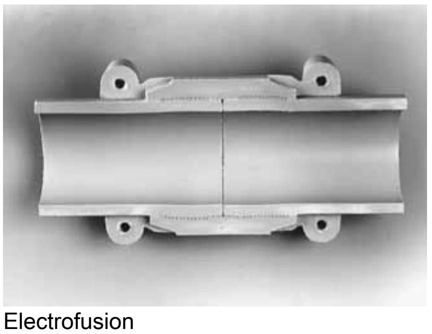
Materials

The material Polybutene (PB)

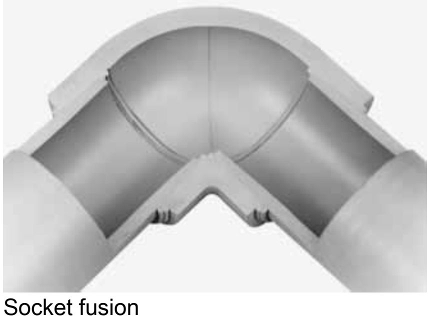
General

Polybutene (PB) is a semi-crystalline thermoplastic from the polyolefin group of polymers. Its high flexibility, temperature resistance and creep rupture strength render this material ideal for use in hot and cold water pipes. PB is created via polymerisation of 1-butylene (C_4H_8), i.e chaining together the basic molecules (monomers). PB is a non-polar material, as are polyethylene (PE) and polypropylene (PP).

The most suitable jointing method for PB is heat fusion. For pressure piping, electrofusion and socket fusion are generally preferred.



Electrofusion



Socket fusion

The creep strength is certified to MRS 14 (minimum required strength) and according to EN ISO 9080 in long-term testing.

The polybutene used by GF Piping Systems for building technology applications features the following qualities:

- High long-term creep strength
- Good resistance to corrosion
- High flexibility
- High resistance to heat ageing
- High resistance to stress cracking
- High noise insulation

Material properties

Properties	Values	Unit	Test norm
Density	0.94	g/cm³	ISO 1183
Melt flow index MFI 190/2.16	0.4	g/10 min	EN ISO 1133
Yield stress at 23 °C	20	MPa	EN ISO 527-1
Elongation at break at 23 °C	300	%	EN ISO 527-1
Flexural modulus of elasticity at 23 °C	450	MPa	ISO 178
Notched impact test at 23 °C	37	kJ/m²	EN ISO 179/1eA
Notched impact test at 0 °C	20	kJ/m²	EN ISO 179/1eA
Ball indentation hardness (132 N)	43	MPa	EN ISO 2039-1
Coefficient of thermal expansion	0.13	mm/mK	ASTM D696
Thermal conductivity at 23 °C	0.19	W/mK	ASTM E1530
Moisture absorption at 23 °C	0.01-0.04	%	EN ISO 62

Mechanical properties

The crystallinity of polybutene (PB) at approx. 50 % is low compared to other polyolefins, rendering it both flexible and robust. These properties are very advantageous for prefabricating riser pipes. The material has very good creep rupture strength at high temperatures and under permanent loads, thus permitting high pressures with relatively small wall thicknesses.

The long-term behaviour under internal pressure is illustrated in the long-term diagram based on the standard EN ISO 15494. The threshold values for pipes and fittings, which are given in the pressure-temperature diagram for PB, are deduced from this. See diagram on page 4 of this chapter.

Resistance to chemicals, weather and UV radiation

Polybutene (PB) is non-polar and therefore easily withstands chemical attack.

For more information, please see the chapter on Chemical Resistance or contact one of our sales companies. When stored or used outdoors, PB, like most natural and plastic materials, will become damaged, especially by the ultraviolet wavelengths of solar radiation in combination with atmospheric oxygen (photooxidation).

Plastic pipes and plastic fittings must be protected from direct ultraviolet radiation. The pipes and fittings are best left in their packaging until ready to use. Do not store outdoors. Please see the chapter General Information.

Thermal properties

Impact resistance and rigidity

Generally speaking, polybutene (PB) may be used at temperatures between -10 °C and 95 °C. Below 0 °C the material's impact resistance diminishes somewhat, although the rigidity will increase at low temperatures. Just as for every other piping material, the medium should be protected from freezing because this could damage the pipe system. Please refer to our pressure temperature diagram, specially for the maximum working temperature.

Linear expansion

Thermoplastics, including PB, have a much lower coefficient of linear expansion than metals, namely 0.13 mm/mK. The resulting forces are, however, very much lower for PB than for metals. Please see the «System Technology and Application Technology» chapter.

Thermal conductivity

The thermal conductivity is 0.19 W/m K (ASTM C177). As a result, the insulation of a PB piping system is much more energy efficient compared to metals, such as copper.

Fire behaviour

Polybutene (PB) belongs to the flammable plastics. The oxygen index is 19%. Below 21% a plastic is considered flammable.
When the flame is removed, PB will continue to form droplets and burn without sooting. When burned, PB produces primarily carbon dioxide, carbon monoxide and water.

Persuant to UL94 (Test for Flammability of Plastic Materials), PB is rated as a slow burning plastic in the horizontal burn test.
According to DIN 4102-1, PB is classified B2 (normal combustibility) and is classified E-d2 according to EN 13501-1.
In the French classification of building materials, polybutene falls in category M3 (small flame). According to ASTM D 1929, PB self ignites at 360 °C. In case of fire, this plastic is extinguished with spray water, foam or carbon dioxide.

Electrical properties

Due to the fact that polybutene (PB) is non-polar, PB is an excellent isolator. External impurities, oxidation or weather conditions considerably reduce the isolating action. Otherwise, the electrical conductivity is practically not dependent on temperature and frequency. The specific contact resistance is $>10 \times 10^{16}$ Ωxcm, the dielectric strength 75 kV/mm.

Physiological properties

The material used by GF Piping Systems meets the formulation specifications of the relevant food law requirements.

Glossar

Density
The densityof a body is the mass m per unit volume V.

Hardness
The hardness refers to the material's resilience against penetration of a body. It is generally measured using the depth of penetration left by a load with a specific geometry in the material.

Melt Flow Index (MFI)
The Melt Flow Index (MFI) indicates how easily the melted polymer flows. It depends on the length of the molecular chains and the number of branches. The mass pressed through a standard die with a 5 kg weight in 10 minutes at 190 °C is measured.

Strength
Strength is resistance of an elastic body to deformation.

Thermal conductivity
Thermal conductivity means the energy transported within a substance in relation to temperature and surface.

Coefficient of thermal expansion
The coefficient of thermal expansion specifies the change of length of a rod, 1 meter in length, after increasing the temperature by 1 °C; it is measured in millimetres.

Impact strength
The impact strength refers to a material's breaking resistance upon impact stress. It is defined as the amount of energy that the material can absorb at its smallest cross-section before it breaks. It is determined in the Charpy notched bar impact test.

Flexural modulus of elasticity
The flexural modulus of elasticity is an expression of a material's rigidity. It is defined as the slope of its stress-strain curve in the linear range.

Tensile strength
Tensile strength is the highest tensile stress which a material can withstand before it breaks. The elongation before it breaks is referred to as elongation at break or ultimate elongation.

Hygiene standards

Polybutene (PB) complies with the KTW recommendations of the German Health Authority for plastics in drinking water. This is confirmed in the test certificate of the Hygiene Institute of the Ruhr.

Hygiene-Institut des Ruhrgebiets

Institut für Umwelthygiene und Umweltmedizin
Direktor: Prof. Dr. rer. nat. L. Dunemann

Hygiene-Institut · Postfach 10 12 55 · 45812 Gelsenkirchen / GERMANY

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E-Mail	a.koch@hyg.de
Internet	www.hyg.de
Reference:	**K-172281-09-Ko/st**
Contact person:	Dr. Andreas Koch
Gelsenkirchen,	14.01.2009

TEST CERTIFICATE
according to the KTW-Guideline

(English version dated 07.11.2005, Ref.-No.: C-133437-05-Ka/st)

Product:	**Drinking water-Installation-moulded parts made of PB, Group 1 (grey)** (SKZ-Product-No.: 1681, Cert.-No.: DVGW DW-8501AT2528)
Specimen:	T-piece Ø 40 mm
Production:	Sternplastic Fertigungs GmbH, 8226 Schleitheim (Schweiz)
Kind of test:	[ ] Product test / Permission test [X] Supervision test 2005

The a.m. **drinking water-installation "moulded parts made of PB, Group 1 (grey)"** meet the requirements according to the test report dated **07.11.2005, Ref.-No.: C-133437-05-Ka/st** for the following applications and temperatures:

Applications:	cold water (23°C)	moderately hot water (60°C)	extremely hot water (85°C)
Pipes ID < 80 mm (domestic distribution)	---	---	---
Pipes 80 mm ≤ ID < 300 mm (supply pipelines)	---	---	---
Pipes ID ≥ 300 mm (mains)	---	---	---
Simple fittings, assembled product housings for pipes ID < 80 mm	passed	passed	---
Simple fittings, assembled product housings for pipes 80 mm ≤ ID < 300 mm	passed	passed	---
Simple fittings, assembled product housings for pipes ID ≥ 300 mm	passed	passed	---
Seals for pipes ID < 80 mm	passed	passed	---
Seals for pipes 80 mm ≤ ID < 300 mm	passed	passed	---
Seals for pipes ID ≥ 300 mm	passed	passed	---
Storage systems within the domestic distribution system including repair products	passed	passed	---
Storage systems outside the domestic distribution system including repair products	passed	passed	---

as far as technically suited.

This test certificate is valid beginning with the date of issue and is ending by **07.11.2010** as far as there are no changes in the formula. After this time it can be extended for further 5 years if demanded.

