GF Piping Systems

+GF+

COOL-FIT® PE Plus

Catalog and Technical Information 2019

GF Piping Systems

COOL-FIT® PE Plus

Pre-insulated system for refrigeration and chilled water

Metric-To-Inch Conversion Chart

16 mm = 3/8"	75 mm = 2½"	355 mm = 14"
20 mm = ½"	90 mm = 3"	400 mm = 16"
25 mm = ¾"	110 mm = 4"	450 mm = 18"
32 mm = 1"	160 mm = 6"	500 mm = 20"
40 mm = 1¼"	225 mm = 8"	630 mm = 24"
50 mm = 1½"	280 mm = 10"	
63 mm = 2"	315 mm = 12"	

www.gfps.com

- Pipe
- Fittings
- Valves
- Instrumentation

Table of Contents

1 COOL-FIT® PE Plus

1.1 General Information

COOL-FIT® PE Plus is a pre-insulated plastic piping system that is a reliable and efficient solution for chilled water and other chilled liquids. The system is maintenance-free, easy to install, and will not corrode over time. Since the insulation on both the fittings and pipe is bonded together at the factory, no condensation can form between the vapor barrier. The weight is a fraction of metal solutions allowing it to be roof-mounted in locations that may be problematic for other systems. Unlike other plastic piping systems, COOL-FIT® PE Plus is designed to handle temperatures as low as -58^{0}F. The high thermal conductivity properties of the system and vapor barrier seal are incredibly efficient and have resulted in energy savings in several projects. Installation procedures can be learned in a matter of hours and are provided on-site by Georg Fischer.

Key Industries	
• Breweries and wineries	• Multi-use buildings
• Food processing	• Retail
• Cold stores	• Universities
• Supermarkets and dairies	• Apartment complexes
• Hospitals	• Hotels

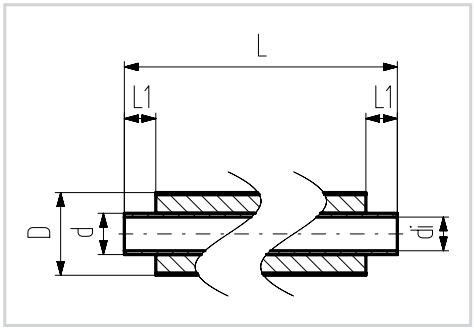
Key Applications	
• HVAC	• Process cooling
• Refrigerated liquid	• Cooling towers

2 System Specification

Specification		COOL-FIT PE Plus
Materials (All three materials are firmly bonded together.)	Pipe	PE100
	Insulation	GF PUR (Polyurethane) foam, halogen free, closed-cell
	Outer jacket	Pipe: PE
		Fitting: PE
Size		d32 (1") – d450 (18")
Joining technology		Electrofusion
Nominal pressure (at 68°F [20°C] Media Water)	16 bar (232 psi), SDR 11 10 bar (150 psi), SDR 17	d32 (1") – d450 (18")
Temperature	Media	-58°F to +140°F (-50 °C to +60 °C)
	Environment	-22°F to +140°F (-30 °C to +60 °C)
Thermal conductivity	$\lambda_{20°C}$ GF HE/PUR Foam PE jacket & inner pipe	 0.015 BTU/hr ft °F; 0.026 W/mK (d160-d450) 0.220 BTU/hr ft °F ; 0.38 W/mK
	Density	≥ 4.37 lb/ft^3; 70 kg/m^3
	Foam cell size	max. Ø 0.5 mm
Mechanical strength (from insulation)	Axial shear strength 2)	≥ 0.12 N/mm^2 (17.4 psi)
	Compressive strength	≥ 0.3 N/mm^2 (43.5 psi)
Color	Outer jacket	Black
Weight (without)	Pipe d32 (1")	0.95 lb/ft (1.41 kg/m)
	Pipe d110 (4")	4.17 lb/ft (6.20 kg/m)
	Pipe d225 (8")	11.15 lb/ft (16.6 kg/m)
Oxygen diffusion at < 58.1°F (14.5° C)	ISO 17455	≤ 0.32 mg/(m^2 d)
Environment		Moisture and vapor-tight
		Weather resistant UV resistant
	Global warming potential GWP	≤ 0.01
	Ozone Depletion Potential ODP	Zero
Standards and Guidelines	EN ISO 15494	Plastic piping systems for industrial applications
	ISO 7	Threaded Joints
	EN ISO 16135	Industrial valves – Ball valves made of thermoplastics
	EN ISO 16136	Industrial valves – Butterfly valves made of thermoplastics
	EN ISO 16137	Industrial valves – Backflow protection made of thermoplastics
	EN ISO 16871	Plastic piping and ducting systems – Plastic pipe and fittings – Method for exposure to direct (natural) weathering
Product declarations	Greenbuildings	According to: DGNB 2015 DGNB 2012 BREEAM 2016 LEED 2009 LEED v4

3 Technical Details

3.1 COOL-FIT® PE Plus Pipe and Fittings



Pipe	Pipe	Pipe	Outer jacket	Free pipe ends		Insulation thickness		Heat transfer coefficient (U)
d x e (mm)	d_i (mm)	d (in)	D x e1 (mm)	(mm)	(in)	(mm)	(in)	(W/m K)
32 x 2.9	26.2	1	90 x 3	36	1.4	26	1.0	0.13
40 x 3.7	32.6	1 ¼	110 x 3.4	40	1.6	31.6	1.2	0.14
50 x 4.6	40.8	1 ½	110 x 3.4	44	1.7	26.6	1.0	0.18
63 x 5.8	51.4	2	125 x 3.8	48	1.9	27.2	1.1	0.21
75 x 6.8	61.4	2 ½	140 x 4.0	55	2.2	28.5	1.1	0.23
90 x 8.2	73.6	3	160 x 4.0	62	2.4	31	1.2	0.24
110 x 10	90	4	180 x 4.0	72	2.8	31	1.2	0.28
160 x 9.5	141.0	6	250 x 5	90	3.5	40	1.6	0.37
225 x 13.4	198.2	8	315 x 6	110	4.3	39	1.5	0.50
280 x 16.6	246.8	10	400 x 6.3	123	4.8	53.7	2.1	0.48
315 x 18.7	277.6	12	450 x 6.4	126	5.0	61.1	2.4	0.48
355 x 21.1	312.8	14	500 x 7.4	133	5.2	65.1	2.6	0.49
400 x 23.7	352.6	16	560 x 8.4	148	5.8	71.6	2.8	0.50
450 x 26.7	396.6	18	630 x 7.6	150	5.9	82.4	3.2	0.50

Pipe	Weight empty		Weight with Water		Volume
d x e (mm)	lb/ft	kg/m	lb/ft	kg/m	(gal/ft)
32 x 2.9	0.95	1.41	1.31	1.95	0.043
40 x 3.7	1.38	2.05	1.94	2.38	0.067
50 x 4.6	1.49	2.22	2.37	3.53	0.105
63 x 5.8	2.01	2.99	3.40	5.06	0.167
75 x 6.8	2.53	3.76	4.52	6.72	0.238
90 x 8.2	3.24	4.82	6.09	9.07	0.342
110 x 10	4.37	6.50	8.64	12.86	0.512
160 x 9.5	6.69	9.95	17.18	25.56	1.257
225 x 13.4	11.15	16.60	31.88	47.45	2.484
280 x 16.6	15.21	22.63	47.33	70.43	3.850
315 x 18.7	19.09	28.41	59.74	88.90	4.871
355 x 21.1	23.76	35.36	75.37	112.16	6.185
400 x 23.7	29.61	44.06	95.19	141.66	7.859
450 x 26.7	37.29	55.49	120.26	178.97	9.942

d) Nominal outer diameter of the PE pipe

d_i) Nominal inside diameter of the pipe

D) Nominal outside diameter of the outer PE jacket

e, e1) Nominal wall thickness

COOL-FIT® PE Plus Fittings

General

COOL-FIT PE Plus fittings are based on the ELGEF electrofusion technology used successfully for more than a decade. They provide a safe and simple installation. The pre-insulated fittings are available in the following two types:

Type A

Electrofusion fitting with integrated heat coils for direct pipe-to-fitting connections. See page 8 for more information.

90° elbow and reducer as an example

Type B

Spigot fitting with pipe ends for COOL-FIT PE Plus electrofusion fittings. See page 8 for more information.

Fusion indicators

After the welding process, the indicator pin appears, confirming that fusion is complete

Sealing lip at fittings Type A d32-d225

The sealing lip ensures a tight fit system.

Label

Fittings are marked clearly with the product name, fitting size, and material code.

Weld bar-code

Product data and fusion parameters can be traced back to production via information codes.

Angle marking

Ends of the fitting markings are used to optimally align the pipe and fitting connections.

Joining

Pipe and Fitting

Type A fittings have a heating coil, which in turn generates energy to heat the material and produce thermal expansion of the pipe fittings. As the polyethylene surfaces melt they expand in volume to close any gaps between the pipe and fitting. Upon completion of the heating phase, the assembly is held stationary by external clamps as the melted materials begin to immediately cool and crystallize into a single homogenous structure. Once completely cooled, the surfaces are permanently joined together and cannot be separated.

Type B fittings feature non-insulated spigot ends. They are connected with electrofusion fittings type A to a pipe.

Fitting-to-fitting

Two COOL-FIT PE Plus fittings are usually connected together by one of the pipe ends or bare nipples. For compact joints, the special COOL-FIT PE Plus barrel nipple with insulation can be used.

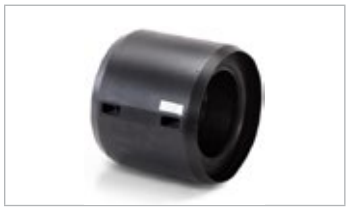
Two COOL-FIT PE Plus Type B fittings can be joined using a type A electrofusion fitting.

Connecting Type A and B fittings are also available.

Components

COOL-FIT PE Plus Electrofusion coupler

COOL-FIT PE Plus electrofusion couplers are used to connect pipe and components with pipe ends like type B fittings, valves and transition fittings.

