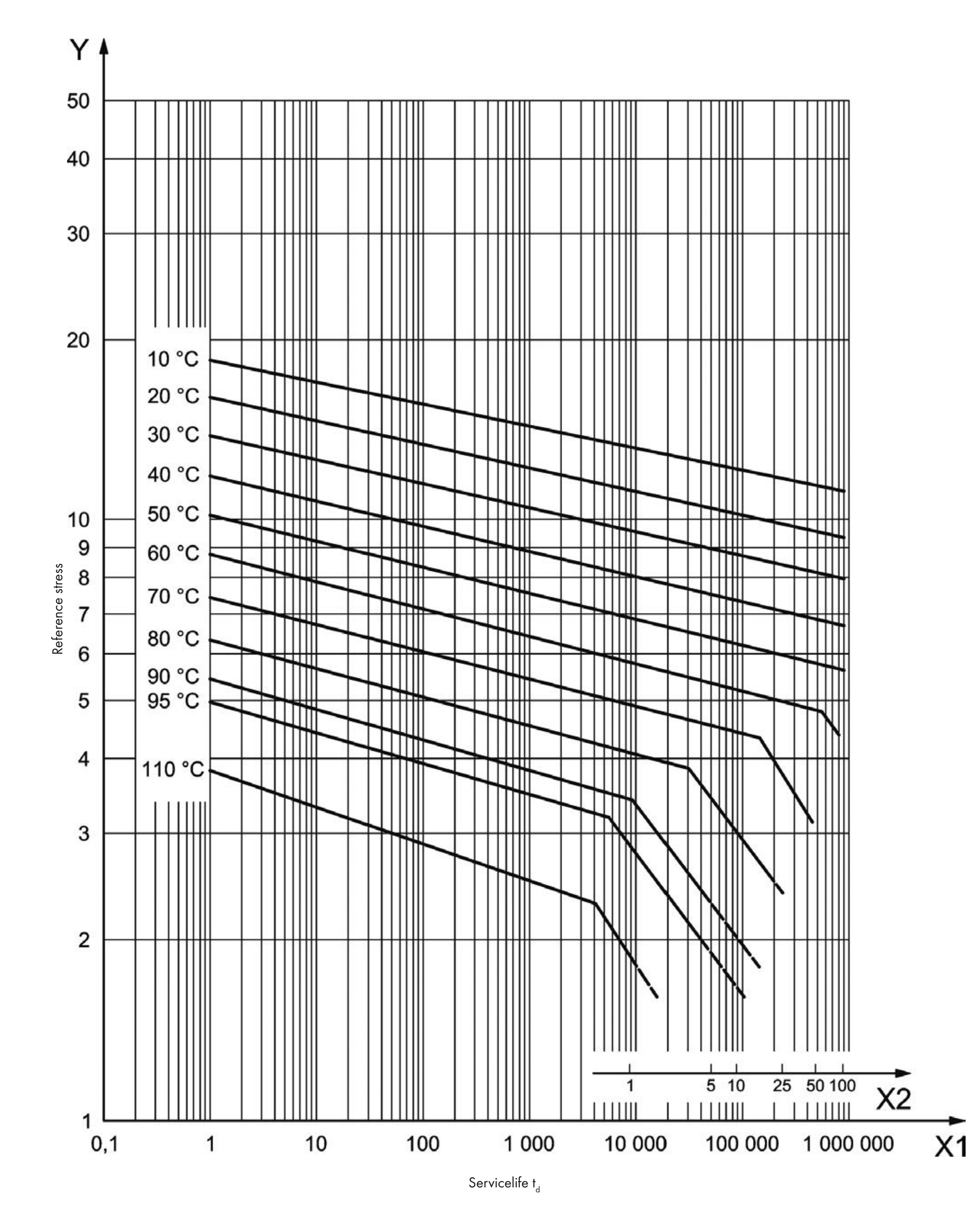
Appendix A

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/cm^3

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.