The Director of the Institute
on behalf of

(Dr.rer.nat. A. Koch)

HYGIENE-INSTITUT DES RUHRGEBIETS Institut für Umwelthygiene und Umweltmedizin

The results and conclusions exclusively refer to the investigated samples and the relevant laws.
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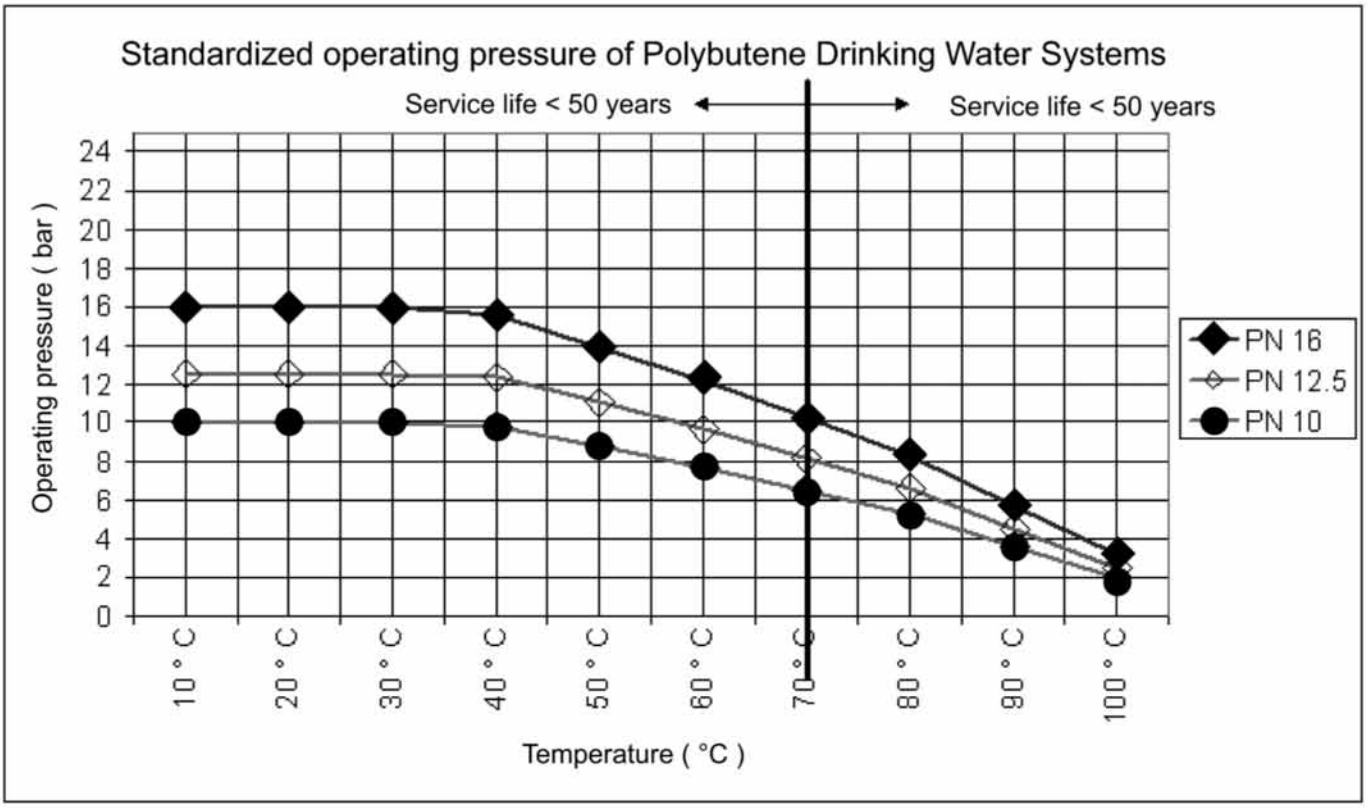
Deutscher Akkreditierungs Rat
DAP-PL-2548.00

Träger des Hygiene-Instituts: Verein zur Bekämpfung der Volkskrankheiten im Ruhrkohlengebiet e.V., Gelsenkirchen

Long-term pressure test for PB

Standardized operating pressure of polybutene drinking water systems



For operational safety and a long lifetime (service life), selecting the right material and pressure rating for the piping components is key. Other factors to be taken into consideration are operating temperature, the medium conveyed and the operating pressure range.

The INSTAFLEX d16 to d110 products have a nominal pressure of PN 16 while the pressure rating for INSTAFLEX BIG d125 to d225 falls under PN 10. The pressure-temperature diagram has been calculated for a service life of 50 years in the drinking water sector. The diagram also figures in a safety factor of SF = 1.5.

Example for INSTAFLEX d16 to d110 (PN 16)
Operating temperature: 70°C
Pressure rating: PN 16
The operating pressure taken from the diagram: 10 bar

Determining the pipe wall thickness and the pressure class

To calculate the wall thickness of polybutene (PB) pipes bearing internal pressure the Kessel formula is applied:

$$s = \frac{p \times d \times SF}{(20 \times \delta_B) + (p \times SF)}$$

s	=	pipe wall thickness [mm]
p	=	operating pressure at 20 °C [bar]
d	=	pipe outer diameter [mm]
δ_B	=	comparative stress
SF	=	safety factor of 1.5

All the pipe dimensions expressed in the standards are based on this calculation formula. According to DIN, EN and ISO standards, the **nominal pressure PN** (Pressure Nominal) indicates the permissible operating pressure in bar at 20 °C. In accordance with the European standardization of systems, the new terms will be additionally used in future.

Example

Nominal pressure PN 16 means that a pipe in this pressure class can be subjected to a pressure of 16 bar at 20 °C.

In sanitary installations, the nominal pressure is not decisive for the pipe and fitting technology, but rather the **building codes and test specifications in the respective country**. These ensure safety in the distribution of hot and cold drinking water.

The critical material requirements are not the nominal pressure, but the operating pressure and the service life.

Example

At an operating pressure of 10 bar and a lifetime of 50 years, the operating temperature may be maximum 70 °C. A safety factor of 1.5 has already been included.

Pipe data for INSTAFLEX PB pipes

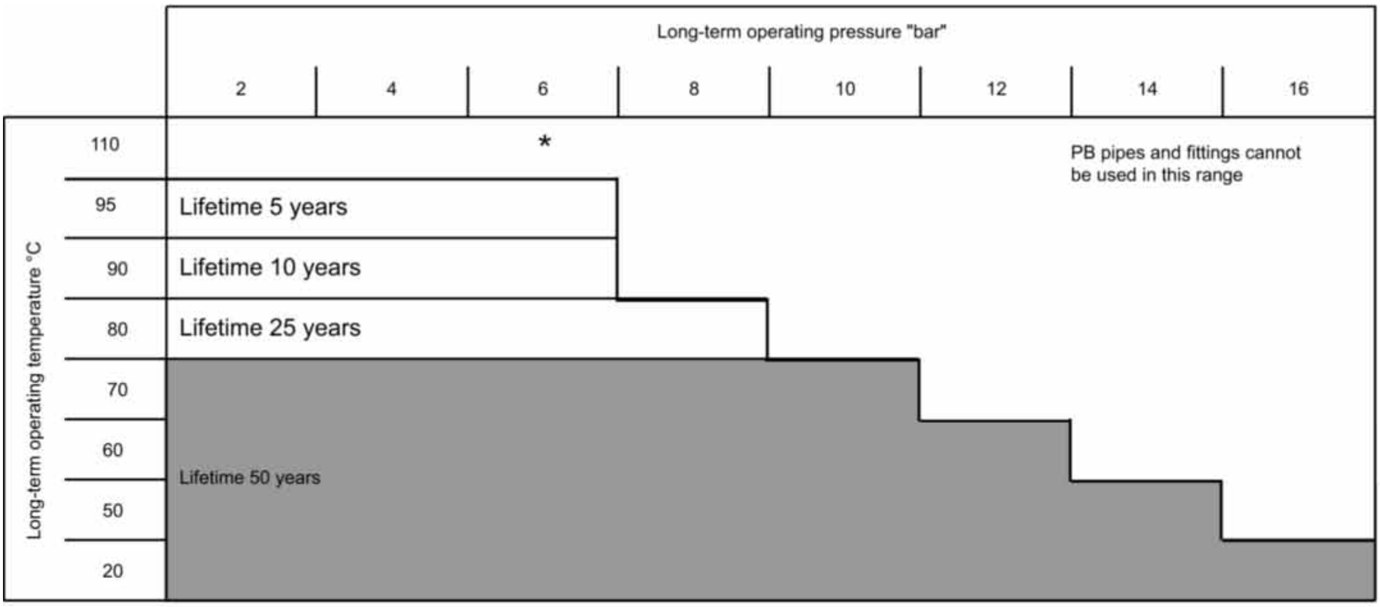
Nominal diameter DN [mm]	Pipe outer diameter d [mm]	Pipe wall thickness s [mm]	Pipe inner diameter d_i [mm]	Weight [kg/m]	Water volume [l/m]
12	16	2.2	11.6	0.088	0.10
15	20	2.8	14.4	0.141	0.16
20	25	2.3	20.4	0.152	0.33
25	32	2.9	26.2	0.254	0.53
32	40	3.7	32.6	0.392	0.83
40	50	4.6	40.8	0.610	1.31
50	63	5.8	51.4	0.969	2.07
65	75	6.8	61.4	1.354	2.96
80	90	8.2	73.6	1.960	4.25
100	110	10.0	90.0	2.920	6.36
125	125	11.4	102.2	3.950	8.20
160	160	14.6	130.8	6.460	13.40
225	225	20.5	184.0	12.700	26.60

Roughness factor k = 0.007
for polybutene per DIN 1988

Range of application for INSTAFLEX PB pipes and fittings d16 - d225

Sanitary

INSTAFLEX is used for the hot and cold water pipes in drinking water installations. National specifications are not just satisfied, they are exceeded.



A safety factor of SF = 1.5
was used in the lifetime calculation

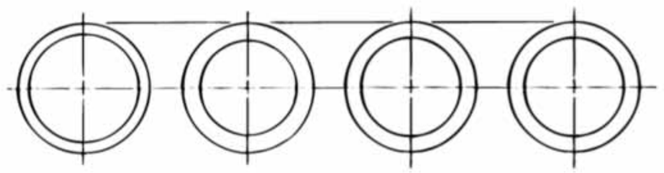
*** Short-term loads up to 110°C are possible for PBd16 and d20 pipes. Tests at 110°C with 7.5 bar internal pipe pressure resulted in lifetimes of <1 year**

Pipe wall thickness «s»

The pipe wall thickness is determined by the comparative stress, the pipe outer diameter and the permissible positive operating pressure at 20 °C.

In reference to the 20 °C curve for a service life of 50 years with safety factor included. Comparison of the drinking water pipelines used in building technology.

