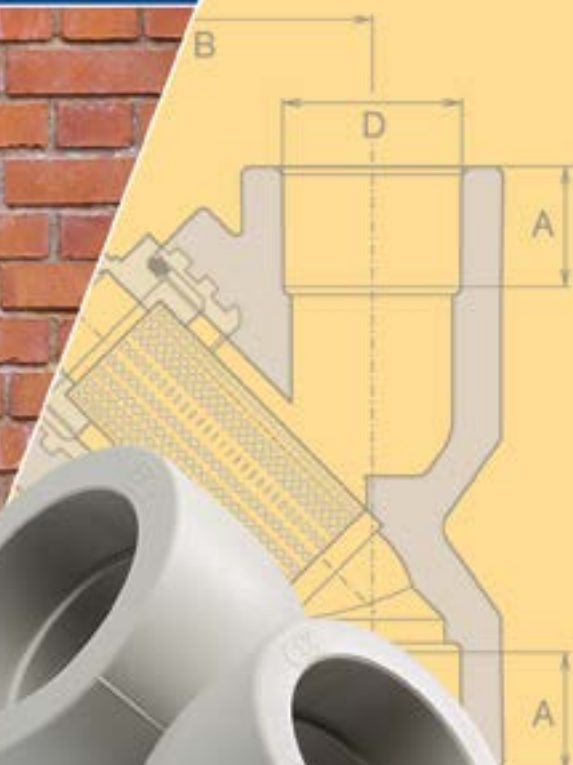


Ekoplastik System

Installation Manual



For water supply and heating

Contents

1. Utilisation of Ekoplastik System	5	10. Assembly Instructions	14-25
		10.1. General	14
2. Guarantee Terms and Conditions	5	10.2. Linear expansion and contraction	15-19
		10.3. Spacing distances of pipe supports	20
3. Product Range – Basic Information	5-6	10.4. Pipe fixing	20-21
		10.5. Pipeline routing	21-23
4. Properties of Ekoplastik System	6	10.6. Coupling to the system	23-24
4.1. Advantages	6	10.7. Insulation	24-25
4.2. Marking of Ekoplastik System	6	10.8. Pressure test	25
4.3. Specification of raw material used in production	6		
4.4. Product manufacturing and testing standards	6	11. Material Transport and Storage	25
4.5. Ekoplastik System is certified in the following countries	7	12. Pressure Test Certificate	26
5. Assumed Media Properties in Piping Systems	7	13. Polyfusion Welding – Working Procedures	27-29
5.1. Basic parameters of internal water distribution systems	7	14. Welding by Electrofitting – Working Procedures	29
5.2. Basic parameters of heating systems	7	15. Repair of Damaged Piping	30
6. Operating parameters of Ekoplastik pipes	7-8	16. Additional Branching	31-32
7. Example of determination the pipeline lifetime in the system	8	17. Pressure Loss Tables	33-43
8. Ekoplastik Pipeline Routing Options	8-9	18. Coefficient of Loss	43
9. Tables	10-13		
9.1. Operating parameters of PPR and PP-RCT piping systems according to DIN 8077/2007	10		
9.2. Mechanical strength PPR isothermal lines	11		
9.3. Mechanical strength PP-RCT isothermal lines	12		
9.4. Operating conditions according to ISO 10508 - application classes	13		

Advantages

- innovative technology
- unique 3 layer pipe reinforced with basalt fiber



System Ekoplastik is produced in grey and green colour.



Major areas of application of individual pipe types

	PPR PN10 Ø 20-125 mm	PPR PN16 Ø 16-125 mm	PPR PN20 Ø 16-125 mm	STABI PLUS Ø 16-110 mm	FIBER BASALT CLIMA Ø 20-125 mm	FIBER BASALT PLUS Ø 20-125 mm
	●	●	●	●	●	●
		●	●	●	●	●
			●	●	●	●
max. 70 °C						
				●		●
max. 90 °C						

Three layer pipes made from PP-RCT

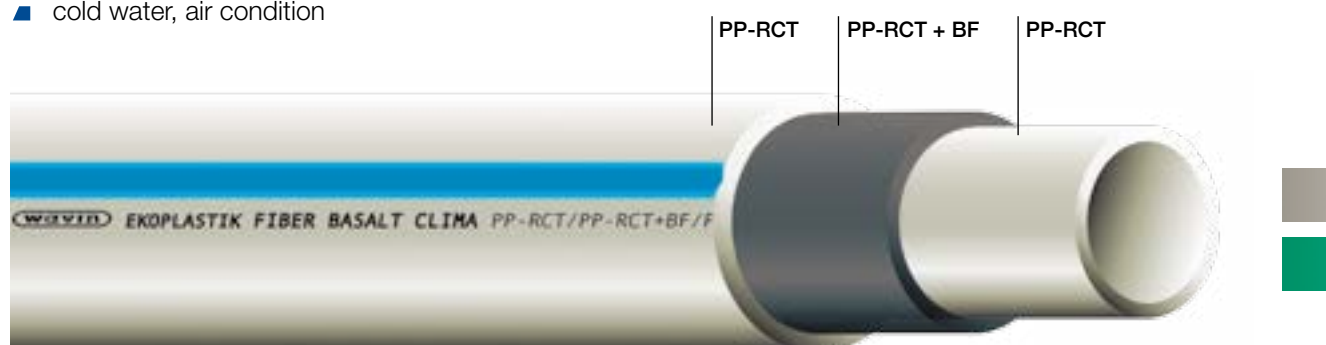
FIBER BASALT PLUS

- 3× lower thermal linear expansion
- without shaving before welding
- hot water, heating



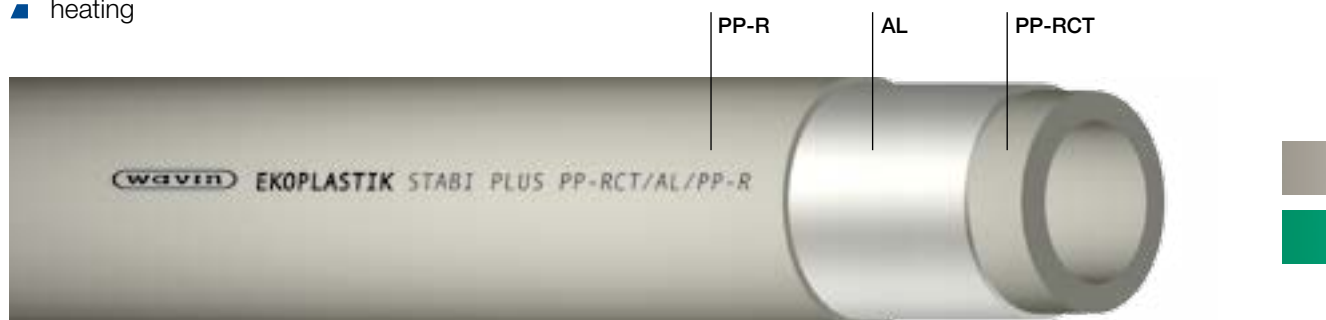
FIBER BASALT CLIMA

- 3× lower thermal linear expansion
- without shaving before welding
- cold water, air condition



STABI PLUS

- 3× lower thermal linear expansion
- oxygen barrier
- heating



1. Utilisation of Ekoplastik System

Ekoplastik piping System can be used for distribution systems in housing, administration and community buildings as well as for industrial and agricultural installations.

Ekoplastik piping system is designed for transport of cold and hot water as well as floor heating. In case of observance of the rules specified hereinafter the system is also suitable for central heating systems.

Ekoplastik piping System can also be used for air distribution. In order to take advantage of its chemical resistance and other system properties and use of the system for transport of other liquids, gaseous or solid media an individual assessment of any such case is needed.

2. Guarantee Terms and Conditions

10-year guarantee period is granted for all standard elements of the Ekoplastik System.

This guarantee is subject to a proper product application and adherence to this installation manual. Twenty-four months guarantee period is granted for other products.

There are separately mentioned standard elements for potable water and cold water and separately standard element for cold water in catalogue of products.

The guarantee is only valid for installations that consist entirely of pipes and fittings of Ekoplastik System. The guarantee does not apply if the installation is combined with products of other producers.

3. Product Range - Basic Information

Pipes and fittings of the Ekoplastik System are produced in the following sizes (external pipe diameter is shown): 16, 20, 25, 32, 40, 50, 63, 75, 90, 110 and 125 mm.

The pipes are produced in various combinations of operating pressure and temperatures in separate pressure lines (of various wall thicknesses):

Fields of application according to the type of pipes

- All plastic pipe (PPR)
 - S 5 (PN 10) for cold water and floor heating
 - S 3,2 (PN 16) for hot water and floor heating
 - S 2,5 (PN 20) for hot water and central heating
- Three layer pipe (PP-RCT) - STABI PLUS with non-perforated aluminum foil (16-63 mm, S 3,2) and STABI PLUS with perforated aluminum foil (75-110 mm, S 4), for hot water and central heating
- Three layer pipe (PP-RCT) – FIBER BASALT PLUS S 3,2 (20-63 mm), S 4 (75-125 mm) reinforced with basalt fiber, for hot water and central heating
- Three layer pipe (PP-RCT) - FIBER BASALT CLIMA S4 (20-32 mm), S5 (40-125 mm) reinforced with basalt fiber for cold water, air condition and cooling

The operation conditions of the water distribution and heating are specified for four different application classes (ISO 10508). Each application class refers to a typical area of use and for a period of 50 years. Each application class must be associated with a design pressure (operating system pressure). This information is given to each pipe at this shape: application class/pressure; for example 1/10 bar. It means that pipe is determined for application classe 1 and maximum operating pressure 10 bar.

The application classes according to ISO 10508

- class 1 (supply of hot water of 60 °C, lifetime of 50 years)
- class 2 (supply of hot water of 70 °C, lifetime of 50 years)
- class 4 (floor heating, low temperature radiators, lifetime of 50 years, assuming (in total for the entire lifetime) 2.5 years at the operating temperature of 20 °C, 20 years at the operating temperature of 40 °C, 25 years at the operating temperature of 60 °C, 2.5 years at the operating temperature of 70 °C)
- class 5 (high temperature radiators, lifetime of 50 years, out of which is (in total for the entire lifetime) 14 years at the operating temperature of 20 °C, 25 years at the operating temperature of 60 °C, 10 years at the operating temperature of 80 °C, 1 year at the operating temperature 90 °C) For each material and pipe series S is determined by the calculation the maximum operating pressure (4, 6, 8, 10 bar) to the application class.

The STABI PLUS pipes are three-layer pipes: the inner wall of the pipe is made of polypropylene type 4 - PP-RCT and has a wall thickness as the pipe S 3,2 and S 4. During the production is associated with the aluminum layer with and subsequently covered with an outer layer of polypropylene. The composition of the layers can be schematically described as PP-RCT/AL/PP-R. Thanks to the aluminum layer have the pipe an oxygen barrier and meet the requirements of DIN 4726 and CSN EN 21003 for oxygen permeability. The pipes have toughness and thermal length expansion comparable with the metal pipes. The PP-RCT pipes are labeled according to the wall thickness by the class "S". For the reason of mechanical protection of the aluminium foil the pipe is furnished with an external polypropylene layer. In some cases, vaporization of residual moisture from production of the internal polypropylene pipe may occurred (in the form of bubbles and blisters under the external layer). However as this external polypropylene layer does not affect the mechanical properties of the pipe, it is considered an aesthetical matter only.

The BASALT FIBER PLUS pipes are three-layer pipes. The inner and outer layer is made of polypropylene type 4 (PP-RCT). The middle layer is from polypropylene type 4 (PP-RCT) reinforced with basalt fibers (BF). The composition of the layers can be schematically described as PP-RCT / PP-RCT + BF / PP-RCT. Thanks to the basalt fiber has the BASALT FIBER PLUS pipe 3 times lower thermal expansion than the all-plastic pipe.

Fittings (and adaptors) are manufactured for all piping types in the highest PN 20 pressure range and in various configurations:

- Full-plastic fittings (sockets, elbows, T-pieces reduced and full-sized, reductions, blindings, cross-pieces).
- Combined fittings with brass, nickel-coated threads for threaded joints (reducing sleeves with metal thread, T-pieces, elbows for wall mounting, wall mounting groups with tap connectors, plastic reducing sleeves with cap nut)
- Combined fittings for flanged joints
- Plastic valves with brass cock plug (classic and under-plaster types)
- Ball valve with a chrome – plated mantle (classic and under-plaster types)
- Special elements (crossovers, compensation pipes)

Equipment and accessories:

- Tools (welding and cutting devices, scrapers, thermometers and assembly jig)
- Fixing clips, metal sleeves, plastic and metal troughs and plugs.

For a detailed and updated list of components see our Product catalogue.

4. Properties of Ekoplastik System

4.1. Advantages

- System lifetime more than 50 years (subject to proper application)
- No health risks
- No corrosion or encrustation
- Flexibility, low weight, easy and clean installation
- Low-noise level, low pressure losses due to friction
- Environmentally friendly product (it can be recycled or safely incinerated)

4.2. Marking of Ekoplastik System

Pipes and fittings are marked during the manufacturing process to enable future tracing. All elements are marked in the following way:

Pipes: WAVIN Ekoplastik, S and PN, size, wall thickness, manufacturing standard (EN ISO 15874 and specifications of use in according to this standard, see an example at page 10), date of production and code of manufacturing line.

Fittings: Ekoplastik – abbreviations EK may be displayed, name of material PPR and size. Separate fitting packages are fitted with package labels containing, except the element type marking, also date of production and releasing inspector identification.

Pipes are marked on terms of the EN ISO 15874 by code S – serie (PN – pressure class).

Relationship between older PN pressure class marking, S and SDR for PPR pipes is listed in the table.

S	5	4	3,2	2,5
SDR	11	9	7,4	6
PN	10	-	16	20

The table can not be used for the new material PP-RCT because the pipes made from this material have better operating parameters (pressure, temperature, life) than PPR pipes.

The possibility to identify each element in a system is an important instrument of quality control management as well as an evidence for potential settlements of guarantee claims.

4.3. Specification of raw material used in production

All plastic pipes and fittings of Ekoplastik System are manufactured in Type 3 polypropylene. Multilayer pipes FIBER BASALT PLUS, FIBER BASALT CLIMA and STABI PLUS are made from polypropylene of new generation - type 4, PP-RCT.

Selected characteristics of pipes

characters		unit	PPR value
Specific gravity	PPR, PP-RCT	g / cm ³	0,9
Thermal expansion coefficient (elongation)	STABI PLUS FIBER	mm / m °C	0,12
	BASALT PLUS		0,05
	FIBER BASALT CLIMA		
Thermal conductivity coefficient	all types of pipes	W / m °C	0,24

4.4. Product manufacturing and testing standards

Ekoplastik PPR System products are manufactured according to internal company standard PN 01 corresponding with the EN ISO 15874 and German Standards DIN 8077 and DIN 8078, DIN 16962, DIN 4726.

The internal company standard is continuously being updated with further specification items taken over from the newly introduced European (EN) System of Standards.

In order to meet quality requirements according to ISO 9001 the following activities are regularly controlled within the framework of specified procedures:

- characteristics of raw materials entering the manufacturing process;
- product/intermediate parameters at individual manufacturing period;
- manufacturing facilities;
- parameters of measuring instruments;

4.5. Ekoplastik System is certified in the following countries:

Belorussia, Bulgaria, Croatia, Czech Republic, Germany, Hungary, Italy, Japan, Poland, Romania, Russia, Slovakia, Slovenia, Spain and Ukraine.

5. Assumed Media Properties in Piping Systems

5.1. Basic parameters of internal water distribution systems

The following table shows basic criteria of pressure class selection – i.e. pressure and temperature values – as they may be present in internal water distribution systems.

medium	max. operating pressure [bar]	max. operating temperature [°C]
cold water	10	up to 20 °C *
PWH (potable water hot)	10	up to 60 °C **

* Maximum temperature of drinking water at 20 °C has been specified due to hygiene.

** Maximum temperature of hot water – 57 °C – is always assumed in PWH distribution systems at the place of mixing tap and specified as a scalding precaution. A short-term overheating to higher temperature levels (70 °C) is assumed for hygiene – a liquidation of pathogenic mycobacteria and bacteria *Legionella pneumophila*.

Ekoplastik System can be used for all internal water distribution systems (i.e. cold drinking water, cold industrial water, hot water, circulation systems).

The 50 years life time period is assumed for the plastic piping system as long as material and pressure lines are correctly selected and the system properly installed. The pressure class depends on the hot water heating system and its control and should therefore be specified by the relevant designer.

5.2. Basic parameters of heating systems

In procedures of suitability assessment of Ekoplastik PPR System elements such as entry value of calculation heating water temperature should be used as the highest temperature occurring in the whole system. The heating system designer will determine this value in accordance with required temperature levels at media entry to radiators, heat source parameters and expansion vessel types. According to this value, the following heating system types are specified.

Recommended values for heating – Ekoplastik System			
Temperature interval			
70 / 50 °C	70 / 60 °C	75 / 65 °C	80 / 60 °C
For low-temperature applications			

6. Operating parameters of Ekoplastik pipes

The operating parameters mean the maximum operating pressure, temperature and lifetime and the relationship between them. The operating parameters are based on the material strength isotherm (PPR or PP-RCT) which shows the dependence of the media temperature, pipe lifetime and pipe tension. For each type of pipe were the tension values converted to the operational pressures and processed in tables (page 10). The assessment in terms of lifetime can be done by the deduction the values from tables or usage of isotherms (PPR and PP-RCT according to the type of pipe).

The following data are necessary for such evaluation:

- maximum temperature of heating water (°C)
- maximum operating pressure (MPa)
- pipe external diameter (mm)
- pipe wall thickness (mm)
- safety factor for heating systems
- annual heating period (in months)

Calculation of pipe service life in heating systems

In order to calculate service life, a value of life factored stress in the pipe wall should be determined according to the following formula

$$\sigma_v = \frac{p \cdot (D - s)}{2 \cdot s} \cdot k$$

indication	
σ_v	factored stress [MPa]
D	pipe external diameter [mm]
s	pipe wall thickness [mm]
p	maximum pressure [MPa]
k	safety factor [for heating systems 1.5]

For calculation purposes: 1 MPa = 10 bars

The determined value of the designed tension will be generated to the vertical line of the chart. We will determine the intersection of this value (horizontal line) with the isotherm of maximum water temperature (oblique line). We lead the vertical line from the intersection vertically downward perpendicular to the horizontal axis, where we deduct the minimum lifetime of the pipeline under continuous operation. In the event that it is a heating system, it is necessary to recalculate the lifetime by the length of the heating season.

At instalation of plastic piping system behind the boiler or water tank, we recommend as a protection against the overheating of the system to install behind the boiler or water tank 1,5 – 2 m piece of steel pipe.

Another suitable design option in plastic piping utilisation is a common horizontal system where a pipeline is laid in a groove or along building structure in a cover (providing mechanical protection, allowing for expansion problems, if any and improved visual appearance). Piping system designs should also be assessed from the point of view of their service life.

7. Example of determination the pipeline lifetime in the system

Input data

parameters	values
piping – selected type	PPR S 2,5 (PN 20)
water max. operating temperature	80 °C
max. operating pressure	0,22 MPa
yearly heating period	7 months
safety factor	1,5

$$\sigma_v = \frac{0,22 \cdot (20 - 3,4)}{2 \cdot 3,4} \cdot 1,5 = 0,80 \text{ MPa}$$

Minimum service of the piping at continuous heating operation (as shown from the graph on page 11 for 80 °C isotherm) would then be 216,000 hours, i.e. 25 years.

The resulting expected service life corrected to yearly heating period would then be as follows:

$$25 \text{ years} \cdot \frac{12 \text{ months}}{7 \text{ months}} = 43 \text{ years}$$

Heating system modifications applied in respect of piping service life

If the result received in the above procedures is not satisfactory, then the following modifications should be applied:

1/ to decrease maximum operating pressure – and make new calculations for service life expectancy – this value is then prolonged.

2/ to decrease maximum operating water temperature – new design calculations should then be made for the relevant heating system as consequently new calculations for service life expectancy – this should be extended a great deal under these circumstances.

8. Ekoplastik Pipeline Routing Options

Routing options for water supply & distribution piping and heating systems are identical (leaving aside specific properties of heating systems as discussed in Chapter V and VII). The major aspects are the requirements for piping protection, support and compensation of expansion.

It is recommended that pipes are installed inside building structures (such as: wall, floor or ceiling structures) or covered. Connections to radiators should be, for visual appearance reasons, made of metal pipes, e.g. a chromium-coated copper pipe.

If the pipes are not covered and/or concealed it is necessary to take into account the fact that visible bubbles and blisters may appear on the Stabi pipes.

Pipes can be laid:

- in wall chases
- in stack partitions
- inside floor/ceiling structures
- along walls (freely or inside covers)
- in installation shafts and channels
- outdoor piping applications should be considered according to concrete conditions

Specific characteristic for underfloor heating

room (purpose)	max. surface floor temperature
living unit	26 °C
bathroom	30 °C
swimming pool surroundings	32 °C

Maximum surface temperatures of walk-on floor layers must comply with in the installations of floor heating systems. Low flow rate levels of heating water (approx. 0.3 m.s⁻¹) are designed for heat transfer in floor heating systems. Piping pressure is designed according to operating parameters of the whole heating system.

Temperature of heating water is determined by a calculation where room type, floor structure and outdoor design temperature for the relevant building locality are used.

Temperature and pressure levels are usually not higher than 45 °C, 0.3 MPa respectively. For these purposes Ekoplastik PPR S 5 (PN10) or S 3,2 (PN16) lines are normally used. Heating circuits are laid using pipes delivered in coils. The pipe coils are more suitable for this purpose as no joints are necessary within the floor structure. Heating pipes are laid in a spiral shape pattern.

Pipe diameters and spacing distances can be calculated. It is also necessary to specify, in the floor heating design, a type of floor heating output control and assure that the maximum floor surface temperature is not exceeded. In rooms where higher output is required and places where people are not expected to stand (under windows) the heating pipes are laid in a dense pattern and, on the other hand, no pipes are laid where furniture is to permanently placed.

There is 100 meter maximum length of a heating coil per one heating circuit.

Room sections with more heating circuits must be separated to allow for expansion (including walk-on layers). Floor structures must also be separated from walls.

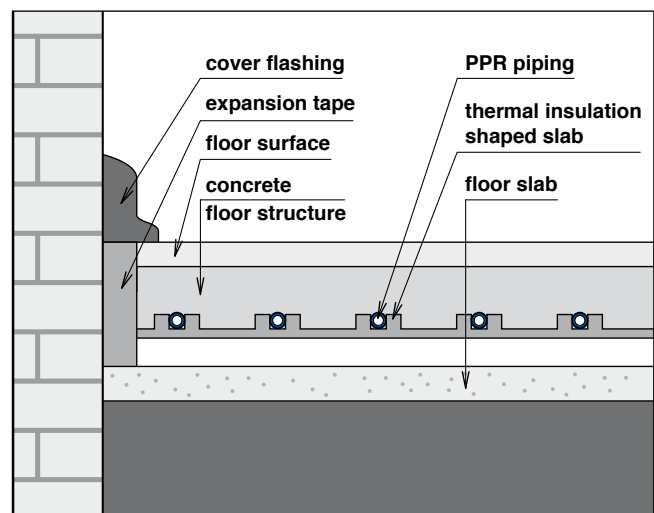
Individual circuits start and end in a manifold. An air bleeding valve must be placed at the highest point of the whole system. To minimise running costs, floor coverings should be made of material of the lowest possible thermal resistance (tiled floor surfaces are usually the most suitable).