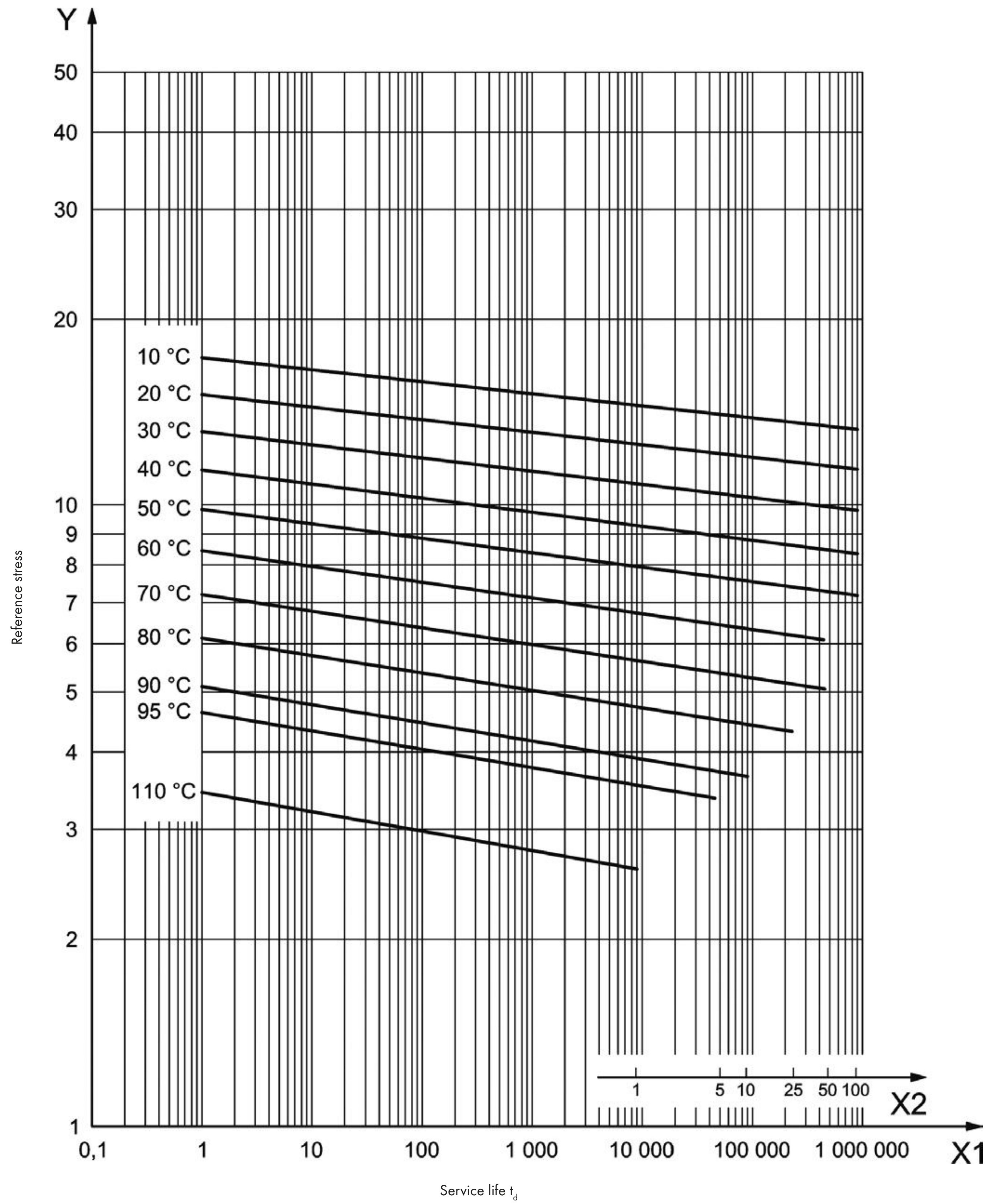
We also certify that during the manufacturing of the above product we do not use or intentionally incorporate into it any of the following materials:

Acrylamide
Aromatic Amines (restricted in Regulation 1907/2006/EC, Annex XVII)
Artificial Musks
Asbestos
Azocolorants (restricted in Regulation 1907/2006/EC, Annex XVII) Azodicarbonamide, semicarbazide
Benzophenones (e.g. 4-MBP, 4-HBP, 2,2´-Dimethoxy-2-phenylacetophenone)
Biocides (Pesti-, Herbi-, Insecti-, Fungi-, Bactericides)
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 Nonylphenolethoxylates; 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



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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.

