4 Standards and guidelines

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

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

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

Table 4.1

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

4.1.1 Classification of operation

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

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

Table 4.2

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

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

Standards and guidelines

4.1.2 Design parameters

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

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

The maximum operating pressure for PP pipes:

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

Table 4.3

4.1.3 Materials

PP materials to be applied are:

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

4.1.4 Long term material strength

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

4.1.5 Geometry of pipes and fittings

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

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

**) only for PP-RCT*

Table 4. Geometry of pipes

Geometry of fittings

Dimensions for sockets. Distinction is made between:

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

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

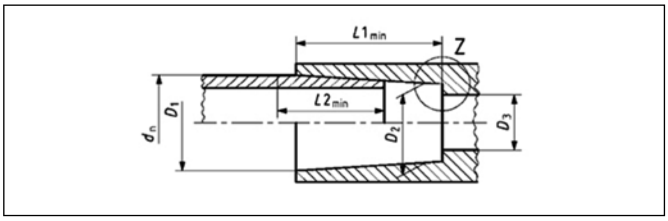


Illustration 4.1

4.1.6 Safety factor and design stress

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

Table 4.5 Safety (design) factor (SF)

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

**) values rounded at 0,01 Mpa*

Table 4.6 Design stress of the material

4.1.7 Tests requirements and parameters

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

Table 4.7 Test requirements and parameters

4.1.8 Pipe and fitting marking

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

Table 4.8 Pipe marking

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

Table 4.9 Geometry of fittings

Standards and guidelines

4.2 Standard DIN 8077/8078 and DIN 16962

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

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

Table 4.10

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

4.2.1 Safety (design) factor

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

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

Table 4.11

4.2.2 Geometry of pipes and fittings

Geometry of pipes

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

Geometry of fittings

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

4.2.3 Maximum Operating Pressure (MOP)

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

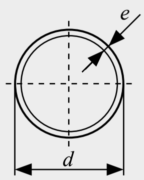
4.3 Maximum Operating Pressure

The Maximum Operating Pressure is calculated according to equation:

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

Equation 4.1

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



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

Equation 4.2

4.3.1 PN rating

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

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

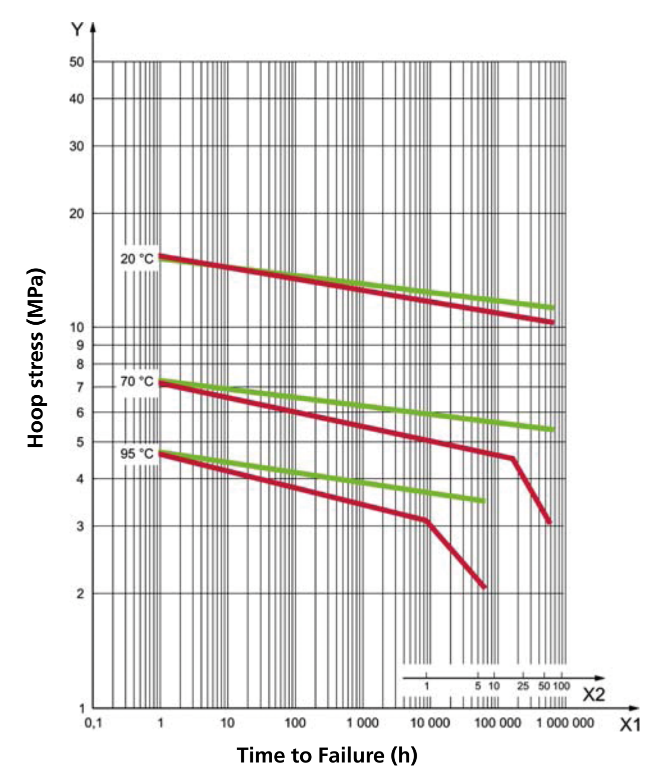
SDR value	PP-R Maximum Operating Pressure (bar)		
	DIN8077:1989 SF = 2,0	ISO 15874:2010 SF = 1,5	DIN8077:2008 SF = 1,25
SDR 6	20,0 (PN 20)	25,7	30,9
SDR 7,4	15,6 (PN 16)	20,4	24,5
SDR 11	10,0 (PN 10)	12,9	15,4

Table 4.12

4.3.2 Advantages PP-RCT over PP-R

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

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



Graphic 4.1

The higher CRS value of PP-RCT material allows:

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

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

Table 4.14

- a smaller wall thickness to achieve an equal operating pressure

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

Table 4.15

Advantages PP-RCT material

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

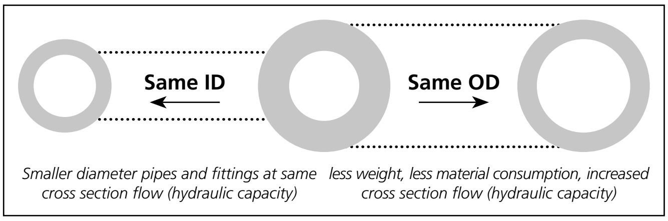


Illustration 4.2

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

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

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

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

Standards and guidelines

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

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

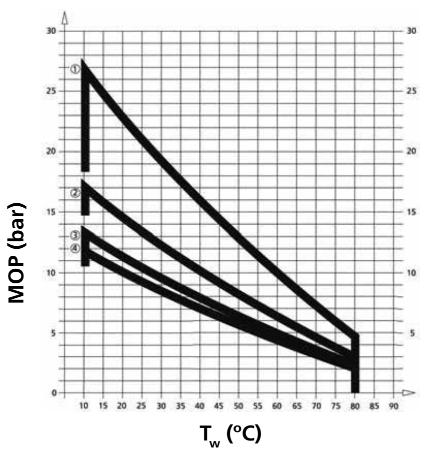
If these operating conditions vary substantial a Minimum Required Strength (MRS) of the weighted average can be applied. This calculation method is called the Miners Rule and is described in standard ISO 13760.

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

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

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

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



Graphic 4.2

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

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

4.4 Product quality

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

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

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

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

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

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

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

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

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

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

Table 4.16 General requirements

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

Table 4.17 General requirements

4.5 Product certification

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

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

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

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

4.6 Approvals

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

Illustration 4.3

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

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

Standards and guidelines

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

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

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

Considerations about the Legionella bacteria and risk for human health
Legionella Pneumophila, the most prevalent form of legionellae by far, is particularly dangerous to humans. This bacteria is found in minimal, generally non-pathogenic quantities not only in groundwater or surface water, but also in drinking water supply systems, as well as in building plumbing drinking water networks.

The bacteria present a pathological effect particularly in the warm vaporized water such as in showers. There are virtually no problems with Legionella bacteria under 18°C. The situation is quite different with water temperatures between 25°C and 50°C: At these temperatures the micro-organisms replicate quickly and do not die until temperatures exceed 60°C.

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

In these buildings specific measures are usually recommended and systematically implemented to prevent the occurrence of Legionella growth and to treat the installation, whenever the level of Legionella has exceeded the regulatory thresholds.

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

Microbial growth is difficult to predict, influenced by multiple factors

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

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

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

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

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

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

Standards and guidelines

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

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

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

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

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

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

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

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

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

Important general recommendations

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

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

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

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

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

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

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

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

Standards and guidelines

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Table 4.18

Standards and guidelines

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

Disinfectant	Chemical Formula	Operation concentration max. value	Operation time max. duration	Operation tempe-rature
Chlorine dioxide	ClO_2	6 mg/l as Cl_2	12 hours	<25°C
Hypochlorite	ClO^-	50 mg/l as $Cl_{2\ (Chlorine)}$	12 hours	<25°C
Permanganate	MnO_4^-	unknown	unknown	<25°C
Hydrogen peroxide	H_2O_2	unknown	unknown	<25°C

Table 4.19

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

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

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

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

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

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

Disinfectant	Chemical Formula	Operation concentration max. value	Operation tempe-rature	Operation time (*) maximum duration
Chlorine dioxide**	ClO_2	0.4 mg/l as ClO_2	60°C	6 months
Hypochlorite	ClO^-	0.3 mg/l as $Cl_{2\ (Chlorine)}$	60°C	6 months
Chlorine	Cl_2	0.3 mg/l as $Cl_{2\ (Chlorine)}$	60°C	6 months
Chlorine dioxide**	ClO_2	0.4 mg/l as ClO_2	< 25°C	18 months
Hypochlorite	ClO^-	0.3 mg/l as $Cl_{2\ (Chlorine)}$	< 25°C	18 months
Chlorine	Cl_2	0.3 mg/l as $Cl_{2\ (Chlorine)}$	< 25°C	18 months

Table 4.20

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

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

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

Disinfectant	Chemical Formula	Operation concentration max. value	Operation tempe-rature	Operation time (*) maximum duration
Chlorine dioxide**	ClO_2	Not recommended		
Hypochlorite	ClO^-	0.3 mg/l as $Cl_{2\ (Chlorine)}$	60°C	6 months
Chlorine	Cl_2	0.3 mg/l as $Cl_{2\ (Chlorine)}$	60°C	6 months
Chlorine dioxide**	ClO_2	Not recommended		
Hypochlorite	ClO^-	0.3 mg/l as $Cl_{2\ (Chlorine)}$	< 25°C	18 months
Chlorine	Cl2	0.3 mg/l as $Cl_{2\ (Chlorine)}$	< 25°C	18 months

Table 4.21

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

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

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

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

Standards and guidelines