Piping position and spacing between pipe centres should be fixed in the course of installation works – pipes may be fixed to a metal network of thermal insulation system and locked into spacing channels or profiled thermal insulation system.

The same instructions for the assembly process must be followed as it is in case of assembly of water distribution systems.

In the course of the laying process the pipe should be carefully reeled off the coil so no twisting occurs. The pipe is then step-by-step fixed to the backing. Special attention should be paid to fixing the pipe to metal backing grids and care should be taken not to damage the pipe. Minimum temperature suitable for installation is 15 °C.

Floor heating systems a very pleasant and effective heating. In order to make full use of all the advantages, the heating system must be carefully designed and other factors should be taken into consideration as, in a typical case, the floor heating system would be only one of several types of the overall building's heating system.



9. Tables

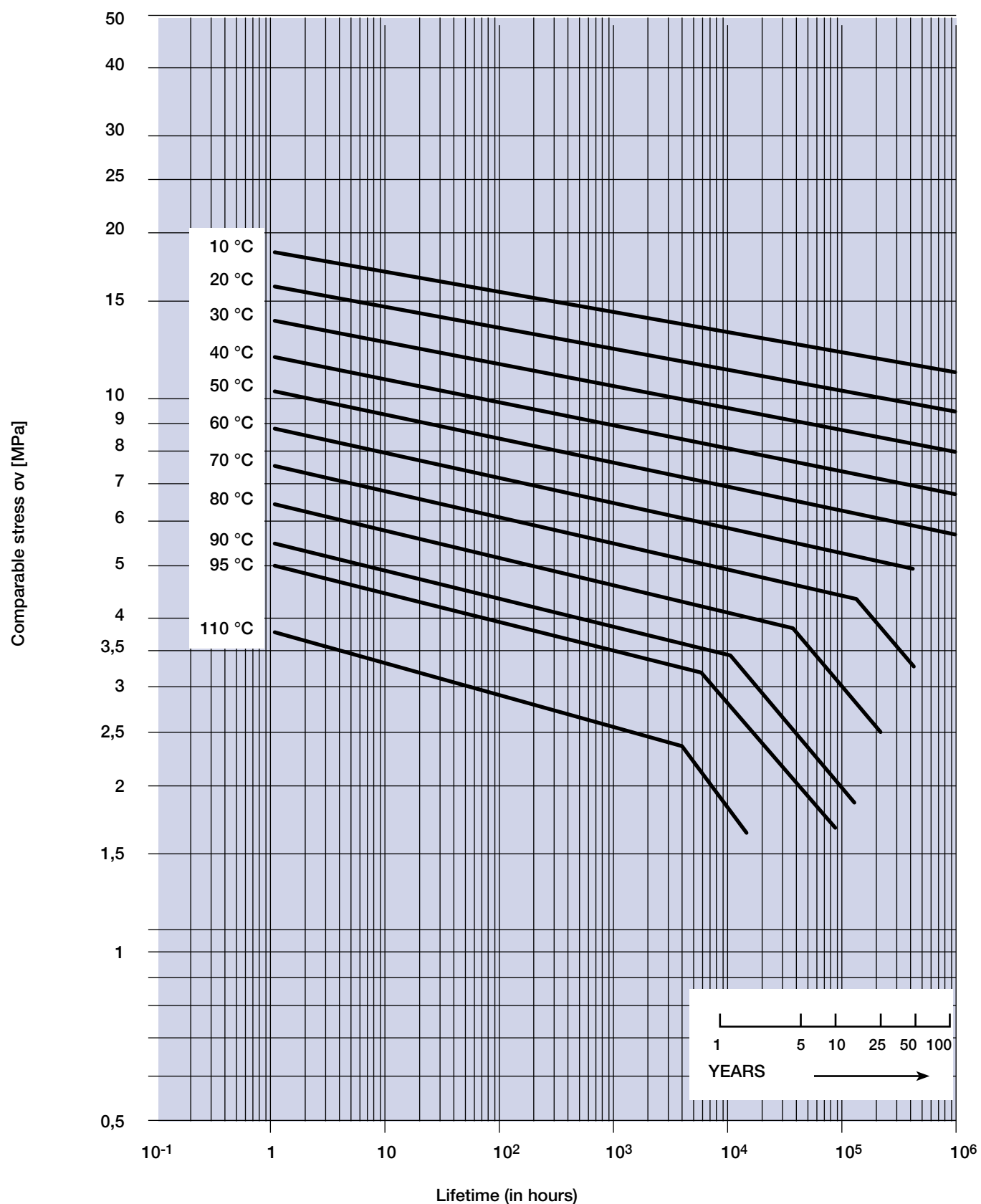
9.1 Operating parameters of PPR and PP-RCT piping systems (according to DIN 8077/2007)

TEMPE- RATURE [°C]	TIME IN OPERATION (YEARS)	PPR			PP-RCT		
					FIBER BASALT PLUS STABI PLUS		FIBER BASALT CLIMA
		S5 (PN10)	S3,2 (PN 16)	S2,5 (PN 20)	S 4	S 3,2	S 5
		MAXIMUM ALLOWABLE PRESSURE (BAR)					
10	1	17,5	27,8	35,1	24,0	30,2	19,0
	5	16,5	26,2	33,0	23,2	29,3	18,4
	10	16,1	25,6	32,2	22,9	28,9	18,2
	25	15,6	24,7	31,1	22,5	28,4	17,9
	50	15,2	24,1	30,3	22,2	28,0	17,7
20	1	15,0	23,7	29,9	20,9	26,3	16,6
	5	14,1	22,3	28,1	20,2	25,4	16,0
	10	13,7	21,7	27,4	19,9	25,1	15,8
	25	13,2	21,0	26,4	19,6	24,6	15,5
	50	12,9	20,4	25,7	19,3	24,3	15,3
30	1	12,7	20,2	25,4	18,1	22,7	14,3
	5	11,9	18,9	23,8	17,4	22,0	13,9
	10	11,6	18,4	23,2	17,2	21,7	13,6
	25	11,2	17,7	22,3	16,9	21,2	13,4
	50	10,9	17,2	21,7	16,6	20,9	13,2
40	1	10,8	17,1	21,6	15,5	19,6	12,3
	5	10,1	16,0	20,2	15,0	18,9	11,9
	10	9,8	15,5	19,6	14,7	18,6	11,7
	25	9,4	15,0	18,8	14,4	18,2	11,5
	50	9,2	14,5	18,3	14,2	17,9	11,3
50	1	9,1	14,5	18,2	13,3	16,7	10,5
	5	8,5	13,5	17,0	12,8	16,1	10,1
	10	8,2	13,1	16,5	12,6	15,8	10,0
	25	7,9	12,6	15,9	12,3	15,5	9,7
	50	7,7	12,2	15,4	12,1	15,2	9,6
60	1	7,7	12,2	15,4	11,2	14,2	8,9
	5	7,1	11,3	14,3	10,8	13,6	8,6
	10	6,9	11,0	13,9	10,6	13,4	8,4
	25	6,6	10,5	13,3	10,4	13,1	8,2
	50	6,4	10,2	12,9	10,2	12,8	8,1
70	1	6,5	10,3	12,9	9,4	11,9	7,5
	5	6,0	9,5	12,0	9,1	11,4	7,2
	10	5,8	9,2	11,6	8,9	11,2	7,0
	25	5,0	8,0	10,0	8,7	10,9	6,9
	50	4,2	6,7	8,5	8,5	10,7	6,8
80	1	5,4	8,6	10,8	7,9	9,9	6,2
	5	4,8	7,6	9,6	7,5	9,5	6,0
	10	4,0	6,4	8,1	7,4	9,3	5,9
	25	3,2	5,1	6,5	7,2	9,1	5,7
95	1	3,8	6,1	7,6	5,9	7,4	4,7
	5	2,6	4,1	5,2	5,6	7,1	4,4
	COLD WATER		HOT WATER				

SAFETY FACTOR 1,5

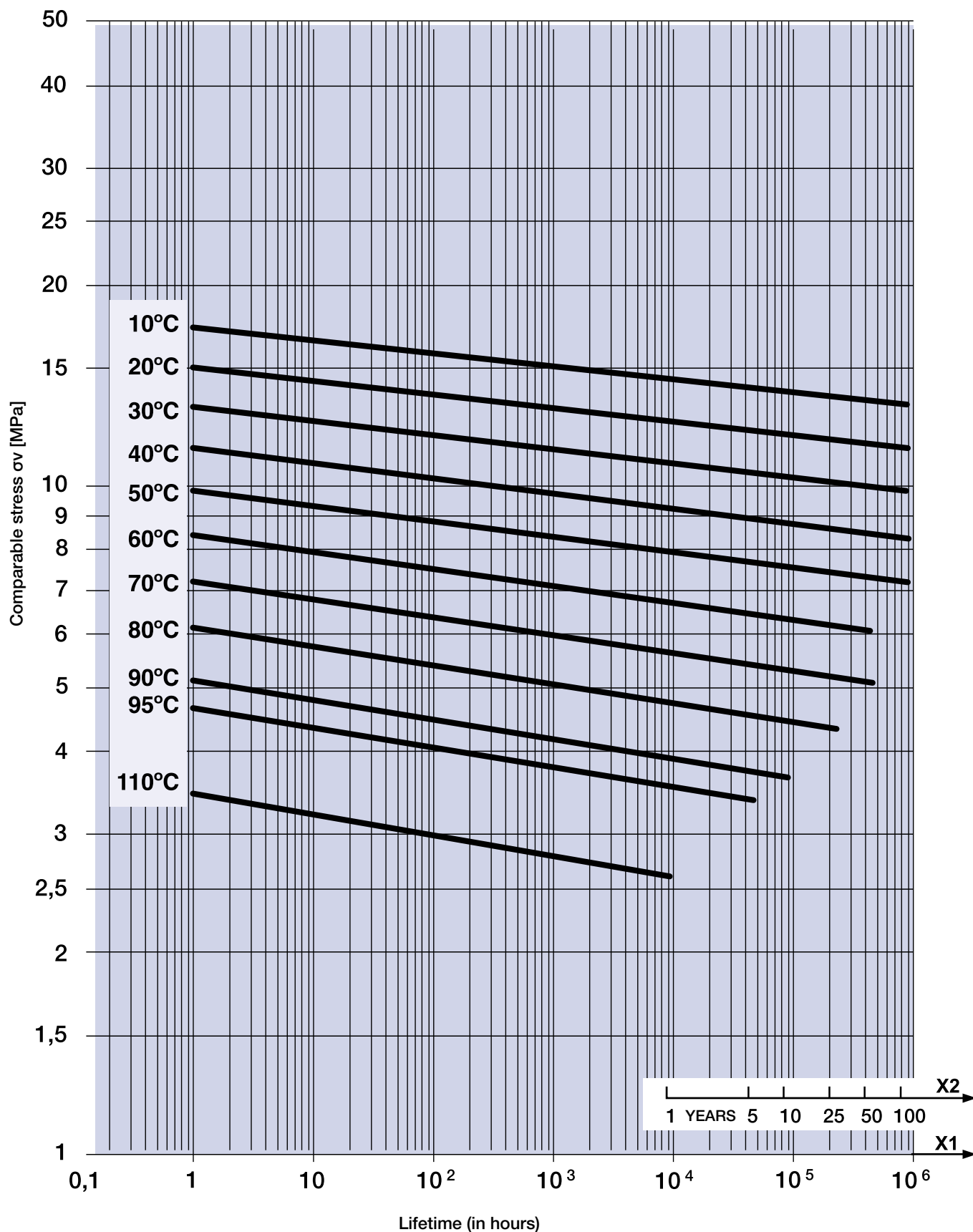
SAFETY FACTOR 1,5

9.2 Mechanical strength PPR isothermal lines



Termination of the isotherm indicates maximum lifetime also at lower tension. The isotherms in the chart do not extend.

9.3 Mechanical strength PP-RCT isothermal lines



Termination of the isotherm indicates maximum lifetime also at lower tension. The isotherms in the chart do not extend.

Operating conditions according to ISO 10508 - application classes

Each class has defined operating parameters of the system for a total hours of time operation of 50 years. At this time there is included also the time when the distribution is exposed to high temperatures (T_{max}) and temperatures during the functional failure of the system (T_{mal}). There is assigned maximum operating pressure to the pipes.

When for the class occurs more than one operating temperature, the periods are summed - see column lifetime total

All pipes compliant with the conditions in the table are suitable for the distributions of cold water for the period of 50 years at 20 °C and a pressure of 10 bar.

Class	lifetime total years	time of operation years / hr	operating temperature T °C	typical use	PPR S 2,5 SDR 6 (PN 20)	PPR S 3,2 SDR 7,4 (PN 16)	PP-RCT S 3,2 SDR 7,4	PP-RCT S 4 SDR 9	PP-RCT S 5 SDR 11
					max. operating pressure (bar)				
1	50 years	49 years	60	hot water 60°C	10	8	10	8	6
		1 year	80						
	Tmal/lifetime by Tmal	100 hr	95						
2	50 years	49 years	70	hot water 70°C	8	6	10	8	6
		1 year	80						
	Tmal/lifetime by Tmal	100 hr	95						
4	50 years	2,5 years	20	floor heating low temperature radiators	10	10	10	8	6
		20 years	40						
		25 years	60						
		2,5 years	70						
	Tmal/lifetime by Tmal	100 hr	100						
5	50 years	14 years	20	high temperature radiators	6	x	8	6	x
		25 years	60						
		10 years	80						
		1 year	90						
	Tmal/lifetime by Tmal	100 hr	100						

Application classes and appropriate maximum operating pressures are listed in the description of each tube.

Example - the pipe from PP-RCT - S 3.2:

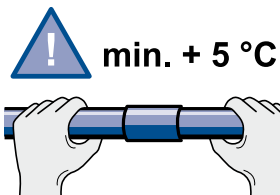
Class 1/10 bar, 2/10 bar, 4/10 bar, 5/8 bar means that the pipe may be used:

- for distribution of hot water of 60 °C - operating pressure 10 bar, lifetime of 50 years (class 1/10)
- for distribution of hot water of 70 °C - operating pressure 10 bar, lifetime of 50 years (class 2/10)
- for underfloor heating and low temperature radiators - operating pressure 10 bar, lifetime of 50 years (class 4/10)
- for high temperature radiators - operating pressure 8 bar, lifetime of 50 years (class 5/8)

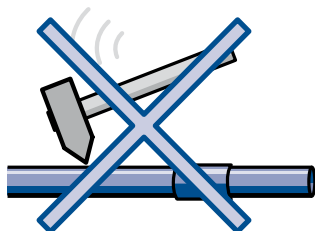
10. Assembly Instructions

10.1. General

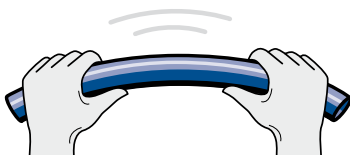
Only components not damaged or contaminated, either during storage or transport, may be used for installation works.



A minimum temperature level for plastic piping installation is, with regard to welding, +5 °C. At lower temperatures it is difficult to provide working conditions for high quality pipe joints.



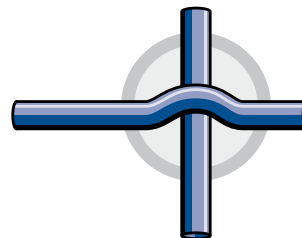
Components of plastic piping systems must be protected against damage during transport and installation.



Pipe bending should be done at +15 °C. For pipes of diameter range 16 – 32 mm a minimum bending radius equals to eight diameters (D).



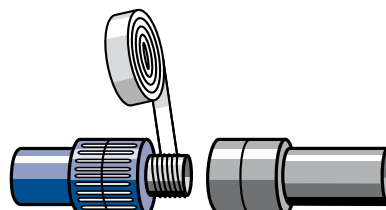
Components must not be exposed to naked flames.



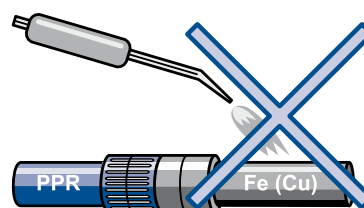
Pipeline cross overs should be made with the use of components specially designed for this purpose.



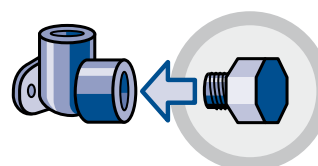
Connecting of plastic parts is done by polyfusion welding, or by the use of electric fittings and butt welding techniques. A high-quality homogeneous joint is the result. An exact working process and appropriate tools must be used in connecting procedures.



Threaded fittings must be used for screw-type joints. Threads should never be cut directly into plastic components. Threads are sealed with a special PTFE tape or sealing compounds.



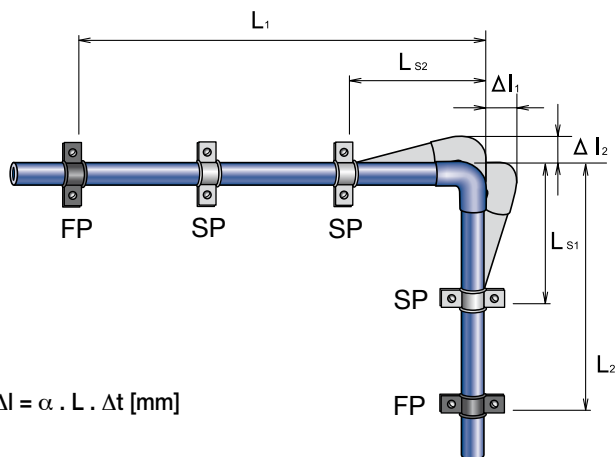
Brazing or soldering of metal fittings should not take place close to a joint between metal and plastic systems because of potential hazard of heat transfer to the fitting.



It is recommended to use plastic plugs for blanking elbows or wall mounting groups (plastic plugs are designated only for temporary use). For long term blanking has to be used plugs with metal thread.

10.2. Linear expansion and contraction

The difference of temperature during installation and under service conditions, i.e. a medium flows through the system at a different temperature to that prevailing during the installation period, results in linear changes – expansion or contraction (Δl).



$$\Delta l = \alpha \cdot L \cdot \Delta t \text{ [mm]}$$

Δl linear change [mm]

α is thermal expansion coefficient of expansion [mm/m °C]
for Ekoplastik PPR design purposes $\alpha = 0,12$
for Ekoplastik STABI PLUS, FIBER BASALT PLUS,
FIBER BASALT CLIMA respectively $\alpha = 0,05$

L design distance (distance of two neighbouring fixed points in the line) [m]

Δt installation and service temperature difference [°C]

$$L_s = k \cdot \sqrt{(D \cdot \Delta l)} \text{ [mm]}$$

L_s compensating length [mm]

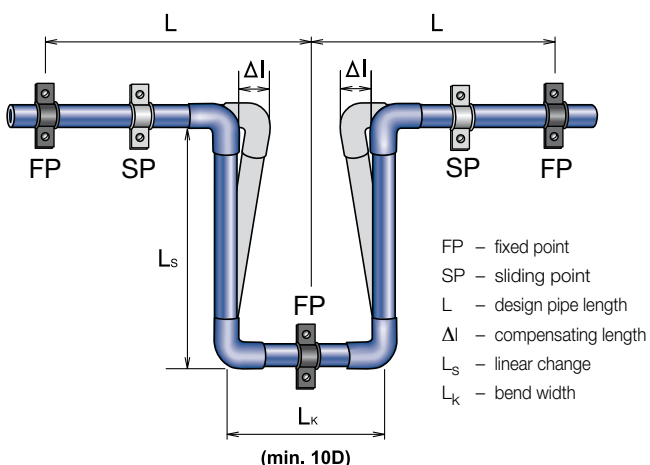
k material constant, for PPR $k = 20$

D pipe outside diameter [mm]

Δl linear change [mm]

If pipeline linear changes are not compensated in a suitable way, i.e. if the pipes can not contract and expand, additional thrust and tensile forces are concentrated in the pipes shortening their service life.

Expansion U-bend



$$L_k = 2 \cdot \Delta l + 150 \text{ [mm]} \text{ and also } L_k \geq 10 \cdot D$$

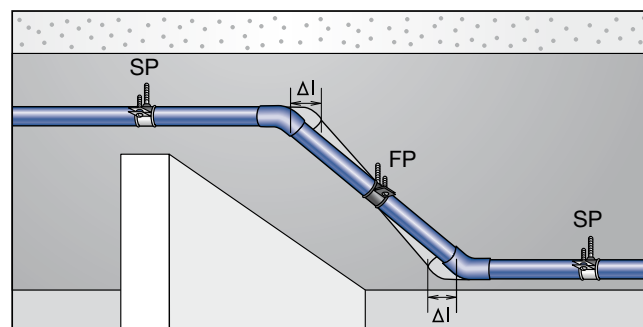
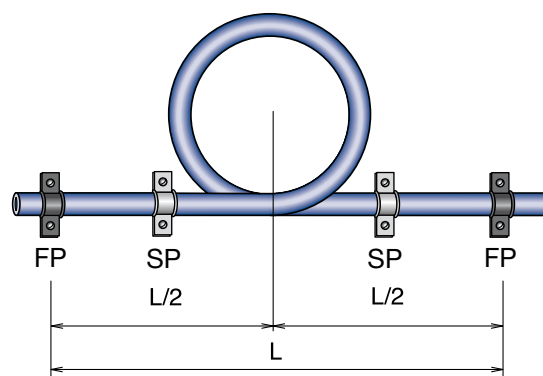
In polypropylene applications material flexibility is used for linear compensations. Pipe bends are also used for these purposes. A suitable compensation technique is the one where the pipeline is deflected perpendicularly to the original route and a free compensating length (marked as L_s) is left at the normal line. The value of L_s compensating length will depend on calculated route extension (shortening), pipe material and diameter.

The values of Δl linear change and L_s compensating length can also be taken from the graphs shown on pages 17, 18 and 19.

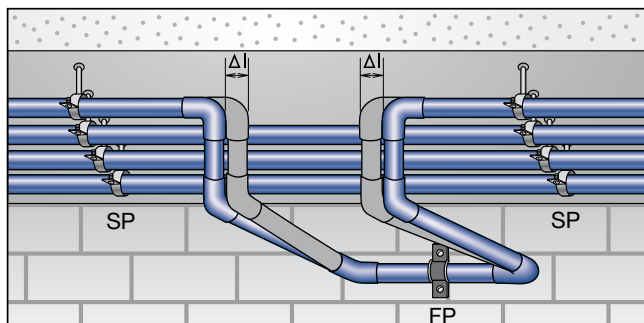
Table of compensation pipe

pipe diametr (mm)	distances of all fixed L-points (m)	
	STABI PLUS, FIBER BASALT PLUS, FIBER BASALT CLIMA	PPR
16	24	8
20	27	9
25	30	10
32	36	12
40	42	14

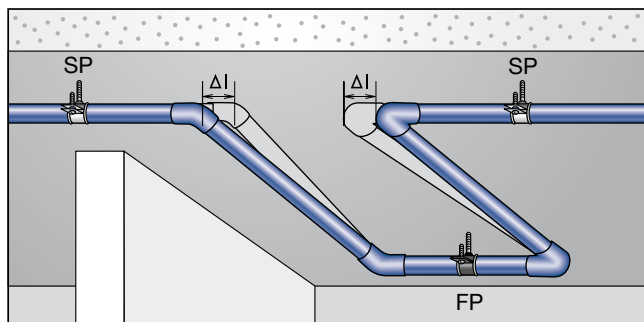
Compensation pipe



Example of compensations by change of path



By changing the height of the pipeline.