Example for a pipe d 40 with DVGW/SVGW approval

Pipe material	**PB** (Polybutene)	**PE-X** (Polyethylene, cross-linked)	**PP-R CT** (Polypropylene, random, temperature-stabilised)	**PVC-C** (Polyvinyl chloride, postchlorinated)	
Pipe dimension d 40 x	3.7	5.5	4.5	4.5	[mm]
Pipe inner diameter	32.6	29.0	31.0	31.0	[mm]
Pipe inner surface	834	660	754	754	[mm²]
Nominal pressure rating	PN 16	PN 20	PN 20	PN 25	
					
Flow velocity at V = 2.0 l/s	2.4	3.0	2.7	2.7	[m/s]
Pressure loss at V = 2.0 l/s	18.4	32.5	23.6	23.6	[mbar/m]
DN Nominal diameter	**32**	**32**	**32**	**32**	[mm]

PN 16 means

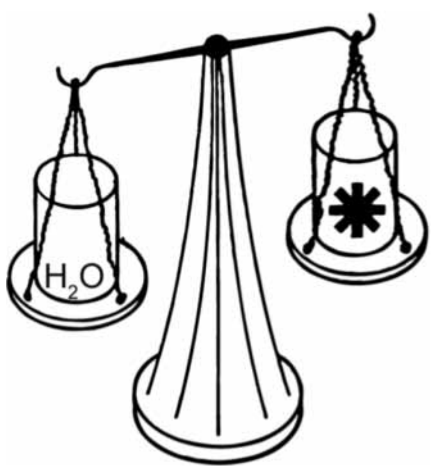
Permissible operating pressure of 16 bar at 20°C and a lifetime of 50 years assuming a safety factor of 1.5 for all materials.

Compressed air

INSTAFLEX has been designed for a temperature range of 0 to 80 °C for compressed air applications. The maximum permissible operating pressure at 20 °C is 16 bar with a calculated safety factor of 1.5.

PB in comparison to other plastics, e.g. PP-R, VPE and PVC-C as well as metals

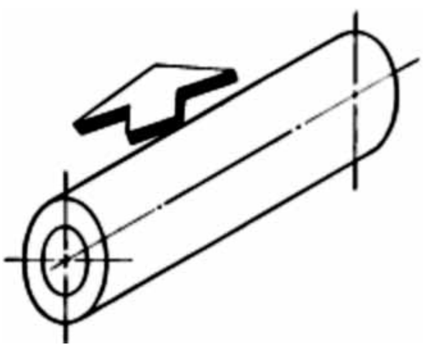
Density «ρ»	**[g/cm³] [kg/dm³]**
Polybutene (PB)	0.94
Polyetyhlene, cross-linked (PE-X)	0.94
Polypropylene, random (PP-R)	0.90
Polyvinyl chloride, postchlorinated (PVC-C)	1.55
Water	1.00
Steel	7.85
Copper	8.89



The density of a body is the ratio of its mass m to its volume V:

ρ = m/V

Thermal conductivity «λ»	[W/mK]
PB	0.19
PE-X	0.41
PP-R	0.24
PVC-C	0.14
Composite	0.43
Water	0.58
Steel	42 to 53
Copper	407.10



Thermal conductivity means the energy transported within a substance in relation to the difference of pipe inner to pipe outer temperature and the pipe wall thickness.

Thermal expansion «α»	[mm/mK]
PB	0.13
PE-X	≈ 0.20
PP-R	0.18
PVC-C	0.08
Composite	0.026
Water	-
Steel	0.012
Copper	0.018
Stainless steel	0.017

Modulus of elasticity «E»	[MPa] [N/mm²]
PB	450
PE-X	600
PP-R	800
PVC-C	2500
Composite	70000
Water	-
Steel	210000
Copper	120000

The E-modulus is the relationship of stress to strain in the elastic range of a material.

The smaller the E-modulus, the more flexible the material. As the E-modulus increases, the material becomes more flexurally rigid.

Determining the length of a flexible section

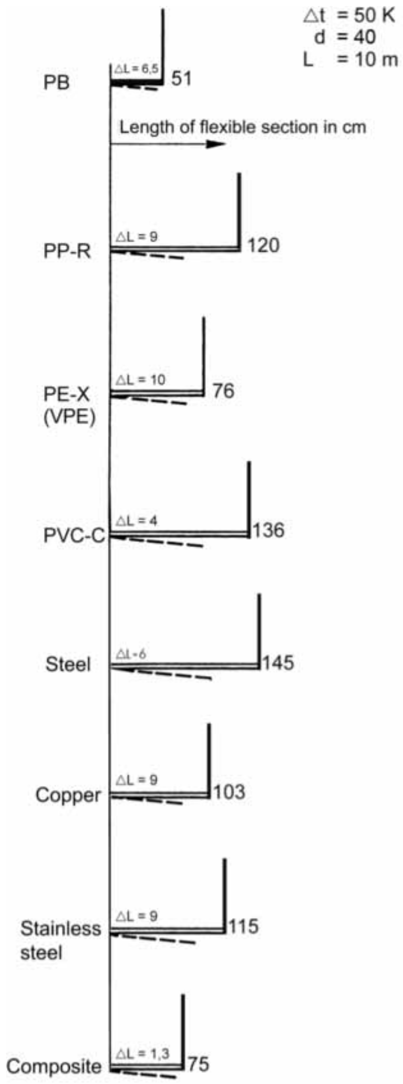
The required length of a flexible section is determined by means of the following formula:

$$L_B = \sqrt{\frac{3\ d_a\ \Delta L\ E_{cm}}{\sigma_b}}$$

Symbol definitions:

d_a = pipe outer diameter (mm)
ΔL = change in length (mm)
E_{cm} = average flexural creep modulus
σ_b = permissible flexural stress ratio

Example:
Determining the length of a flexible section



Δt = temperature difference [K]
DN = nominal diameter [mm]
L = length of expansion leg [mm]
ΔL = thermally dependent change in length [mm]

Jointing systems

Just as important as the pipe and the pipe material are the jointing technology and the metal materials of the fittings.

The interplay of various factors, such as too high or too low pH values, chlorides, free carbonic acid, corrosive nitrate and sulphate ion concentrations, lead to increasingly aggressive waters. This heightens the risk of corrosion for metal materials.

Traditional installation systems made of metals, such as steel, galvanised steel, copper and with stainless steel coatings, cannot be used in every situation due to inconsistent water qualities and are no longer approved for use in certain areas.

INSTAFLEX takes account of these trends. All the fittings are made of high-quality **CR hot-pressed brass**. CR brass is resistant to corrosion according to ISO 6509, the highest international standard. CR brass is even superior to red brass in regard its mechanical properties.

In a **homogenous** jointing system, like the INSTAFLEX electrofusion and socket fusion system, of analogous polybutene (PB) for pipes and fittings, corrosion problems can also be excluded.

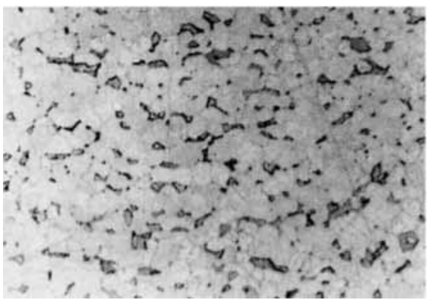
Properties of different material alloys

Material	Cast brass GK-Cu Zn 37 Pb	CR pressed brass Cu Zn 39 Pb 2	CR brass Cu Zn 36 Pb 2 As	Red brass G-Cu Sn 5 Zn Pb	Stainless steel 1.4301
Norms	DIN EN 1982	DIN EN 12420	DIN EN 12164 DIN EN 12165	DIN EN 1982	
Hardness HB 10 (N/mm²)	≥ 70	80 - 100	≥ 70	≥ 60	130 - 180
Tensile strength (N/mm²)	≥ 280	370 - 440	≈ 280	≥ 240	>500
Break elongation (%)	>20	≈ 30	≈ 30	>16	≈ 50
Yield point (N/mm²)	>90	280 - 360	≈ 200	>90	>200
Corrosion resistance	low	not quite up to ISO 6509	resistant as per ISO 6509	resistant as per ISO 6509	resistant as per ISO 6509
Abrasion behaviour	not so good	good	good	not good	good

Microstructure view of various alloys

Brass:

The dense and very homogenous microstructure of **dezincification-resistant CR hot-pressed brass** is a major contributing factor to the excellent leak tightness and strength durability of the fittings.



CR pressed brass, dense, homogenous microstructure

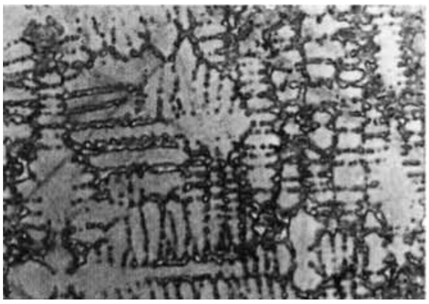
The tensile strength of the hot-pressed parts made of **CuZn39Pb2 CR brass** is min. 360 N/mm², with an elongation at break of at least 20% and a hardness HB of 75. The 0.2 % yield point is min.110 N/mm².

For hot-pressed parts of CuZn36Pb2As, **dezincification-resistant CR brass,** the tensile strength is min. 280 N/mm², with an elongation at break of at least 30 % and a hardness HB of 70. The 0.2 % yield point is min. 90 N/mm². Components, e.g. valve connections, of brass are therefore capable of handling high mechanical loads.

Red brass

The tensile strength of cast components made of **G-CuSn5ZnPb red brass** is min. 220 N/mm², with an elongation at break of at least 16 % and a hardness HB of 60. The 0.2 % yield point is min. 90 N/mm².

The acidular and coarse microstructure of red brass or cast brass fittings raises the risk of leakage, especially under mechanical loads.



Red brass, acicular, coarse microstructure

The reduced deformability of red brass compared to brass means that cracking is to be expected under building site conditions where there are high mechanical loads.

High stability, good deformability and general robustness under building site conditions are the outstanding features of **CR brass** and **dezincification-resistant CR brass** as compared to **red brass**.

INSTAFLEX metal fittings are manufactured of dezincification-resistant CR brass.

Corrosion behaviour

Dezincification

In soft water which contains chloride, brass tends to dezincify. For such water, a dezincification-resistant CR brass is preferred. The dezincification resistance of CR brass is established in ISO 6509. Further evidence of the resistance of CR brass to these waters is substantiated in 20 years of experience.

Dezincification-resistant CR brass is on a level with red brass in relation to dezincification.

Environmental stress cracking

Besides dezincifying, brass can also exhibit environmental stress cracking. Environmental stress cracking occurs when at least one of the four following conditions are present:

- a material susceptible to stress cracking
- internal/external tensile stress on the component
- a corrosive medium, e.g. ammonia
- moisture

Sources:

- EMPA report, Federal Materials Testing Institute
- Report from the Association for Brass Quality Standards

Environmental stress cracking occurs very seldom in red brass in connection with drinking water; it cannot however be completely ruled out.

Reducing environmental stress cracking

INSTAFLEX fittings are subjected to a thermal stress relieving process (stress-relief annealing). Due to its material composition which differs from brass, dezincification-resistant brass is not only much more resistant to dezincification, but also to stress cracking. Only dezincification-resistant brass is used for INSTAFLEX.