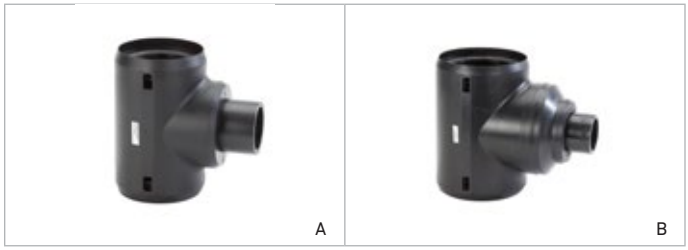


COOL-FIT PE Plus Elbows 45° and 90°

COOL-FIT PE Plus T90 equal and COOL-FIT T90° reduced

Type A sizes 32mm-225mm (1" - 8"): Run

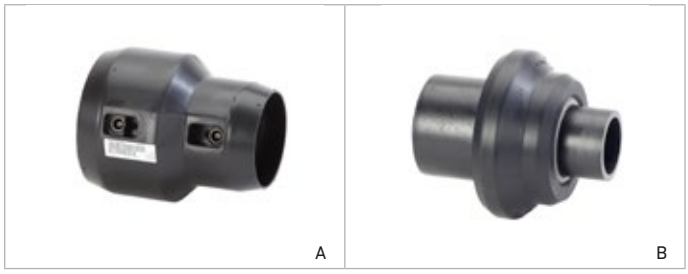
Type B sizes 280mm - 450mm (10" - 18"): Branch



COOL-FIT PE Plus reducer

The COOL-FIT PE Plus reducer can be used to decrease the diameter of the piping system to accommodate process specifications. The COOL-FIT PE Plus reducer can be used to decrease the flow rate

- Type A sizes 32mm - 50mm (1" - 1½")
- Type B sizes 63mm - 160mm (2" - 6")



COOL-FIT PE Plus barrel nipple

COOL-FIT PE Plus barrel nipple serves as a compact direct connector for type A fittings.

COOL-FIT PE Plus T90 and Reducer Combination Chart

Branch \ Run	40	50	63	75	90	110	160	225
32	X	X	X	O	O	O	O	O
40		X	X	O	O	O	O	O
50			X	O	O	O	O	O
63				Δ	Δ	Δ	Δ	Δ
75					Δ	Δ	□	□
90						Δ	Δ	Δ
110							Δ	Δ

Δ) T90° reduced
X) T90° equal + reducer type A
O) T90° reduced to d63 + reducer type A
□) T90° reduced to d90 + coupler d90 + reducer type B

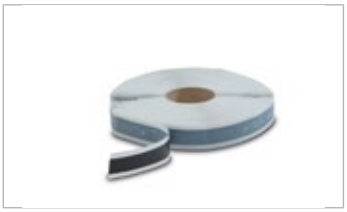
Accessories for dimensions d32 - d225

Insulation for fusion contacts

Supplied with each fitting. Prevent formation of a cold bridge at the fusion contacts. Insulation parts can also serve as an indicator that a connection has been welded. Install insulation after welding to show that the welding has been completed.

Sealing tape

The sealing tape with width 25mm ensures proper vapor sealing.



COOL-FIT® PE Plus Valves

The plastic valves designed for COOL-FIT PE Plus are supplied including PUR insulation shells with a protective PE jacket. The sealing faces between the shells are vapor tight by design. No additional tape or sealant is required.

Releasable plastic bands for sizes d32 (1")– d63 (2") with tension locks for sizes d75 (2½") – d225 (8") permit the pre-insulated shells to be fitted to and removed from the valves easily, allowing for quick maintenance.

The insulated ball valve in ABS is available in sizes d32 (1") – d90 (3"). For sizes d110 (4") – d225 (8"), butterfly valve kits which consist of a butterfly valve, flange adaptor, backing flange PP-St, screw-kits and insulation half shells. Both valve types are available either as manually operated or electrically actuated version.

The electric actuators used feature the following benefits:

- Position feedback via relays (open/close/middle)
- Heating element to prevent condensation
- Optical position indicator with LED status monitoring
- Third position between “open” and “closed” optional
- Relay output for “ready to operate” and 7-segment error display
- Integrated manual override with magnetic lock
- Long service life due to robust design and superior electronics
- Flexible configuration thanks to modular concept
- Numerous monitoring and control options
- Simple handling

COOL-FIT® PE Plus flange joints

Transition fittings and flange connectors enable connections to either metal or plastic systems. The components supplied includes insulation half shells with a protective PE jacket. The sealing faces between the shells are vapor tight by design.

	Size	Material	Thread type/ connector/bolt circle
Adaptor fitting	d32 – d63 1“ – 2“	PE – stainless steel	male thread (NPT), female thread (NPT)
Unions	d32 – d63 d32 – d110	PE – PE, PE – ABS	Welding spigots cementing sockets
Flange Adaptor (flange joints)	d32 – d225	PE	

COOL-FIT® PE Plus Flex Hoses

The EPDM rubber flexible hoses permit access to the chillers, fan coils, and allow expansion and contraction within the system. The tear-resistant protective jacket and its insulation stabilize the cooling fluid temperature inside the system.

COOL-FIT® PE Plus Instrument Fittings

The COOL-FIT PE Plus fittings are used to install various types of sensors to the system. Pressure or temperature sensors can be connected using the NPT female thread.

3.2 COOL-FIT® PE Plus Tools

Electrofusion machines are required to join COOL-FIT PE Plus components. The range includes dedicated and multipurpose electrofusion machines which are reliable and easy to use.

Long Fusion adaptors

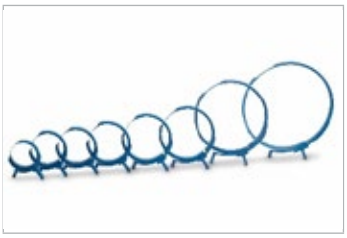
Long Fusion adaptors serve as an extension of the fusion plugs of electrofusion machines. Compared to standard adaptors, the longer adaptor length matches the insulation of the COOL-FIT PE Plus electrofusion fittings. The long fusion adaptors are needed for electrofusion of fittings d ≥ d160/D250

Y-cable kit for COOL-FIT fixed point

Saves half of the normal welding time of the COOL-FIT fixed points.

Assembly aids

The COOL-FIT PE Plus assembly aids are used for an easy mounting of the COOL-FIT PE Plus fitting on pipe.



Foam removal tool and peeling tool – manually operated

The foam removal tool is used to prepare shortened COOL-FIT PE Plus pipe for electrofusion. The tool removes the foam, cuts the outer jacket, and peels the surface of the core pipe. The tool is available in three versions based on the following sizes:

1. for sizes d32 (1") – d90 (3")
2. for sizes d110 (4") – d225 (8")
3. for sizes d250 (10") – d450 (18")

Powered foam removal and peeling tool

The powered foam removal tool is also used to prepare a shortened COOL-FIT PE Plus pipe for electro fusion. Utilizing commonly used power drills, it serves as a supplement to the manually operated tool. The tool is available as a kit for d32 (1")-d63 (2") sizes.

Clamping tool

Clamping tool is designed to support the proper alignment and stress-free installation of the COOL-FIT PE Plus system. In order to secure the COOL-FIT pipe during the fusion and cooling process, it is recommended that the pipe and fittings be secured with installation clamps. By fitting the assembly with COOL-FIT installation clamps, optimal fusion is achieved by limiting the movement during the welding and cool-down process.

The hinge allows the use of the clamps on elbows and reducers. Depending on the length of the pipe, 2 or 4 of the glass-reinforced plastic holders can be used. Tension bands are included and a T-adaptor is optional available.

4 Dimensioning and Design

Plastics have different physical characteristics than metals. These characteristics must be taken into account when designing and installing thermoplastic piping systems. Although COOL-FIT PE Plus is a very robust system, care should be taken to avoid damage during handling and transportation.

For over 50 years, Georg Fischer Piping Systems has developed and sold a variety of plastic piping systems such as pre-insulated systems for cooling applications. Experience has shown that plastic provides an economical and reliable alternative to metal when designers and installers take account of the recommendations in the attached technical manual. Piping systems must be able to move to accommodate changes in length caused by fluctuations in temperature and pressure. To allow for these changes, the use of pipe holders that permit movement is required.

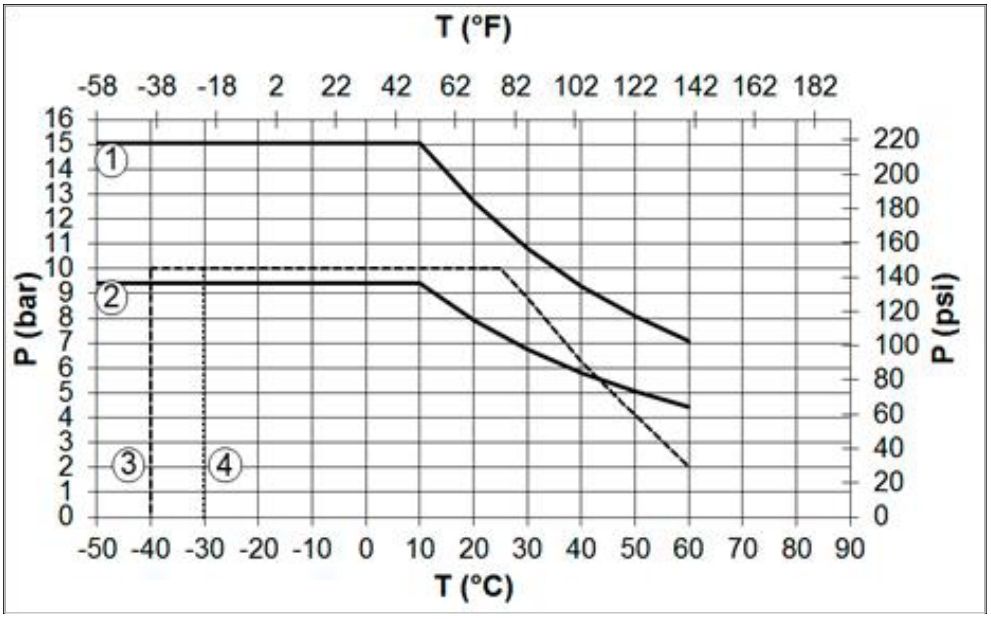
The following technical information contains detailed instructions. However, there might be aspects of your design that may require additional considerations. For more information, please contact your local Georg Fischer Piping Systems representative. Additional information is also available on the official Georg Fischer Piping Systems website.

4.2 COOL-FIT® PE Plus pressure-temperature diagram

The pressure resistance for thermoplastic pipe with water media is always specified at +68°F(+20 °C). At higher temperatures, additional consideration must be made for a lower maximum operating pressure.

The graph shows the maximum permissible pressure for COOL-FIT PE Plus pipe and fittings up to a media temperature of +140°F (+60 °C). The graph is based on an ambient temperature of +68°F(+20 °C). A safety factor of 1.6 and a minimum lifespan of 25 years have been allowed for in all calculations.