Expansion U-bend

Examples given for Ekoplastik PPR piping

1) Data input:

parameter	symbol	value	unit
linear change	Δl	?	mm
thermal expansion coefficient	α	0,12	mm/m °C
pipe length	L	10	m
operating temperature inside the pipe	t_p	60	°C
temperature at installation	t_m	20	°C
difference between operating and installation temperature levels ($\Delta t = t_p - t_m$)	Δt	40	°C

Solution:
 $\Delta l = \alpha \cdot L \cdot \Delta t$ [mm]
 $\Delta l = 0,12 \cdot 10 \cdot 40 = 48 \text{ mm}$

2) Data input:

parameter	symbol	value	unit
compensating length	Δl	?	mm
PPR material constant	k	20	–
external pipe diameter	D	40	mm
linear change as calculated above	Δl	48	mm

Solution:
 $L_s = k \cdot \sqrt{(D \cdot \Delta l)}$ [mm]
 $L_s = 20 \cdot \sqrt{(40 \cdot 48)} = 876 \text{ mm}$

3) Data input:

parameter	symbol	value	unit
expansion U-bend width			
external pipe diameter	D	40	mm
linear change as calculated above	Δl	48	mm

Solution:
 $L_k = 2 \cdot \Delta l + 150$ [mm]
 $L_k = 2 \cdot 48 + 150 = 246 \text{ mm}$
 $L_k > 10 D$
 $246 \text{ mm} < 10 \cdot 40 \Rightarrow L_k = 400 \text{ mm}$

Pipe pre-stressing can be also used for the purposes of linear expansion compensation; the compensating length may be made shorter in this way. The pre-stressing orientation is opposite to the expected linear change and its value equals to about one half.

4) Data input:

parameter	symbol	value	unit
compensating length at pre-stressing	L_{sp}	?	mm
PPR material constant	k	20	–
external pipe diameter	D	40	mm
linear change as calculated above	Δl	48	mm

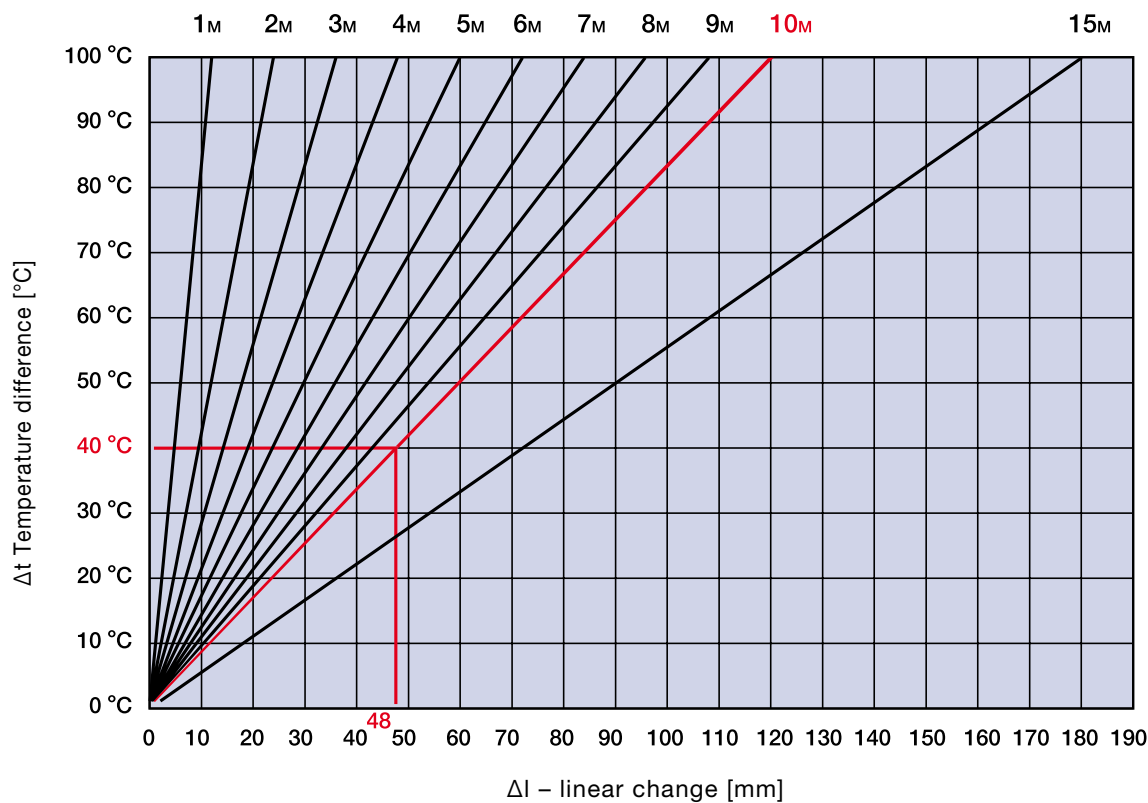
Solution:
 $L_{sp} = k \cdot \sqrt{(D \cdot \frac{1}{2})}$ [mm]
 $L_{sp} = 20 \cdot \sqrt{(40 \cdot 24)} = 620 \text{ mm}$

The calculated free length (L_{sp}) is assumed length without any sustaining or suspending elements (within this length) obstructing the expansion. The free length (L_{sp}) should not exceed max. spacing distance between supporting elements corresponding to the pipe diameter and media temperature as shown in Chapter 10, Part 10.3.

Linear expansion Ekoplastik PPR piping

Examples: $L = 10\text{ m}$, $\Delta t = 40\text{ °C}$

Calculation of pipe length L



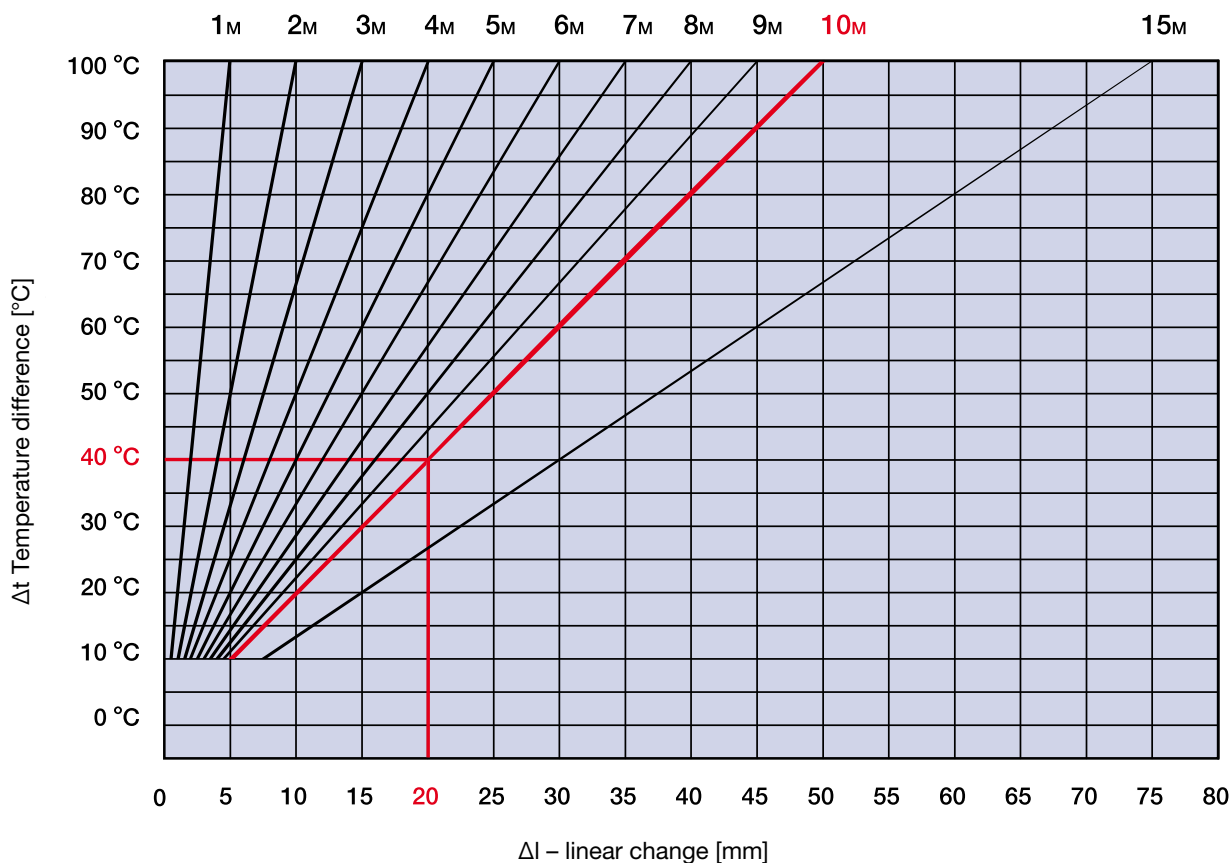
pipe length	temperature difference Δt							
	10 °C	20 °C	30 °C	40 °C	50 °C	60 °C	70 °C	80 °C
	linear change Δl [mm]							
1 m	1	2	4	5	6	7	8	10
2 m	2	5	7	10	12	14	17	19
3 m	4	7	11	14	18	22	25	29
4 m	5	10	14	19	24	29	34	38
5 m	6	12	18	24	30	36	42	48
6 m	7	14	22	29	36	43	50	58
7 m	8	17	25	34	42	50	59	67
8 m	10	19	29	38	48	58	67	77
9 m	11	22	32	43	54	65	76	86
10 m	12	24	36	48	60	72	84	96
15 m	18	36	54	72	90	108	126	144

Rounded to whole numbers.

Linear expansion Ekoplastik PPR STABI PLUS, FIBER BASALT PLUS, FIBER BASALT CLIMA

Examples: $L = 10\text{ m}$, $\Delta t = 40\text{ °C}$

Calculation of pipe length L

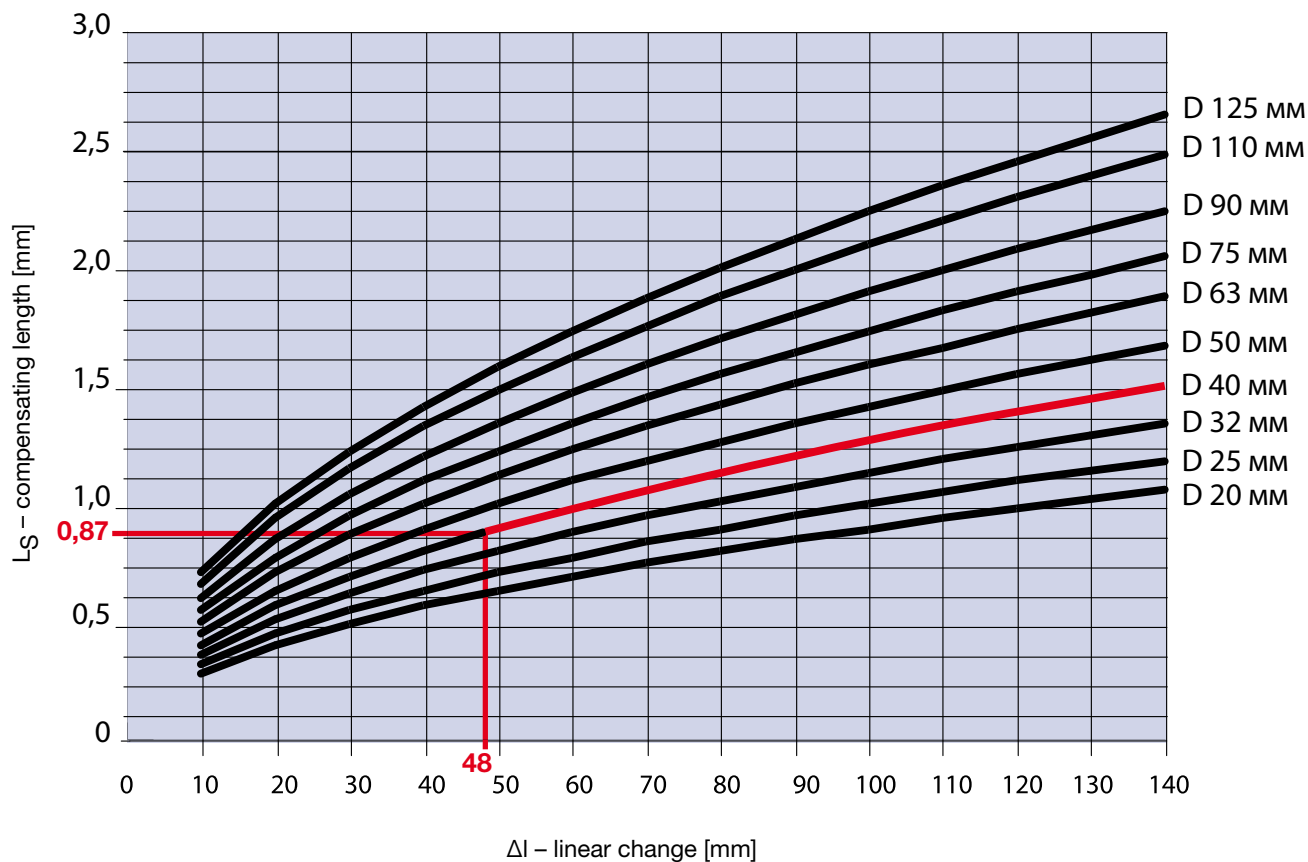


pipe length	temperature difference Δt							
	10 °C	20 °C	30 °C	40 °C	50 °C	60 °C	70 °C	80 °C
	linear change Δl [mm]							
1 m	1	1	2	2	3	3	4	4
2 m	1	2	3	4	5	6	7	8
3 m	2	3	5	6	8	9	11	12
4 m	2	4	6	8	10	12	14	16
5 m	3	5	8	10	13	15	18	20
6 m	3	6	9	12	15	18	21	24
7 m	4	7	11	14	18	21	25	28
8 m	4	8	12	16	20	24	28	32
9 m	5	9	14	18	23	27	32	36
10 m	5	10	15	20	25	30	35	40
15 m	8	15	23	30	38	45	53	60

Rounded to whole numbers.

Determination of L_S – compensating length

Examples for pipe $D = 40$ mm, $\Delta l = 48$ mm



pipe diameter [mm]	Δl – linear change [mm]													
	10	20	30	40	50	60	70	80	90	100	110	120	130	140
	L_S – compensating length [mm]													
16	0,25	0,36	0,44	0,51	0,57	0,62	0,67	0,72	0,76	0,80	0,84	0,88	0,91	0,95
20	0,28	0,40	0,49	0,57	0,63	0,69	0,75	0,80	0,85	0,89	0,94	0,98	1,02	1,06
25	0,32	0,45	0,55	0,63	0,71	0,77	0,84	0,89	0,95	1,00	1,05	1,10	1,14	1,18
32	0,36	0,51	0,62	0,72	0,80	0,88	0,95	1,01	1,07	1,13	1,17	1,24	1,29	1,34
40	0,40	0,57	0,69	0,80	0,89	0,98	1,06	1,13	1,20	1,26	1,33	1,39	1,44	1,5
50	0,45	0,63	0,77	0,89	1,00	1,10	1,18	1,26	1,34	1,41	1,48	1,55	1,61	1,67
63	0,50	0,71	0,87	1,00	1,12	1,23	1,33	1,42	1,50	1,59	1,66	1,74	1,81	1,88
75	0,55	0,77	0,95	1,10	1,22	1,34	1,45	1,55	1,64	1,73	1,82	1,90	1,97	2,05
90	0,60	0,85	1,04	1,20	1,34	1,47	1,59	1,70	1,80	1,90	1,99	2,08	2,16	2,24
110	0,66	0,94	1,15	1,33	1,48	1,62	1,75	1,88	1,99	2,10	2,20	2,30	2,39	2,48
125	0,71	1,00	1,22	1,41	1,58	1,73	1,87	2,00	2,12	2,24	2,35	2,45	2,55	2,65

Rounded to whole numbers.

10.3. Spacing distances of pipe supports

Maximum distances of supports of pipeline Ekoplastik PPR S 5 (PN 10) pipe (horizontal pipeline)

Ø pipe [mm]	spacing distances in [cm] at temperature of		
	20 °C	30 °C	40 °C
16	75	70	70
20	80	75	70
25	85	85	85
32	100	95	95
40	110	110	105
50	125	120	115
63	140	135	130
75	155	150	145
90	165	165	155
110	185	180	175
125	200	195	185

Maximum distances of supports of pipeline Ekoplastik PPR S 2,5 (PN 20) pipe (horizontal pipeline)

Ø pipe [mm]	spacing distances in [cm] at temperature of					
	20 °C	30 °C	40 °C	50 °C	60 °C	80 °C
16	90	85	85	80	80	65
20	95	90	85	85	80	70
25	100	100	100	95	90	85
32	120	115	115	110	100	90
40	130	130	125	120	115	100
50	150	150	140	130	125	110
63	170	160	155	150	145	125
75	185	180	175	160	155	140
90	200	200	185	180	175	150
110	220	215	210	195	190	165
125	235	230	225	210	200	170

Maximum distances of supports of pipeline Ekoplastik PPR S 3,2 (PN 16) pipe (horizontal pipeline)

Ø pipe [mm]	spacing distances in [cm] at temperature of					
	20 °C	30 °C	40 °C	50 °C	60 °C	80 °C
16	80	75	75	70	70	60
20	90	80	80	80	70	65
25	95	95	95	90	80	75
32	110	105	105	100	95	80
40	120	120	115	105	100	95
50	135	130	125	120	115	100
63	155	150	145	135	130	115
75	170	165	160	150	145	125
90	180	180	170	165	160	135
110	200	195	190	180	175	155
125	220	215	200	195	190	165

Maximum spacing distances STABI PLUS, FIBER BASALT PLUS and FIBER BASALT CLIMA pipes (independently of water temperature)

Ø pipe [mm]	spacing distances in [cm] at temperature of	
	STABI PLUS	FIBER BASALT PLUS FIBER BASALT CLIMA
16	110	
20	120	80
25	140	100
32	145	110
40	150	120
50	155	130
63	165	150
75	170	145
90	190	155
110	205	160
125	220	165

Maximum distances of supports for vertical pipelines should be multiplied with 1,3 factor

10.4. Pipe fixing

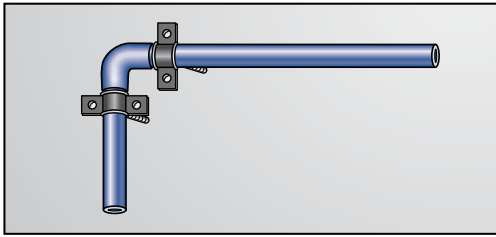
The pipeline route design must respect distribution system material – i.e. its thermal coefficient of expansion in the first place, necessity to allow for expansion, given operating conditions (a combination of pressure and temperature levels) and a type of pipe joints. The fixing of distribution systems is performed so that fixed and slidably mounted points are recognised when expected linear changes of pipes are considered.

Pipe fixing techniques

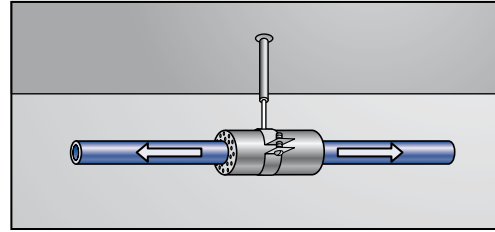
Two kinds of supports are being recognised from the point of view of pipe fixing

Fixed points (FP):

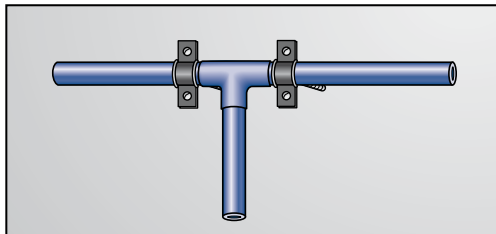
This is a type of fixing where no allowance for pipe expansion is made, i.e. the pipe can not move along its axis in the place of support (it can not slide).



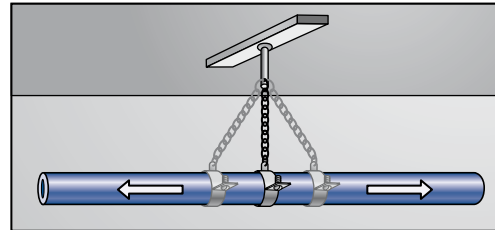
– at pipe bend



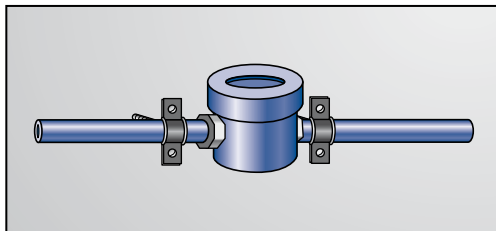
– by loose pipe-strap



– at pipe branch



– by pipe-strap suspended on hooks



– at the place of pipe fitting

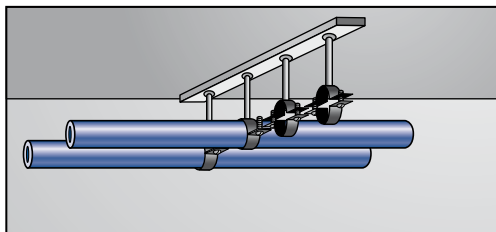
Application of plastic clamps



Suitable for H&C water supply

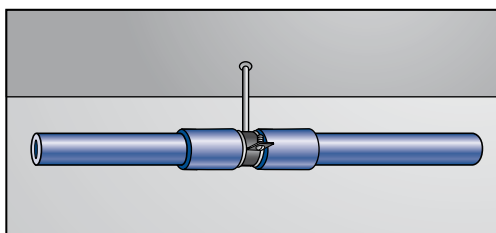


For hot water must be a clamp installed on insulation bigger for one dimension.