Summary

With consideration to all the properties,
correct system design and layout, and optimal selection of the material alloys, brass components, especially those made of **dezincification-resistant CR brass**, are superior to red brass in conventional sanitary installations.

INSTAFLEX components are manufactured of dezincification-resistant CR hot-pressed brass.

Other materials used in INSTAFLEX

All the system parts which come into contact with drinking water are commodities regulated by food law.

Copper alloys

Brass is a copper-zinc alloy and is deemed corrosion-resistant as well as erosion-resistant. In drinking water distribution, brass is used primarily for fittings which do not come into contact with the medium.
Material designation according to DIN 17660:
Cu Zn 39 Pb 3

Dezincification-resistant **CR brass**, in combination with low pH drinking water, is resistant to dezincification and, thanks to its composition, is also less susceptible to stress cracking.
Material designation according to DIN 12164:
CR-Cu Zn 36 Pb 2 As

Non-metal materials

Non-metal materials must comply with KTW recommendations of the German Health Authority.

Elastomers are rubber-like plastics and are mainly used for seals. In the INSTAFLEX range, elastomers can be found in the seals of removable unions and in valves.

EPDM is the acronym for ethylene-propylene-diene-rubber. The EPDM seals used in INSTAFLEX comply with KTW recommendations and can be used at a constant operating temperature of 90 °C with short-term increases up to 120 °C. EPDM seals are standard in INSTAFLEX components.

NBR (nitrile-rubber) can be used up to a constant operating temperature of 90 °C with short-term increases up to 120 °C.

Approvals

Approvals

INSTAFLEX

Approval conditions

Distribution systems for drinking water are subject to the approval of or registration with the national gas and water associations.

The approval or registration ensures that state-of-the-art technology is implemented and observed. This means of regulation obligates the system manufacturer to maintain a quality control system including a catalogue of measures and to continually and seamlessly monitor production processes.

In addition, external monitoring by a recognised test institute is mandatory. Such self-monitoring and external control guarantee the quality of the products.

Overview of national standards

Country	Basis for testing	Institute
Australia	AS/NZS 4129 MP 52-Spec 435 MP 52-Spec 012	**SAI Global**
Belgium	ATG 05/1871	**BUtgb UBAtc**
Germany	Arbeitsblatt W 544 Arbeitsblatt W 534 DIN 16968/16969 DIN 16831	**DVGW**
France	Avis Technique 14/07-1177	**CSTB**
Great Britain	British Standards BS 6920 BS7291-2 Water Regulations (WRAS)	**BSI**
Netherlands	KIWA ATA / BRL 536C	**KIWA**
Austria	ÖNORM EN ISO 15876 Richtlinie W 38	**ÖVGW**
Portugal	ISO 9001 EN ISO 15876-1 to 5 CEN ISO/TS 15876-7	**SGS**
Sweden	NKB Product Rules No. 3 BBR 3 BVL	**SITAC**
Switzerland	Bau- und Prüfvorschriften W/TPW 129, SN EN ISO 15876	**SVGW**
Spain	UNE-EN ISO 15876-1: 2004 UNE-EN ISO 15876-2: 2004	**AENOR**

Technical rules and testing regulations define the state of the art.

The **application parameters** established by the DVGW (German Technical and Scientific Association on Gas and Water) for pipe systems in drinking water installations are:

- temperature 70°C
- pressure 10 bar
- service life 50 years
- safety factor 1.5

In the framework of implementing the international ISO 15876 norm nationally, the manufacturer must indicate the application classes which correspond to his pipe system and the individual parameters. For INSTAFLEX these are:

- 16 and 20 mm: classes 1/2/4/5–10 bar
- from 25 mm: classes 1/2/4–10 bar, classes 5–8 bar

Approvals for INSTAFLEX

Country	Institute	Reg. No.	Remarks
Australia	SAI	SUK 01923	d16 - d110
Belgium	UBATc	05/1871	d16 - d110
Germany	DVGW	DW-8501AT2528 DW-8501AT2529 DW-8501AQ3144 DW-8501AW0424	d16 - d50 electro / socket fusion d63 - d110 electro / socket fusion d16 - d20 compression joints d25 - d63 compression joints
England	BSI WRAS	KM39698 0805500	d16 - d32 PB - material
France	CSTB	CSTBat-33-1177 CSTBat-78-1177 CSTBat-109-1177 CSTBat-147-1177	d16 - d110
Netherlands	KIWA	K 48336, 48341, 48377	d16 - d110
Austria	ÖVGW	W1.119	d16 - d110
Portugal	SGS	Pending	d16 - d110
Sweden	SITAC	0273/97	d16 - d110
Switzerland	SVGW VKF	8703-1961 Z16819	d16 - d110 Fire prevention approval
Spain	AENOR	001/004170 Pending	d16 - d25 d32 - d110

Shipbuilding

China	CCS	HBTO3170142	d16 - d110
Bureau Veritas	BV	12232/BO BV	d16 - d225
German Lloyds	GL	74455-96HH 21049-04HH	d16 - d225 Norma couplings
Italy	RINA	MAC187203CS Pending	d16 - d110 d125 - d225
Lloyd's Register	LR	02/20008_E2	d16 - d225
Norway	DNV	K3207 K3208 K3209 Pending	d16 - d110 d16 - d110 d16 - d110 d125 - d225
Russia	RMROS	04.00058.250	d16 - d110
USA	ABS	04-LD465502-3PDA	d16 - d110

Technical regulations and standards

Technical regulations and standards

General

Standards and regulations

Water specialists rely on the standards and regulations applicable in their respective countries.

Until a uniform **«European Technical Standard for Sanitary Installations»** is adopted, the country-specific **«Accepted Rules of Technology»** continue to be valid.

Technical regulations for water installations in:

Germany	**DIN 1988 (TRWI)**
	DIN EN 806
Switzerland	**SVGW Leitsätze W3**
	SN EN 806
Austria	**Ö-NORM B5155**
	Ö-NORM EN 806
Great Britain	**Water laws**
	BS 6920-1
	BS EN 806

The specifications also state the legal basis from which the technical and hygienic suitability of components and materials is determined. In order to verify suitability and correctly identify products, manufacturers are required to label their products and plant constructors are obligated to utilise only clearly marked products.

For the construction of drinking water systems, the following standards and guidelines apply:

Germany DIN/DVGW

- DIN 1988 (TRWI)
  DIN EN 806
- DIN 4109 Noise protection in high-rises
- DIN 4102 Fire behaviour of building materials
  DIN EN 13238
- EnEv Energy-saving ordinance

Switzerland SVGW

- W3 guidelines for building water installations
- SIA 181 Noise protection in residential buildings
- SN EN 806 Part 1: SIA 385301
- SN EN 806 Part 2: SIA 385302

Great Britain BS

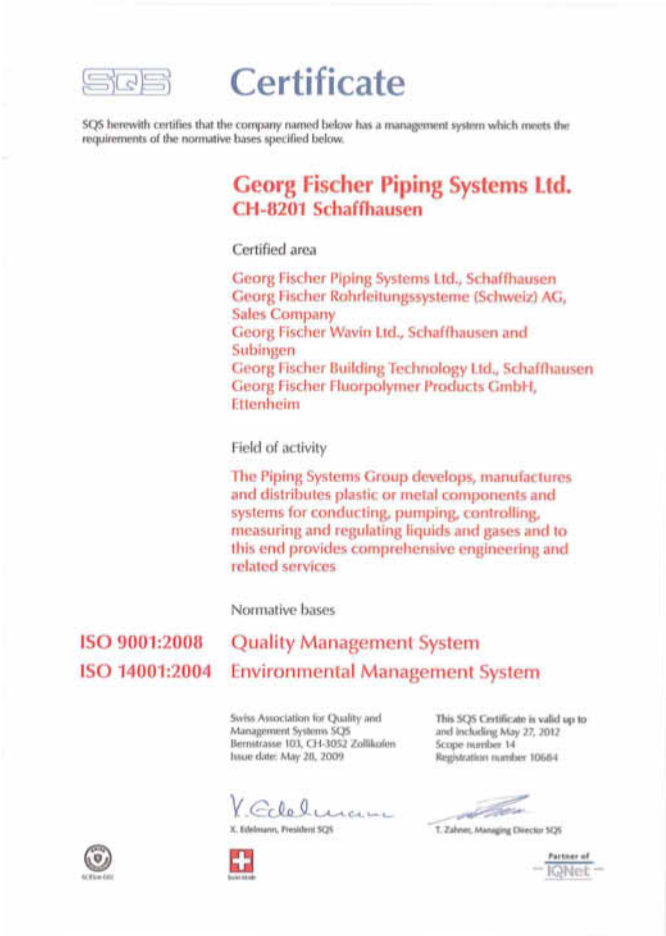
- BS 5955-8
  Specifications for the installation of thermoplastic pipes and fittings in building services: drinking water, hot water, heating installations.

Testing and certification

Quality and quality control are a top priority at GF Piping Systems!

Standards, external and internal test guidelines contain the basic specifications and hallmarks of quality required of pipes, connections and piping components. Besides checking the dimensional accuracy, the purpose of the required testing is to establish the quality and the monitoring of quality in order to ensure safety for a system lifetime of 50 years.

Proof of the hygienic suitability of pipes and components used to conduct the number one food «drinking water» is given in external testing according to the respective guidelines. Recognised, independent test centres continually monitor the quality of the PB material. Only successfully tested and quality controlled pipes and fittings may carry the seal of approval.


Certificate

SQS herewith certifies that the company named below has a management system which meets the requirements of the normative bases specified below.

Georg Fischer Piping Systems Ltd.
CH-8201 Schaffhausen

Certified area

Georg Fischer Piping Systems Ltd., Schaffhausen
Georg Fischer Rohrleitungssysteme (Schweiz) AG, Sales Company
Georg Fischer Wavin Ltd., Schaffhausen and Subingen
Georg Fischer Building Technology Ltd., Schaffhausen
Georg Fischer Fluorpolymer Products GmbH, Ettenheim

Field of activity

The Piping Systems Group develops, manufactures and distributes plastic or metal components and systems for conducting, pumping, controlling, measuring and regulating liquids and gases and to this end provides comprehensive engineering and related services

Normative bases

ISO 9001:2008 Quality Management System
ISO 14001:2004 Environmental Management System

Swiss Association for Quality and Management Systems SQS
Bernstrasse 103, CH-3052 Zollikofen
Issue date: May 28, 2009

This SQS Certificate is valid up to and including May 27, 2012
Scope number 14
Registration number 10684

X. Edelmann, President SQS

T. Zahner, Managing Director SQS

Partner of IQNet

INSTAFLEX pipes and fittings are tested and monitored for quality by the accredited «SKZ» Test Centre in Würzburg and other institutes. The frame of reference for confirmation of suitability is 50 years, based on the operating conditions in the respective country.