Pressure/temperature limits for COOL-FIT® PE Plus pipe, fittings, valves – water as secondary refrigerant



P) Allowable pressure (bar, psi)
T) Temperature (°C, °F)
C) Safety factor

1) COOL-FIT PE Plus Pipe and fitting d32 – d110, C = 1.6, SDR11
2) COOL-FIT PE Plus Pipe and fitting d160 – d450, C = 1.6, SDR17
3) COOL-FIT PE Plus Ball valve PN10
4) COOL-FIT PE Plus Butterfly valve PN10

Influence of secondary refrigerants with antifreeze additives

COOL-FIT PE Plus is generally resistant to secondary refrigerants such as glycol and salt solutions. For some refrigerants a reduction factor is necessary depending on the type and mixing ratio. The permissible operating pressure is corrected downwards from the pressure-temperature curve for water.

Reduction factors	COOL-FIT PE Plus Pipe and Fitting	COOL-FIT PE Plus Valves
Inorganic brine solutions	F = 1.0	F = 1.0
Organic salt solutions	F = 1.0	F = 1.25
Glycol solutions (max. 50 %)	F = 1.1	F = 1.7

For the calculation, the following formula is used:

$$P_{AF} = \frac{P_w}{AF}$$

P_{AF} Permissible pressure with reduction factor
P_W Permissible pressure for water
AF Reduction factor

Glycol solutions

COOL-FIT PE Plus can be used with glycol solutions with concentrations up to 50%. The chemical resistance of COOL-FIT PE Plus systems is suitable for the following glycol types:

Brand name	Manufacturer	Type
Antifrogen N	Clariant	Ethylene glycol
Antifrogen L	Clariant	Propylene glycol
Showbrine Blue Showa standard EC brine	Showa Brine	Ethylene glycol
Tyfocor L	Tyfo	Propylene glycol
Tyfocor	Tyfo	Ethylene glycol
DOWFROST	DOW	Propylene glycol
Zytrec FC	Frigol	Propylene glycol
Zytrec LC	Frigol	Propylene glycol
Zytrec MC	Frigol	Ethylene glycol
Neutrogel Neo	Climalife Dehon	Ethylene glycol
Friogel Neo	Climalife Dehon	Propylene glycol
DOWTHERM SR-1	DOW	Ethylene glycol

When using other secondary refriegerants, compatibility with COOL-FIT PE Plus should be clarified with Georg Fischer Piping Systems.

Example – glycol dissolved in water

For water-glycol mixture ≤ 50%, the reduction factor for the pressure-temperature diagram is 1.7 (for COOL-FIT PE Plus valves). Thus, at +10 °C, with a minimum life of 25 years, the maximum allowable working pressure is reduced as follows:

$$P_{AF} = \frac{10 \text{ bar}}{1.7} = 5.88 \text{ bar}$$

Organic salt solutions

These media are usually potassium formates or potassium acetates: aqueous solutions with low viscosity at low temperatures. COOL-FIT PE Plus can be used with the media below. The manufacturer's instructions must be followed.

Brand name	Manufacturer	Type
Kilfrost ALV	Clariant	Brine
Zytrec S-55	Frigol	Brine
Temper[1)]	Temper	Brine
Hycool	Addcon	Brine

1) Please contact Georg Fischer Piping Systems

For detailed information on resistance and reduction factors, see Planning Fundamentals "Material selection – Chemical resistance".

4.3 Polyethylene (PE)

The core pipe of COOL-FIT PE Plus is PE-100. Since it comes in contact with the media, its properties are of particularly high relevance.

Properties of PE (approximate)

Property	PE 100-value[1]	Unit	Testing standard
Density	0.95	g/cm³	EN ISO 1183-1
Yield stress at 73°F (23°C)	25	N/mm²	EN ISO 527-1
Tensile modulus at 73°F (23°C)	900	N/mm²	EN ISO 527-1
Charpy notched impact strength at 73°F (23°C)	83	kJ/m²	EN ISO 179-1/1 eA
Charpy notched impact strength at -40°F (-40°C)	13	kJ/m²	EN ISO 179-1/1 eA
Crystallite melting point	130	°C	DIN 51007
Thermal conductivity at 73°F (23°C)	0.38	W/m K	EN 12664
Water absorption at 73°F (23°C)	0.01 to 0.04	%	EN ISO 62
Color	9,005	-	RAL
Oxygen Index (LOI)	17.4	%	4589-1

1) Typical, measured on material characteristics, should not be used for calculations.

General information

Polymers which consist only of carbon and hydrogen (hydrocarbons) are called polyolefins. Polyethylene (PE) belongs to this group. It is a semi-crystalline thermoplastic. Polyethylene is the best known standard polymer. The chemical formula is:(CH2-CH2)n. It is an environmentally friendly, hydrocarbon product. PE is considered a non-polar material, meaning it does not dissolve in common solvents and hardly swells. As a result, PE pipes cannot be solvent cemented. The appropriate joining method for this material is heat fusion. Modern PE100 grades show a bimodal molecular weight distribution, i.e., they consist of two different kinds of molecular chains (short and long). These polyethylenes combine high tensile strength with high resistance against fast and slow crack propagation. PE also shows a very high impact resistance throughout its entire temperature range. Because PE is a robust materials with acute resistance to fracture, it has significant advantages in applications where lower temperatures (down to -58°F) would cause other thermoplastic piping systems to become brittle.

Advantages of PE

- Light weight
- Excellent flexibility
- Good wear resistance (abrasion resistance)
- Corrosion resistance
- Ductile fracture properties
- High impact strength even at very low temperatures
- Very good chemical resistance
- Weldable

Mechanical properties, chemicals, weathering and abrasion resistance

UV and weather resistance

PE is a weather resistant material due to the carbon black additives used in the GF resin. This stabilizes the material against UV exposure, so it can be used in wind and rain without restrictions.

Chemical resistance

PE exhibits good resistance to a wide range of media. For detailed information, please see the detailed chemical resistance list from Georg Fischer Piping Systems.

Abrasion resistance

PE has excellent resistance to abrasive wear. You can therefore find PE piping systems in use in numerous applications for transporting solids and media containing solids.

Thermal and electrical properties

Operating limits

At higher temperatures, the tensile strength and stiffness of the material are reduced.

Electrical properties

PE, like most thermoplastics, is non-conductive. This means that systems in PE do not suffer from electrolytic corrosion. However, the non-conductive properties must be taken into consideration, as electrostatic charges can build up in the pipe. Polyethylene has good electrical insulation properties. The volume resistance is 3.5 x 10^{16} Ωcm, the surface resistance 10^{13} Ω. This must be taken into account in applications where there is danger of fire or explosion.

4.4 Hydraulic design

Determination of pipe diameter based on flow rate

As a first approximation, the required pipe cross-section for a certain flow rate can be calculated using the following formula:

$$d_i = 18.8 \cdot \sqrt{\frac{Q_1}{v}} \quad \text{oder} \quad d_i = 35.7 \cdot \sqrt{\frac{Q_2}{v}}$$

v	flow velocity (m/s)
d_i	Pipe internal diameter (mm)
Q_1	Flow rate (m^3/h)
Q_2	Flow rate (l/s)
18.8	Conversion factor for units Q_1 (m^3/h)
35.7	Conversion factor for units Q_2 (l/s)

Example calculation of an internal diameter d_i

COOL-FIT PE Plus pipe	SDR17
Flow rate Q_2	55 l/s
Usual flow velocity v	1.5 m/s

$$d_i = 35.7 \cdot \sqrt{\frac{55}{1.5}} = 216.2 \text{ mm}$$

A pipe with d225/D315 is used. After the internal diameter has been determined that way, the actual flow rate is determined with the following formula:

$$v = 354 \cdot \frac{Q_1}{d_i^2} = 1.8 \frac{m}{s} \quad \text{oder} \quad v = 1275 \cdot \frac{Q_2}{d_i^2} = 1.8 \frac{m}{s}$$

v	Flow velocity v (m/s)
d_i	Pipe internal diameter (mm)
Q_1	Flow rate (m^3/h)
Q_2	Flow rate (l/s)
354	Conversion factor for units Q_1 (m^3/h)
1275	Conversion factor for units Q_2 (l/s)

Determination of pipe diameter based on cooling capacity

As a first approximation, the required pipe cross section for a certain cooling capacity can be calculated using the following formula.

$$d_i = 18.8 \cdot \sqrt{\frac{\left(\frac{Q_L \cdot 3600}{\Delta T \cdot c \cdot \rho}\right)}{v}}$$

d_i Pipe inner diameter (mm)
Q_L Cooling capacity in kW
ΔT Temperature difference supply - return (K)
c Specific heat capacity (kW*s/(kg*K))
ρ Density of the medium (kg/m³)
v Flow velocity (m/s)

Example for calculating the inner diameter d_i based on cooling capacity with water medium water

Cooling capacity Q_L	2000 kW
Specific heat capacity (20 °C) c	4.187 kJ/(kg*K)
Water density (20 °C) ρ	998.2 kg/m³
Temperature difference ΔT	10 K
Flow velocity v	1.5 m/s

$$d_i = 18.8 \cdot \sqrt{\frac{\left(\frac{2000 \cdot 3600}{10 \cdot 4.187 \cdot 998.2}\right)}{1.5}} = 18.8 \cdot \sqrt{\frac{172.3}{1.5}} = 201.5 \text{ mm}$$

The flow rate should be estimated on the basis of the intended purpose of the pipe. As a guide for the flow rate, the following specifications apply.

Fluid

v = 0.5 – 1.0 m/s for the suction side

v = 1.0 – 3.0 m/s for the pressure side

This method of calculation of pipe diameter does not allow for hydraulic losses. They must be calculated separately. The following sections serve that purpose.

Conversion table with units of flow rate.