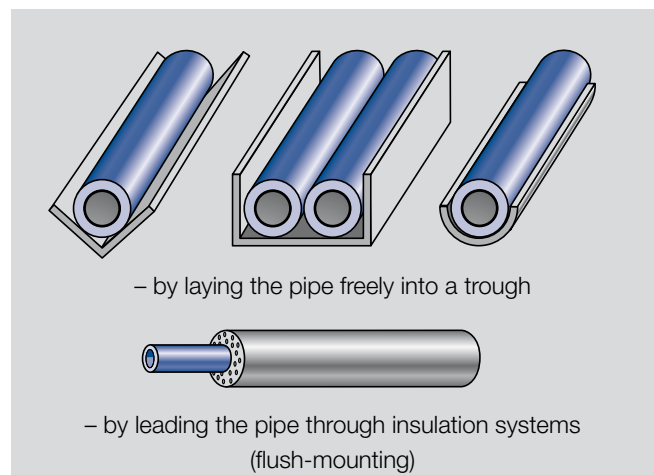


– by tightly drawn pipe-strap (only for horizontal piping)

Another locations of plastic pipeline

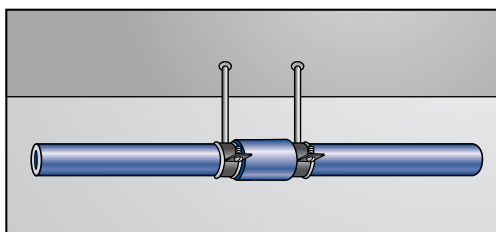


– by sleeve between pipe fittings



– by laying the pipe freely into a trough

– by leading the pipe through insulation systems (flush-mounting)



– by fixing at fitting places

Sliding point (SP):

This is a type of fixing where the pipe is not allowed to move sideways but expansion movements are not restricted (elongation, shrinkage). Slidable mounting can be designed as follows

10.5. Pipeline routing

Pipes should be installed in a minimum gradient of 0.5 % towards the lowest system points where system emptying by drain faucet or shut off valves with outlet is made possible.

The piping system must be divided into separate parts that can be closed, if necessary. Straight valves and plastic ball taps are used for this purpose. For build in installation the shut off valves or ball taps are used. It is necessary to test fitting functions (closing/opening) before they are installed.

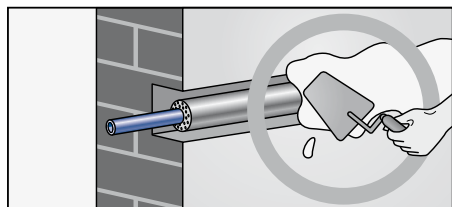


A wall mounting group with tap connectors is recommended to be used in a termination place where valve mixers are installed. WALL MOUNTING GROUP WITH TAP CONNECTORS FOR GYPSUM WALL – with exact hole spacing 20 x 1/2" (code SNKK020SXX) is determined for the assemblies where the grooves for Stabilization, e.g. while installing under gypsum wall, are not used. The hole spacing is the same as of valve mixers, and it can be adjusted to 100, 135, 150 mm. When ducting the distribution under the wall it is advisable to use WALL MOUNTING GROUP WITH TAP CONNECTORS 20 x 1/2" (code SNKK020XXX) or 25 x 1/2" (code SNKK025XXX), where the hole spacing of the threads is shifted so as the possible roughness of the distribution could be adjusted by mounting extensions. Again used for valve mixers of spacing 150, 135, 100 mm. The use of this set helps to complete the installation in high quality and quickly, without any inaccuracies. If the distribution system is terminated by pipe bends then their fixed and accurate positioning must be ensured. If two wall-mounted bends are installed for dispensing valve mixers (bath tube, shower and washbasin mixers) their identical height and parallel pipe fitting axis must be observed. No torsion load to wall mounting group with tap connectors may occur as a result of dispensing mixer installations.

It is therefore recommended to mount the elements to assembling plate of on-wall plates which helps to keep their exact positioning. The assembling plates have installation holes to install the plates according to common spacing sizes of dispensing valve mixers.

Routing of Ekoplastik PPR inlet piping

Inlet piping systems are made mainly of 16 – 20 mm diameters that are usually laid in wall channels. The channel of insulated pipe routing must be free of obstacles and allow for expansion. Beside its thermal properties the insulation system also protects the pipe against mechanic damage as well as a layer making piping expansion more easy. An insulation system of expanded polystyrene or polyurethane (foam) is recommended. Before the piping system is bricked in the pipes must be thoroughly

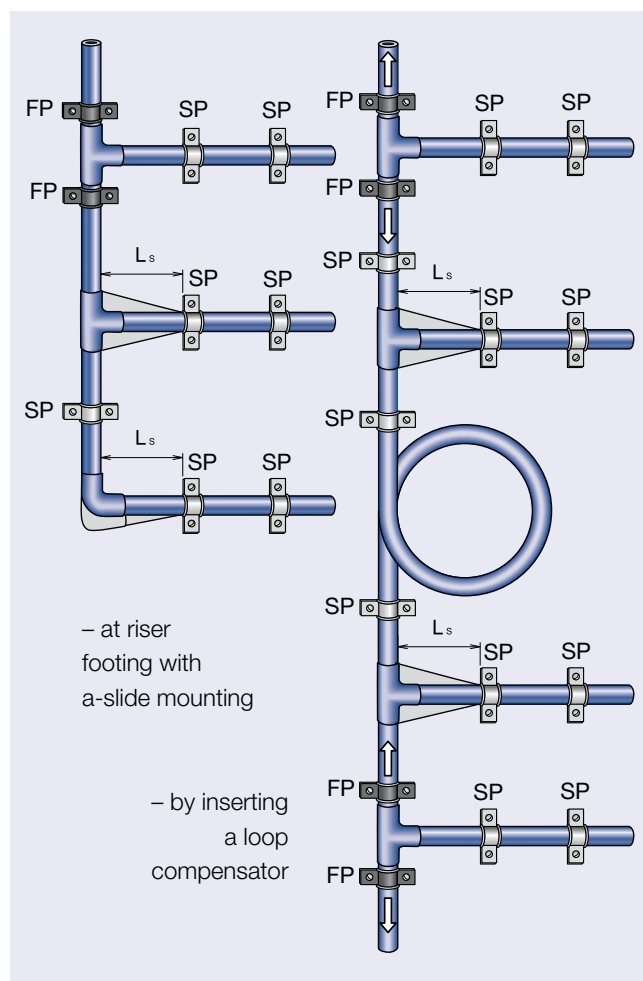


fixed to the channel (using plastic or metal pipe-straps or by plastering at some places, etc.).

If water supply / distribution piping systems are installed inside stack partitions then they must be fixed in a suitable way – such as with a system of metal clamps and supporting elements. The systems must be insulated and positioned allowing for expansion. If water supply /distribution piping systems are installed inside floor/ceiling structures then flexible plastic protective sleeves (made of polyethylene) are used for protection against mechanic damage while the air layer between the sleeve and pipe works as a thermal insulation. Piping systems freely laid are rarely used for short distances in areas where visual appearance is not a priority (laundry, building service areas, etc.). Supporting elements must be positioned with a necessary care to fix the piping and consider a compensation of pipe expansion in connecting sections where the pipes are covered as well as to apply a good insulation system to the piping. (if, for instance, a cold water pipe is led freely on-wall in a heated area then a risk of surface condensation will be considerable). Piping systems may be led freely on-wall where there is no risk of mechanic damage while in normal operation.

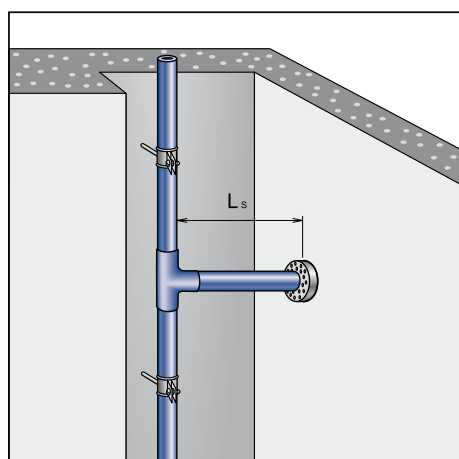
Routing of Ekoplastik PPR riser piping

In the case of riser piping it is necessary to consider precisely the layout of fixed points and sliding mounts as well as creation

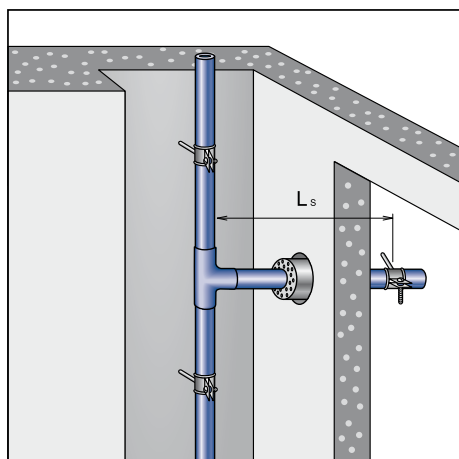


of a suitable expansion compensation system. The adjustments for expansion in riser piping systems are provided as follows: If it is necessary to divide the riser into several expansion sections then it can be achieved by placing fixed points. The riser fixed points are always fixed under and over T-pieces at a branch pipe or socket which, at the same time, prevents the riser to fall. The pipe expansion must be accounted for between these fixed points as follows:

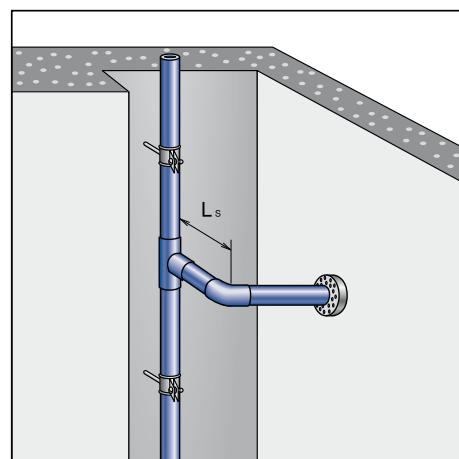
In branching off feeder piping it is necessary to allow for the riser expansion by:



– keeping a sufficient distance from the wall pass-through point



– creating a possibility of branch pipe movement in the wall pass-through point

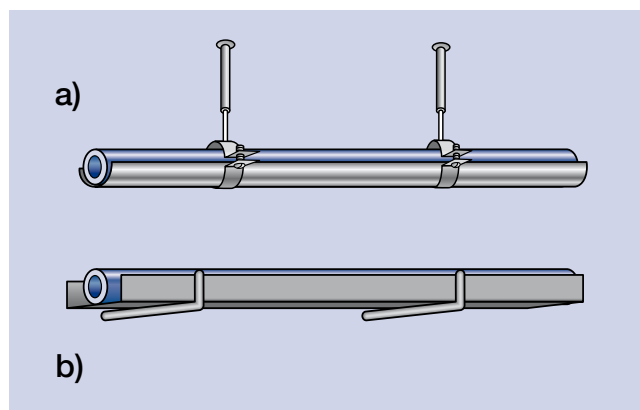


– creating a compensating length allowing for an expansion at the riser normal line

Routing of horizontal Ekoplastik PPR piping

It is necessary, in horizontal piping systems, to respect precisely expansion conditions and solve how allow for them and lay the piping correctly.

The most common routing is in galvanised metal or plastic troughs, in clamps or in-wall channels (this one must be kept free).



The compensation for expansion is performed, most commonly, by a change in the routing or by the use of expansion U-bends but a use of a pipe compensation is also possible.

The expansion adjustment may be designed both in perpendicular and parallel plane to the ceiling structures. In option a) a pipe is insulated (see Chapter 10, Part 10.7.) including the through on-the-spot, while in option b) an insulated pipe is laid into the trough.

Routing of Ekoplastik STABI PLUS, FIBER BASALT PLUS inlet piping

STABI PLUS, FIBER BASALT PLUS and FIBER BASALT CLIMA have a three times lower expansion, higher rigidity and a better mechanic resistance than STABI PLUS, FIBER BASALT PLUS and FIBER BASALT CLIMA can be installed by the same above described technique for the all-plastic systems, i.e. with conventional adjustments for expansion where the potential of longer support spacing would be used while, at the same time, the expansion and adjustment lengths would be shorter.

In the routing inside in-wall channels so called "rigid" assembly can be used which means that the pipe is secured to fixed points so that thermal expansion is transferred to the piping material and thus does not show. A basic assumption in this case are clamps sufficiently designed and anchored to hold the piping system.

10.6. Coupling to the system

The Ekoplastik pipeline system can be coupled by welding or mechanic coupling. Coupling of pipes and fittings is done in the same way by all types of pipes – the fittings are the same. In case of Ekoplastik STABI PLUS pipes it is necessary to remove the upper PPR and middle aluminium layers in the insertion length to the throat of the fitting (using special shavers) before the commencement of welding works.

Welding

Polyfusion welding, application of electric fittings or butt welding techniques can be used. All the methods must be applied accurately according to standard working procedures, using reliable instruments parameters of which are checked.

Pipe cutting

Pipes can be cut (by a saw or shears) with the use of well-sharpened tools only. Use of special shears or plastic pipe cutter is recommended.



Threaded couplings, plastic/metal couplings

Plastic/metal couplings in hot water piping and heating systems contain pressed-in brass nickel-coated threads (both external and internal).



If a coupling is not fitted with a hexa- or multigonal piece directly on its metal part, tightening wrenches with a tape should be used.

WARNING:

For thermal/technical and physical/mechanic reasons the use of plastic threaded couplings is not permissible in sanitary engineering. Plastic threaded couplings may be used, for instance, in temporary distribution systems. Plastic plugs should be used for closing of elbows for wall mounting and universal wall mounting groups with tap connectors until dispenser pipe fittings (valves) are installed.

Sealing of couplings

Threaded couplings may be sealed with a Teflon tape sealing teflon fibre or special sealant only.

10.7. Insulation

While hot water piping systems and heating systems are insulated against heat losses, the cold water pipes are conversely insulated against heat gain and pipe condensation. From the point of view of drinking water health requirements, the insulation of a cold water system is important to keep the temperature level under 20 °C as well as keeping hot water at the upper limit (given by the standard of protection against scalding) – both cases are concerned with a bacteria effect reduction. Keeping hot water at the required temperature level together with properly functioning circulation are important parts of protection against bacteria (such as: Legionella pneumophila) beside some other technical solutions (such as thermal sterilisation).

The thickness and kind of insulation layers are determined on the basis of thermal resistance of the insulation system to be used, air humidity in the area of the piping system and a difference between the room temperature (air) and that one of flowing water.

The whole piping system, along its whole route including fittings and valves, must be insulated. It is necessary to maintain a minimum insulation layer thickness along both pipe diameter and pipeline route (this means that insulation types that are wrapped over the pipes as cut lengthwise must be, after the installation, bonded again into a uniform profile (e.g. using an adhesive, clamps or a sealing tape).

Minimum thermal insulation layer for cold water system – example

Placement / routing of pipes	insulation layer thickness $\lambda = 0,040 \text{ W/mK}$
freely laid pipes in unheated areas (such as: basement areas)	4 mm
freely laid pipes in heated areas	9 mm
pipes in crawlways without a-hot water line running in parallel	4 mm
pipes in crawlways with a-hot water line running in parallel	13 mm
independently running underplaster pipes (in channels)	4 mm
underplaster pipes (in channels) running in parallel with a-hot water line	13 mm
pipes cast over with concrete	4 mm

Remark: the above thickness values must be re-calculated for other thermal characteristics

If hot water is distributed then it should be taken into consideration that plastic pipes possess better thermal insulation properties than metal ones. An application of plastic pipes in such systems may therefore mean a significant cost-saving solution!

In systems of high demand (such as: bathrooms, bathtubs, washing machines, etc.) heat losses in plastic pipes with flowing water are 20 % compared to metal ones. Another 15 % can be saved by a thorough insulation. In systems of small and/or short-time demand where pipes are not heated to operating temperatures regularly, only 10 % of savings can be expected, however, 20 % can be expected at peak demand.

The insulation layer thickness for hot water systems usually fluctuates in the range of 9 through 15 mm at the value of thermal resistance: $\lambda = 0.040 \text{ W/mK}$.

10.8. Pressure test

The distribution system can be filled with water no sooner than one hour after the last weld was performed.

After the system completion a pressure test must be performed under the conditions as follows:

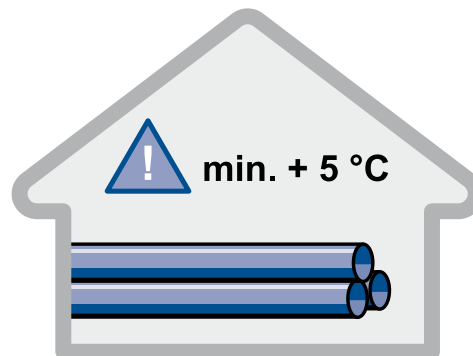
testing pressure:	min. 1,5 MPa (15 bar)
test commencement:	min. 12 hour after bleeding and additional pressurising of the system
test duration time:	60 minutes
max. pressure drop:	0,02 MPa (0,2 bar)

Any piping system prepared for this test must be laid according to the design, clean and visible along its whole length. The system is tested without hydrants and water-meters (flow-meters) and other valves /pipe fittings with an exception of bleeding equipment. Already installed closing valves should be left open. Water dispensing fittings may be installed only if they conform with the testing pressure, however, under standard conditions they are usually replaced with plugs. The piping system is filled from the lowest point so that all bleeding points are open from the beginning and then being step-by-step closed, once water without air bubbles runs out of them. The pipeline length is usually taken according to local conditions with a recommended max. length of 100 metres.

After fulling the system with water will be the internal water system stabilized with testing overpressure at least 12 hours, after this period is overpressure increased to 15 bars (testing overpressure). The pressure test lasts 60 minutes and maximum allowable pressure drop is 0.02 MPa. If the value of pressure drop is higher then a leaking spot must be discovered, the relevant defect fixed and a new pressure test performed. A record on the test must be prepared, for instance in a form of Pressure Test Certificate – vide Chapter XII (this record / certificate forms one of the documents necessary for warranty claim filing).

11. Material Transport and Storage

The system components must be protected against weather, UV radiation and contamination.

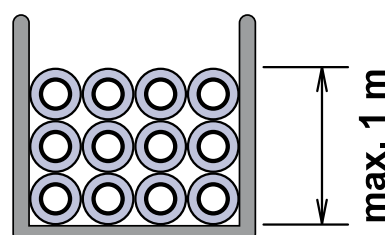


Stores of plastic components must be separated from such areas where solvents, adhesives, paints or similar products are stored.

It is recommended to store the components at minimum temperature of 5 °C. If the temperature is lower than 5 °C, it is necessary to be careful at pipeline manipulation.

Plastic pipes in stock must be supported along their whole lengths or protected in another suitable way against deflection. Plastic pipe fittings are usually stored in sacks on pallets or freely loaded in boxes, containers, baskets, etc. Maximum storage height of one metre must be respected if plastic pipes are stored in plastic sleeves and/or pipe fittings in plastic sacks. Each of the different types of pipes and fittings are stored separately. When dispatching from storage, the oldest stock should be dispatched first.

During their transport it is not allowed to drag pipes over the ground or lorry deck. The components/pipes must not be transported by throwing or letting them fall off the lorry to the ground. If they are transported to/on the site then they must be protected against mechanical damage and stored at the spot on a suitable underlay where protected against dirt, solvents, direct heat (contact with a radiator, etc.). The components are supplied in protective covers (pipes in polyethylene bags, pipe fittings also in sacks or cardboard boxes) and it is desirable to let them in these as long as possible before the start of installation works (as a protection against dirt).



12. Pressure Test Certificate

Description of installed system:

Place:

Building / structure:

PRESSURE TEST CERTIFICATE

Piping systems installed lenght

Ekoplastik pipe diameter [mm]	pipe / line length [m]	pressure class	description of pipe
16			
20			
25			
32			
40			
50			
63			
75			
90			
110			
125			

The highest outlet point.....m above pressure gauge

Pressure test:

Test started at / day: time:

Testing pressure: MPa (test start)

Pressure after 1 hour: MPa

Pressure drop during the test. MPa

Test ended at/day: time:

Result of test:

on behalf of Client: (we confirm by our signature a taking-over of installation, which is free and clear)

.....
place

.....
date

.....
rubber stamp & signature

on behalf of Supplier:

.....
place

.....
date

.....
rubber stamp & signature

13. Polyfusion Welding - Working Procedures

Tools

- 1/ Electric polyfusion welding machine fitted with welding adapters of suitable dimensions, incl. a movable feeder cable.
- 2/ Contact thermometer.
- 3/ Special shears or cutter (i.e. jaw plus cutting wheel), metal hand-saw at a pinch.
- 4/ Short blade sharp penknife.
- 5/ Textile rag (non-synthetic material only).
- 6/ Degreaser (Tangit, Spirit).
- 7/ Pocket, folding rule + marker.
- 8/ Scraper and assembly jig for welding of diameters over 50 mm.
- 9/ Pipe shaver, if Ekoplastik Stabi pipes are to be coupled.

Checking of the tools

Welding adapters are to be fixed firmly to the welding machine first (this is usually made with screws – depending on the welding machine type). The welder controller is then set up to 250 – 270 °C and connected to power supply. Time necessary to heat the welding machine up will depend on ambient conditions. Once the welding machine is hot the welding adapters are cleaned of impurities left from a previous use using a rag of non-synthetic textile – otherwise Teflon surfaces might be damaged. The work with the welding apparatus may start when it is sufficiently hot which should be checked using a LED diode and contact thermometer. The contact thermometer is used for fine temperature tuning up to 250 – 270 °C.

A proper function of special shears or cutting wheel should be checked by two cuts performed on a pipe assigned to testing purposes. During the trial cutting no depression of outer pipe diameter should result, otherwise the tools must be sharpened again.

Checking of the materials

All the material should be inspected thoroughly before the works start. The components must not display in any case wall thinning defects, closing elements should be checked for their proper functioning and all the threads with matching pieces for a free motion. Welding sockets and pipe end to be inserted should be cleaned and degreased. Fittings are then tested by sliding them on the heating plug (which is, of course, cold at this moment) and checked for undesirable loose matching. Wobbling fittings must be discarded!!!

Welding procedures

1/ A desirable pipe length is measured and cut off. If a metal handsaw was used then off-cuts must be cleaned from the pipe edges.



2/ It is further recommended to bevel (approximate angle: 30 – 45 °C) outer edges of the pipe ends (the ends to be heated) by the use of a special cutter or a sharp knife. This procedure is strongly recommended especially for pipe diameters over 40 mm. This modification prevents material sweeping when pipe ends are inserted into fittings.



3/ If Ekoplastik Stabi components are to be welded then outer PPR and middle aluminium layers should be removed first (using special shavers) along the whole pipe section to be inserted into the pipe fitting socket. The resulting pipe is then further processed in the same way as Ekoplastik PPR allplastic pipes are.

4/ If larger diameters are to be welded (40mm and more) a check of their ovality would be of great importance. It would be also necessary to scrape off the top layer of oxides (i.e. 0,1 mm) in the whole pipe length to be inserted. The oxide layer can influence adversely the weld quality.

5/ The insertion length (of the pipe end to be inserted into a pipe fitting) should be marked on the pipe with a felt pen or a marker. In doing this it is necessary to consider the fact that the pipe must not be pushed into the fitting as far as to its dead stop in the fitting socket. About 1 mm gap should be preserved for material accumulation so as not to reduce the fitting internal diameter.

6/ It is, furthermore, recommended to mark also the weld position on both the pipe and fitting preventing a possibility of a turn of pipe once it is inserted. Installation marks on fittings could serve also to this purpose.





7/ The surfaces to be welded should be cleaned and de-greased after the marking was completed. If this step is left out then melted layers can be bonded inadequately! Now the heating-up process may start.

8/ Owing to its thicker wall (needing more time to get heated through) the fitting should be pushed over the hot plug first and a check for a loose contact is made again. A fitting that does not match the plug over its whole surface should be discarded because uneven contact (and material heating up) may result in low-quality welds. The pipe is slid into the plug next and the same procedure is applied as for the fitting.