Under ISO and DIN norms and existing test guidelines, the manufacturer is obligated to statistically evaluate the product by means of the prescribed testing during the production process. This is set down in a catalogue of quality control measures, as well as periodic **external**

monitoring conducted by test institutes. This continuous and stringent **in-house testing** is the basis of quality control at GF Piping Systems.

Test guidelines:

Germany	DVGW	Worksheet W534
		W544/W270
		DIN 16968 and 16969
		DIN 16831/DIN 50930
	KTW	Recommendations of the Federal Health Authority
		(BGes. BL. Jg. 1977, 1 and 2 Mitt. ff.)
Switzerland	SVGW	Building and test guidelines
		W/TPW 129
		W/TPW 143
Austria	ÖVGW	Guideline W38
		ONEN 15876
Netherlands	KIWA	BRL-K 536/01
Belgium	UBAtc	ATG 92/1871
	BUtg b	
France	SOCOTEC	C.S.T.B. Nr.: 09.24
Great Britain	WRc	Approval per British Standard BS 6920

Operating conditions

The long-term operating pressures permissible for INSTAFLEX pipes and fittings in the cold water range correspond to their nominal pressures (PN).

d16 to 110 complies with PN 16
d125 to 225 complies with PN 10

The pressure and temperature requirements for an **assumed operating duration of 50 years** with a calculated **safety factor of 1.5** are summarised in the following table.

Germany - DVGW (DIN 1988/Part 2)

Medium	Operating overpressure [bar]	Temperature [°C]	Annual duration [h/a]
Cold water	0 to 10 (fluctuating)	up to 25*	8760
Hot water	0 to 10 (fluctuating)	up to 60	8710
		up to 85	50

* Reference temperature for creep rupture strength: 20 °C

Switzerland - SVGW (Guideline W3)

Medium	Load duration	Temperature [°C]	Operating pressure [bar]
Cold water	Long-term operation	20	10
Hot water	Long-term operation	60	10
Exceptional load accumulated over the system lifetime	1000 h	95	10

Hygiene standards

Polybutene pipes have been proved to be hygienically suitable for hot and cold drinking water pipelines. The test results of the DVGW research centre at the Engler-Bunte Institute of the University of Karlsruhe
have shown that polybutene pipes satisfy the KTW recommendations of the Federal Health Authority (BGA).

The suitability in terms of the material composition qualifies the INSTAFLEX system as a «commodity» under General Food Law.

The KTW guideline analyses the hygienic quality of organic materials that come into contact with drinking water. The following federal health periodicals have been published in this regard:
2005 48: 1409-1415
2007 50: 1180-1181
2008 51: In preparation, current status: 14.04.2008

Germany
Plastics in the food industry, recommendations of the Federal Health Authority; ed. R. Frank and H. Mühlschlegel, Carl Heymanns Verlag KG, Cologne, Berlin, Bonn, Munich.
LMBG (Food and Other Commodities Act) of 15.08.1974; BGesundhBL T 1, S. 1945 ff.

Austria
Per decree Zl. IV-445.850/2-6/86 of the Federal Ministry of Health and Environmental Protection as well as the investigative report kl. 1399/6-87 of the Environmental Protection Institute, body of public law.

Great Britain
According to WRC per BS 6920-1 for non-metal products used to convey water intended for human consumption with regard to their effect on the water quality.

INSTAFLEX

Fire behaviour and fire protection

Fire protection

INSTAFLEX pipes of polybutene (PB) fall under fire category **4.2** (normal inflammability) for building materials according to **VKF*** regulations and are therefore approved in Switzerland.

BZ no.: Z 16 819

In Germany polybutene (PB) pipes belong to **fire protection class B2** according to **DIN 4102**, Part 11.

If fire protection measures are required in wall and ceiling ducts for pipes from size **d32** and up, only fire-retarding sealing with the respective approval may be used.

Buried pipes generally require no special fire protection measures. The regulations in the particular country must be observed.

* Association of Cantonal Fire Insurance Companies in Switzerland

Fire behaviour

Switzerland
When exposed to an open flame, polybutene burns with a bright flame and continues to burn on its own after the source of ignition has been removed. The fumes and smoke smell of wax and paraffin. When the flame is extinguished, it smells like a candle that has gone out.

Germany
The formation of toxic or corrosive combustion products is impossible for polybutene because there are no halogens in its molecular structure.

Fire mains

When using PB pipes for fire mains, the local fire regulations must be observed.

According to SVGW guidelines W3 fire mains must be made of non-flammable material or installed in a fire-retardant manner as per **EI 30 (nbb)** :

- buried or in-wall
- in a shaft with fire bulkheads
- in an open installation, the insulation must be at least category EI 30 (nbb).

Category EI 30 (nbb)
The fire-insulated, water-filled PB pipe must be protected so that in a so-called "standard fire" the temperature on the cold side of the insulation (inner side) cannot reach 140 °C in 30 minutes. After 30 minutes, the pipeline must still be operational.

Example of insulation according to the VKF fire protection index

For an EI 30 (nbb) category, pipe half-shells of mineral wool and in the appropriate diameter are mounted staggered and adjacently, the gaps are filled with adhesive and tied with binding wire.

TA no.: 4062

F	Supporting and space enclosing structures/ false ceiling/panelling/ flameproof coatings
T	Movable closures
R	Smoke and fire-resistant closures
K	Fire dampers
S	Sealing, bulkheads
A	Elevator shaft doors

Laying pipes with bitumen

If INSTAFLEX is laid on solvent-containing bitumen tracks or if it comes into contact with solvent-containing bitumen coatings, the bitumen must first be completely dry.

Please follow the manufacturer's instructions.

In certain cases, INSTAFLEX PB pipes must be protected with solvent-resistant aluminium-clad insulation.

Laying pipes with hot-asphalt flooring

If INSTAFLEX is laid under hot-asphalt flooring, the pipes must be specially protected because this type of flooring is laid at a temperature of about 250 °C. In this case, the INSTAFLEX pipes are first laid on a rough concrete slab and covered with a granular insulation at least 10 mm deep (e.g. Perlite gravel). An insulating board of perlite and fibre must be placed on the gravel before the surface can be walked on to pour the hot asphalt.

Potential equalisation

According to DIN VDE 0100-540, potential equalisation is required between all types of protective earthing conductors and any «conductive» pipes. INSTAFLEX is not a conductive piping system and hence cannot be used for potential equalisation per DIN VDE 0100.

Protecting drinking water

If all the specifications of the national technical regulations for construction of drinking water systems are abided by, then it is safe to assume that the requirements for drinking water quality are fulfilled from the receiving point to the tapping point.

It must be warranted that neither impairment **(1)** of the drinking water, nor health risks **(2)** to the consumer may occur.

Causes of contamination or health risk in drinking water

1. Backflow of contaminated water
2. Connection to non-drinking water systems **(3)**
3. External effects **(4)**
4. Materials, supplies and auxiliary materials
5. Stagnation **(5)**
6. Unprofessional and faulty maintenance

(1) Impairment:

Changes in the drinking water which do not pose a health risk to the consumer

(2) Health risk:

Changes in the drinking water which are hazardous to health

(3) e.g. rainwater systems

(4) e.g. conducted through shafts or trenches

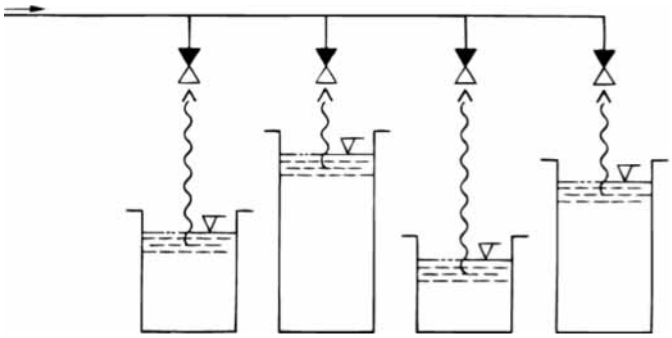
(5) For periods of stagnation of 4 weeks or more, rinsing the pipeline is recommended for hygienic reasons.

Safety measures to prevent backflow of contaminated water

Precautions must be taken to prevent backflow.

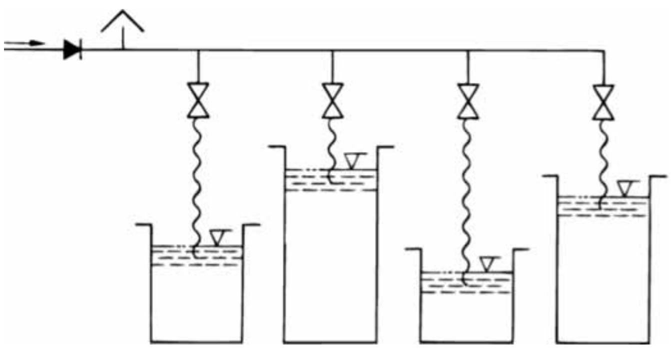
Individual protection

In individual protection, each tapping point and each device which represents a potential source of contamination or a health risk from an altered drinking water quality is safeguarded **individually**.



Collective protection

In collective protection, several or all the tapping points and devices which represent a potential source of contamination or health risk from an altered drinking water quality are protected **jointly** by one safeguard.



Sound insulation

Applicable standards

Germany	DIN 4109	Sound insulation in high-rises
Switzerland	SIA 181	Sound insulation in residential buildings

Measures

Most important in sound insulation is a suitable **floor plan**. If planning is done correctly, it is still the most effective means of sound insulation and incurs no extra costs. Rooms can be arranged advantageously from a noise prevention point of view and plumbing fixtures and pipelines placed accordingly.

Moreover, there is the requirement that **walls** of rooms needing sound insulation to which pipes (water and sewage lines), valves or plumbing fixtures are fastened must have an area-related mass (mass per unit area) of 220 kg/m² (no particular verification required). See the sound reduction index for conventional building materials.

In terms of active sound insulation in water installations, the use of **low-noise valves** is a key factor. These valves belong to valve group I, with a valve noise level according to DIN 52218 of $\mathbf{L_{AG} \leq 20}$ **dB(A).**

In structure-borne sound transmission, the sound velocity in the **material** is a major criterion. This value is determined in relation to the density and modulus of elasticity of a material. Plastics have low sound velocities which is why INSTAFLEX is ideal for sound insulation of water installations.