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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 Musks
Asbestos
Azocolorants (restricted in Regulation 1907/2006/EC, Annex XVII) Azodicarbonamide, semicarbazide
Benzophenones (e.g. 4-MBP, 4-HBP, 2,2´-Dimethoxy-2-phenylacetophenone)
Biocides (Pesti-, Herbi-, Insecti-, Fungi-, Bactericides)
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 Nonylphenolethoxylates; 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 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	Operating years	Maximum Operating Pressure			
°C		SDR 11	SDR 7,4	SDR 6	SDR 5
10	1	21,1	33,4	42,1	53,0
	5	19,8	31,5	39,7	49,9
	10	19,3	30,7	38,6	48,7
	25	18,7	29,7	37,4	47,0
	50	18,2	28,9	36,4	45,9
	100	17,8	28,2	35,5	44,7
20	1	18,0	28,5	35,9	45,2
	5	16,9	26,8	33,7	42,5
	10	16,4	26,1	32,8	41,4
	25	15,9	25,2	31,7	39,9
	50	15,4	24,5	30,9	38,9
	100	15,0	23,9	30,2	37,8
30	1	15,3	24,2	30,5	38,5
	5	14,3	22,7	28,6	36,0
	10	13,9	22,1	27,8	35,0
	25	13,4	21,3	26,8	33,8
	50	13,0	20,7	26,1	32,9
	100	12,7	20,1	25,4	31,9
40	1	13,0	20,6	25,9	32,6
	5	12,1	19,2	24,2	30,5
	10	11,8	18,7	23,5	29,6
	25	11,3	18,0	22,6	28,5
	50	11,0	17,4	22,0	27,7
	100	10,7	16,9	21,4	26,9
50	1	11,0	17,4	21,9	27,6
	5	10,2	16,2	20,4	25,7
	10	9,9	15,7	19,8	25,0
	25	9,5	15,1	19,0	24,0
	50	9,2	14,7	18,5	23,3
	100	9,0	14,2	17,9	22,6
60	1	9,2	14,7	18,5	23,3
	5	8,6	13,6	17,2	21,6
	10	8,3	13,2	16,6	21,0
	25	8,0	12,7	16,0	20,1
	50	7,7	12,3	15,5	19,5
70	1	7,8	12,3	15,5	19,6
	5	7,2	11,4	14,4	18,1
	10	7,0	11,1	13,9	17,5
	25	6,0	9,6	12,1	15,2
	50	5,1	8,1	10,2	12,8
80	1	6,5	10,3	13,0	16,4
	5	5,7	9,1	11,5	14,5
	10	4,8	7,7	9,7	12,2
	25	3,9	6,2	7,8	9,8
95	1	4,6	7,3	9,2	11,6
	5	3,1	4,9	6,2	7,8
	(10)	(2,6)	(4,1)	(5,2)	(6,6)

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

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

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

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 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
70	1	9,0	11,3	14,3	18,0	22,7
	5	8,6	10,9	13,7	17,3	21,7
	10	8,5	10,7	13,5	16,9	21,3
	25	8,3	10,4	13,1	16,5	20,8
	50	8,1	10,2	12,9	16,2	20,5
80	1	7,5	9,5	11,9	15,0	18,9
	5	7,2	9,0	11,4	14,4	18,1
	10	7,0	8,9	11,2	14,1	17,7
	25	6,9	8,6	10,9	13,7	17,3
95	1	5,6	7,1	8,9	11,2	14,2
	5	5,3	6,7	8,5	10,7	13,5
	(10)	(5,2)	(6,6)	(8,3)	(10,5)	(13,2)

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

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
70	1	7,5	9,4	11,9	15,0	18,9
	5	7,2	9,1	11,4	14,4	18,1
	10	7,0	8,9	11,2	14,1	17,8
	25	6,9	8,7	10,9	13,8	17,4
	50	6,8	8,5	10,7	13,5	17,0
80	1	6,2	7,9	9,9	12,5	15,8
	5	6,0	7,5	9,5	12,0	15,1
	10	5,9	7,4	9,3	11,7	14,8
	25	5,7	7,2	9,1	11,4	14,4
95	1	4,7	5,9	7,4	9,4	11,8
	5	4,4	5,6	7,1	8,9	11,2
	(10)	(4,3)	(5,5)	(6,9)	(8,7)	(11,0)

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

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.

wefatherm

Appendix B

Appendix B7-1

Maximum flow rate

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

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

Appendix B7-2

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

$\sum V_R$	V_S	$\sum V_R$	V_S	$\sum V_R$	V_S	$\sum V_R$	V_S	$\sum V_R$	V_S	$\sum V_R$	V_S	$\sum V_R$	V_S	$\sum V_R$	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 V̊.