(m³/h)	(l/min)	(l/s)	(m³/s)
1.0	16.67	0.278	2.78×10^{-4}
0.06	1.0	0.017	1.67×10^{-5}
3.6	60	1.0	1.00×10^{-3}
3600	60 000	1000	1.0

Correlation of outer diameter - inner diameter

To determine the outer diameter based on the internal diameter and SDR, the following formula can be used:

$$d = d_i \cdot \frac{SDR}{SDR - 2}$$

Correlation between pipe external and internal diameter

d_i (mm)	26.2	32.6	40.8	51.4	61.4	73.6	90	141.0	198.2
d (mm)	32	40	50	63	75	90	110	160	225

4.5 Nomogram for easy calculation of diameter and pressure loss

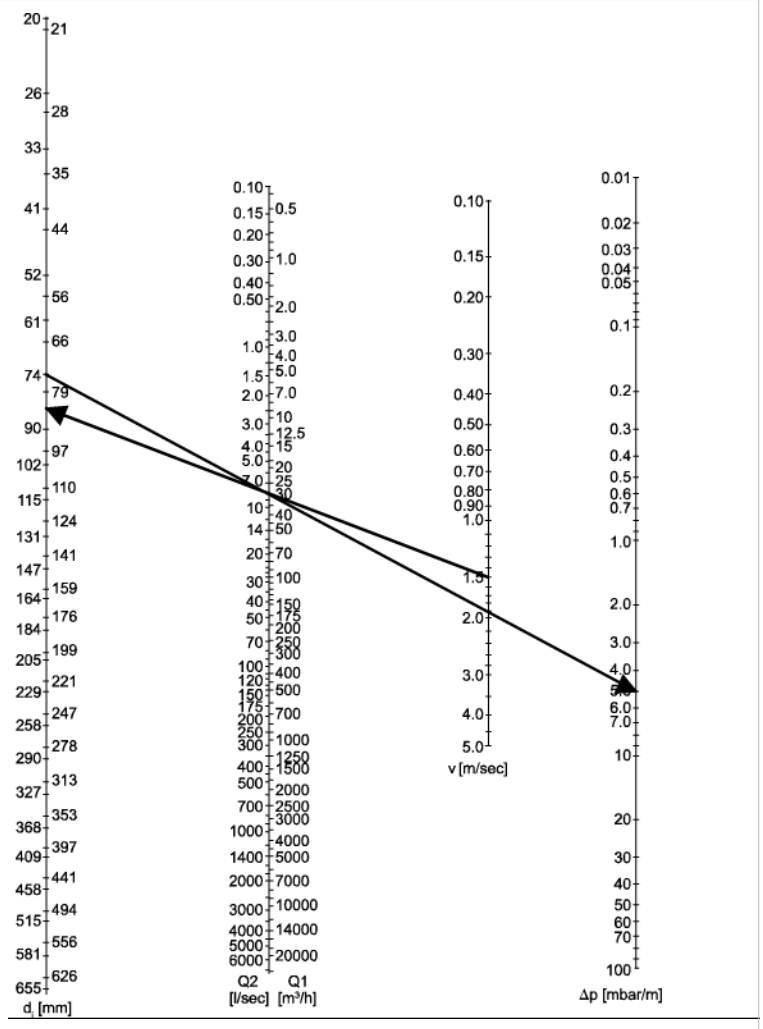
The nomogram below can be used to simplify the determination of the diameter required. The pressure loss in the pipe can be read off per meter of the pipe length.

The pressure loss calculated using the nomogram only applies to flows of substances with density 1000 kg/m³, i.e. water. Further pressure losses from fittings, valves, etc. also need to be considered using the instructions that follow.

Using the nomogram

Based on a flow velocity of 4.9 ft/s (1.5 m/s), a line is drawn through the desired flow rate (i.e. 30 m³/h) to the axis which shows an internal diameter d_i (≈ 84 mm). Here, a closely matching diameter (74 mm for SDR11) and a second line is drawn back through the desired flow rate to the pressure drop axis Δp (5 mbar per meter of pipe).

Nomogram for COOL-FIT® PE Plus pipe (PE, SDR11) using the metric system



For detailed information on the determination of diameter and pressure loss, see Planning Fundamentals "Hydraulic calculation and pressure losses of metric industrial piping systems".

4.6 Pressure loss

Pressure loss in straight pipe

In determining pressure losses in straight pipe sections, a distinction is made between laminar and turbulent flows. The Reynolds number (Re) determines this. The change from laminar to turbulent occurs at the critical Reynolds number Re_{crit} = 2320.

In practice laminar flows occur particularly for the movement of viscous liquids. In most applications, including flows of aqueous materials, there is turbulent flow with a substantially more uniform velocity distribution over the pipe cross-section than in laminar flow.

The pressure loss in a straight pipe section is inversely proportional to the pipe diameter and is calculated as follows:

$$\Delta p_R = \lambda \cdot \frac{L}{d_i} \cdot \frac{\rho}{2 \cdot 10^2} \cdot v^2$$

Δp_R	Pressure loss in the straight pipe run (bar)
λ	Pipe friction factor
L	Length of the straight pipe section (m)
d_i	Inner diameter of the pipe (mm)
ρ	Density of the flow material (kg/m³) (1 g/cm³ = 1000 kg/m³) for water 20 °C = 998.2 kg/m³
v	Flow velocity v (m/s)

In practice, when making a rough calculation (i. e. smooth plastic pipe and turbulent flow) it is enough to use the value λ = 0.02 to represent the hydraulic pressure loss.

Pressure losses in fittings

Coefficient of resistance

The pressure losses depend upon the type of fitting as well as on the flow in the fitting. The so-called coefficient of resistance (ζ value) is used for calculations.

Fitting type	Coefficient of resistance ζ	
Elbow 90°	1.2	
Elbow 45°	0.3	
Tee-90[1)]	1.3	
Reducer (contraction)	0.5	
Reducer (extension)	1.0	
Coupler, Flange joints, Transition Fittings	d32: 0.8 d40: 0.7 d50: 0.6	d63: 0.4 d75: 0.3 d90-d225: 0.1

1) For a more detailed view differentiate between coalescence and separation values for ζ up to a maximum of 1.3 can be found in the respective literature. The overall pressure loss in a Tee is very small, it is reasonable to assume ζ = 1.3

Calculation of the pressure loss

To calculate the total pressure loss in all fittings in a piping system, take the sum of the individual losses, i. e. the sum of all the ζ-values. The pressure loss can then be calculated according to the following formula:

$$\Delta p_{Fi} = \Sigma\zeta \cdot \frac{v^2}{2 \cdot 10^5} \cdot \rho$$

Δp_{Fi}	Pressure loss of all fittings (bar)
$\Sigma\zeta$	Sum of all individual losses
v	Flow velocity v (m/s)
ρ	Density of the medium in kg/m³ (1 g/cm³ = 1000 kg/m³)

Pressure loss in valves

The k_v factor is a convenient means of calculating the hydraulic flow rates for valves. It allows for all internal resistances and for practical purposes is regarded as reliable. It is defined as the flow rate of water in liters per minute with a pressure drop of 1 bar across the valve. The technical data of the Georg Fischer Piping Systems valves contains the k_v values as well as pressure loss charts. The latter make it possible to read off the pressure loss directly. But the pressure loss can also be calculated from the k_v value according to the following formula:

$$\Delta p_{Ar} = \left(\frac{Q}{k_v}\right)^2 \cdot \frac{\rho}{1000}$$

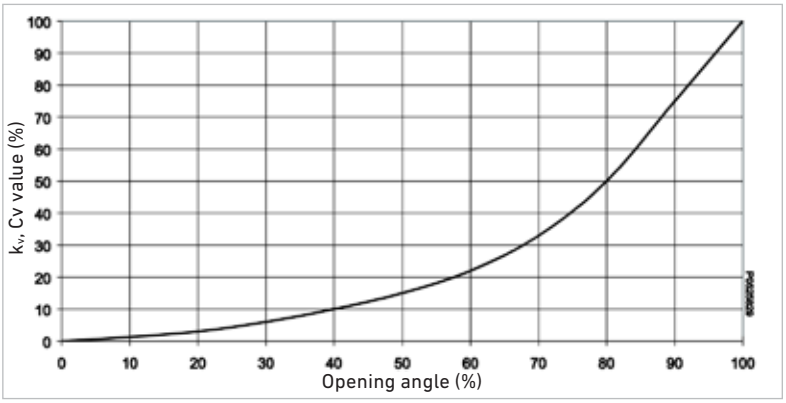
Δp_{Ar}	Pressure loss for the valve (bar)
Q	Flow rate (m³/h)
ρ	Density of the conveyed medium (kg/m³) (1 g/cc = 1000 kg/m³)
k_v	Valve characteristic value (m³/h)

Valves

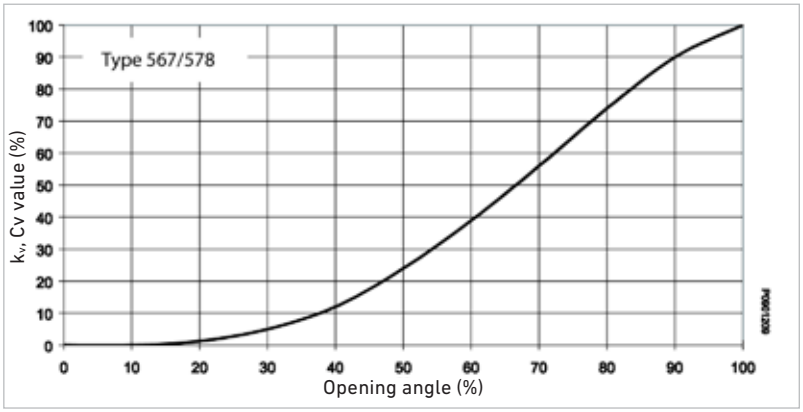
DN (mm)	Size (inch)	K_v 100 (l/min)	C_v100 (gal/min)	K_v 100 (m³/h)
32[1]	1	700	49.0	42
40[1]	1 ¼	1000	70.0	60
50[1]	1 ½	1600	112.0	96
63[1]	2	3100	217.1	186
75[1]	2 ½	5000	350.0	300
90[1]	3	7000	490.0	420
110[2]	4	6500	455	390
160[2]	6	16600	1162	1000
225[2]	8	39600	2772	2380

1) COOL-FIT PE Plus Ball valve
2) COOL-FIT PE Plus Butterfly valve

Flow characteristic Ball valve



Flow characteristic butterfly valve



Pressure difference between the static pressure

If the piping system is installed vertically, then a geodetic pressure difference must be calculated for it. This pressure difference is calculated as follows:

$$\Delta p_{geod} = \Delta H_{geod} \cdot \rho \cdot 10^{-4}$$

Δp_{geod}	Geodetic pressure difference (bar)
ΔH_{geod}	Difference in elevation of the piping system (m)
ρ	Density of the medium (kg/m³) (1 g/cm³ = 1000 kg/m³)

At closed systems, the geodetic pressure difference does not need to be considered

Sum of pressure losses

The sum of all pressure drops for a piping system is calculated as follows:

$$\Sigma\Delta p = \Delta p_R + \Delta p_{Fi} + \Delta p_{Ar} + \Delta p_{geo}$$

Example for pressure drop calculations

The following example illustrates the calculation process for determining the pressure loss of a piping system.