Sound reduction index of conventional building materials

Stone type	Wall thickness [cm]	Stone gross density [kg/m³]	Mass per unit area with mortar without plaster [kg/m²]	Weighted sound reduction index [dB]	Mass per unit area with plaster 1x1.5 cm [kg/m²] [1)]	Weighted sound reduction index [dB]	Mass per unit area with plaster 2x1.5 cm [kg/m²] [2)]	Weighted sound reduction index [dB]
Pumice-solid brick and expanded clay, e.g. Liapor	9.5 11.5 17.5 24.0 30.0	1100	104.5 126.5 192.5 264.0 330.0	37 39 44 47 50	119.5 141.5 207.5 279.0 345.0	38 40 44 48 50	134.5 156.5 222.5 294.0 360.0	40 41 45 49 51
Pumice-hollow brick and expanded clay, e.g. Liapor	17.5 24.0 30.0 36.5	1100	192.5 264.0 330.0 401.5	44 47 50 52	207.5 279.0 345.0 416.5	44 48 50 53	222.5 294.0 360.0 431.5	45 49 51 53
Honeycomb brick (small format)	11.5 17.5 24.0 30.0	1400	161.0 245.0 336.0 420.0	42 46 50 53	176.0 260.0 351.0 435.0	43 47 51 53	191.0 275.0 366.0 450.0	44 48 51 54
Light brick (large format)	11.5 17.5 24.0 30.0	1200	138.5 210.0 288.0 360.0	40 45 48 51	153.0 225.0 303.0 375.0	41 45 49 51	168.0 240.0 318.0 390.0	42 46 50 52
Porous brick, e.g. Poroton, Unipor, Pori-Klimaton	11.5 17.5 24.0 30.0	1000	115.0 175.0 240.0 300.0	38 43 46 49	130.0 190.0 255.0 315.0	39 44 47 49	145.0 205.0 270.0 330.0	40 44 48 60
Porous concrete, e.g. Ytong, Hebel	10.0 12.5 15.0 20.0 25.0 30.0 360	800	80.0 10.0 120.0 160.0 200.0 240.0 292.0	33 36 38 42 44 46 48	95.0 115.0 135.0 175.0 215.0 225.0 307.0	36 38 40 43 45 47 49	110.0 130.0 150.0 190.0 230.0 270.0 322.0	37 39 41 44 46 48 50
Sand-lime brick, solid brick	11.5 17.5 24.0 30.0	1750	201.0 306.0 420.0 525.0	44 49 53 55	216.0 321.0 435.0 540.0	45 50 53 56	231.0 336.0 450.0 555.0	46 50 54 56
Perforated brick	11.5 17.5 24.0 30.0 36.0	1500	172.5 262.5 360.0 450.0 547.5	42 47 51 54 56	187.5 277.5 375.0 465.0 562.5	43 48 51 54 56	202.5 292.5 390.0 480.0 577.5	44 48 52 54 56
Clay full brick	11.5	1800	207.0	44	222.0	45	237.0	46
Concrete	10.0	2350	235.0	46				

[1)] e.g. gypsum plaster 1.0 kg/dm³ gross density (DIN 4109 Part 3) Plaster thickness 1.5 cm = 15 kg/m², both sides = 30 kg/m²

[2)] e.g. lime plaster/lime cement plaster 1.8 kg/dm³ gross density plaster thickness 1.5 cm = 25 kg/m², both sides = 50 kg/m²

Source: DIN 1055 and manufacturer's data

Noise behaviour of INSTAFLEX polybutene (PB) valves

Noise emission from INSTAFLEX polybutene valves is less than 20 dB (A). This complies with the DIN 52218 requirements for low-noise valves in **valve group I**.

Dimension DN/d [bar/mm]	Valve noise emission L_{AG} [dB (A)] at 3 bar flow pressure
15/20	over 10
20/25	over 10
25/32	12
32/40	over 10
40/50	12
50/63	13

Sound velocity in materials

	Density [kg/dm³]	**E-modulus [N/mm²]**	**Sound velocity [m/s]**
Steel	7.95	210000	6000
Copper	8.9	120000	3900
PB (Polybutene)	0.94	450	620
PVC-C(Polyvinyl chloride, post-chlorinated)	1.56	3500	2350
PE-X(Polyethylene, crosslinked)	0.95	600	800
Soft rubber	0.90	90	320

Heat insulation of drinking water pipes

Heat insulation of the system complies with DIN 1988 requirements (drinking water - cold) and the energy conservation ordinance EnEV (drinking water - hot).

Germany

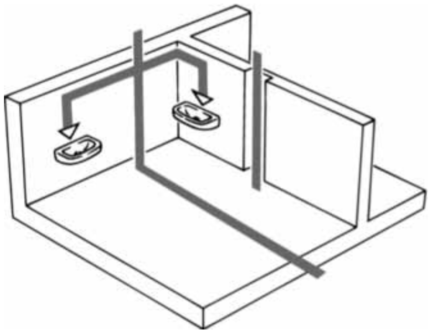
Insulation of cold water pipes (DIN 1988-2)

Cold water pipes should be placed at an adequate distance from heat sources. If this is not feasible, the pipelines should be insulated so that the water quality is not negatively affected by the heat. At the same time, cold water pipes must be protected against condensation.

The given minimum thickness of the insulation layer is based on a thermal conductivity of **λ = 0.040 W/mK**. For other thermal conductivities, the thickness of the insulation layer needs to be recalculated. According to DIN 1988-2 the following thicknesses of the insulation layer for drinking water pipes (cold) must be taken into account:

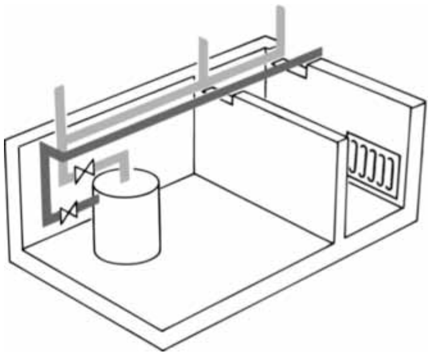
Installation situation I
4 mm minimum thickness of insulation layer

- pipeline installed openly in unheated rooms (basement)
- pipeline on concrete ceiling
- pipeline in duct, without hot water pipe
- pipeline in wall slit, riser pipes



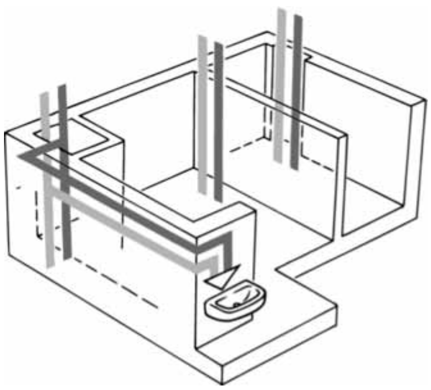
Installation situation II
9 mm minimum thickness of insulation layer

- pipeline installed openly in heated room



Installation situation III
13 mm minimum thickness of insulation layer

- pipeline in duct, next to hot water pipe
- pipeline in wall recess, next to hot water pipe



Insulation of hot water pipes according to EnEV (Energy Conservation Ordinance)

To limit heat dissipation, heat distribution pipes and hot water pipes as well as valves must be insulated.

Central heating pipes which are located in heated rooms or in structural elements between heated rooms of **a user** and whose heat output can be affected by shutoff devices need not be insulated. This also pertains to hot water pipes up to an inner diameter of 22 mm which are not connected to the circulation and are not equipped with electric pipe heaters.

Although the EnEV ordinance does not call for mandatory insulation of drinking water installations, they should nevertheless be insulated for the following reasons:

- reduction of heat dissipation
- sound insulation
- protection of piping

The given minimum thickness of the insulation layer is based on a thermal conductivity of **λ = 0.035 W/mK**. For other thermal conductivities, the thickness of the insulation layer needs to be recalculated. Insulation layer thicknesses for hot water pipes according to EnEV can be found in Table 1:

Table 1:

Line	Type of pipeline/valve	Minimum thickness of insulation layer, based on thermal conductivity 0.035 W/mK
1	Inner diameter up to 22 mm	20 mm
2	Inner diameter between 22 mm and 35 mm	30 mm
3	Inner diameter between 35 mm and 100 mm	same as inner diameter
4	Inner diameter more than 100 mm	100 mm
5	Pipes and valves according to lines 1 to 4 in wall and ceiling recesses, in pipe intersection area, at connection points, for central pipe network distributors.	½ of requirements of lines 1 to 4
6	Central heating pipes according to lines 1 to 4, which are installed after this ordinance has come into effect in structural elements between heated rooms of various users.	½ of requirements of lines 1 to 4
7	Pipes according to line 6 in floor construction	6 mm

For pipe insulation arrangements other than a circular insulation (e.g. eccentric), an equivalent restriction of heat dissipation, as in Table 1, must be warranted.

Switzerland

Hot water pipes are to be insulated in compliance with cantonal energy and building law.

Great Britain

Installation systems must be insulated according to Part 2 of the Building Regulations, making certain that the appropriate measures are taken. Evidence must be provided that the maximum heat loss is below the value given in the Non-Domestic Heating Compliance Guide.

Circulation lines

Switzerland

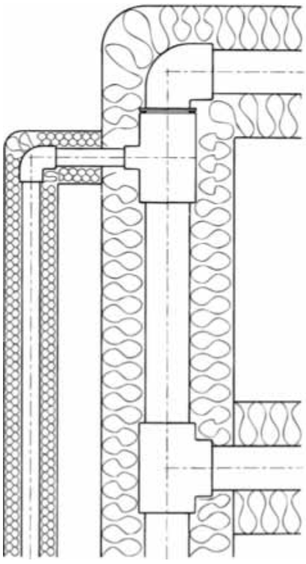
Hot water and circulation pipes are to be insulated in compliance with cantonal energy law.

Germany

Hot water and circulation pipes are to be insulated according to the energy conservation ordinance EnEV. A circulation line is calculated and regulated under DIN 1988 and W 551/W 552/W 553.

Conventional dual lines

Both pipelines must be insulated and fastened separately.

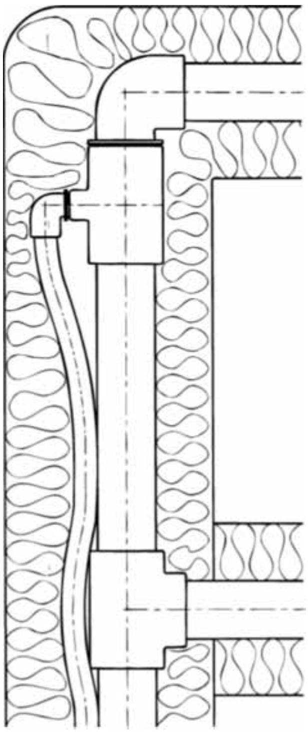


Hot water pipe and circulation pipe as dual line

Pipe-to-pipe configuration

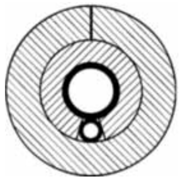
Both pipelines required only one set of insulation and fastening. This entails less cost and effort. Calculations have shown that this configuration results in ca. 30 % less heat loss compared to the conventional solution.