Pipe roughness:	K = 0,007 mm	V̊ = flow rate (l/s)
Density:	ρ = 998,2 kg/m³	R = pressure gradient (mbar/m)
Temperature:	t = 20 °C	v = flow speed (m/s)
Kinematic viskosity:	ν = 1,003 x 10^{-6} m²/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
V̊	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 mm	$\dot{V}$ = flow rate (l/s)
Density:	ρ = 998,2 kg/m³	R = pressure gradient (mbar/m)
Temperature:	t = 20 °C	v = flow speed (m/s)
Kinematic viskosity:	ν = 1,003 x 10^{-6} m²/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 $\mathring{V}$.

Pipe roughness:	K = 0,007 mm	$\mathring{V}$ = flow rate (l/s)
Density:	ρ = 998,2 kg/m³	R = pressure gradient (mbar/m)
Temperature:	t = 20 °C	v = flow speed (m/s)
Kinematic viskosity:	ν = 1,003 x 10^{-6} m²/s	

d x s $\mathring{V}$	d_i	20 x 3,4 13,2 mm	25 x 4,2 16,6 mm	32 x 5,4 21,2 mm	40 x 6,7 26,6 mm	50 x 8,3 33,4 mm	63 x 10,5 42,0 mm	75 x 12,5 50,0 mm	90 x 15,0 60,0 mm	110 x 18,3 73,4 mm	125 x 20,8 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 $\mathring{V}$.

Pipe roughness: K = 0,007 mm
Density: ρ = 983,2 kg/m³
Temperature: t = 60 °C
Kinematic viskosity: ν = 0,47 x 10⁻⁶ m²/s

$\mathring{V}$ = flow rate (l/s)
R = pressure gradient (mbar/m)
v = flow speed (m/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
$\mathring{V}$	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	-

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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 mm
Density: ρ = 983,2 kg/m³
Temperature: t = 60 °C
Kinematic viskosity: ν = 0,47 x 10^{-6} m²/s

$\dot{V}$ = flow rate (l/s)
R = pressure gradient (mbar/m)
v = flow speed (m/s)

d x s $\dot{V}$	d_i	20 x 3,4 13,2 mm	25 x 4,2 16,6 mm	32 x 5,4 21,2 mm	40 x 6,7 26,6 mm	50 x 8,3 33,4 mm	63 x 10,5 42,0 mm	75 x 12,5 50,0 mm	90 x 15,0 60,0 mm	110 x 18,3 73,4 mm	125 x 20,8 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 V̊.

Pipe roughness:	K = 0,007 mm	V̊ = flow rate (l/s)
Density:	ρ = 983,2 kg/m³	R = pressure gradient (mbar/m)
Temperature:	t = 60 °C	v = flow speed (m/s)
Kinematic viskosity:	ν = 0,47 x 10^{-6} m²/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
V̊	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 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 V̊.

Pipe roughness:	K = 0,007 mm	V̊ = flow rate (l/s)
Density:	ρ = 998,2 kg/m³	R = pressure gradient (mbar/m)
Temperature:	t = 20 °C	v = flow speed (m/s)
Kinematic viskosity:	ν = 1,003 x 10^{-6} m²/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
V̊	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 $\mathring{V}$.

Pipe roughness: K = 0,007 mm
Density: ρ = 998,2 kg/m³
Temperature: t = 20°C
Kinematic viskosity: ν = 1,003 x 10^{-6} m²/s

$\mathring{V}$ = flow rate (l/s)
R = pressure gradient (mbar/m)
v = flow speed (m/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
$\mathring{V}$	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

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Appendix B

Appendix B8-9

Pipe friction gradient/flow speed of Wefatherm pipes SDR 7,4

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

Pipe roughness: K = 0,007 mm
Density: ρ = 998,2 kg/m³
Temperature: t = 20 °C
Kinematic viskosity: ν = 1,003 x 10^{-6} m²/s

V̊ = flow rate (l/s)
R = pressure gradient (mbar/m)
v = flow speed (m/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**
V̊	**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 $\mathring{V}$.