		Number of Fittings
COOL-FIT PE Plus pipe	d40 mm	12 x 90° angle
SDR11 - flow rate	1.5 l/s	4 x 45° angle
Medium	Water	3 x T-piece
Density of the medium	1.0 g/cm³	3 x screws
Length straight pipe	15 m	2 x flange connections
Height difference	2.0 m	1 x ball valve, 80 % opened

The wall thickness of the piping system can be calculated as follows with the SDR:

$$e = \frac{d}{SDR} = \frac{40\ mm}{11} = 3.6\ mm$$

The inner diameter of the piping system is as follows:

$$d_i = d - 2 \cdot e = d - \frac{2 \cdot d}{SDR} = 32.8\ mm$$

With the desired flow rate of 1.5 l/s, the flow velocity is as follows:

$$v = 1275 \cdot \frac{Q_2}{d_i^2} = 1275 \cdot \frac{1.5}{32.8^2}\ \frac{m}{sec} = 1.78\ \frac{m}{sec}$$

Pressure loss	Formula
Pressure loss for straight pipe sections	$\Delta p_R = 0.02 \cdot \frac{15}{32.8} \cdot \frac{1000}{2 \cdot 10^2} 1.78^2 = 0.14$ bar
Pressure loss for fittings incl. connections	$\Sigma\zeta = (12 \cdot 1.2) + (4 \cdot 0.3) + (3 \cdot 1.3) + (5 \cdot 0.7) = 23$
	$\Delta p_{Fi} = 23 \cdot \frac{1.78^2}{2 \cdot 10^5} \cdot 1000 = 0.36$ bar
Pressure loss for the valve 80 % opened. With the flow characteristics diagram for ball valves type 546, from an 80 % opening angle a percentile k_v value of 50 % can be read out,that means 50 % of the k_v value 100: 0.5 * 60 m^3/ H (flow rate 1.5 l/s = 5.4 m^3/h)	$\Delta p_{Ar} = \left(\frac{5.4}{0.5 \cdot 60}\right)^2 \cdot \frac{1000}{1000} = 0.03$ bar
Pressure loss of height difference	$\Delta p_{geod} = 2.0 \cdot 1000 \cdot 10^{-4} = 0.2$ bar
Whole pressure loss of the piping	$\Sigma\Delta p = 0.14$ bar + 0.36 bar + 0.03 bar + 0.2 bar = 0.73 bar

4.7 Dimension comparison of COOl-FIT PE Plus and Metal

COOL-FIT PE Plus		Metal	
d (mm)	d_i (mm)	d (inches)	d_a (mm)
32	26.2	1	33.7
40	32.6	1 ¼	42.4
50	40.8	1 ½	48.3
63	51.4	2	60.3
75	61.4	2 ½	75.3
90	73.6	3	88.9
110	90.0	4	114.3
160	141.0	6	168.3
225	198.2	8	193.7
280	246.8	10	273.0
315	277.6	12	323.9
355	312.8	14	355.6
400	352.6	16	406.4
450	396.6	18	457.0

d) Nominal external diameter of PE/metal pipe

d_i) Nominal internal diameter of pipe

4.8 Z-dimension method

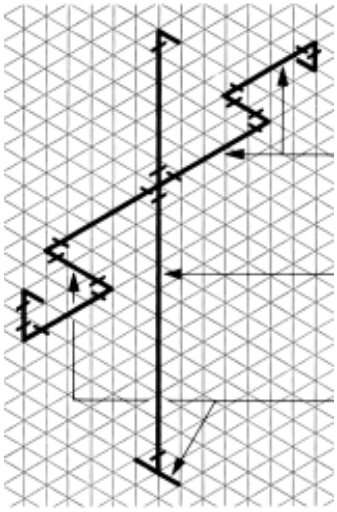
Overview

The Georg Fischer Piping Systems method of assembly is highly efficient. We use a fast and precise way of preparing whole groups of the pipe according to the engineering design plan.

The respective pipe group with the corresponding design dimensions and cut lengths can be entered into the isometric paper of Georg Fischer Piping Systems, see Measuring Sheet on page 28.

Please adhere to the following guidelines for drawing:

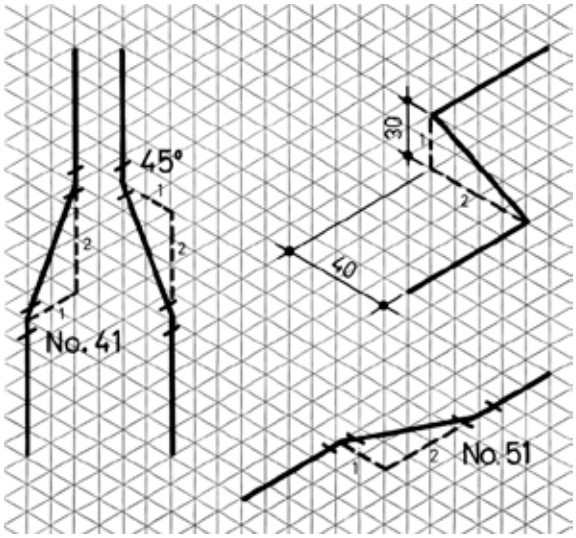
Pipe running perpendicular to one another	Pipe running diagonally



Horizontally:
left and right

Vertical

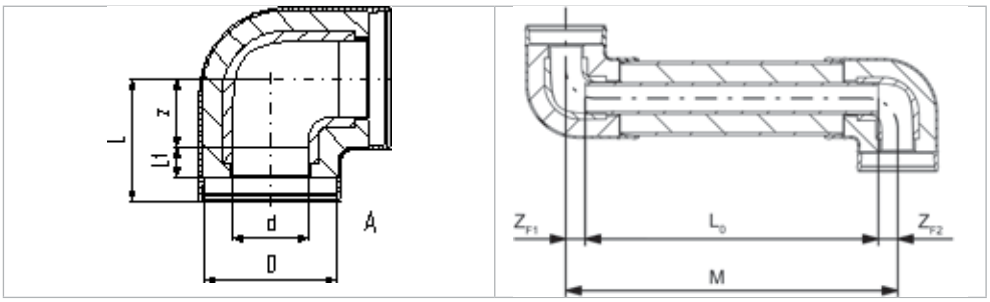
Horizontally:
front and rear



The z-dimensions of the fittings are needed for determining the actual cutting lengths of the pipe. The tables in our product ranges and in the online catalogs contain all the relevant data for the fittings. The length of pipe to be cut is given as in the following diagram by the distance between the center of adjoining fittings less the sum of the z-dimension of the fittings. (See page 27 for the pipe cut length).

Procedure

Electrofusion



Formula for determining the required pipe length

$L_0 = M - Z_{F1} - Z_{F2}$

L_0 Pipe length to be cut
M Center to center distance between fittings
z_{F1} z measurement for fitting 1
z_{F2} z measurement for fitting 2

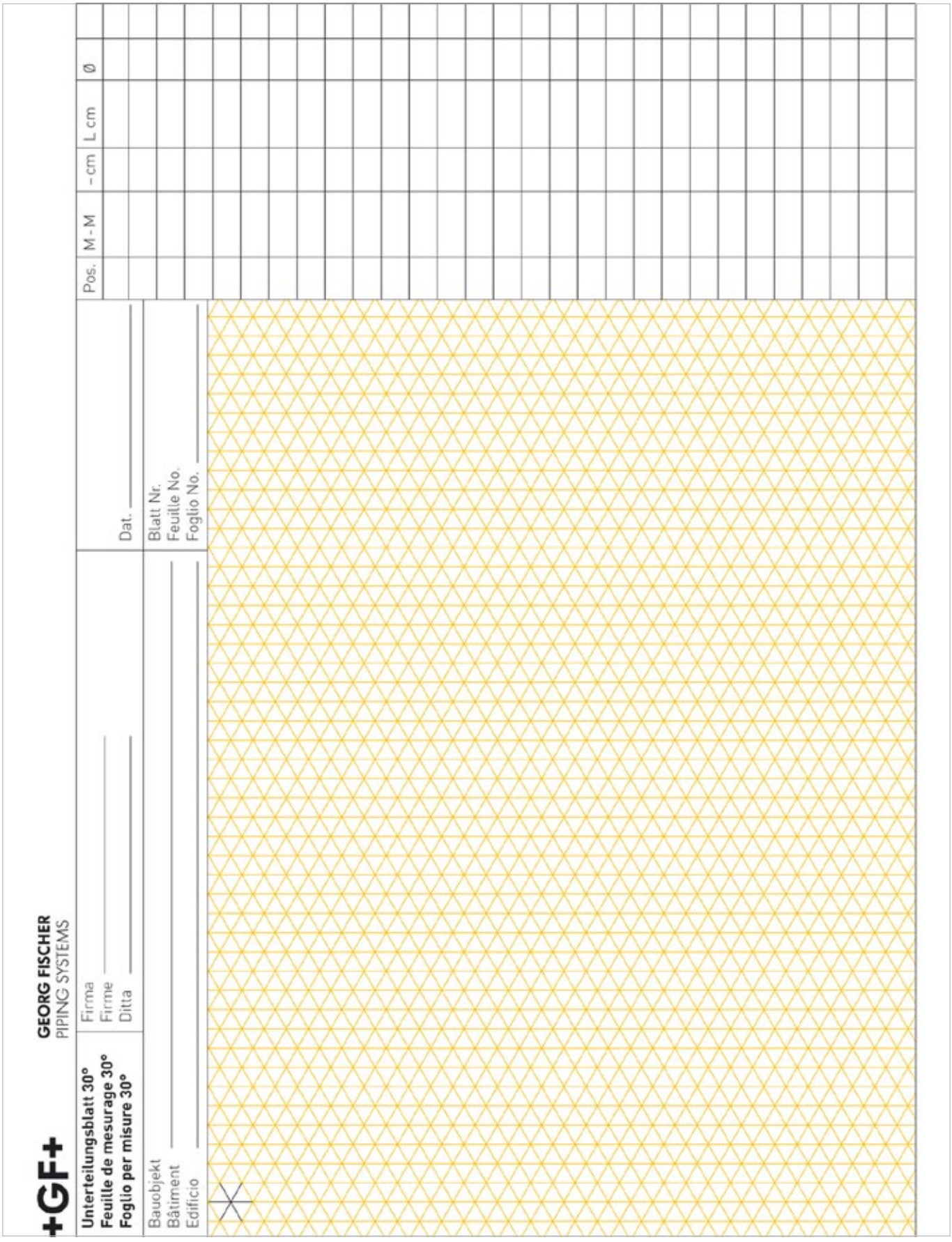
Example

Dimension	d32/D90
Center to center distance M	1000 mm
z measurement for 90° elbow z_{F1}	20 mm
z measurement for 90° elbow z_{F2}	20 mm

M = 1000 mm; L_0 = ?