Source: SIA-Ing. Karl Bösch, Switzerland

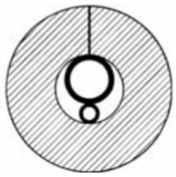


Hot water pipe and circulation pipe in a pipe-to-pipe configuration

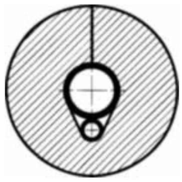
Examples for pipe-to-pipe configuration



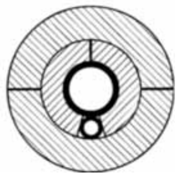
Double, soft polyethlylene (PE) insulation



Soft polyethylene (PE) insulation



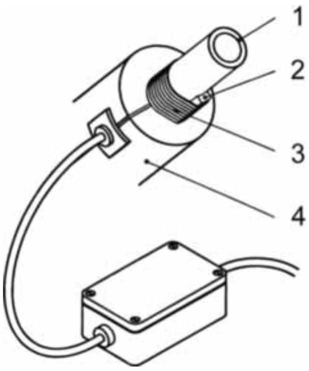
Mineral insulation (fibreglass) tied with wire



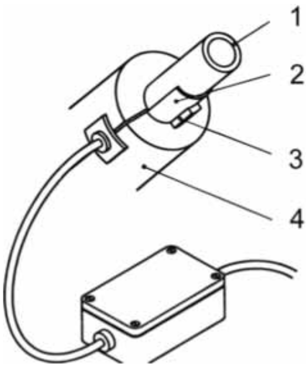
Hard-foam polyethylene (HDPE)insulation tied with wire or sheathed

Trace heating

Self-regulating trace heaters whose surface temperature does not exceed 65 °C may be used on the pipes. The trace heater has to be adapted to the water temperature. For better heat transfer, the entire length of the trace heater should be attached with a wide aluminium tape so that it covers as much of the medium-conveying pipe as possible. For pipes with carriers, the trace heater should be attached to the carrier.



1 INSTAFLEX pipe
2 Trace heater
3 Aluminium tape
4 Insulation



1 INSTAFLEX pipe
2 Carrier
3 Trace heater
4 Insulation

When installing trace heaters on INSTAFLEX pipes, please follow the installation instructions of the heater manufacturer. Do not double wrap the trace heater on INSTAFLEX pipes. This also applies to carriers.

Drinking water heater

Continuous flow heater

The maximum temperatures permitted for long-time operation are specified in the operating conditions.

The use of continuous flow heaters in connection with INSTAFLEX pipes has been tested and approved. Thermally or electronically controlled devices are preferable to hydraulically controlled ones because these can in some instances continue to heat uncontrolled causing INSTAFLEX to overheat.

The advantages of a modern plastic piping system like **INSTAFLEX** can be fully utilised with an electronically-controlled continuous flow heater from the companies **STIEBEL ELTRON, VAILLANT** and **AEG**. Tests with AEG continuous flow heaters in our test lab showed no negative effects on INSTAFLEX, even in case of malfunctions (brief overheating, air pockets in the heat exchanger, etc.).

Safety equipment of drinking water heating systems has been taken up in DIN 1988, Part 2, Paragraph 6.2.2 per decree of the **DVGW-FA W 5.01 of 11.11.1991**.

The requirements for safety equipment of drinking water heating systems are set down in DIN EN 60335-1, Part 1. For electric heaters of drinking water, the following standards also apply:

- VDE 0700-1, Part 1
- DIN EN 603352-2-15/VDE 0700-15, Part 15
- DIN EN 60335-2-24/VDE 0700-24, Part 24
- DIN EN 60335-2-35/VDE 0700-35, Part 35
- DIN EN 60335-2-80/VDE 0700-80, Part 243

To protect pipe materials and joints, temperature control units or safety temperature limiters should be used with drinking water heaters which guarantee that the water temperature cannot exceed 95 °C at any time and in any location, even with post-heating (coasting). On hydraulically controlled devices, an automatic shutoff must ensure that pressures above 10 bar cannot occur due to post-heating.

Condensation

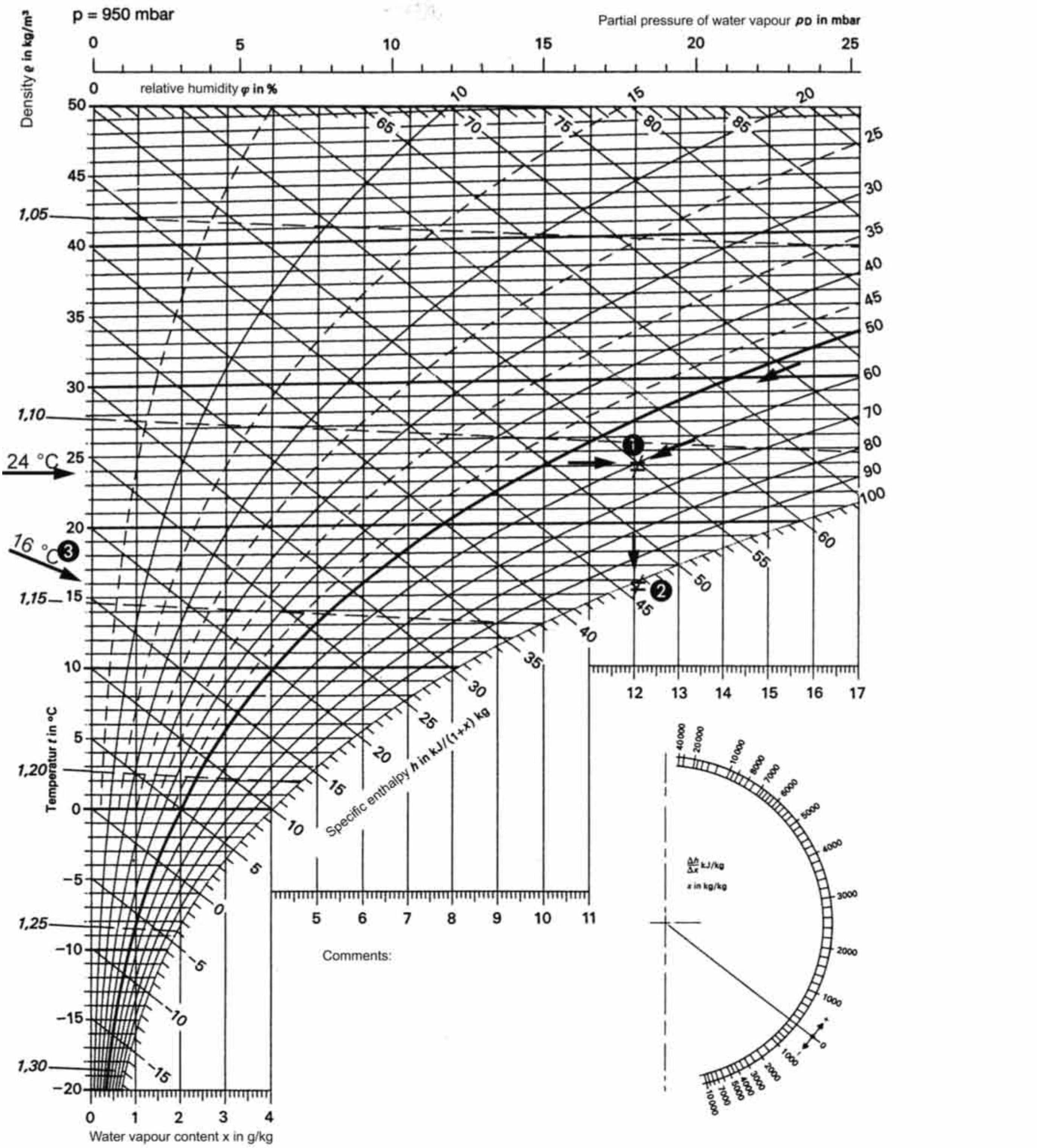
According to DIN 1988, Part 2, it is not necessary to protect pipes against the formation of condensation if they are adequately encased, e.g. pipe-in-sleeve. INSTAFLEX polybutene pipes are offered as a pipe-in-sleeve system from dimension d16 to dimension d25.

Determining condensation formation on pipes

The h-x diagram (Mollier diagram) indicates how high the moisture content of air is in relation to temperature and pressure.

h	=	enthalpy
x	=	moisture content in air
H	=	540 m above sea level

H - x diagram



Example:
Water temp. 16 °C
Air temp. 24°C
Air humidity 60%

❶ Find intersection of 24 °C air temperature and 60% air humidity

❷ Form intersection at 100% relative humidity.Vertically under intersection point❶