9/ Both components are heated for the period shown in Table 1, page 29. The heating-up time is measured starting the moment when both the pipe and fitting are over the plug in their whole marked lengths. If the sliding operation seems to be difficult a slight component turning (max. 10°) on the plug is admissible until they are slid over their whole lengths. No turning is allowed during the heating up period; this could cause material accumulation in some sections.

10/ After the end of the heating-up period both the fitting and pipe are removed and coupled inserting the pipe into the fitting socket in a gentle and uniform pressure for the whole marked length. Again, no turning is allowed. An axis alignment of both components is then checked. Table 2 on page 29 shows maximum permissible intervals between the component removal from the plug and assembly of the pipe with the pipe fitting socket. If these intervals are not followed then melted layers may cool excessively creating thus low-quality joint (lack of fusion).

Any fresh joint should be fixed for a period of 20 – 30 seconds before its partial cooling takes place, fixing thus the pipe end against sliding it out of the socket under the welding pressure and/or against a change of position of the pipe end and socket.

The piping system may be filled with water not earlier than one hour after the last weld has been completed.

Recommendation for welding operations involving large diameters: Up to 40 mm diameter pipes may be welded in hand, however, machine welding (or, at least, a use of welding jig) is recommended for 50 mm diameters and higher in order to provide necessary thrust forces and get the pipes correctly aligned.

I. Preparation of pipes



bevelling



scraping



II. Welding



fixing and aligning components in jig, then heating-up



adjustment after heating up period



finished weld after cooling period

Table: 1

D [mm]	heat-up time [s]	D [mm]	heat-up time [s]
16	5	63	24
20	5	75	30
25	7	90	40
32	8	110	50
40	12	125	60
50	18		

Table: 2

D [mm]	heat-up time [s]	cooling time [min]	
		fixation (s)	total (min)
16, 20	4	6	2
25	4	10	2
32	6	10	4
40, 50	6	20	4
63, 75	8	30	6
90	8	40	6
110	10	50	8
125	10	60	8

14. Welding by Electrofitting - Working Procedures

Tools

- 1/ Electric welding machine for electric welding of plastic pipes (electrofitting welder).
- 2/ Special shears or cutter.
- 3/ Textile rag (non-synthetic material only).
- 4/ Degreaser, sharp knife with short blade.
- 5/ Meter + marker.
- 6/ Installation jig to fasten pipe and fitting in right position.
- 7/ Scraper and assembly jig for welding of diameters over 50 mm.
- 8/ Pipe shaver, if Ekoplastik Stabi pipes are to be coupled.

Tool preparations

The welding machine is positioned at the workplace and feeding cable is unreeled. Correct functioning of cutting tools (for details see Chapter Polyfusion Welding).

Welding procedures

Pipes are cut by special shears or a cutting wheel. After the checking of components (pipes and fittings) the welding machine is to be prepared.

Pipes are treated in required lengths and oxidised layers are removed with a scraper or special agent and external pipe surfaces plus internal surfaces of electrofittings are degreased (using spirit or Tangit) afterwards.

Then the electrofitting insertion depth is marked. If Ekoplastik Stabi piping is to be assembled then outer PPR and middle aluminium layers should be removed first (using special cutters) along the whole pipe section to be inserted into the socket of electrofitting and then the pipe joint is inserted there. Position of the pipe should be fixed in the socket because, due to the volume expansion of heated plastic material, pipe could be pushed out of its place.

The electrofitting welding machine is then connected to the power supply (220V) and it is necessary to wait some time until the welding machine gets operational. The contacts of electrofitting piece and welding machine are then connected. Welding starts after the START button is pushed and the welding machine automatically switches itself off as soon as the weld is completed. A correct process of electric welding is indicated by excessive plastic material squeezed out of check-points on external electrofitting surfaces.

The piping system assembled this way may be loaded with water not earlier than one hour after the last weld has been completed



It is very important to let the performed joint become cold before next using.

The performed joint should be also protected from mechanical tension (like turning and pressure or pipe pressure).

15. Repair of Damaged Piping



- A unique way of repairing pipes drilled through – it should be part of every plumber's kit.
- Considerably reduces the extent of demolition work and damage to tiles.
- The set comprises a special heating adapter and repairing stakes.
- The adapter is an universal one for all types of non-paired welding machines incl. angle welding machines.
- A special non-paired adapter is now part of the welding set.
- The set is intended for repairing of the drilled through pipeline Ekoplastik PPR and Ekoplastik Stabi.
- It is a universal fit for all diameters between 20 and 125 mm, as well as for all pressure lines.
- It operates on the principle of polyfusion welding and all general rules for polyfusion welding are applicable – see the Assembly regulations directive Ekoplastik PPR.

The required tools: repairing set, a piece of cloth or napkin to use for degreasing and drying out, tape measure, pencil, screwdriver, scissors (pliers), the special welding adapters, correcting spike and the welding machine. Turn on the welding machine with the fixed welding adapter, set it to the maximum and wait for the second soaking cycle minimally.



The drilled hole must be redrilled (calibrated) with a 10 mm drill.



Dry and degrease. Measure and mark the depth of insertion on the stake depending on the wall thickness of the drilled pipe + 2 mm; set the distance ring on the heating adaptor



Start heating the repairing stake and adaptor and insert the heating stake slowly and without turning into the prepared hole. Heat for 5 seconds.



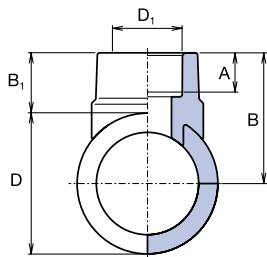
Take down the repairing stake and insert without turning into the heated hole.



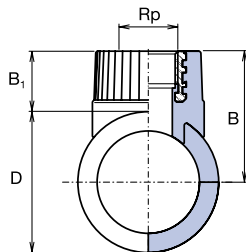
When it cools down, cut off the remaining part of the repairing stake with a pair of shears.

If using the repair set without any previous experience, we recommend that you test out with two check welds, cut them and visually check the weld – both the fusion of the material and the size of melted collars.

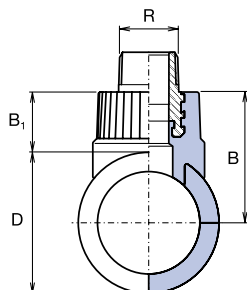
16. Additional Branching



All plastic weld in saddle



Weld in saddle with metal thread female



Weld in saddle with metal thread male

- The large assortment of fittings allows for the creation of branching of diameter 32, 40 mm or branching with internal and external thread (3/4").
- For the Ekoplastik PPR and Ekoplastik Stabi pipelines of diameters 63, 75, 90, 110, 125 mm and for all pressure lines.
- The principle of polyfusion welding type C is maintained.
- Special heating adaptors for weld in saddle for each diameter of pipeline, universal for all types of flat welding machines.
- Saves work and space – substitution of "T"– pieces and reduction.
- By connecting the saddle and the pipe, a perfect joint is achieved throughout the entire welding area.



Branching 32 mm for a pipeline of diameter 90 mm.

Old technique (on the left): "T" piece 90 mm, reduction 90/63 mm and reduction 63/32 mm was used. New technique (on the right): welding saddle 90 × 32 mm was used.



Useful tools: special drill, drilling machine, piece of fabric or napkin for degreasing, special heating adaptor for weld in saddle, welding machine, edge chamfering tool (for Stabi pipes)

	diametr	D mm	D ₁ mm	Rp	R	A mm	B ₁ mm	B mm
1	63 × 32	63	32			18	27,0	58,5
	75 × 32	75	32			18	27,0	64,5
	90 × 32	90	32			18	27,0	72,0
	110 × 32	110	32			18	25,7	80,7
	110 × 40	110	40			21	25,7	80,7
2	63 × 3/4"	63		3/4"			27,0	58,5
	75 × 3/4"	75		3/4"			27,0	64,5
	90 × 3/4"	90		3/4"			27,0	72,0
3	63 × 3/4"	63			3/4"		44,8	76,3
	75 × 3/4"	75			3/4"		44,8	82,3
	90 × 3/4"	90			3/4"		44,8	89,8

Dimensions are given in millimetres.



Drill a hole into the pipe with the special drill.



Clean. If you use the Stabi pipe, chamfer the edge of the drilled hole. Clean and degrease the adapting pipe as well as the drilled hole.



First heat the hole. Put an adapter into the drilled hole. After you make a weld on piece on the whole perimeter of the adapter put a plastic weld in saddle on the adapter so that the mark on the saddle and the mark on the adapter are on one level. Heat the hole and the plastic weld in saddle. In case of weld in saddle parts 110 × 32 and 110 × 40 is the heating-up time same as in case of dimension 40 mm = 12 sec.



Put the heated saddle on the heated hole and fix for about 16 seconds. One hour later you can run water in and expose it to pressure.

17. Pressure Loss Tables

S 5 (PN10) water temperature = 10° C																				
k=0,01	20 × 2,3 mm		25 × 2,5 mm		32 × 3,0 mm		40 × 3,7 mm		50 × 4,6 mm		63 × 5,8 mm		75 × 6,9 mm		90 × 8,2 mm		110 × 10 mm		125 × 11,4 mm	
Q l/s	R kPa/m	v m/s	R kPa/m	v m/s	R kPa/m	v m/s	R kPa/m	v m/s	R kPa/m	v m/s	R kPa/m	v m/s	R kPa/m	v m/s	R kPa/m	v m/s	R kPa/m	v m/s	R kPa/m	v m/s
0,01	0,006	0,1																		
0,02	0,020	0,1	0,006	0,1																
0,03	0,041	0,2	0,012	0,1	0,003	0,1														
0,04	0,067	0,2	0,019	0,1	0,006	0,1														
0,05	0,099	0,3	0,029	0,2	0,008	0,1	0,003	0,1												
0,06	0,137	0,3	0,039	0,2	0,011	0,1	0,004	0,1												
0,07	0,180	0,4	0,052	0,2	0,015	0,1	0,005	0,1	0,002	0,1										
0,08	0,227	0,4	0,065	0,3	0,019	0,2	0,006	0,1	0,002	0,1										
0,09	0,280	0,5	0,080	0,3	0,023	0,2	0,008	0,1	0,003	0,1										
0,10	0,337	0,5	0,097	0,3	0,028	0,2	0,009	0,1	0,003	0,1										
0,12	0,465	0,6	0,133	0,4	0,038	0,2	0,013	0,1	0,004	0,1	0,001	0,1								
0,14	0,611	0,8	0,175	0,4	0,050	0,3	0,017	0,2	0,006	0,1	0,002	0,1								
0,16	0,774	0,9	0,222	0,5	0,063	0,3	0,022	0,2	0,007	0,1	0,002	0,1	0,001	0,1						
0,18	0,954	1,0	0,273	0,6	0,078	0,3	0,027	0,2	0,009	0,1	0,003	0,1	0,001	0,1						
0,20	1,150	1,1	0,329	0,6	0,094	0,4	0,032	0,2	0,011	0,2	0,004	0,1	0,002	0,1						
0,30	2,370	1,6	0,674	1,0	0,192	0,6	0,065	0,4	0,022	0,2	0,007	0,1	0,003	0,1	0,001	0,1				
0,40	3,971	2,1	1,124	1,3	0,319	0,8	0,108	0,5	0,037	0,3	0,012	0,2	0,005	0,1	0,002	0,1	0,001	0,1		
0,50	5,939	2,7	1,675	1,6	0,474	0,9	0,160	0,6	0,055	0,4	0,018	0,2	0,008	0,2	0,003	0,1	0,001	0,1		
0,60	8,266	3,2	2,322	1,9	0,655	1,1	0,221	0,7	0,076	0,5	0,025	0,3	0,011	0,2	0,005	0,1	0,002	0,1		
0,70			3,064	2,2	0,863	1,3	0,291	0,8	0,099	0,5	0,033	0,3	0,014	0,2	0,006	0,2	0,002	0,1		
0,80			3,900	2,5	1,095	1,5	0,369	1,0	0,126	0,6	0,042	0,4	0,018	0,3	0,008	0,2	0,003	0,1	0,002	0,1
0,90			4,826	2,9	1,352	1,7	0,455	1,1	0,155	0,7	0,051	0,4	0,022	0,3	0,009	0,2	0,004	0,1	0,002	0,1
1,00			5,844	3,2	1,634	1,9	0,549	1,2	0,187	0,8	0,062	0,5	0,027	0,3	0,011	0,2	0,004	0,2	0,002	0,1
1,20					2,269	2,3	0,760	1,4	0,258	0,9	0,085	0,6	0,037	0,4	0,015	0,3	0,006	0,2	0,003	0,1
1,40					2,998	2,6	1,001	1,7	0,340	1,1	0,112	0,7	0,049	0,5	0,020	0,3	0,008	0,2	0,004	0,1
1,60					3,819	3,0	1,273	1,9	0,431	1,2	0,142	0,8	0,062	0,5	0,026	0,4	0,010	0,3	0,005	0,2
1,80					4,732	3,4	1,574	2,2	0,532	1,4	0,175	0,9	0,076	0,6	0,031	0,4	0,012	0,3	0,006	0,2
2,00							1,903	2,4	0,642	1,5	0,211	1,0	0,092	0,7	0,038	0,5	0,014	0,3	0,008	0,2
2,20							2,262	2,6	0,762	1,7	0,250	1,1	0,108	0,7	0,045	0,5	0,017	0,3	0,009	0,3
2,40							2,649	2,9	0,891	1,8	0,292	1,2	0,126	0,8	0,052	0,6	0,020	0,4	0,010	0,3
2,60							3,064	3,1	1,029	2,0	0,337	1,3	0,146	0,9	0,060	0,6	0,023	0,4	0,012	0,3
2,80							3,507	3,4	1,176	2,1	0,385	1,3	0,166	1,0	0,069	0,7	0,026	0,4	0,014	0,3
3,00									1,332	2,3	0,436	1,4	0,188	1,0	0,078	0,7	0,030	0,5	0,016	0,4
3,20									1,497	2,4	0,489	1,5	0,211	1,1	0,087	0,8	0,033	0,5	0,018	0,4
3,40									1,671	2,6	0,545	1,6	0,235	1,2	0,097	0,8	0,037	0,5	0,019	0,4
3,60									1,854	2,8	0,604	1,7	0,260	1,2	0,107	0,8	0,041	0,6	0,022	0,4
3,80									2,045	2,9	0,666	1,8	0,287	1,3	0,118	0,9	0,045	0,6	0,024	0,5
4,00									2,246	3,1	0,731	1,9	0,314	1,4	0,129	0,9	0,049	0,6	0,026	0,5
4,20									2,454	3,2	0,798	2,0	0,343	1,4	0,141	1,0	0,054	0,7	0,028	0,5
4,40									2,672	3,4	0,868	2,1	0,373	1,5	0,153	1,0	0,058	0,7	0,031	0,5
4,60									2,898	3,5	0,940	2,2	0,404	1,6	0,166	1,1	0,063	0,7	0,034	0,6
4,80											1,016	2,3	0,436	1,6	0,179	1,1	0,068	0,8	0,037	0,6
5,00											1,093	2,4	0,469	1,7	0,193	1,2	0,073	0,8	0,039	0,6
5,20													0,492	1,8	0,203	1,2	0,078	0,8	0,041	0,6
5,40													0,523	1,8	0,218	1,3	0,083	0,9	0,045	0,7
5,60													0,560	2,0	0,234	1,3	0,088	0,9	0,048	0,7
5,80													0,598	2,0	0,247	1,4	0,094	0,9	0,051	0,7
6,00													0,637	2,0	0,264	1,4	0,099	0,9	0,054	0,7
6,20													0,672	2,1	0,281	1,5	0,105	1,0	0,058	0,8
6,40													0,714	2,2	0,295	1,5	0,113	1,0	0,061	0,8
6,60													0,757	2,2	0,313	1,6	0,119	1,0	0,064	0,8
6,80													0,801	2,3	0,332	1,6	0,125	1,1	0,068	0,8
7,00													0,831	2,4	0,351	1,7	0,132	1,1	0,071	0,9

S 3,2 (PN16) water temperature = 10° C

k=0,01	16 × 2,3mm		20 × 2,8mm		25 × 3,5mm		32 × 4,5mm		40 × 5,6mm		50 × 6,9mm		63 × 8,7mm		75 × 10,4mm		90 × 12,5mm		110 × 15,2mm		125 × 17,1mm	
Q l/s	R kPa/m	v m/s	R kPa/m	v m/s	R kPa/m	v m/s	R kPa/m	v m/s	R kPa/m	v m/s	R kPa/m	v m/s	R kPa/m	v m/s	R kPa/m	v m/s	R kPa/m	v m/s	R kPa/m	v m/s	R kPa/m	v m/s
0,01	0,025	0,1	0,008	0,1																		
0,02	0,083	0,2	0,027	0,1	0,009	0,1																
0,03	0,170	0,3	0,056	0,2	0,019	0,1	0,006	0,1														
0,04	0,282	0,4	0,093	0,2	0,032	0,2	0,010	0,1	0,003	0,1												
0,05	0,418	0,5	0,137	0,3	0,047	0,2	0,015	0,1	0,005	0,1												
0,06	0,576	0,6	0,189	0,4	0,065	0,2	0,020	0,1	0,007	0,1	0,002	0,1										
0,07	0,756	0,7	0,248	0,4	0,085	0,3	0,027	0,2	0,009	0,1	0,003	0,1										
0,08	0,958	0,8	0,313	0,5	0,108	0,3	0,034	0,2	0,012	0,1	0,004	0,1										
0,09	1,180	0,9	0,386	0,6	0,133	0,4	0,041	0,2	0,014	0,1	0,005	0,1	0,002	0,1								
0,10	1,422	1,0	0,465	0,6	0,160	0,4	0,050	0,2	0,017	0,2	0,006	0,1	0,002	0,1								
0,12	1,967	1,2	0,641	0,7	0,221	0,5	0,069	0,3	0,023	0,2	0,008	0,1	0,003	0,1	0,001	0,1						
0,14	2,588	1,4	0,843	0,9	0,290	0,6	0,090	0,3	0,031	0,2	0,010	0,1	0,003	0,1	0,002	0,1						
0,16	3,285	1,6	1,068	1,0	0,367	0,6	0,114	0,4	0,039	0,2	0,013	0,2	0,004	0,1	0,002	0,1						
0,18	4,056	1,8	1,316	1,1	0,452	0,7	0,140	0,4	0,048	0,3	0,016	0,2	0,005	0,1	0,002	0,1	0,001	0,1				
0,20	4,900	2,0	1,588	1,2	0,544	0,8	0,168	0,5	0,058	0,3	0,019	0,2	0,006	0,1	0,003	0,1	0,001	0,1				
0,30	10,182	2,9	3,277	1,8	1,118	1,2	0,345	0,7	0,118	0,5	0,040	0,3	0,013	0,2	0,006	0,1	0,002	0,1	0,001	0,1		
0,40			5,499	2,5	1,868	1,6	0,574	1,0	0,196	0,6	0,066	0,4	0,022	0,2	0,010	0,2	0,004	0,1	0,002	0,1		
0,50			8,236	3,1	2,786	2,0	0,854	1,2	0,290	0,8	0,097	0,5	0,032	0,3	0,014	0,2	0,006	0,2	0,002	0,1		
0,60					3,869	2,4	1,183	1,4	0,401	0,9	0,134	0,6	0,045	0,4	0,020	0,3	0,008	0,2	0,003	0,1		
0,70					5,112	2,8	1,558	1,7	0,528	1,1	0,176	0,7	0,058	0,4	0,026	0,3	0,011	0,2	0,004	0,1		
0,80					6,513	3,1	1,980	1,9	0,669	1,2	0,223	0,8	0,074	0,5	0,032	0,3	0,014	0,2	0,005	0,2	0,003	0,1
0,90					8,071	3,5	2,448	2,2	0,826	1,4	0,275	0,9	0,091	0,6	0,040	0,4	0,017	0,3	0,006	0,2	0,003	0,1
1,00							2,960	2,4	0,997	1,5	0,332	1,0	0,110	0,6	0,048	0,4	0,020	0,3	0,008	0,2	0,004	0,2
1,20							4,117	2,9	1,382	1,8	0,459	1,2	0,152	0,7	0,066	0,5	0,028	0,4	0,011	0,2	0,006	0,2
1,40							5,449	3,4	1,824	2,1	0,604	1,4	0,199	0,9	0,087	0,6	0,037	0,4	0,014	0,3	0,007	0,2
1,60									2,322	2,5	0,767	1,6	0,253	1,0	0,110	0,7	0,046	0,5	0,018	0,3	0,009	0,3
1,80									2,874	2,8	0,948	1,7	0,311	1,1	0,136	0,8	0,057	0,5	0,022	0,4	0,011	0,3
2,00									3,480	3,1	1,145	1,9	0,376	1,2	0,164	0,9	0,069	0,6	0,026	0,4	0,014	0,3
2,20									4,139	3,4	1,360	2,1	0,446	1,3	0,194	1,0	0,081	0,7	0,031	0,4	0,016	0,3
2,40											1,591	2,3	0,521	1,5	0,227	1,0	0,095	0,7	0,036	0,5	0,019	0,4
2,60											1,839	2,5	0,601	1,6	0,261	1,1	0,109	0,8	0,041	0,5	0,021	0,4
2,80											2,104	2,7	0,686	1,7	0,298	1,2	0,125	0,8	0,047	0,6	0,024	0,4
3,00											2,385	2,9	0,777	1,8	0,337	1,3	0,141	0,9	0,053	0,6	0,027	0,5
3,20											2,682	3,1	0,873	2,0	0,379	1,4	0,158	1,0	0,060	0,6	0,031	0,5
3,40											2,995	3,3	0,974	2,1	0,422	1,5	0,176	1,0	0,067	0,7	0,035	0,5
3,60											3,324	3,5	1,080	2,2	0,468	1,6	0,195	1,1	0,074	0,7	0,039	0,6
3,80													1,190	2,3	0,515	1,6	0,215	1,1	0,081	0,8	0,043	0,6
4,00													1,306	2,4	0,565	1,7	0,235	1,2	0,089	0,8	0,047	0,6
4,20													1,427	2,6	0,617	1,8	0,257	1,3	0,097	0,8	0,051	0,7
4,40													1,553	2,7	0,671	1,9	0,279	1,3	0,105	0,9	0,055	0,7
4,60													1,683	2,8	0,727	2,0	0,302	1,4	0,114	0,9	0,059	0,7
4,80													1,819	2,9	0,785	2,1	0,326	1,4	0,123	1,0	0,064	0,7
5,00													1,959	3,1	0,845	2,2	0,351	1,5	0,132	1,0	0,069	0,8
5,20															0,895	2,3	0,373	1,6	0,138	1,0	0,073	0,8
5,40															0,962	2,3	0,399	1,6	0,151	1,1	0,079	0,8
5,60															1,030	2,4	0,426	1,7	0,161	1,1	0,084	0,9
5,80															1,093	2,5	0,454	1,8	0,171	1,2	0,091	0,9
6,00															1,166	2,6	0,483	1,8	0,182	1,2	0,096	0,9
6,20															1,241	2,7	0,512	1,9	0,193	1,3	0,102	1,0
6,40															1,310	2,8	0,542	1,9	0,204	1,3	0,108	1,0
6,60															1,389	2,9	0,574	2,0	0,216	1,3	0,114	1,0
6,80															1,470	3,0	0,605	2,1	0,227	1,4	0,120	1,1
7,00															1,544	3,0	0,638	2,1	0,240	1,4	0,126	1,1