Pipe roughness: K = 0,007 mm
Density: ρ = 983,2 kg/m³
Temperature: t = 60 °C
Kinematic viskosity: ν = 0,47 x 10^{-6} m²/s

$\mathring{V}$ = flow rate (l/s)
R = pressure gradient (mbar/m)
v = flow speed (m/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
$\mathring{V}$	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 V̊.

Pipe roughness:	K = 0,007 mm	V̊ = flow rate (l/s)
Density:	ρ = 983,2 kg/m³	R = pressure gradient (mbar/m)
Temperature:	t = 60 °C	v = flow speed (m/s)
Kinematic viskosity:	ν = 0,47 x 10⁻⁶ m²/s	

d x s V̊	d_i	20 x 2,8 14,4 mm	25 x 3,5 18,0 mm	32 x 4,4 23,2 mm	40 x 5,5 29,0 mm	50 x 6,9 36,2 mm	63 x 8,6 45,8 mm	75 x 10,3 54,4 mm	90 x 12,3 65,4 mm	110 x 15,1 79,8 mm	125 x 17,1 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 mm
Density: ρ = 983,2 kg/m³
Temperature: t = 60 °C
Kinematic viskosity: ν = 0,47 x 10^{-6} m²/s

$\dot{V}$ = flow rate (l/s)
R = pressure gradient (mbar/m)
v = flow speed (m/s)

d x s / $\dot{V}$	d_i	20 x 2,8 14,4 mm	25 x 3,5 18,0 mm	32 x 4,4 23,2 mm	40 x 5,5 29,0 mm	50 x 6,9 36,2 mm	63 x 8,6 45,8 mm	75 x 10,3 54,4 mm	90 x 12,3 65,4 mm	110 x 15,1 79,8 mm	125 x 17,1 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 B8-13

Pipe frinction gradient/flow speed of Wefatherm pipes SDR 9

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

Pipe roughness: K = 0,007 mm
Density: ρ = 998,2 kg/m³
Temperature: t = 20 °C
Kinematic viskosity: ν = 1,003 x 10^{-6} m²/s

$\mathring{V}$ = flow rate (l/s)
R = pressure gradient (mbar/m)
v = flow speed (m/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
$\mathring{V}$	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 frinction gradient/flow speed of Wefatherm pipes SDR 9

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

Pipe roughness:	K = 0,007 mm	$\mathring{V}$ = flow rate (l/s)	
Density:	ρ = 998,2 kg/m³	R = pressure gradient (mbar/m)	
Temperature:	t = 20 °C	v = flow speed (m/s)	
Kinematic viskosity:	ν = 1,003 x 10⁻⁶ m²/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
$\mathring{V}$	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 frinction gradient/flow speed of Wefatherm pipes SDR 9
Pipe friction gradient R and calculated flow speed in dependence of flow rate $\mathring{V}$.

Pipe roughness: K = 0,007 mm
Density: ρ = 998,2 kg/m³
Temperature: t = 20 °C
Kinematic viskosity: ν = 1,003 x 10^{-6} m²/s

$\mathring{V}$ = flow rate (l/s)
R = pressure gradient (mbar/m)
v = flow speed (m/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
$\mathring{V}$	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 $\mathring{V}$.

Pipe roughness:	K = 0,007 mm	$\mathring{V}$ = flow rate (l/s)
Density:	ρ = 983,3 kg/m³	R = pressure gradient (mbar/m)
Temperature:	t = 60 °C	v = flow speed (m/s)
Kinematic viskosity:	ν = 0,478 x 10^{-6} m²/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
$\mathring{V}$	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 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 V̊.

Pipe roughness: K = 0,007 mm
Density: ρ = 983,3 kg/m³
Temperature: t = 60 °C
Kinematic viskosity: ν = 0,478 x 10^{-6} m²/s

V̊ = flow rate (l/s)
R = pressure gradient (mbar/m)
v = flow speed (m/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
V̊	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 V̊.