❸ Minimum pipe surface temperature to avoid formation of condensed water

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Pipe surface temperature

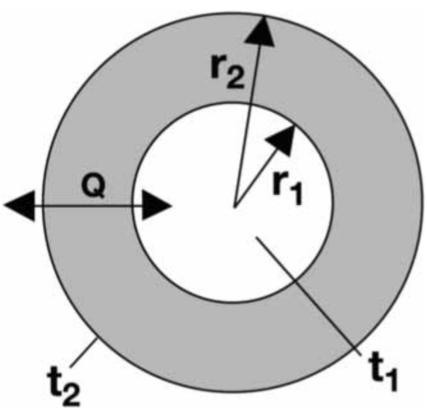
	d40	Pipe outer temperature [°C]														
W	22	18.8	19.1	19.5	19.8	20.1	20.4	20.7	21.1	21.4	21.7	22.0	22.6	23.3	23.9	24.5
a	21	18.2	18.5	18.8	19.1	19.4	19.7	20.1	20.4	20.7	21.0	21.3	22.0	22.6	23.2	23.7
t	20	17.5	17.8	18.1	18.4	18.7	19.1	19.4	19.7	20.0	20.3	20.6	21.3	21.9	22.5	23.2
e	19	16.8	17.1	17.4	17.7	18.1	18.4	18.7	19.0	19.3	19.6	20.0	20.6	21.2	21.9	22.5
r	18	16.1	16.4	16.7	17.1	17.4	17.7	18.0	18.3	18.6	19.0	19.3	19.9	20.5	21.2	21.8
	17	15.4	15.7	16.1	16.4	16.7	17.0	17.3	17.6	18.0	18.3	18.6	19.2	19.9	20.5	21.1
t	16	14.7	15.1	15.4	15.7	16.0	16.3	16.6	17.0	17.3	17.6	17.9	18.5	19.2	19.8	20.4
e	15	14.1	14.4	14.9	15.0	15.3	15.6	16.0	16.3	16.6	16.9	17.2	17.9	18.5	19.1	19.8
m	14	13.4	13.7	14.0	14.3	14.6	15.0	15.3	15.6	15.9	16.2	16.5	17.2	17.8	18.4	19.1
p	13	12.7	13.0	13.3	13.6	14.0	14.3	14.6	14.9	15.2	15.5	15.9	16.5	17.1	17.8	18.4
e	12	12.0	12.3	12.6	13.0	13.3	13.6	13.9	14.2	14.5	14.9	15.2	15.8	16.4	17.1	17.7
r	11	11.3	11.6	12.0	12.3	12.6	12.9	13.2	13.5	13.9	14.2	14.5	15.1	15.8	16.4	17.0
a	10	10.6	11.0	11.3	11.6	11.9	12.2	12.5	12.9	13.2	13.5	13.8	14.4	15.1	15.7	16.4
t	9	10.0	10.3	10.6	10.9	11.2	11.5	11.9	12.2	12.5	12.8	13.1	13.8	14.4	15.0	15.7
u	8	9.3	9.6	9.9	10.2	10.5	10.9	11.2	11.5	11.8	12.1	12.4	13.1	13.7	14.4	15.0
r	7	8.6	8.9	9.2	9.5	9.9	10.2	10.5	10.8	11.1	11.4	11.8	12.4	13.0	13.7	14.3
e	6	7.9	8.2	8.5	8.9	9.2	9.5	9.8	10.1	10.4	10.8	11.1	11.7	12.4	13.0	13.6
[°C]	5	7.2	7.5	7.5	8.2	8.5	8.8	9.1	9.4	9.8	10.1	10.4	11.0	11.7	12.3	12.9
	4	6.5	6.9	7.2	7.5	7.8	8.1	8.4	8.8	9.1	9.4	9.7	10.4	11.0	11.6	12.3
		12	13	14	15	16	17	18	19	20	21	22	24	26	28	30
		Air temperature [°C]														

Example:
Polybutene pipe: 40 x 3.7
Water temperature: 16 °C
Air temperature: 24 °C
Air humidity: 60 %
Minimum pipe surface temperature from h-x diagram 15.5 °C

The temperature of 18.5 °C. taken from the pipe surface temperature table, means that condensation will not form.

GF Piping Systems will gladly provide you with data for other pipe dimensions from the INSTAFLEX system.

Calculation of pipe surface temperature



$$Q = \frac{2 \cdot \pi \cdot l \cdot (t_1 - t_L)}{\frac{\ln \frac{r_2}{r_1}}{\lambda} + \frac{l}{\alpha_K \cdot r_2}}$$

$$t_2 = t_1 - \frac{Q \cdot \ln \frac{r_2}{r_1}}{2 \cdot \pi \cdot l \cdot \lambda}$$

Q	=	heat flow [W]
l	=	pipe length [m]
t_1	=	water temperature [°C]
t_2	=	outer pipe surface temperature [°C]
t_L	=	air temperature [°C]
α_K	=	heat transfer coefficient [W/m² * K], calculated from measurements
λ	=	heat conductivity of the material [W/m * K]
r_1	=	pipe inner radius [m]
r_2	=	pipe outer radius [m]

Surface temperature of different pipes

	Pb		Steel		Copper	
Heat conductivity λ [W/m * K]	0.19		67		372	
Heat transfer coefficient [W/m² * K]	25		25		25	
Air temperature t_L [°C]	20		20		20	
Water temperature t_1 [°C]	10	60	10	60	10	60
Pipe dimension	d40 x 3.7		d42 x 3.25		d35 x 1.5	
Pipe surface temperature t_2 [°C]	13	47	10	60	10	60

Calculating heat emission from uninsulated polybutene pipes

$$k_R = \frac{\pi}{\frac{1}{\alpha_i \cdot d_i} + \frac{1}{\alpha_i \cdot d_a} + \frac{1}{2 \cdot \lambda} \cdot \ln \frac{d_a}{d_i}}$$

Example:
Uninsulated PB pipe d40 x 3.7

α_i= 6000 W/m²K
α_a= 10 W/m²K
λ = 0,19 W/mK

k_R = overall heat transfer coefficient [W/mK]
α_i = heat transfer coefficient on inside (water-pipe) [W/m²K]
α_a = heat transfer coefficient on outside (pipe-air) [W/m²K]
d_a = pipe outer diameter [m]
d_i = pipe inner diameter [m]
λ = heat conductivity of polybutene [W/mK]

$$k_R = \frac{\pi}{\frac{1}{6000 \cdot 0.0326} + \frac{1}{10 \cdot 0.04} + \frac{1}{2 \cdot \lambda} \cdot \ln \frac{0.04}{0.0326}} = 1.18 \frac{W}{mK}$$

$$\dot{Q} = k_R \cdot (T_a - T_i)$$

$\dot{Q}$ = heat loss (heat output)
T_a = ambient temperature
T_i = media temperture

T_a = 20°C
T_i = 60°C

Temperature difference ΔT = 40K

$$\dot{Q} = 1.03 \cdot (60 - 20) = 41.2 \frac{W}{m}$$

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Heat emission for INSTAFLEX PB pipes, uninsulated

	ΔT	(t_1-t_2)	20	30	40	50	60	70	k_R
Pipe-	16	11.6	8.98	13.47	17.97	22.46	26.95	31.44	0.449
	20	14.4	10.91	16.37	21.83	27.28	32.74	38.20	0.546
	25	20.4	14.06	21.09	28.11	35.14	42.17	49.20	0.703
dia-	32	26.2	17.52	26.29	35.05	43.81	52.57	61.34	0.876
	40	32.6	21.16	31.74	42.32	52.90	63.48	74.06	1.058
	50	40.8	25.48	38.22	50.96	63.71	76.45	89.19	1.274
meter	60	51.4	30.61	45.92	61.22	76.53	91.84	107.14	1.531
	75	61.4	35.10	52.64	70.19	87.74	105.29	122.84	1.755
	90	73.6	40.02	60.03	80.04	100.05	120.06	140.07	2.001
	110	90	45.98	68.97	91.96	144.95	137.94	160.93	2.299
	d_a [mm]	d_i [mm]	Q [W/m]						[W/mK]

Heat loss Q [W/mk]

Values for polybutene

α_i = 6000 W/m²k
α_a = 10 W/m²k
λ_R = 0.19
λ_D = 0.0025 W/mk

Fluid temperature of 5-12 °C
Room temperature with maximum humidity 75 % r. h.

ΔT = temperature difference [K]
d_a = pipe outer diameter [mm]
d_i = pipe inner diameter [mm]
Q = heat loss (heat emission) [W/m]
k_R = overall heat transfer coefficient [W/mK]
α_i = heat transfer coefficient inside [W/m²k]
α_a = heat transfer coefficient outside [W/m²k]
λ_R = heat conductivity of polybutene [W/mk]
λ_D = heat conductivity of insulation [W/mk]

Insulation thickness of cold water polybutene pipes

	Room temperature [°C]					
Dimension	**15**	**20**	**25**	**30**	**35**	**40**
d16 x 2.2	10	10	20	20	20	30
d20 x 2.8	10	10	20	20	20	30
d25 x 2.3	10	10	20	20	20	30
d32 x 2.9	10	10	20	20	20	30
d40 x 3.7	10	10	20	20	30	30
d50 x 4.6	10	10	20	20	30	30
d63 x 5.8	10	20	20	30	30	30
d75 x 6.8	10	20	20	30	30	30
d90 x 8.2	10	20	20	30	30	30
d110 x 10.0	10	20	20	30	30	30

Flushing drinking water pipelines

According to EN 806, DIN 1988, as well as the W3 Guidelines of the Swiss Association of Gas and Water (SVGW), drinking water pipelines must be flushed thoroughly in order to remove residue, such as rust, shavings, traces of cutting oil and welding flux.

For this reason the pipelines must be flushed intermittently with an air/water mixture and drinking water while under pressure. This type of flushing is mandatory for **metal pipelines** because of corrosion.

In the corrosion-proof drinking water distribution system INSTAFLEX, where no auxiliary materials, e.g. cutting oil, welding flux or adhesives, are used for fusion, compression or push-fit joining, this costly method of flushing is not necessary.

However, flushing the lines is still advised for hygienic reasons. This is done by filling the system with drinking water and then opening all the outlet valves. See also the chapter on disinfection of drinking water systems.

Germany
For more information on flushing drinking water systems please see the ZVSHK data sheet based on TR-WI DIN 1988.

Disinfection of drinking water systems

In order to supply drinking water which is clean and pure, it is crucial that the water does not become contaminated on its way to the consumer. Worksheet W291 of the DVGW regulatory body (German Technical and Scientific Association on Gas and Water) describes how to disinfect components which come into contact with drinking water, e.g. pipelines. A contamination of the drinking water with pathogenic germs can have such devastating consequences that every possible measure to avoid such risk must be taken.

Correct disinfection of drinking water systems is an important prerequisite to ensure compliance with the strict microbiological threshold values and recommended values of drinking water ordinances.
Disinfectants are hazardous substances for health and the environment, which is why their use must be carefully planned and executed according to the guidelines of occupational safety and environmentally compatible disposal.

Optional disinfectants

Sodium hypochlorite	$NaOCl$
Hydrogen peroxide	H_2O_2
Potassium permanganate	$KMnO_4$
Calcium hypochlorite	$Ca(ClO)_2$

Disinfection can take place either during the pressure test or when the disinfectant solution is allowed to stand for at least 12 hours in the pipeline. Due to the higher pressure during the pressure test, the water containing disinfectant can penetrate into the pores and gaps.

Following disinfection, the pipeline must be flushed thoroughly, and prior to starting up the system again, it must be ascertained that the threshold values for disinfectants in drinking water are not exceeded.

Recommended values for disinfection of drinking water according to the EU Guideline of 15th July 1980

No.	Description	Permissible added amount [mg/l]	Threshold value after treatment [mg/l]	Calculated as	Reaction product: Threshold value after treatment [mg/l]	Reaction product: calculated as
1	Chlorine Sodium hypochlorite, Calcium hypochlorite, Magnesium hypochlorite Chloride of lime	1.2	0.3	free chlorine	0.01	Trihaloge methane
2	Chlorine dioxide	0.4	0.2	ClO2	0.2	Chlorite
3	Ozone	10	0.05	O3	0.01	Trihalogen methane