L_0 = 1000 mm – 20 mm – 20 mm = 960 mm

Measuring Sheet



4.9 Length changes and flexible sections

Overview

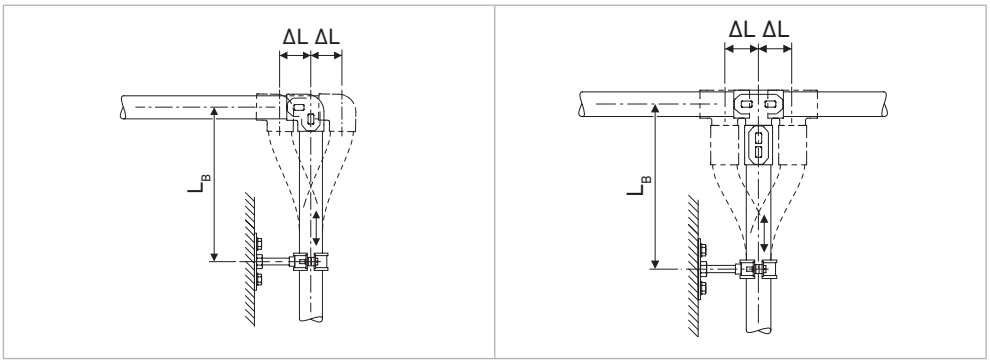
Length changes ΔL and expansion bend L_B – General

All materials expand or contract. Variations in temperature cause more significant length changes in thermoplastic materials than in metals. In the case of an above-ground installation, wall or duct mounted pipework, it is necessary to make suitable provision for length changes to prevent additional stresses.

To accommodate a change in length, the following options can be considered:

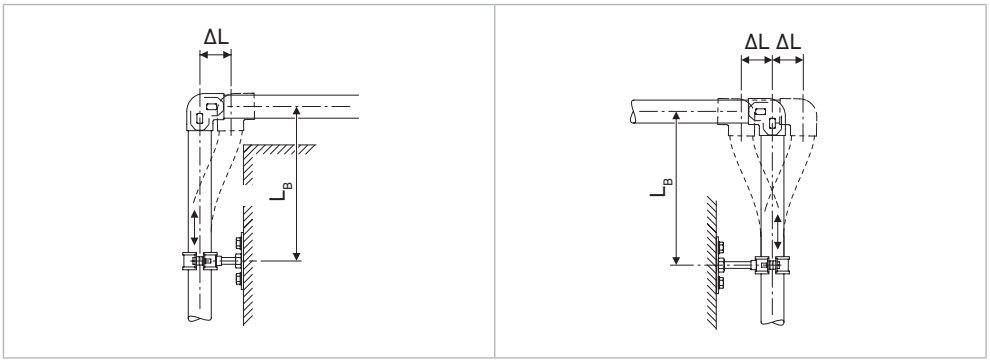
A Flexible sections
B Flexible hoses
C Compensators

Flexible sections are the most common, the simplest and the most economical solution. The calculations and positioning of flexible sections are therefore described in detail.



ΔL) Change in length
L_B) Flexible section

Thermoplastics are subject to more significant thermal expansion and contraction than metallic materials. A pipe installed above ground, against walls or in ducts, require changes in length to prevent any extra strain on the pipe.



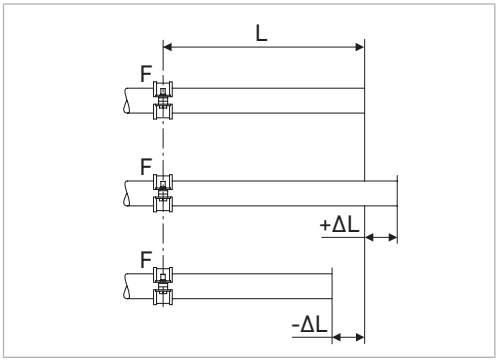
Flexible sections arise naturally at any branching or change in the direction of the piping system. Fixed pipe brackets must not restrain the movement L_B of the flexible section as a result of a change ΔL in length.

Length Change Calculation

To determine the **change in length due to temperature** ΔL (mm) of COOL-FIT PE Plus pipe, the following temperatures must be known:

Installation temperature

- Minimum flow temperature
- Maximum flow temperature
- Minimum ambient temperature
- Maximum ambient temperature



F) Fixpoint
L) Length of pipe section

The following tables show changes in length at different media temperatures for certain conditions. To determine the change in length for other conditions, the COOLING Tool-Box can be used. Contact your local Georg Fischer Piping Systems representative or visit www.gfps.com

Example of use:

Installation temperature	77°F (25 °C)
Min. ambient temperature	77°F (25 °C) constant
Max. ambient temperature	77°F (25 °C) constant
Min. flow temperature	See table
Max. flow temperature	77°F (25 °C)

Length change ΔL (mm) at 20° C (68°F) flow temperature				
L (m)	25	50	100	150
d32	-5	-10	-20	-30
d40	-5	-11	-22	-33
d50	-7	-14	-29	-43
d63	-8	-17	-33	-58
d75	-9	-18	-36	-66
d90	-10	-20	-40	-72
d110	-11	-23	-45	-81
d160	-10	-21	-42	-63
d225	-12	-24	-47	-71

Length change ΔL (in) at 20° C (68°F) flow temperature				
L (ft)	82	164	328	492
d32	-0.2	-0.4	-0.8	-1.2
d40	-0.2	-0.4	-0.9	-1.3
d50	-0.3	-0.6	-1.1	-1.7
d63	-0.3	-0.7	-1.3	-2.3
d75	-0.4	-0.7	-1.4	-2.6
d90	-0.4	-0.8	-1.6	-2.8
d110	-0.4	-0.9	-1.8	-3.2
d160	-0.4	-0.8	-1.7	-2.5
d225	-0.5	-0.9	-1.9	-2.8

L) Pipe length

Length change ΔL (mm) at 15° C (59°F) flow temperature				
L (m)	25	50	100	150
d32	-11	-21	-42	-63
d40	-11	-23	-46	-69
d50	-15	-30	-61	-91
d63	-17	-35	-69	-104
d75	-19	-38	-75	-113
d90	-21	-42	-84	-125
d110	-23	-47	-94	-140
d160	-22	-43	-86	-129
d225	-24	-48	-97	-145

Length change ΔL (in) at 15° C (59°F) flow temperature				
L (ft)	82	164	328	492
d32	-0.4	-0.8	-1.7	-2.5
d40	-0.4	-0.9	-1.8	-2.7
d50	-0.6	-1.2	-2.4	-3.6
d63	-0.7	-1.4	-2.7	-4.1
d75	-0.7	-1.5	-3.0	-4.4
d90	-0.8	-1.7	-3.3	-4.9
d110	-0.9	-1.9	-3.7	-5.5
d160	-0.9	-1.7	-3.4	-5.1
d225	-0.9	-1.9	-3.8	-5.7

L) Pipe length

Length change ΔL (mm) at 10° C (50°F) flow temperature				
L (m)	25	50	100	150
d32	-17	-33	-66	-100
d40	-18	-36	-72	-109
d50	-24	-48	-95	-143
d63	-27	-54	-108	-161
d75	-29	-58	-117	-175
d90	-32	-64	-129	-193
d110	-36	-72	-144	-215
d160	-33	-66	-133	-199
d225	-37	-74	-148	-222

Length change ΔL (in) at 10° C (50°F) flow temperature				
L (ft)	82	164	328	492
d32	-0.7	-1.3	-2.6	-3.9
d40	-0.7	-1.4	-2.8	-4.3
d50	-0.9	-1.9	-3.7	-5.6
d63	-1.1	-2.1	-4.3	-6.3
d75	-1.1	-2.3	-4.6	-6.9
d90	-1.3	-2.5	-5.1	-7.6
d110	-1.4	-2.8	-5.7	-8.5
d160	-1.3	-2.6	-5.2	-7.8
d225	-1.5	-2.9	-5.8	-8.7

L) Pipe length

Length change ΔL (mm) at 5° C (41°F) flow temperature				
L (m)	25	50	100	150
d32	-23	-46	-93	-139
d40	-25	-50	-101	-151
d50	-33	-66	-131	-197
d63	-37	-74	-148	-222
d75	-40	-80	-160	-240
d90	-44	-88	-176	-264
d110	-49	-97	-195	-292
d160	-45	-91	-181	-272
d225	-50	-100	-200	-301

Length change ΔL (in) at 5° C (41°F) flow temperature				
L (ft)	82	164	328	492
d32	-0.9	-1.8	-3.7	-5.5
d40	-1.0	-2.0	-4.0	-5.9
d50	-1.3	-2.6	-5.2	-7.8
d63	-1.5	-2.9	-5.8	-8.7
d75	-1.6	-3.1	-6.3	-9.4
d90	-1.7	-3.5	-6.9	-10.4
d110	-1.9	-3.8	-7.7	-11.5
d160	-1.8	-3.6	-7.1	-10.7
d225	-2.0	-3.9	-7.9	-11.9

L) Pipe length

Length change ΔL (mm) at 0° C (32°F) flow temperature				
L (m)	25	50	100	150
d32	-30	-60	-121	-181
d40	-33	-65	-131	-196
d50	-42	-85	-169	-254
d63	-47	-95	-190	-285
d75	-51	-102	-205	-307
d90	-56	-112	-224	-336
d110	-62	-124	-247	-371
d160	-58	-115	-230	-346
d225	-63	-127	-254	-381

Length change ΔL (in) at 0° C (32°F) flow temperature				
L (ft)	82	164	328	492
d32	-1.2	-2.4	-4.8	-7.1
d40	-1.3	-2.6	-5.2	-7.7
d50	-1.7	-3.3	-6.7	-10.0
d63	-1.9	-3.7	-7.5	-11.2
d75	-2.0	-4.0	-8.1	-12.1
d90	-2.2	-4.4	-8.8	-13.2
d110	-2.4	-4.9	-9.7	-14.6
d160	-2.3	-4.5	-9.1	-13.6
d225	-2.5	-5.0	-10.0	-15.0

L) Pipe length

Length change ΔL (mm) at -5° C (23°F) flow temperature				
L (m)	25	50	100	150
d32	-37	-75	-150	-225
d40	-41	-81	-162	-243
d50	-52	-104	-208	-313
d63	-58	-116	-233	-349
d75	-63	-125	-250	-375
d90	-68	-137	-273	-410
d110	-75	-150	-300	-449
d160	-70	-140	-280	-421
d225	-77	-154	-307	-461

Length change ΔL (in) at -5° C (23°F) flow temperature				
L (ft)	82	164	328	492
d32	-1.5	-3.0	-5.9	-8.9
d40	-1.6	-3.2	-6.4	-9.6
d50	-2.0	-4.1	-8.2	-12.3
d63	-2.3	-4.6	-9.2	-13.7
d75	-2.5	-4.9	-9.8	-14.8
d90	-2.7	-5.4	-10.7	-16.1
d110	-3.0	-5.9	-11.8	-17.7
d160	-2.8	-5.5	-11.0	-16.6
d225	-3.0	-6.1	-12.1	-18.1