S 3,2 (PN16) water temperature = 50° C

Q 1/s	R kPa/m	v m/s	R kPa/m	v m/s	R kPa/m	v m/s	R kPa/m	v m/s	R kPa/m	v m/s	R kPa/m	v m/s	R kPa/m	v m/s	R kPa/m	v m/s	R kPa/m	v m/s	R kPa/m	v m/s	R kPa/m	v m/s
0,01	0,020	0,1	0,007	0,1																		
0,02	0,068	0,2	0,022	0,1	0,008	0,1																
0,03	0,138	0,3	0,045	0,2	0,016	0,1	0,005	0,1														
0,04	0,230	0,4	0,075	0,2	0,026	0,2	0,008	0,1	0,003	0,1												
0,05	0,342	0,5	0,112	0,3	0,038	0,2	0,012	0,1	0,004	0,1												
0,06	0,473	0,6	0,154	0,4	0,053	0,2	0,016	0,1	0,006	0,1	0,002	0,1										
0,07	0,623	0,7	0,203	0,4	0,070	0,3	0,022	0,2	0,007	0,1	0,002	0,1										
0,08	0,792	0,8	0,257	0,5	0,088	0,3	0,027	0,2	0,009	0,1	0,003	0,1										
0,09	0,978	0,9	0,317	0,6	0,108	0,4	0,034	0,2	0,011	0,1	0,004	0,1	0,001	0,1								
0,10	1,183	1,0	0,382	0,6	0,131	0,4	0,040	0,2	0,014	0,2	0,005	0,1	0,002	0,1								
0,12	1,644	1,2	0,530	0,7	0,181	0,5	0,056	0,3	0,019	0,2	0,006	0,1	0,002	0,1	0,001	0,1						
0,14	2,175	1,4	0,698	0,9	0,238	0,6	0,073	0,3	0,025	0,2	0,008	0,1	0,003	0,1	0,001	0,1						
0,16	2,773	1,6	0,888	1,0	0,302	0,6	0,093	0,4	0,032	0,2	0,011	0,2	0,004	0,1	0,002	0,1						
0,18	3,439	1,8	1,099	1,1	0,373	0,7	0,115	0,4	0,039	0,3	0,013	0,2	0,004	0,1	0,002	0,1	0,001	0,1				
0,20	4,172	2,0	1,330	1,2	0,450	0,8	0,138	0,5	0,047	0,3	0,016	0,2	0,005	0,1	0,002	0,1	0,001	0,1				
0,30	8,828	2,9	2,785	1,8	0,935	1,2	0,285	0,7	0,096	0,5	0,032	0,3	0,011	0,2	0,005	0,1	0,002	0,1	0,001	0,1		
0,40			4,731	2,5	1,578	1,6	0,478	1,0	0,161	0,6	0,054	0,4	0,018	0,2	0,008	0,2	0,003	0,1	0,001	0,1		
0,50			7,161	3,1	2,376	2,0	0,716	1,2	0,240	0,8	0,080	0,5	0,026	0,3	0,012	0,2	0,005	0,2	0,002	0,1		
0,60					3,325	2,4	0,997	1,4	0,334	0,9	0,110	0,6	0,036	0,4	0,016	0,3	0,007	0,2	0,003	0,1		
0,70					4,425	2,8	1,322	1,7	0,441	1,1	0,146	0,7	0,048	0,4	0,021	0,3	0,009	0,2	0,003	0,1		
0,80					5,675	3,1	1,689	1,9	0,562	1,2	0,185	0,8	0,061	0,5	0,026	0,3	0,011	0,2	0,004	0,2	0,002	0,1
0,90					7,073	3,5	2,098	2,2	0,696	1,4	0,229	0,9	0,075	0,6	0,033	0,4	0,014	0,3	0,005	0,2	0,003	0,1
1,00							2,549	2,4	0,843	1,5	0,277	1,0	0,091	0,6	0,039	0,4	0,016	0,3	0,006	0,2	0,003	0,1
1,20							3,577	2,9	1,178	1,8	0,385	1,2	0,126	0,7	0,055	0,5	0,023	0,4	0,009	0,2	0,005	0,2
1,40							4,770	3,4	1,565	2,1	0,510	1,4	0,166	0,9	0,072	0,6	0,030	0,4	0,011	0,3	0,006	0,2
1,60									2,004	2,5	0,650	1,6	0,211	1,0	0,091	0,7	0,038	0,5	0,014	0,3	0,008	0,3
1,80									2,494	2,8	0,807	1,7	0,261	1,1	0,113	0,8	0,047	0,5	0,018	0,4	0,009	0,3
2,00									3,036	3,1	0,980	1,9	0,316	1,2	0,136	0,9	0,057	0,6	0,021	0,4	0,011	0,3
2,20									3,629	3,4	1,168	2,1	0,376	1,3	0,162	1,0	0,067	0,7	0,025	0,4	0,013	0,3
2,40											1,372	2,3	0,441	1,5	0,190	1,0	0,079	0,7	0,030	0,5	0,015	0,4
2,60											1,592	2,5	0,511	1,6	0,220	1,1	0,091	0,8	0,034	0,5	0,018	0,4
2,80											1,828	2,7	0,585	1,7	0,251	1,2	0,104	0,8	0,039	0,6	0,020	0,5
3,00											2,079	2,9	0,664	1,8	0,285	1,3	0,118	0,9	0,044	0,6	0,023	0,5
3,20											2,345	3,1	0,748	2,0	0,320	1,4	0,132	1,0	0,050	0,6	0,025	0,5
3,40											2,627	3,3	0,837	2,1	0,358	1,5	0,148	1,0	0,055	0,7	0,029	0,6
3,60											2,925	3,5	0,930	2,2	0,398	1,6	0,164	1,1	0,061	0,7	0,032	0,6
3,80													1,028	2,3	0,439	1,6	0,181	1,1	0,067	0,8	0,035	0,6
4,00													1,131	2,4	0,483	1,7	0,198	1,2	0,074	0,8	0,039	0,7
4,20													1,239	2,6	0,528	1,8	0,217	1,3	0,081	0,8	0,042	0,7
4,40													1,351	2,7	0,575	1,9	0,236	1,3	0,088	0,9	0,046	0,7
4,60													1,468	2,8	0,624	2,0	0,256	1,4	0,095	0,9	0,050	0,7
4,80													1,589	2,9	0,676	2,1	0,277	1,4	0,103	1,0	0,053	0,8
5,00													1,716	3,1	0,729	2,2	0,298	1,5	0,111	1,0	0,057	0,8
5,20															0,774	2,3	0,318	1,6	0,117	1,0	0,062	0,8
5,40															0,832	2,3	0,341	1,6	0,127	1,1	0,066	0,9
5,60															0,893	2,4	0,365	1,7	0,136	1,1	0,070	0,9
5,80															0,949	2,5	0,389	1,8	0,145	1,2	0,076	0,9
6,00															1,014	2,6	0,414	1,8	0,154	1,2	0,081	0,9
6,20															1,081	2,7	0,440	1,9	0,164	1,3	0,086	1,0
6,40															1,142	2,8	0,467	1,9	0,173	1,3	0,091	1,0
6,60															1,212	2,9	0,494	2,0	0,183	1,3	0,096	1,0
6,80															1,285	3,0	0,522	2,1	0,194	1,4	0,101	1,1
7,00															1,351	3,0	0,551	2,1	0,204	1,4	0,107	1,1

S 2,5 (PN20) water temperature = 10° C

k=0,01	16 × 2,7 mm		20 × 3,4 mm		25 × 4,2 mm		32 × 5,4 mm		40 × 6,7 mm		50 × 8,4 mm		63 × 10,5 mm		75 × 12,5 mm		90 × 15,0 mm		110 × 18,4 mm		125 × 20,8 mm	
Q l/s	R kPa/m	v m/s	R kPa/m	v m/s	R kPa/m	v m/s	R kPa/m	v m/s	R kPa/m	v m/s	R kPa/m	v m/s	R kPa/m	v m/s	R kPa/m	v m/s	R kPa/m	v m/s	R kPa/m	v m/s	R kPa/m	v m/s
0,01	0,035	0,1	0,012	0,1																		
0,02	0,118	0,2	0,041	0,1	0,014	0,1	0,004	0,1														
0,03	0,240	0,3	0,084	0,2	0,028	0,1	0,009	0,1	0,003	0,1												
0,04	0,399	0,5	0,140	0,3	0,047	0,2	0,015	0,1	0,005	0,1												
0,05	0,591	0,6	0,207	0,4	0,070	0,2	0,022	0,1	0,007	0,1	0,003	0,1										
0,06	0,816	0,7	0,286	0,4	0,096	0,3	0,030	0,2	0,010	0,1	0,004	0,1										
0,07	1,071	0,8	0,375	0,5	0,126	0,3	0,039	0,2	0,013	0,1	0,005	0,1	0,002	0,1								
0,08	1,357	0,9	0,475	0,6	0,159	0,4	0,050	0,2	0,017	0,1	0,006	0,1	0,002	0,1								
0,09	1,673	1,0	0,585	0,7	0,196	0,4	0,061	0,3	0,021	0,2	0,007	0,1	0,002	0,1								
0,10	2,017	1,1	0,704	0,7	0,236	0,5	0,073	0,3	0,025	0,2	0,009	0,1	0,003	0,1	0,001	0,1						
0,12	2,791	1,4	0,973	0,9	0,325	0,6	0,101	0,3	0,034	0,2	0,012	0,1	0,004	0,1	0,002	0,1						
0,14	3,676	1,6	1,279	1,0	0,427	0,6	0,133	0,4	0,045	0,3	0,016	0,2	0,005	0,1	0,002	0,1	0,001	0,0				
0,16	4,669	1,8	1,622	1,2	0,540	0,7	0,168	0,5	0,057	0,3	0,020	0,2	0,006	0,1	0,003	0,1	0,001	0,1				
0,18	5,768	2,0	2,000	1,3	0,665	0,8	0,206	0,5	0,070	0,3	0,024	0,2	0,008	0,1	0,003	0,1	0,001	0,1				
0,20	6,971	2,3	2,414	1,5	0,802	0,9	0,249	0,6	0,084	0,4	0,029	0,2	0,010	0,1	0,004	0,1	0,002	0,1				
0,30	14,522	3,4	4,994	2,2	1,650	1,4	0,510	0,8	0,172	0,5	0,060	0,3	0,019	0,2	0,008	0,2	0,004	0,1	0,001	0,1		
0,40			8,397	2,9	2,761	1,8	0,849	1,1	0,286	0,7	0,099	0,5	0,032	0,3	0,014	0,2	0,006	0,1	0,002	0,1		
0,50					4,125	2,3	1,264	1,4	0,425	0,9	0,147	0,6	0,048	0,4	0,021	0,3	0,009	0,2	0,003	0,1		
0,60					5,735	2,8	1,752	1,7	0,587	1,1	0,203	0,7	0,066	0,4	0,029	0,3	0,012	0,2	0,005	0,1		
0,70					7,585	3,2	2,311	2,0	0,773	1,3	0,267	0,8	0,087	0,5	0,038	0,4	0,016	0,2	0,006	0,2		
0,80							2,939	2,3	0,981	1,4	0,338	0,9	0,110	0,6	0,048	0,4	0,020	0,3	0,008	0,2	0,004	0,2
0,90							3,635	2,5	1,211	1,6	0,417	1,0	0,135	0,6	0,059	0,5	0,025	0,3	0,010	0,2	0,005	0,2
1,00							4,399	2,8	1,463	1,8	0,503	1,2	0,163	0,7	0,071	0,5	0,030	0,4	0,011	0,2	0,006	0,2
1,20							6,127	3,4	2,031	2,2	0,696	1,4	0,225	0,9	0,097	0,6	0,041	0,4	0,016	0,3	0,008	0,2
1,40									2,683	2,5	0,917	1,6	0,296	1,0	0,128	0,7	0,054	0,5	0,021	0,3	0,011	0,3
1,60									3,417	2,9	1,165	1,8	0,375	1,2	0,162	0,8	0,068	0,6	0,026	0,4	0,013	0,3
1,80									4,233	3,2	1,441	2,1	0,463	1,3	0,200	0,9	0,083	0,6	0,032	0,4	0,017	0,3
2,00											1,742	2,3	0,559	1,4	0,241	1,0	0,101	0,7	0,039	0,5	0,021	0,4
2,20											2,070	2,5	0,663	1,6	0,286	1,1	0,119	0,8	0,046	0,5	0,024	0,4
2,40											2,423	2,8	0,775	1,7	0,334	1,2	0,139	0,8	0,054	0,6	0,028	0,4
2,60											2,803	3,0	0,894	1,9	0,385	1,3	0,160	0,9	0,062	0,6	0,033	0,5
2,80											3,208	3,2	1,022	2,0	0,440	1,4	0,183	1,0	0,070	0,7	0,037	0,5
3,00											3,638	3,5	1,158	2,2	0,498	1,5	0,207	1,1	0,080	0,7	0,042	0,6
3,20													1,301	2,3	0,559	1,6	0,232	1,1	0,089	0,8	0,047	0,6
3,40													1,452	2,5	0,623	1,7	0,259	1,2	0,099	0,8	0,052	0,6
3,60													1,610	2,6	0,691	1,8	0,286	1,3	0,110	0,9	0,058	0,7
3,80													1,776	2,7	0,761	1,9	0,316	1,3	0,121	0,9	0,064	0,7
4,00													1,949	2,9	0,835	2,0	0,346	1,4	0,133	1,0	0,069	0,7
4,20													2,131	3,0	0,912	2,1	0,377	1,5	0,145	1,0	0,076	0,8
4,40													2,319	3,2	0,992	2,2	0,410	1,6	0,157	1,0	0,083	0,8
4,60													2,515	3,3	1,075	2,3	0,444	1,6	0,170	1,1	0,089	0,8
4,80													2,718	3,5	1,161	2,4	0,480	1,7	0,184	1,1	0,097	0,9
5,00															1,251	2,5	0,516	1,8	0,198	1,2	0,105	0,9
5,20															1,332	2,7	0,548	1,8	0,207	1,2	0,111	1,0
5,40															1,426	2,8	0,587	1,9	0,222	1,3	0,120	1,0
5,60															1,522	2,9	0,626	2,0	0,235	1,3	0,128	1,0
5,80															1,622	3,0	0,667	2,1	0,251	1,4	0,135	1,1
6,00															1,735	3,1	0,710	2,1	0,268	1,4	0,145	1,1
6,20																	0,753	2,2	0,285	1,5	0,152	1,1
6,40																	0,797	2,3	0,300	1,5	0,162	1,2
6,60																	0,843	2,3	0,318	1,6	0,172	1,2
6,80																	0,897	2,4	0,336	1,6	0,179	1,2
7,00																	0,945	2,5	0,352	1,7	0,190	1,3

S 2,5 (PN20) water temperature = 50° C

k=0,01	16 × 2,7 mm		20 × 3,4 mm		25 × 4,2 mm		32 × 5,4 mm		40 × 6,7 mm		50 × 8,4 mm		63 × 10,5 mm		75 × 12,5 mm		90 × 15,0 mm		110 × 18,4 mm		125 × 20,8 mm	
Q l/s	R kPa/m	v m/s	R kPa/m	v m/s	R kPa/m	v m/s	R kPa/m	v m/s	R kPa/m	v m/s	R kPa/m	v m/s	R kPa/m	v m/s	R kPa/m	v m/s	R kPa/m	v m/s	R kPa/m	v m/s	R kPa/m	v m/s
0,01	0,028	0,1	0,010	0,1																		
0,02	0,096	0,2	0,034	0,1	0,011	0,1	0,004	0,1														
0,03	0,196	0,3	0,690	0,2	0,023	0,1	0,007	0,1	0,002	0,1												
0,04	0,326	0,5	0,114	0,3	0,038	0,2	0,012	0,1	0,004	0,1												
0,05	0,485	0,6	0,169	0,4	0,057	0,2	0,018	0,1	0,006	0,1	0,002	0,1										
0,06	0,672	0,7	0,234	0,4	0,078	0,3	0,024	0,2	0,008	0,1	0,003	0,1										
0,07	0,886	0,8	0,308	0,5	0,102	0,3	0,032	0,2	0,011	0,1	0,004	0,1	0,001	0,1								
0,08	1,126	0,9	0,390	0,6	0,130	0,4	0,040	0,2	0,014	0,1	0,005	0,1	0,002	0,1								
0,09	1,392	1,0	0,482	0,7	0,160	0,4	0,050	0,3	0,017	0,2	0,006	0,1	0,002	0,1								
0,10	1,684	1,1	0,582	0,7	0,193	0,5	0,060	0,3	0,020	0,2	0,007	0,1	0,002	0,1	0,001	0,1						
0,12	2,344	1,4	0,807	0,9	0,267	0,6	0,082	0,3	0,028	0,2	0,010	0,1	0,003	0,1	0,001	0,1						
0,14	3,104	1,6	1,065	1,0	0,351	0,6	0,108	0,4	0,037	0,3	0,013	0,2	0,004	0,1	0,002	0,1	0,001	0,0				
0,16	3,962	1,8	1,356	1,2	0,446	0,7	0,137	0,5	0,046	0,3	0,016	0,2	0,005	0,1	0,002	0,1	0,001	0,1				
0,18	4,918	2,0	1,679	1,3	0,551	0,8	0,169	0,5	0,057	0,3	0,020	0,2	0,006	0,1	0,003	0,1	0,001	0,1				
0,20	5,972	2,3	2,033	1,5	0,666	0,9	0,204	0,6	0,069	0,4	0,024	0,2	0,008	0,1	0,003	0,1	0,001	0,1				
0,30	12,680	3,4	4,273	2,2	1,388	1,4	0,423	0,8	0,141	0,5	0,049	0,3	0,016	0,2	0,007	0,2	0,003	0,1	0,001	0,1		
0,40			7,281	2,9	2,348	1,8	0,710	1,1	0,236	0,7	0,081	0,5	0,026	0,3	0,011	0,2	0,005	0,1	0,002	0,1		
0,50					3,541	2,3	1,065	1,4	0,353	0,9	0,121	0,6	0,039	0,4	0,017	0,3	0,007	0,2	0,003	0,1		
0,60					4,964	2,8	1,486	1,7	0,491	1,1	0,168	0,7	0,054	0,4	0,023	0,3	0,010	0,2	0,004	0,1		
0,70					6,616	3,2	1,972	2,0	0,649	1,3	0,221	0,8	0,071	0,5	0,031	0,4	0,013	0,2	0,005	0,2		
0,80							2,523	2,3	0,828	1,4	0,281	0,9	0,090	0,6	0,039	0,4	0,016	0,3	0,006	0,2	0,003	0,2
0,90							3,138	2,5	1,027	1,6	0,348	1,0	0,111	0,6	0,048	0,5	0,020	0,3	0,008	0,2	0,004	0,2
1,00							3,816	2,8	1,245	1,8	0,421	1,2	0,135	0,7	0,058	0,5	0,024	0,4	0,009	0,2	0,005	0,2
1,20							5,364	3,4	1,742	2,2	0,587	1,4	0,187	0,9	0,080	0,6	0,033	0,4	0,013	0,3	0,007	0,2
1,40									2,317	2,5	0,778	1,6	0,247	1,0	0,106	0,7	0,044	0,5	0,017	0,3	0,009	0,3
1,60									2,971	2,9	0,994	1,8	0,315	1,2	0,135	0,8	0,056	0,6	0,021	0,4	0,011	0,3
1,80									3,702	3,2	1,235	2,1	0,390	1,3	0,167	0,9	0,069	0,6	0,026	0,4	0,014	0,3
2,00											1,501	2,3	0,473	1,4	0,202	1,0	0,083	0,7	0,032	0,5	0,017	0,4
2,20											1,791	2,5	0,563	1,6	0,240	1,1	0,099	0,8	0,038	0,5	0,019	0,4
2,40											2,106	2,8	0,660	1,7	0,281	1,2	0,116	0,8	0,044	0,6	0,023	0,4
2,60											2,445	3,0	0,765	1,9	0,325	1,3	0,134	0,9	0,051	0,6	0,027	0,5
2,80											2,809	3,2	0,877	2,0	0,373	1,4	0,153	1,0	0,058	0,7	0,030	0,5
3,00											3,197	3,5	0,996	2,2	0,423	1,5	0,174	1,1	0,066	0,7	0,035	0,6
3,20													1,123	2,3	0,476	1,6	0,195	1,1	0,074	0,8	0,039	0,6
3,40													1,256	2,5	0,532	1,7	0,218	1,2	0,083	0,8	0,043	0,6
3,60													1,397	2,6	0,591	1,8	0,242	1,3	0,092	0,9	0,048	0,7
3,80													1,545	2,7	0,653	1,9	0,267	1,3	0,101	0,9	0,054	0,7
4,00													1,701	2,9	0,718	2,0	0,293	1,4	0,111	1,0	0,058	0,7
4,20													1,863	3,0	0,786	2,1	0,321	1,5	0,121	1,0	0,064	0,8
4,40													2,033	3,2	0,856	2,2	0,349	1,6	0,132	1,0	0,070	0,8
4,60													2,210	3,3	0,930	2,3	0,379	1,6	0,143	1,1	0,075	0,8
4,80													2,394	3,5	1,006	2,4	0,410	1,7	0,155	1,1	0,081	0,9
5,00															1,086	2,5	0,442	1,8	0,167	1,2	0,088	0,9
5,20															1,158	2,7	0,470	1,8	0,175	1,2	0,093	1,0
5,40															1,242	2,8	0,504	1,9	0,188	1,3	0,101	1,0
5,60															1,327	2,8	0,539	2,0	0,199	1,3	0,108	1,0
5,80															1,416	2,9	0,575	2,1	0,214	1,4	0,114	1,1
6,00															1,517	3,1	0,612	2,1	0,228	1,4	0,122	1,1
6,20																	0,651	2,2	0,243	1,5	0,128	1,1
6,40																	0,690	2,3	0,256	1,5	0,137	1,2
6,60																	0,730	2,3	0,272	1,6	0,146	1,2
6,80																	0,778	2,4	0,288	1,6	0,152	1,2
7,00																	0,821	2,5	0,301	1,7	0,162	1,3