Pipe roughness:	K = 0,007 mm	V̊ = flow rate (l/s)	
Density:	ρ = 983,3 kg/m³	R = pressure gradient (mbar/m)	
Temperature:	t = 60 °C	v = flow speed (m/s)	
Kinematic viskosity:	ν = 0,478 x 10^{-6} m²/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
V̊	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 $\mathring{V}$.

Pipe roughness: K = 0,007 mm
Density: ρ = 998,2 kg/m³
Temperature: t = 20 °C
Kinematic viskosity: ν = 1,003 x 10^{-6} m²/s

$\mathring{V}$ = flow rate (l/s)
R = pressure gradient (mbar/m)
v = flow speed (m/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
$\mathring{V}$	d_i	16,2 mm	20,4 mm	26,0 mm	32,6 mm	40,8 mm	51,4 mm	61,2 mm	73,6 mm	90,0 mm	102,2 mm
0,01	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 $\mathring{V}$.

Pipe roughness: K = 0,007 mm
Density: ρ = 998,2 kg/m³
Temperature: t = 20 °C
Kinematic viskosity: ν = 1,003 x 10^{-6} m²/s

$\mathring{V}$ = flow rate (l/s)
R = pressure gradient (mbar/m)
v = flow speed (m/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
$\mathring{V}$	d_i	16,2 mm	20,4 mm	26,0 mm	32,6 mm	40,8 mm	51,4 mm	61,2 mm	73,6 mm	90,0 mm	102,2 mm
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

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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 $\mathring{V}$.

Pipe roughness:	K = 0,007 mm	$\mathring{V}$ = flow rate (l/s)
Density:	ρ = 998,2 kg/m³	R = pressure gradient (mbar/m)
Temperature:	t = 20 °C	v = flow speed (m/s)
Kinematic viskosity:	ν = 1,003 x 10^{-6} m²/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
$\mathring{V}$	d_i	16,2 mm	20,4 mm	26,0 mm	32,6 mm	40,8 mm	51,4 mm	61,2 mm	73,6 mm	90,0 mm	102,2 mm
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 $\mathring{V}$.

Pipe roughness: K = 0,007 mm
Density: ρ = 983,2 kg/m³
Temperature: t = 60 °C
Kinematic viskosity: ν = 0,47 x 10⁻⁶ m²/s

$\mathring{V}$ = flow rate (l/s)
R = pressure gradient (mbar/m)
v = flow speed (m/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
$\mathring{V}$	d_i	16,2 mm	20,4 mm	26,0 mm	32,6 mm	40,8 mm	51,4 mm	61,2 mm	73,6 mm	90,0 mm	102,2 mm
0,01	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 $\mathring{V}$.

Pipe roughness: K = 0,007 mm
Density: ρ = 983,2 kg/m³
Temperature: t = 60 °C
Kinematic viskosity: ν = 0,47 x 10^{-6} m²/s

$\mathring{V}$ = flow rate (l/s)
R = pressure gradient (mbar/m)
v = flow speed (m/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
$\mathring{V}$	d_i	16,2 mm	20,4 mm	26,0 mm	32,6 mm	40,8 mm	51,4 mm	61,2 mm	73,6 mm	90,0 mm	102,2 mm
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 $\mathring{V}$.

Pipe roughness: K = 0,007 mm

Density: ρ = 983,2 kg/m³

Temperature: t = 60 °C

Kinematic viskosity: ν = 0,47 x 10^{-6} m²/s

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

R = pressure gradient (mbar/m)

v = flow speed (m/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
$\mathring{V}$	d_i	16,2 mm	20,4 mm	26,0 mm	32,6 mm	40,8 mm	51,4 mm	61,2 mm	73,6 mm	90,0 mm	102,2 mm
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

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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 V̊.

V̊ = 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 viskosity: 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 viskosity: ν = 0,414 x 10^{-6} m²/s

V̊ l/s	V̊ l/min	V̊ m³/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 V̊.

V̊ = 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 viskosity: 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 viskosity: ν = 0,414 x 10^{-6} m²/s

			d_e	160	200	250	315	160	200	250	315
V̊	V̊	V̊	s	14,6	18,2	22,7	28,6	14,6	18,2	22,7	28,6
l/s	l/min	m³/h	di	130,8	163,6	204,6	257,8	130,8	163,6	204,6	257,8
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