L) Pipe length

Length change ΔL (mm) at -10° C (14°F) flow temperature				
L (m)	25	50	100	150
d32	-45	-90	-180	-270
d40	-49	-97	-195	-292
d50	-62	-124	-245	-373
d63	-69	-138	-276	-414
d75	-74	-148	-296	-445
d90	-81	-161	-322	-483
d110	-88	-176	-352	-528
d160	-83	-165	-331	-496
d225	-90	-180	-361	-541

Length change ΔL (in) at -10° C (14°F) flow temperature				
L (ft)	82	164	328	492
d32	-1.8	-3.5	-7.1	-10.6
d40	-1.9	-3.8	-7.7	-11.5
d50	-2.4	-4.9	-9.6	-14.7
d63	-2.7	-5.4	-10.9	-16.3
d75	-2.9	-5.8	-11.7	-17.5
d90	-3.2	-6.3	-12.7	-19
d110	-3.5	-6.9	-13.9	-20.8
d160	-3.3	-6.5	-13.0	-19.5
d225	-3.5	-7.1	-14.2	-21.3

L) Pipe length

Length change ΔL (mm) at -15° C (5°F) flow temperature				
L (m)	25	50	100	150
d32	-53	-106	-211	-317
d40	-57	-114	-228	-342
d50	-72	-145	-289	-434
d63	-80	-160	-320	-481
d75	-86	-171	-343	-514
d90	-93	-186	-372	-558
d110	-101	-202	-405	-607
d160	-95	-190	-381	-571
d225	-104	-207	-414	-621

Length change ΔL (in) at -15° C (5°F) flow temperature				
L (ft)	82	164	328	492
d32	-2.1	-4.2	-8.3	-12.5
d40	-2.2	-4.5	-9.0	-13.5
d50	-2.8	-5.7	-11.4	-17.1
d63	-3.1	-6.3	-12.6	-18.9
d75	-3.4	-6.7	-13.5	-20.2
d90	-3.7	-7.3	-14.6	-22
d110	-4.0	-8.0	-15.9	-23.9
d160	-3.7	-7.5	-15.0	-22.5
d225	-4.1	-8.1	-16.3	-24.4

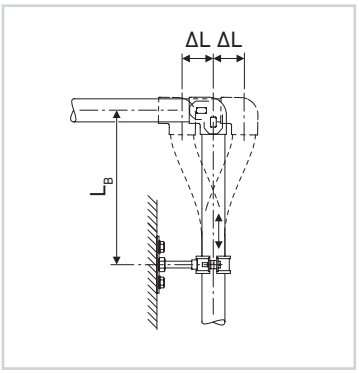
L) Pipe length

COOL-FIT® PE Plus Flexible sections

Flexible Section L_B

The values for L_B (mm) from this table can be used for a given ΔL (mm) and the relevant pipe size:

Flexible section L_B (mm)													
ΔL (mm)	10	20	30	40	50	60	70	80	90	100	150	200	300
d32	78	110	135	156	174	191	206	221	234	247	302	349	427
d40	86	122	149	172	193	211	228	244	259	273	334	386	472
d50	86	122	149	172	193	211	228	244	259	273	334	386	472
d63	92	130	159	184	206	225	243	260	276	291	356	411	503
d75	97	138	168	195	218	238	257	275	292	308	377	435	533
d90	104	147	180	208	233	255	275	294	312	329	403	465	570
d110	110	156	191	221	247	270	292	312	331	349	427	493	604
d160	130	184	225	260	291	318	344	368	390	411	503	581	712
d225	146	206	253	292	326	357	386	413	438	461	565	653	799

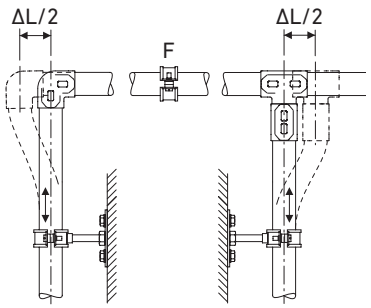
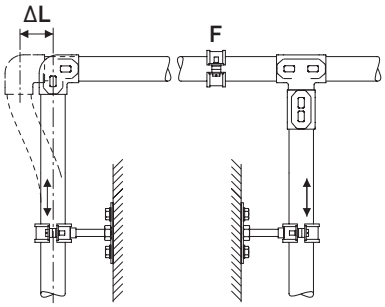


Flexible section L_B (in)													
ΔL (mm)	10	20	30	40	50	60	70	80	90	100	150	200	300
d32	3.07	4.33	5.31	6.14	6.85	7.52	8.11	8.70	9.21	9.72	11.89	13.74	16.81
d40	3.39	4.80	5.87	6.77	7.60	8.31	8.98	9.61	10.20	10.75	13.15	15.20	18.58
d50	3.39	4.80	5.87	6.77	7.60	8.31	8.98	9.61	10.20	10.75	13.15	15.20	18.58
d63	3.62	5.12	6.26	7.24	8.11	8.86	9.57	10.24	10.87	11.46	14.02	16.18	19.80
d75	3.82	5.43	6.61	7.68	8.58	9.37	10.12	10.83	11.50	12.13	14.84	17.13	20.98
d90	4.09	5.79	7.09	8.19	9.17	10.04	10.83	11.57	12.28	12.95	15.87	18.31	22.44
d110	4.33	6.14	7.52	8.70	9.72	10.63	11.50	12.28	13.03	13.74	16.81	19.41	23.78
d160	5.12	7.24	8.86	10.24	11.46	12.52	13.54	14.49	15.35	16.18	19.80	22.87	28.03
d225	5.75	8.11	9.96	11.50	12.83	14.06	15.20	16.26	17.24	18.15	22.24	25.71	31.46

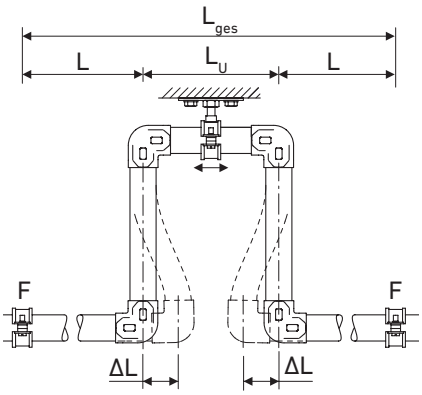
4.10 Installation

Recommendations for installation

Most piping systems have occasional changes in directions which will allow the thermally included length changes to be compensated for offsets of the pipe beyond the bends. The following examples show how the changes can be distributed in pipe sections by suitable positioning of fixed brackets:

Recommended installation	Not recommended installation
	

Expansion loops can be installed to compensate changes in length when flexible sections cannot be included at a change in direction or branch in the piping system or if substantial changes in the length of a straight section need to be compensated. In such a case the compensation for changes in length is distributed over two flexible sections.



Bending stress can lead to leaks in mechanical joints.

Do not use any unions or flanged connections close to expansion bends and loops.

Pre-Stressing

In particularly difficult situations with large changes in one direction only, it is possible to pre-stress the flexible section during installation in order to reduce the length of LB, as illustrated in the next example:

Example

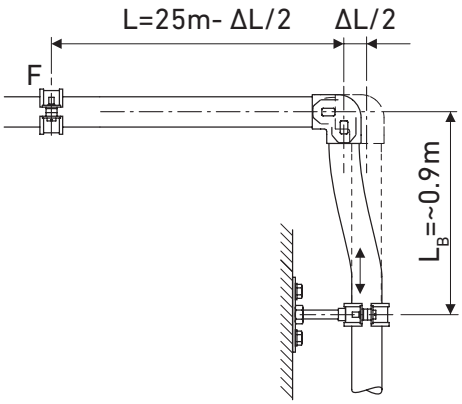
Pipe length L	25 m
Diameter	d225/D315 mm
Installation temperature	77°F (25 °C)
Min ambient temperature	77°F (25 °C) constant
Max ambient temperature	77°F (25 °C) constant
Min flow temperature	50°F (10 °C)
Max flow temperature	77°F (25 °C)

Change in length from the table or COOLING Tool-Box:
-ΔL = 39 mm

A flexible section to take up a change in length of +/- ΔL = 40 mm needs to be L_B (mm) = 2920 mm long according to the table.

If the flexible section is pre-stressed to ΔL/2, the flexible section required is reduced to ~2060 mm (2.06 m). The change in length starting from the 0 position is then +/- ΔL/2 = 39/2 = 19.5 mm. (0.77")

By pre-stressing the flexible section makes it possible to reduce its required length in installations where space is restricted. Pre-stressing also reduces the bending of the flexible section in service, improving the appearance of the piping system.



4.11 Pipe bracket spacing and support of piping systems

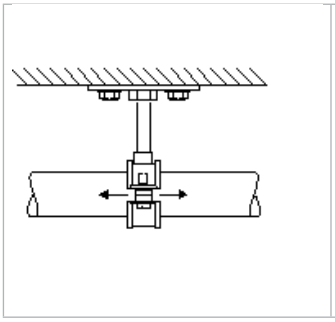
Overview

COOL-FIT PE Plus pipe should be installed using supports designed for use with plastics and should be installed taking care not to damage or overstress the pipe.

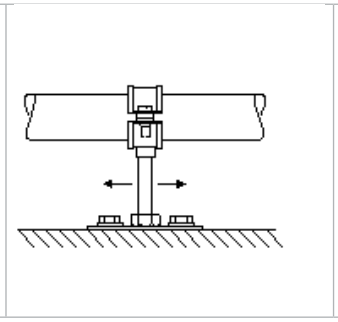
Thanks to the excellent insulating properties of the COOL-FIT PE Plus pipe and its hard, impact resistant outer jacket, standard pipe clamps with hard plastic inlay may be used.

Pipe Bracket Requirements

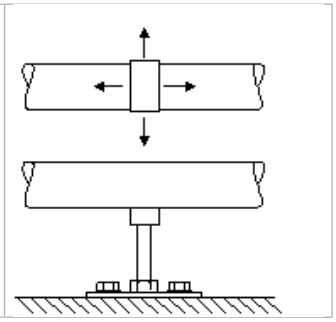
A loose bracket is a pipe bracket which allows axial movement of the pipe. This allows stress-free compensation of temperature changes and compensation of any other operating condition changes.



Axial displacement of the pipe through the clamp.



The pipe is fixed by the clamp with free axial displacement

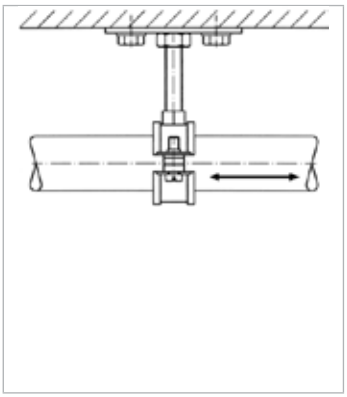


The pipe is fixed by the clamp with free biaxial displacement

The inner diameter of the bracket must be larger than the outer diameter of the pipe to allow free movement of the pipe. The inner edges of the brackets should be free from any sharp contours to avoid damaging the pipe surface.