S 2,5 (PN20) water temperature = 80° C

k=0,01	16 × 2,7 mm		20 × 3,4 mm		25 × 4,2 mm		32 × 5,4 mm		40 × 6,7 mm		50 × 8,4 mm		63 × 10,5 mm		75 × 12,5 mm		90 × 15,0 mm		110 × 18,4 mm		125 × 20,8 mm	
Q l/s	R kPa/m	v m/s	R kPa/m	v m/s	R kPa/m	v m/s	R kPa/m	v m/s	R kPa/m	v m/s	R kPa/m	v m/s	R kPa/m	v m/s	R kPa/m	v m/s	R kPa/m	v m/s	R kPa/m	v m/s	R kPa/m	v m/s
0,01	0,026	0,1	0,009	1,1																		
0,02	0,087	0,2	0,030	1,1	0,010	0,1	0,003	0,1														
0,03	0,179	0,3	0,062	0,2	0,021	0,1	0,006	0,1	0,002	0,1												
0,04	0,299	0,5	0,104	0,3	0,035	0,2	0,011	0,1	0,004	0,1												
0,05	0,446	0,6	0,155	0,4	0,051	0,2	0,016	0,1	0,005	0,1	0,002	0,1										
0,06	0,619	0,7	0,214	0,4	0,071	0,3	0,022	0,2	0,007	0,1	0,003	0,1										
0,07	0,818	0,8	0,282	0,5	0,094	0,3	0,029	0,2	0,010	0,1	0,003	0,1	0,001	0,1								
0,08	1,042	0,9	0,359	0,6	0,119	0,4	0,037	0,2	0,012	0,1	0,004	0,1	0,001	0,1								
0,09	1,291	1,0	0,443	0,7	0,146	0,4	0,045	0,3	0,015	0,2	0,005	0,1	0,002	0,1								
0,10	1,565	1,1	0,536	0,7	0,177	0,5	0,054	0,3	0,018	0,2	0,006	0,1	0,002	0,1	0,001	0,1						
0,12	2,186	1,4	0,746	0,9	0,245	0,6	0,075	0,3	0,025	0,2	0,009	0,1	0,003	0,1	0,001	0,1						
0,14	2,905	1,6	0,988	1,0	0,323	0,6	0,099	0,4	0,033	0,3	0,012	0,2	0,004	0,1	0,002	0,1	0,001	0,0				
0,16	3,719	1,8	1,261	1,2	0,412	0,7	0,126	0,5	0,042	0,3	0,015	0,2	0,005	0,1	0,002	0,1	0,001	0,1				
0,18	4,630	2,0	1,565	1,3	0,510	0,8	0,155	0,5	0,052	0,3	0,018	0,2	0,006	0,1	0,003	0,1	0,001	0,1				
0,20	5,636	2,3	1,900	1,5	0,617	0,9	0,188	0,6	0,063	0,4	0,022	0,2	0,007	0,1	0,003	0,1	0,001	0,1				
0,30	12,090	3,4	4,031	2,2	1,296	1,4	0,391	0,8	0,130	0,5	0,045	0,3	0,014	0,2	0,006	0,2	0,003	0,1	0,001	0,1		
0,40			6,918	2,9	2,206	1,8	0,661	1,1	0,218	0,7	0,075	0,5	0,024	0,3	0,010	0,2	0,004	0,1	0,002	0,1		
0,50					3,346	2,3	0,995	1,4	0,327	0,9	0,111	0,6	0,036	0,4	0,015	0,3	0,006	0,2	0,002	0,1		
0,60					4,712	2,8	1,395	1,7	0,456	1,1	0,155	0,7	0,050	0,4	0,021	0,3	0,009	0,2	0,003	0,1		
0,70					6,304	3,2	1,858	2,0	0,605	1,3	0,205	0,8	0,065	0,5	0,028	0,4	0,012	0,2	0,005	0,2		
0,80							2,384	2,3	0,774	1,4	0,261	0,9	0,083	0,6	0,036	0,4	0,015	0,3	0,006	0,2	0,003	0,2
0,90							2,974	2,5	0,963	1,6	0,324	1,0	0,103	0,6	0,044	0,5	0,018	0,3	0,007	0,2	0,003	0,2
1,00							3,626	2,8	1,171	1,8	0,392	1,2	0,124	0,7	0,053	0,5	0,022	0,4	0,009	0,2	0,004	0,2
1,20							5,121	3,4	1,645	2,2	0,549	1,4	0,173	0,9	0,074	0,6	0,031	0,4	0,012	0,3	0,006	0,2
1,40									2,197	2,5	0,730	1,6	0,230	1,0	0,098	0,7	0,040	0,5	0,016	0,3	0,008	0,3
1,60									2,826	2,9	0,936	1,8	0,293	1,2	0,125	0,8	0,051	0,6	0,020	0,4	0,010	0,3
1,80									3,532	3,2	1,166	2,1	0,364	1,3	0,155	0,9	0,064	0,6	0,024	0,4	0,012	0,3
2,00											1,421	2,3	0,443	1,4	0,188	1,0	0,077	0,7	0,029	0,5	0,015	0,4
2,20											1,700	2,5	0,528	1,6	0,224	1,1	0,092	0,8	0,035	0,5	0,018	0,4
2,40											2,003	2,8	0,621	1,7	0,263	1,2	0,107	0,8	0,041	0,6	0,021	0,4
2,60											2,331	3,0	0,721	1,9	0,304	1,3	0,124	0,9	0,047	0,6	0,024	0,5
2,80											2,682	3,2	0,828	2,0	0,349	1,4	0,142	1,0	0,054	0,7	0,027	0,5
3,00											3,058	3,5	0,942	2,2	0,397	1,5	0,162	1,1	0,061	0,7	0,031	0,6
3,20													1,064	2,3	0,447	1,6	0,182	1,1	0,069	0,8	0,036	0,6
3,40													1,192	2,5	0,501	1,7	0,204	1,2	0,077	0,8	0,039	0,6
3,60													1,328	2,6	0,557	1,8	0,226	1,3	0,085	0,9	0,044	0,7
3,80													1,471	2,7	0,616	1,9	0,250	1,3	0,094	0,9	0,049	0,7
4,00													1,621	2,9	0,679	2,0	0,275	1,4	0,103	1,0	0,053	0,7
4,20													1,778	3,0	0,744	2,1	0,301	1,5	0,113	1,0	0,058	0,8
4,40													1,942	3,2	0,812	2,2	0,328	1,6	0,123	1,0	0,064	0,8
4,60													2,113	3,3	0,882	2,3	0,356	1,6	0,134	1,1	0,068	0,8
4,80													2,292	3,5	0,956	2,4	0,386	1,7	0,145	1,1	0,074	0,9
5,00															1,033	2,5	0,416	1,8	0,156	1,2	0,081	0,9
5,20															1,081	2,7	0,436	1,8	0,161	1,2	0,085	1,0
5,40															1,160	2,8	0,467	1,9	0,173	1,3	0,092	1,0
5,60															1,242	2,9	0,500	2,0	0,184	1,3	0,099	1,0
5,80															1,326	3,0	0,534	2,1	0,199	1,4	0,105	1,1
6,00															1,422	3,1	0,569	2,1	0,210	1,4	0,112	1,1
6,20																	0,605	2,2	0,224	1,5	0,118	1,1
6,40																	0,642	2,3	0,236	1,5	0,126	1,2
6,60																	0,680	2,3	0,251	1,6	0,134	1,2
6,80																	0,725	2,4	0,266	1,6	0,140	1,2
7,00																	0,765	2,5	0,279	1,7	0,149	1,3

S4, S3,2 water temperature = 10° C FIBER BASALT PLUS, STABI PLUS																							
k=0,01	16 × 2,3 mm			20 × 2,8 mm		25 × 3,5mm		32 × 4,5mm		40 × 5,6mm		50 × 6,9mm		63 × 8,6mm		75 × 8,4 mm		90 × 10,1 mm		110 × 12,3mm		125 × 14,0 mm	
Q l/s	R kPa/m	v m/s	R kPa/m	v m/s	R kPa/m	v m/s	R kPa/m	v m/s	R kPa/m	v m/s	R kPa/m	v m/s	R kPa/m	v m/s	R kPa/m	v m/s	R kPa/m	v m/s	R kPa/m	v m/s	R kPa/m	v m/s	
0,01	0,025	0,1	0,008	0,1																			
0,02	0,083	0,2	0,027	0,1	0,009	0,1																	
0,03	0,170	0,3	0,056	0,2	0,019	0,1																	
0,04	0,282	0,4	0,093	0,2	0,032	0,2																	
0,05	0,418	0,5	0,137	0,3	0,047	0,2	0,015	0,1															
0,06	0,576	0,6	0,189	0,4	0,065	0,2	0,020	0,1															
0,07	0,756	0,7	0,248	0,4	0,085	0,3	0,027	0,2															
0,08	0,958	0,8	0,313	0,5	0,108	0,3	0,034	0,2	0,012	0,1													
0,09	1,180	0,9	0,386	0,6	0,133	0,4	0,041	0,2	0,014	0,1													
0,10	1,422	1,0	0,465	0,6	0,160	0,4	0,050	0,2	0,017	0,2													
0,12	1,967	1,2	0,641	0,7	0,221	0,5	0,069	0,3	0,023	0,2	0,008	0,1											
0,14	2,588	1,4	0,843	0,9	0,290	0,6	0,090	0,3	0,031	0,2	0,010	0,1											
0,16	3,285	1,6	1,068	1,0	0,367	0,6	0,114	0,4	0,039	0,2	0,013	0,2											
0,18	4,056	1,8	1,316	1,1	0,452	0,7	0,140	0,4	0,048	0,3	0,016	0,2	0,005	0,1									
0,20	4,900	2,0	1,588	1,2	0,544	0,8	0,168	0,5	0,058	0,3	0,019	0,2	0,006	0,1	0,002	0,1							
0,30	10,182	2,9	3,277	1,8	1,118	1,2	0,345	0,7	0,118	0,5	0,040	0,3	0,013	0,2	0,004	0,1							
0,40			5,499	2,5	1,868	1,6	0,574	1,0	0,196	0,6	0,066	0,4	0,022	0,2	0,010	0,2	0,003	0,1					
0,50			8,236	3,1	2,786	2,0	0,854	1,2	0,290	0,8	0,097	0,5	0,032	0,3	0,014	0,2	0,004	0,1					
0,60					3,869	2,4	1,183	1,4	0,401	0,9	0,134	0,6	0,045	0,4	0,017	0,3	0,006	0,2					
0,70					5,112	2,8	1,558	1,7	0,528	1,1	0,176	0,7	0,058	0,4	0,022	0,3	0,007	0,2	0,003	0,1			
0,80					6,513	3,1	1,980	1,9	0,669	1,2	0,223	0,8	0,074	0,5	0,028	0,3	0,010	0,2	0,004	0,1			
0,90					8,071	3,5	2,448	2,2	0,826	1,4	0,275	0,9	0,091	0,6	0,034	0,4	0,012	0,2	0,005	0,2			
1,00							2,960	2,4	0,997	1,5	0,332	1,0	0,110	0,6	0,046	0,5	0,014	0,3	0,005	0,2	0,003	0,1	
1,20									4,117	2,9	1,382	1,8	0,459	1,2	0,152	0,7	0,061	0,5	0,019	0,3	0,007	0,2	
1,40									5,449	3,4	1,824	2,1	0,604	1,4	0,199	0,9	0,076	0,6	0,026	0,4	0,009	0,2	
1,60											2,322	2,5	0,767	1,6	0,253	1,0	0,095	0,7	0,032	0,4	0,012	0,3	
1,80											2,874	2,8	0,948	1,7	0,311	1,1	0,113	0,8	0,039	0,5	0,015	0,3	
2,00											3,480	3,1	1,145	1,9	0,376	1,2	0,136	0,8	0,047	0,5	0,018	0,4	
2,20											4,139	3,4	1,360	2,1	0,446	1,3	0,157	0,9	0,055	0,6	0,021	0,4	
2,40													1,591	2,3	0,521	1,5	0,183	1,0	0,066	0,6	0,025	0,4	
2,60													1,839	2,5	0,601	1,6	0,207	1,1	0,076	0,7	0,028	0,5	
2,80													2,104	2,7	0,686	1,7	0,236	1,1	0,086	0,7	0,033	0,5	
3,00													2,385	2,9	0,777	1,8	0,263	1,2	0,097	0,8	0,037	0,5	
3,20													2,682	3,1	0,873	2,0	0,295	1,3	0,111	0,8	0,042	0,6	
3,40													2,995	3,3	0,974	2,1	0,325	1,4	0,123	0,9	0,046	0,6	
3,60													3,324	3,5	1,080	2,2	0,360	1,4	0,135	0,9	0,052	0,6	
3,80															1,190	2,3	0,393	1,5	0,149	1,0	0,056	0,7	
4,00															1,306	2,4	0,432	1,6	0,165	1,1	0,062	0,7	
4,20															1,427	2,6	0,467	1,7	0,180	1,1	0,067	0,7	
4,40															1,553	2,7	0,509	1,7	0,195	1,2	0,074	0,8	
4,60															1,683	2,8	0,547	1,8	0,210	1,2	0,079	0,8	
4,80															1,819	2,9	0,592	1,9	0,226	1,3	0,086	0,8	
5,00															1,959	3,1	0,632	2,0	0,246	1,3	0,092	0,9	
5,20																	0,680	2,0	0,264	1,4	0,100	0,9	
5,40																	0,730	2,1	0,281	1,4	0,106	0,9	
5,60																	0,775	2,2	0,300	1,5	0,114	1,0	
5,80																	0,828	2,3	0,322	1,5	0,120	1,0	
6,00																	0,875	2,3	0,342	1,6	0,129	1,1	
6,50																	0,952	2,4	0,395	1,7	0,147	1,1	
7,00																	1,154	2,7	0,451	1,8	0,169	1,2	
7,50																	1,241	2,8	0,512	2,0	0,193	1,3	
8,00																	1,399	3,0	0,575	2,1	0,217	1,4	
8,50																		0,642	2,2	0,240	1,5		
9,00																			0,713	2,4	0,267	1,6	
9,50																			0,786	2,5	0,296	1,7	
10,00																			0,864	2,6	0,326	1,8	
10,50																				0,944	2,7	0,353	
11,00																				1,028	2,9	0,386	
11,50																				1,122	3,0	0,419	
12,00																					0,450	2,1	
12,50																					0,486	2,2	
13,00																					0,524	2,3	
13,50																					0,563	2,4	
14,00																					0,598	2,4	
15,50																					0,639	2,5	
15,00																					0,681	2,6	
15,50																					0,725	2,7	
16,00																					0,76,		

S4, S3,2 water temperature = 50° C FIBER BASALT PLUS, STABI PLUS																							
k=0,01	16 × 2,3mm		20 × 2,8mm		25 × 3,5mm		32 × 4,5mm		40 × 5,6mm		50 × 6,9mm		63 × 8,6mm		75 × 8,4mm		90 × 10,1mm		110 × 12,3mm		125 × 14,0mm		
Q l/s	R kPa/m	v m/s	R kPa/m	v m/s	R kPa/m	v m/s	R kPa/m	v m/s	R kPa/m	v m/s	R kPa/m	v m/s	R kPa/m	v m/s	R kPa/m	v m/s	R kPa/m	v m/s	R kPa/m	v m/s	R kPa/m	v m/s	
0,01	0,020	0,1	0,007	0,1																			
0,02	0,068	0,2	0,022	0,1	0,008	0,1																	
0,03	0,138	0,3	0,045	0,2	0,016	0,1	0,005	0,1															
0,04	0,230	0,4	0,075	0,2	0,026	0,2	0,008	0,1	0,003	0,1													
0,05	0,342	0,5	0,112	0,3	0,038	0,2	0,012	0,1	0,004	0,1													
0,06	0,473	0,6	0,154	0,4	0,053	0,2	0,016	0,1	0,006	0,1	0,002	0,1											
0,07	0,623	0,7	0,203	0,4	0,070	0,3	0,022	0,2	0,007	0,1	0,002	0,1											
0,08	0,792	0,8	0,257	0,5	0,088	0,3	0,027	0,2	0,009	0,1	0,003	0,1											
0,09	0,978	0,9	0,317	0,6	0,108	0,4	0,034	0,2	0,011	0,1	0,004	0,1	0,001	0,1									
0,10	1,183	1,0	0,382	0,6	0,131	0,4	0,040	0,2	0,014	0,2	0,005	0,1	0,002	0,1									
0,12	1,644	1,2	0,530	0,7	0,181	0,5	0,056	0,3	0,019	0,2	0,006	0,1	0,002	0,1									
0,14	2,175	1,4	0,698	0,9	0,238	0,6	0,073	0,3	0,025	0,2	0,008	0,1	0,003	0,1									
0,16	2,773	1,6	0,888	1,0	0,302	0,6	0,093	0,4	0,032	0,2	0,011	0,2	0,004	0,1									
0,18	3,439	1,8	1,099	1,1	0,373	0,7	0,115	0,4	0,039	0,3	0,013	0,2	0,004	0,1	0,001	0,1							
0,20	4,172	2,0	1,330	1,2	0,450	0,8	0,138	0,5	0,047	0,3	0,016	0,2	0,005	0,1	0,002	0,1							
0,30	8,828	2,9	2,785	1,8	0,935	1,2	0,285	0,7	0,096	0,5	0,032	0,3	0,011	0,2	0,003	0,1	0,001	0,1					
0,40			4,731	2,5	1,578	1,6	0,478	1,0	0,161	0,6	0,054	0,4	0,018	0,2	0,005	0,2	0,002	0,1					
0,50			7,161	3,1	2,376	2,0	0,716	1,2	0,240	0,8	0,080	0,5	0,026	0,3	0,008	0,2	0,003	0,1					
0,60					3,325	2,4	0,997	1,4	0,334	0,9	0,110	0,6	0,036	0,4	0,011	0,2	0,005	0,2					
0,70					4,425	2,8	1,322	1,7	0,441	1,1	0,146	0,7	0,048	0,4	0,014	0,3	0,006	0,2	0,002	0,1			
0,80					5,675	3,1	1,689	1,9	0,562	1,2	0,185	0,8	0,061	0,5	0,018	0,3	0,008	0,2	0,003	0,1			
0,90					7,073	3,5	2,098	2,2	0,696	1,4	0,229	0,9	0,075	0,6	0,023	0,3	0,010	0,2	0,004	0,2			
1,00							2,549	2,4	0,843	1,5	0,277	1,0	0,091	0,6	0,028	0,4	0,011	0,3	0,004	0,2	0,002	0,1	
1,20							3,577	2,9	1,178	1,8	0,385	1,2	0,126	0,7	0,037	0,5	0,015	0,3	0,006	0,2	0,003	0,2	
1,40							4,770	3,4	1,565	2,1	0,510	1,4	0,166	0,9	0,050	0,5	0,021	0,4	0,008	0,2	0,004	0,2	
1,60									2,004	2,5	0,650	1,6	0,211	1,0	0,063	0,6	0,026	0,4	0,010	0,3	0,006	0,2	
1,80									2,494	2,8	0,807	1,7	0,261	1,1	0,079	0,7	0,032	0,5	0,012	0,3	0,007	0,2	
2,00									3,036	3,1	0,980	1,9	0,316	1,2	0,094	0,8	0,039	0,5	0,015	0,4	0,008	0,3	
2,20									3,629	3,4	1,168	2,1	0,376	1,3	0,113	0,8	0,046	0,6	0,017	0,4	0,01	0,3	
2,40											1,372	2,3	0,441	1,5	0,131	0,9	0,055	0,6	0,021	0,4	0,011	0,3	
2,60											1,592	2,5	0,511	1,6	0,153	1,0	0,063	0,7	0,023	0,5	0,013	0,4	
2,80											1,828	2,7	0,585	1,7	0,174	1,1	0,072	0,7	0,027	0,5	0,015	0,4	
3,00											2,079	2,9	0,664	1,8	0,199	1,1	0,081	0,8	0,030	0,5	0,017	0,4	
3,20											2,345	3,1	0,748	2,0	0,222	1,2	0,093	0,8	0,035	0,6	0,017	0,4	
3,40											2,627	3,3	0,837	2,1	0,250	1,3	0,103	0,9	0,038	0,6	0,021	0,5	
3,60											2,925	3,5	0,930	2,2	0,275	1,4	0,114	0,9	0,043	0,6	0,023	0,5	
3,80													1,028	2,3	0,306	1,4	0,125	1,0	0,047	0,7	0,025	0,5	
4,00													1,131	2,4	0,334	1,5	0,139	1,1	0,047	0,7	0,027	0,6	
4,20													1,239	2,6	0,368	1,6	0,152	1,1	0,056	0,7	0,031	0,6	
4,40													1,351	2,7	0,399	1,7	0,164	1,2	0,062	0,8	0,034	0,6	
4,60													1,468	2,8	0,435	1,7	0,178	1,2	0,066	0,8	0,036	0,6	
4,80													1,589	2,9	0,469	1,8	0,192	1,3	0,073	0,8	0,039	0,7	
5,00													1,716	3,1	0,508	1,9	0,209	1,3	0,077	0,9	0,042	0,7	
5,20															0,544	2,0	0,224	1,4	0,084	0,9	0,045	0,7	
5,40															0,586	2,0	0,239	1,4	0,089	0,9	0,048	0,7	
5,60															0,623	2,1	0,255	1,5	0,096	1,0	0,052	0,8	
5,80															0,669	2,2	0,275	1,5	0,102	1,0	0,054	0,8	
6,00															0,716	2,3	0,292	1,6	0,109	1,1	0,058	0,8	
6,50															0,826	2,4	0,338	1,7	0,125	1,1	0,067	0,9	
7,00															0,950	2,6	0,388	1,8	0,144	1,2	0,078	1,0	
7,50															1,083	2,8	0,441	2,0	0,164	1,3	0,087	1,0	
8,00															1,225	3,0	0,497	2,1	0,185	1,4	0,098	1,1	
8,50																	0,556	2,2	0,205	1,5	0,111	1,2	
9,00																	0,618	2,4	0,229	1,6	0,123	1,2	
9,50																	0,684	2,5	0,254	1,7	0,137	1,3	
10,00																	0,753	2,6	0,280	1,8	0,149	1,4	
10,50																	0,824	2,7	0,304	1,8	0,163	1,4	
11,00																	0,900	2,9	0,333	1,9	0,178	1,5	
11,50																	0,984	3,0	0,362	2,0	0,194	1,6	
12,00																			0,390	2,1	0,208	1,6	
12,50																			0,422	2,2	0,225	1,7	
13,00																			0,455	2,3	0,243	1,8	
13,50																			0,489	2,4	0,261	1,8	
14,00																			0,521	2,4	0,277	1,9	
14,50																			0,557	2,5	0,297	2,0	
15,00																			0,595	2,6	0,317	2,0	
15,50																			0,634	2,7	0,337	2,1	
16,00																			0,669	2,8	0,359	2,2	
16,50																			0,711	2,9	0,378	2,2	
17,00																			0,753	3,0	0,400	2,3	
17,50																					0,423	2,4	
18,00																						0,447	2,4
18,50																						0,468	2,5
19,00																						0,493	2,6
19,50																						0,518	2,6
20,00																						0,544	2,7
20,50																						0,567	2,8
21,00																						0,594	2,8
21,50																						0,622	2,9
22,00																						0,651	3,0

S4, S3,2 water temperature = 80° C FIBER BASALT PLUS, STABI PLUS																							
k=0,01	16 × 2,3mm			20 × 2,8mm		25 × 3,5mm		32 × 4,5mm		40 × 5,6mm		50 × 6,9mm		63 × 8,6mm		75 × 8,4mm		90 × 10,1mm		110 × 12,3mm		125 × 14,0mm	
Q l/s	R kPa/m	v m/s	R kPa/m	v m/s	R kPa/m	v m/s	R kPa/m	v m/s	R kPa/m	v m/s	R kPa/m	v m/s	R kPa/m	v m/s	R kPa/m	v m/s	R kPa/m	v m/s	R kPa/m	v m/s	R kPa/m	v m/s	
0,01	0,015	0,1	0,004	0,1																			
0,02	0,061	0,2	0,019	0,1	0,007	0,1																	
0,03	0,117	0,3	0,038	0,2	0,014	0,1	0,004	0,1															
0,04	0,198	0,4	0,067	0,2	0,023	0,2	0,007	0,1	0,002	0,1													
0,05	0,297	0,5	0,098	0,3	0,034	0,2	0,010	0,1	0,004	0,1													
0,06	0,414	0,6	0,134	0,4	0,047	0,2	0,013	0,1	0,005	0,1	0,002	0,1											
0,07	0,550	0,7	0,175	0,4	0,062	0,3	0,019	0,2	0,007	0,1	0,002	0,1											
0,08	0,686	0,8	0,221	0,5	0,074	0,3	0,023	0,2	0,008	0,1	0,003	0,1											
0,09	0,855	0,9	0,272	0,6	0,092	0,4	0,030	0,2	0,010	0,1	0,004	0,1	0,001	0,1									
0,10	1,040	1,0	0,328	0,6	0,111	0,4	0,034	0,2	0,011	0,2	0,004	0,1	0,001	0,1									
0,12	1,462	1,2	0,465	0,7	0,155	0,5	0,048	0,3	0,016	0,2	0,006	0,1	0,002	0,1									
0,14	1,926	1,4	0,612	0,9	0,206	0,6	0,064	0,3	0,021	0,2	0,008	0,1	0,003	0,1									
0,16	2,479	1,6	0,777	1,0	0,263	0,6	0,082	0,4	0,028	0,2	0,010	0,2	0,003	0,1									
0,18	3,067	1,8	0,976	1,1	0,327	0,7	0,097	0,4	0,034	0,3	0,011	0,2	0,004	0,1	0,001	0,1							
0,20	3,496	2,0	1,180	1,2	0,397	0,8	0,119	0,5	0,041	0,3	0,013	0,2	0,004	0,1	0,002	0,1							
0,30	8,047	2,9	2,492	1,8	0,828	1,2	0,247	0,7	0,083	0,5	0,027	0,3	0,009	0,2	0,003	0,1	0,001	0,1					
0,40			4,299	2,5	1,406	1,6	0,419	1,0	0,139	0,6	0,047	0,4	0,015	0,2	0,005	0,2	0,002	0,1					
0,50			6,539	3,1	2,129	2,0	0,631	1,2	0,212	0,8	0,070	0,5	0,023	0,3	0,007	0,2	0,003	0,1					
0,60					3,018	2,4	0,885	1,4	0,293	0,9	0,095	0,6	0,032	0,4	0,010	0,2	0,004	0,2					
0,70					4,030	2,8	1,180	1,7	0,388	1,1	0,127	0,7	0,042	0,4	0,013	0,3	0,005	0,2	0,002	0,1			
0,80					5,183	3,1	1,530	1,9	0,501	1,2	0,164	0,8	0,053	0,5	0,016	0,3	0,007	0,2	0,003	0,1			
0,90					6,513	3,5	1,907	2,2	0,621	1,4	0,200	0,9	0,065	0,6	0,020	0,3	0,009	0,2	0,003	0,2			
1,00							2,323	2,4	0,761	1,5	0,244	1,0	0,079	0,6	0,025	0,4	0,010	0,3	0,004	0,2	0,002	0,1	
1,20							3,277	2,9	1,062	1,8	0,346	1,2	0,109	0,7	0,034	0,5	0,014	0,3	0,005	0,2	0,003	0,2	
1,40							4,389	3,4	1,423	2,1	0,457	1,4	0,148	0,9	0,045	0,5	0,019	0,4	0,007	0,2	0,004	0,2	
1,60									1,835	2,5	0,583	1,6	0,188	1,0	0,057	0,6	0,024	0,4	0,009	0,3	0,005	0,2	
1,80									2,281	2,8	0,731	1,7	0,233	1,1	0,071	0,7	0,029	0,5	0,011	0,3	0,006	0,2	
2,00									2,792	3,1	0,888	1,9	0,282	1,2	0,085	0,8	0,035	0,5	0,013	0,4	0,007	0,3	
2,20									3,354	3,4	1,067	2,1	0,340	1,3	0,103	0,8	0,041	0,6	0,016	0,4	0,009	0,3	
2,40											1,253	2,3	0,399	1,5	0,119	0,9	0,050	0,6	0,019	0,4	0,010	0,3	
2,60											1,465	2,5	0,462	1,6	0,140	1,0	0,057	0,7	0,021	0,5	0,011	0,4	
2,80											1,680	2,7	0,529	1,7	0,159	1,1	0,065	0,7	0,025	0,5	0,013	0,4	
3,00											1,910	2,9	0,607	1,8	0,182	1,1	0,074	0,8	0,027	0,5	0,015	0,4	
3,20											2,167	3,1	0,684	2,0	0,203	1,2	0,084	0,8	0,031	0,6	0,017	0,4	
3,40											2,426	3,3	0,765	2,1	0,229	1,3	0,094	0,9	0,035	0,6	0,019	0,5	
3,60											2,715	3,5	0,850	2,2	0,253	1,4	0,104	0,9	0,039	0,6	0,021	0,5	
3,80															0,947	2,3	0,282	1,4	0,114	1,0	0,042	0,7	
4,00															1,042	2,4	0,308	1,5	0,127	1,1	0,047	0,7	
4,20															1,140	2,6	0,340	1,6	0,139	1,1	0,051	0,7	
4,40															1,244	2,7	0,368	1,7	0,151	1,2	0,056	0,8	
4,60															1,360	2,8	0,403	1,7	0,163	1,2	0,060	0,8	
4,80															1,472	2,9	0,434	1,8	0,176	1,3	0,066	0,8	
5,00															1,589	3,1	0,471	1,9	0,192	1,3	0,071	0,9	
5,20																	0,504	2,0	0,206	1,4	0,077	0,9	
5,40																	0,544	2,0	0,221	1,4	0,081	0,9	
5,60																	0,585	2,1	0,235	1,5	0,088	1,0	
5,80																	0,622	2,2	0,254	1,5	0,093	1,0	
6,00																	0,666	2,3	0,270	1,6	0,100	1,1	
6,50																	0,770	2,4	0,313	1,7	0,115	1,1	
7,00																	0,888	2,6	0,360	1,8	0,132	1,2	
7,50																	1,013	2,8	0,409	2,0	0,151	1,3	
8,00																	1,147	3,0	0,462	2,1	0,171	1,4	
8,50																		0,517	2,2	0,189	1,5	0,102	1,2
9,00																			0,576	2,4	0,212	1,6	
9,50																			0,638	2,5	0,235	1,7	
10,00																			0,703	2,6	0,259	1,8	
10,50																			0,771	2,7	0,282	1,8	
11,00																			0,842	2,9	0,309	1,9	
11,50																			0,922	3,0	0,337	2,0	
12,00																					0,362	2,1	
12,50																					0,393	2,2	
13,00																					0,424	2,3	
13,50																					0,456	2,4	
14,00																					0,486	2,4	
14,50																					0,520	2,5	
15,00																					0,556	2,6	
15,50																					0,593	2,7	
16,00																					0,627	2,8	
16,50																					0,666	2,9	
17,00																					0,706	3,0	
17,50																							
18,00																							
18,50																							
19,00																							
19,50																							
20,00																							
20,50																							
21,00																							
21,50																							
22,00																							

S4, S5 water temperature = 10°C FIBER BASALT CLIMA

k=0,01	20 x 2,3 mm		25 x 2,8 mm		32 x 2,9 mm		40 x 3,7 mm		50 x 4,6 mm		63 x 5,8 mm		75 x 6,9 mm		90 x 8,2 mm		110 x 10 mm		125 x 11,4 mm	
Q l/s	R kPa/m	v m/s	R kPa/m	v m/s	R kPa/m	v m/s	R kPa/m	v m/s	R kPa/m	v m/s	R kPa/m	v m/s	R kPa/m	v m/s	R kPa/m	v m/s	R kPa/m	v m/s	R kPa/m	v m/s
0,01	0,006	0,1																		
0,02	0,020	0,1																		
0,03	0,041	0,2	0,011	0,1	0,003	0,1														
0,04	0,067	0,2	0,016	0,1	0,006	0,1														
0,05	0,099	0,3	0,022	0,2	0,008	0,1	0,003	0,1												
0,06	0,137	0,3	0,033	0,2	0,011	0,1	0,004	0,1												
0,07	0,180	0,4	0,055	0,2	0,015	0,1	0,005	0,1	0,002	0,1										
0,08	0,227	0,4	0,076	0,3	0,019	0,2	0,006	0,1	0,002	0,1										
0,09	0,280	0,5	0,091	0,3	0,023	0,2	0,008	0,1	0,003	0,1										
0,10	0,337	0,5	0,113	0,3	0,028	0,2	0,009	0,1	0,003	0,1										
0,12	0,465	0,6	0,156	0,4	0,038	0,2	0,013	0,1	0,004	0,1	0,001	0,1								
0,14	0,611	0,8	0,198	0,5	0,050	0,3	0,017	0,2	0,006	0,1	0,002	0,1								
0,16	0,774	0,9	0,252	0,5	0,063	0,3	0,022	0,2	0,007	0,1	0,002	0,1	0,001	0,1						
0,18	0,954	1,0	0,312	0,6	0,078	0,3	0,027	0,2	0,009	0,1	0,003	0,1	0,001	0,1						
0,20	1,150	1,1	0,377	0,7	0,094	0,4	0,032	0,2	0,011	0,2	0,004	0,1	0,002	0,1						
0,30	2,370	1,6	0,757	1,0	0,192	0,6	0,065	0,4	0,022	0,2	0,007	0,1	0,003	0,1	0,001	0,1				
0,40	3,971	2,1	1,268	1,4	0,319	0,8	0,108	0,5	0,037	0,3	0,012	0,2	0,005	0,1	0,002	0,1	0,001	0,1		
0,50	5,939	2,7	1,895	1,7	0,474	0,9	0,160	0,6	0,055	0,4	0,018	0,2	0,008	0,2	0,003	0,1	0,001	0,1		
0,60	8,266	3,2	2,636	2,0	0,655	1,1	0,221	0,7	0,076	0,5	0,025	0,3	0,011	0,2	0,005	0,1	0,002	0,1		
0,70			3,487	2,4	0,863	1,3	0,291	0,8	0,099	0,5	0,033	0,3	0,014	0,2	0,006	0,2	0,002	0,1		
0,80			4,448	2,7	1,095	1,5	0,369	1,0	0,126	0,6	0,042	0,4	0,018	0,3	0,008	0,2	0,003	0,1	0,002	0,1
0,90			5,484	3,0	1,352	1,7	0,455	1,1	0,155	0,7	0,051	0,4	0,022	0,3	0,009	0,2	0,004	0,1	0,002	0,1
1,00			6,657	3,4	1,634	1,9	0,549	1,2	0,187	0,8	0,062	0,5	0,027	0,3	0,011	0,2	0,004	0,2	0,002	0,1
1,20					2,269	2,3	0,760	1,4	0,258	0,9	0,085	0,6	0,037	0,4	0,015	0,3	0,006	0,2	0,003	0,1
1,40					2,998	2,6	1,001	1,7	0,340	1,1	0,112	0,7	0,049	0,5	0,020	0,3	0,008	0,2	0,004	0,1
1,60					3,819	3,0	1,273	1,9	0,431	1,2	0,142	0,8	0,062	0,5	0,026	0,4	0,010	0,3	0,005	0,2
1,80					4,732	3,4	1,574	2,2	0,532	1,4	0,175	0,9	0,076	0,6	0,031	0,4	0,012	0,3	0,006	0,2
2,00							1,903	2,4	0,642	1,5	0,211	1,0	0,092	0,7	0,038	0,5	0,014	0,3	0,008	0,2
2,20							2,262	2,6	0,762	1,7	0,250	1,1	0,108	0,7	0,045	0,5	0,017	0,3	0,009	0,3
2,40							2,649	2,9	0,891	1,8	0,292	1,2	0,126	0,8	0,052	0,6	0,020	0,4	0,010	0,3
2,60							3,064	3,1	1,029	2,0	0,337	1,3	0,146	0,9	0,060	0,6	0,023	0,4	0,012	0,3
2,80							3,507	3,4	1,176	2,1	0,385	1,3	0,166	1,0	0,069	0,7	0,026	0,4	0,014	0,3
3,00									1,332	2,3	0,436	1,4	0,188	1,0	0,078	0,7	0,030	0,5	0,016	0,4
3,20									1,497	2,4	0,489	1,5	0,211	1,1	0,087	0,8	0,033	0,5	0,018	0,4
3,40									1,671	2,6	0,545	1,6	0,235	1,2	0,097	0,8	0,037	0,5	0,019	0,4
3,60									1,854	2,8	0,604	1,7	0,260	1,2	0,107	0,8	0,041	0,6	0,022	0,4
3,80									2,045	2,9	0,666	1,8	0,287	1,3	0,118	0,9	0,045	0,6	0,024	0,5
4,00									2,246	3,1	0,731	1,9	0,314	1,4	0,129	0,9	0,049	0,6	0,026	0,5
4,20									2,454	3,2	0,798	2,0	0,343	1,4	0,141	1,0	0,054	0,7	0,028	0,5
4,40									2,672	3,4	0,868	2,1	0,373	1,5	0,153	1,0	0,058	0,7	0,031	0,5
4,60									2,898	3,5	0,940	2,2	0,404	1,6	0,166	1,1	0,063	0,7	0,034	0,6
4,80											1,016	2,3	0,436	1,6	0,179	1,1	0,068	0,8	0,037	0,6
5,00											1,093	2,4	0,469	1,7	0,193	1,2	0,073	0,8	0,039	0,6
5,20													0,492	1,8	0,203	1,2	0,078	0,8	0,041	0,6
5,40													0,523	1,8	0,218	1,3	0,083	0,9	0,045	0,7
5,60													0,560	2,0	0,234	1,3	0,088	0,9	0,048	0,7
5,80													0,598	2,0	0,247	1,4	0,094	0,9	0,051	0,7
6,00													0,637	2,0	0,264	1,4	0,099	0,9	0,054	0,7
6,20													0,672	2,1	0,281	1,5	0,105	1,0	0,058	0,8
6,40													0,714	2,2	0,295	1,5	0,113	1,0	0,061	0,8
6,60													0,757	2,2	0,313	1,6	0,119	1,0	0,064	0,8
6,80													0,801	2,3	0,332	1,6	0,125	1,1	0,068	0,8
7,00													0,831	2,4	0,351	1,7	0,132	1,1	0,071	0,9

S4, S5 water temperature = 50°C FIBER BASALT CLIMA

k=0,01	20 x 2,3 mm		25 x 2,8 mm		32 x 2,9 mm		40 x 3,7 mm		50 x 4,6 mm		63 x 5,8 mm		75 x 6,9 mm		90 x 8,2 mm		110 x 10 mm		125 x 11,4 mm	
Q l/s	R kPa/m	v m/s	R kPa/m	v m/s	R kPa/m	v m/s	R kPa/m	v m/s	R kPa/m	v m/s	R kPa/m	v m/s	R kPa/m	v m/s	R kPa/m	v m/s	R kPa/m	v m/s	R kPa/m	v m/s
0,01	0,040	0,1																		
0,02	0,013	0,1																		
0,03	0,032	0,2	0,009	0,1	0,002	0,1														
0,04	0,052	0,2	0,019	0,1	0,003	0,1														
0,05	0,080	0,3	0,027	0,2	0,006	0,1	0,002	0,1												
0,06	0,108	0,3	0,035	0,2	0,009	0,1	0,003	0,1												
0,07	0,146	0,4	0,049	0,2	0,011	0,1	0,004	0,1	0,001	0,1										
0,08	0,181	0,4	0,060	0,3	0,015	0,2	0,006	0,1	0,002	0,1										
0,09	0,220	0,5	0,072	0,3	0,018	0,2	0,006	0,1	0,002	0,1										
0,10	0,271	0,5	0,089	0,3	0,022	0,2	0,008	0,1	0,003	0,1										
0,12	0,367	0,6	0,124	0,4	0,028	0,2	0,010	0,1	0,003	0,1										
0,14	0,487	0,8	0,158	0,5	0,038	0,3	0,014	0,2	0,005	0,1										
0,16	0,623	0,9	0,203	0,5	0,049	0,3	0,017	0,2	0,006	0,1	0,002	0,1								
0,18	0,774	1,0	0,252	0,6	0,058	0,3	0,022	0,2	0,007	0,1	0,003	0,1	0,001	0,1						
0,20	0,925	1,1	0,306	0,7	0,071	0,4	0,025	0,2	0,008	0,2	0,003	0,1	0,001	0,1						
0,30	1,947	1,6	0,624	1,0	0,149	0,6	0,051	0,4	0,018	0,2	0,006	0,1	0,002	0,1	0,001	0,1				
0,40	3,319	2,2	1,059	1,4	0,245	0,7	0,086	0,5	0,030	0,3	0,009	0,2	0,004	0,1	0,002	0,1				
0,50	4,999	2,7	1,599	1,7	0,370	0,9	0,128	0,6	0,043	0,4	0,014	0,2	0,006	0,2	0,003	0,1	0,001	0,1		
0,60	7,046	3,2	2,242	2,0	0,511	1,1	0,178	0,7	0,060	0,5	0,020	0,3	0,008	0,2	0,004	0,1	0,001	0,1		
0,70			2,289	2,4	0,682	1,3	0,235	0,8	0,080	0,5	0,026	0,3	0,011	0,2	0,004	0,2	0,002	0,1		
0,80			3,837	2,7	0,865	1,5	0,300	1,0	0,100	0,6	0,034	0,4	0,014	0,3	0,006	0,2	0,002	0,1	0,001	0,1
0,90			4,757	3,0	1,080	1,7	0,371	1,1	0,125	0,7	0,040	0,4	0,017	0,3	0,007	0,2	0,003	0,1	0,002	0,1
1,00			5,805	3,4	1,304	1,9	0,450	1,2	0,149	0,8	0,049	0,5	0,021	0,3	0,009	0,2	0,004	0,2	0,002	0,1
1,20					1,844	2,2	0,629	1,4	0,210	0,9	0,069	0,6	0,030	0,4	0,012	0,3	0,005	0,2	0,003	0,2
1,40					2,455	2,6	0,835	1,7	0,277	1,1	0,089	0,7	0,038	0,5	0,016	0,3	0,006	0,2	0,003	0,2
1,60					3,149	3,0	1,069	1,9	0,352	1,2	0,115	0,8	0,049	0,5	0,021	0,4	0,008	0,3	0,004	0,2
1,80					3,926	3,3	1,330	2,2	0,442	1,4	0,143	0,9	0,061	0,6	0,025	0,4	0,009	0,3	0,005	0,2
2,00							1,618	2,4	0,534	1,5	0,171	1,0	0,074	0,7	0,030	0,5	0,011	0,3	0,006	0,2
2,20							1,934	2,6	0,635	1,7	0,205	1,1	0,086	0,7	0,036	0,5	0,014	0,4	0,008	0,3
2,40							2,276	2,9	0,751	1,8	0,242	1,2	0,101	0,8	0,042	0,6	0,016	0,4	0,009	0,3
2,60							2,629	3,1	0,869	2,0	0,278	1,3	0,118	0,9	0,049	0,6	0,019	0,4	0,010	0,3
2,80							3,024	3,4	0,994	2,1	0,320	1,4	0,135	1,0	0,056	0,7	0,021	0,4	0,011	0,3
3,00									1,128	2,3	0,365	1,5	0,151	1,0	0,064	0,7	0,024	0,5	0,013	0,4
3,20									1,280	2,5	0,408	1,6	0,171	1,1	0,071	0,8	0,027	0,5	0,015	0,4
3,40									1,430	2,6	0,458	1,6	0,192	1,2	0,079	0,8	0,029	0,5	0,016	0,4
3,60									1,589	2,8	0,506	1,7	0,214	1,2	0,089	0,9	0,034	0,6	0,018	0,4
3,80									1,766	2,9	0,562	1,8	0,234	1,3	0,096	0,9	0,037	0,6	0,020	0,5
4,00									1,941	3,1	0,620	1,9	0,258	1,4	0,107	1,0	0,040	0,6	0,022	0,5
4,20									2,124	3,2	0,675	2,0	0,283	1,4	0,117	1,0	0,044	0,7	0,024	0,5
4,40									2,328	3,4	0,738	2,1	0,310	1,5	0,126	1,0	0,048	0,7	0,026	0,6
4,60									2,527	3,5	0,805	2,2	0,333	1,6	0,137	1,1	0,051	0,7	0,028	0,6
4,80											0,866	2,3	0,361	1,6	0,149	1,1	0,055	0,8	0,031	0,6
5,00											0,938	2,4	0,391	1,7	0,162	1,2	0,061	0,8	0,033	0,6
5,20											1,012	2,5	0,421	1,8	0,172	1,2	0,065	0,8	0,035	0,6
5,40											1,081	2,6	0,448	1,8	0,185	1,3	0,070	0,9	0,038	0,7
5,60											1,160	2,7	0,481	1,9	0,199	1,3	0,074	0,9	0,040	0,7
5,80											1,242	2,8	0,515	2,0	0,210	1,4	0,079	0,9	0,043	0,7
6,00											1,318	2,9	0,549	2,0	0,225	1,4	0,084	0,9	0,045	0,7
6,20											1,405	3,0	0,580	2,1	0,239	1,5	0,089	1,0	0,049	0,8
6,40											1,486	3,1	0,617	2,2	0,252	1,5	0,095	1,0	0,051	0,8
6,60											1,578	3,2	0,654	2,2	0,267	1,6	0,101	1,0	0,053	0,8
6,80											1,672	3,3	0,693	2,3	0,284	1,6	0,106	1,1	0,057	0,8
7,00											1,760	3,4	0,727	2,4	0,300	1,7	0,111	1,1	0,060	0,9

18. Coefficient of Loss ζ for Fittings System Ekoplastik PPR

FITTING				ζ
		Socket		0,2
		Reduction by 2 dimension		0,55
		Elbow 90 °		1,5
		Tee – passage in case of separation of flow		1,1

FITTING				ζ
		Tee – separation of flow		1,5
		Tee reduced – passage in case of flow		1,1
		Tee – reduced separation of flow		4,3
		Reducing sleeve with metal thread		0,4
		Metal reducer with cap nut		8,3

Ekoplastik System

Installation Manual



WAVIN Ekoplastik s.r.o.:

- the biggest producer of plastic piping systems in Central Europe
- established quality products in more than 50 countries
- member of WAVIN group
- innovative technology

WAVIN GROUP

- the biggest producer of plastic piping systems in Europe
- turnover of approximately EUR 1.2 billion
- forty manufacturing sites in 25 countries

Wavin provides effective solutions for essential needs of daily life: safe distribution of drinking water; sustainable management of rainwater and waste water; energy-efficient heating and cooling for buildings. Wavin's European leadership, local presence, commitment to innovation and technical support, all benefit our customers. We consistently achieve the highest sustainability standards and ensure total reliability of supply to support our customers to achieve their objectives.