It is recommended to use brackets with spacers in the bolts which also avoids clamping the bracket on the pipe

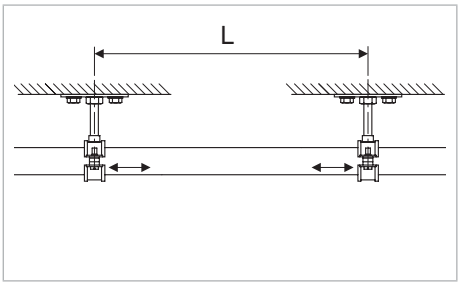
The axial movement of the piping may not be hindered by fittings arranged next to the pipe bracket or other diameter changes. Sliding brackets and hanging brackets permit the pipe to move in different directions. Attaching a sliding block to the base of the pipe bracket allows free movement of the pipe along a flat supporting surface. Sliding and hanging brackets are needed in situations where the piping system changes direction and free movement of the pipe must be allowed.



Spacers prevent pinching the pipe

Pipe bracket spacing

Plastic pipelines need to be supported at certain intervals depending on several factors; the material, the average pipe wall temperature, the density of the fluid transported and the size & wall thickness of the pipe. Determining the spacing between pipe brackets is based on the permissible deflection of the pipe between consecutive brackets.



L) Pipe bracket spacing

Pipe bracket intervals L for COOL-FIT PE Plus

d/D (mm)	32/90	40/110	50/110	63/125	75/140	90/160	110/180	160/250	225/315
L (ft)	5.91	6.4	6.4	6.56	6.89	7.05	7.55	8.53	9.35

d/D (mm)	250/355	280/400	315/450	355/500	400/560	450/630
L (ft)	10.83	11.48	12.14	12.8	13.45	14.11

d/D (mm)	32/90	40/110	50/110	63/125	75/140	90/160	110/180	160/250	225/315
L (m)	1.80	1.95	1.95	2.00	2.10	2.15	2.30	2.60	2.85

d/D (mm)	250/355	280/400	315/450	355/500	400/560	450/630
L (m)	3.30	3.50	3.70	3.90	4.10	4.30

The pipe clamp intervals from the table can be increased by 30% for vertical pipe. Multiply the values given by 1.3 in this case.

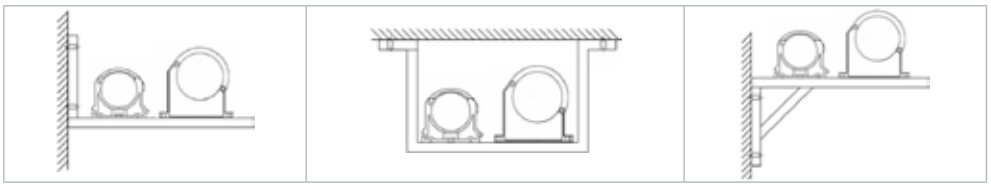
KLIP-IT pipe brackets

These robust plastic pipe brackets can be used not only under rigorous operating conditions, but also where the pipework is subject to aggressive media or atmospheric conditions. Pipe brackets and pipe clamps from Georg Fischer Piping Systems are suitable for all pipe materials used.

Do not use KLIP-IT pipe brackets as fixed points!

COOL FIT PE Plus Pipe sizes d90 to d400

The KLIP-IT brackets must be installed in the standing position (see below image) The support distance given in the following, specified for the KLIP-IT clamps, apply only to the mounting method.



Arranging fixed points

A fixed point is a bracket which prevents the pipe from moving in any direction. The purpose of a fixed point is to control tension caused by temperature changes and guide the expansion/ contraction in a certain direction.

Fixpoint design

The pipe must not be fixed by clamping it in the pipe bracket. This can cause deformation and physical damage to the pipe, damage that sometimes does not appear until very much later.

Pipe brackets must be robust and have the ability to dissipate the forces resulting from changes in pipe length. Hanging brackets or KLIP-IT pipe brackets are unsuitable for use as fixed points.

COOL-FIT® PE Plus Fixpoint

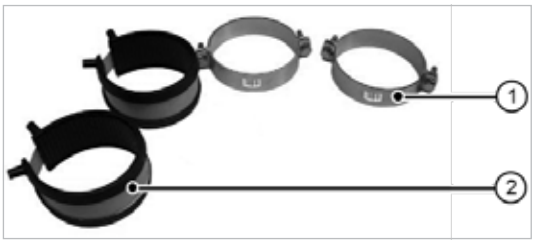
The COOL-FIT PE Plus fixed point consists of fusion tapes and brackets. The electrofusion bands need to be installed on each side of the bracket that will be dissipating the forces (fixed point). There shall be no space between the bands and this bracket. When installing these bands, the use of metal brackets (included) is required to build up the fusion pressure as well as hold them in place during the fusion process. For fusion, use an MSA 2.x, MSA 4.x, MSA 250, 300, 350, 400 or commercially available 110-V electrofusion unit. If you use an MSA electrofusion unit by Georg Fischer Piping Systems, use the y-cable kit with code 790.156.032.

The table below shows the the maximum allowed forces on the fusion bands

Diameter (mm)	32/ 90	40/ 110	50/ 110	63/ 125	75/ 140	90/ 160	110/ 180	d160/ D250	d225/ D315	d250/ D355
Maximum force F (lbs)	449.62	674.43	1124.04	1798.47	2248.08	2248.08	2248.08	2248.08	2248.08	2248.08

⚠ **The fixed points must be calculated according to the application and therefore to the forces generated. Fixed point brackets and cross braces are not included.**

Scope of delivery



1) Clamps to hold the bands in place during the fusion process.
2) Electrofusion band

Y-cable kit for COOL-FIT fixed points

The COOL-FIT Y-cables can be used for a faster installation of COOL-FIT fix points. Since electrofusion bands always come in pairs, Y-cables allow for a simultaneous fusion process, cutting fusion time in half.

Rigidly fixed installations

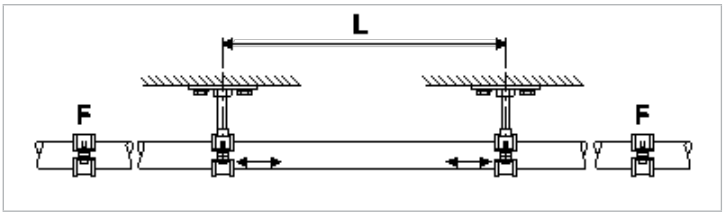
⚠ **The pipe which is axially clamped and rigidly fixed must be tested for damage. In most cases, this test results in a reduction of the maximum internal pressure and more tightly spaced supports. The forces acting on the fixed points should be considered.**

COOL-FIT PE Plus pipe and fittings are suitable for a rigidly fixed installation

Values for forces acting on fixed points as well as the resulting pipe bracket spacing are listed in following tables.

Example of use:

Installation temperature	77°F (25 °C)
Min. ambient temperature	77°F (25 °C) constant
Max. ambient temperature	77°F (25 °C) constant
Min. flow temperature	See table
Max. flow temperature	77°F (25 °C)



Fixpoint forces F and maximal pipe bracket spacing L at 59°F (15 °C) flow temperature									
d/D (mm)	**32/90**	**40/110**	**50/110**	**63/125**	**75/140**	**90/160**	**110/180**	**160/250**	**225/315**
F (kN)	0.42	0.67	0.98	1.53	2.12	3.05	4.5	6.51	12.72*
L (mm)	1800	1950	1900	2000	2100	2150	2200	2600	2850
Fixpoint forces F and maximal pipe bracket spacing L at 41°F (5 °C) flow temperature									
d/D (mm)	**32/90**	**40/110**	**50/110**	**63/125**	**75/140**	**90/160**	**110/180**	**160/250**	**225/315**
F (kN)	0.97	1.53	2.27	3.55	4.93	7.09	10.49*	15.12*	29.59*
L (mm)	1800	1950	1900	2000	2100	2150	2200	2600	2850
Fixpoint forces F and maximal pipe bracket spacing L at 23°F (-5 °C) flow temperature									
d/D (mm)	**32/90**	**40/110**	**50/110**	**63/125**	**75/140**	**90/160**	**110/180**	**160/250**	**225/315**
F (kN)	1.62	2.57	3.84	6.01	8.36	12.03*	17.81*	25.65*	50.27*
L (mm)	1800	1950	1900	2000	2100	2150	2200	2600	2850
Fixpoint forces F and maximal pipe bracket spacing L at 5°F (-15 °C) flow temperature									
d/D (mm)	**32/90**	**40/110**	**50/110**	**63/125**	**75/140**	**90/160**	**110/180**	**160/250**	**225/315**
F (kN)	2.38	3.77	5.66	8.88	12.34*	17.78*	26.34*	37.9*	74.38*
L (mm)	1800	1950	1900	2000	2100	2150	2200	2600	2850

* max allowed force for COOL-FIT fixed point exceeded

⚠ **Please contact Georg Fischer Piping Systems for rigidly fixed installations that contain ball valves and mechanical joints as well as if the max. allowed forced on the fixed points are exceeded**

4.12 Hoses

Installation of elastomer hoses

To ensure the usability of hose lines and to avoid shortening their service life through additional stresses, please note the following:

- Hose lines must be installed so that their natural position and movement is not obstructed.
- During operation, hose lines must in principle not be subjected to external forces such as tension, torsion and compression, unless they have been specially made for the purpose.
- The minimum radius of curvature specified by the manufacturer must be observed.
- Buckling is to be avoided, particularly by the joint.
- Before putting the system into operation, check that the mechanical connections are properly tightened.
- If there is visible external damage, the hose line must not be put into operation.
- The connection fittings should be firmly fastened together.

Proper use of the hose line

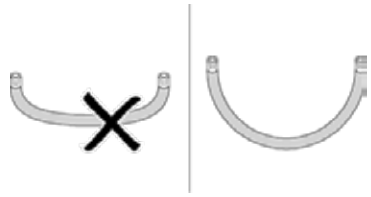
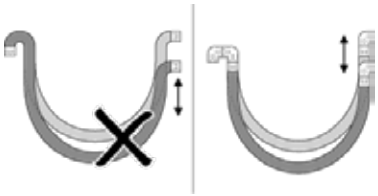
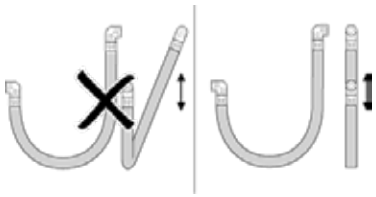
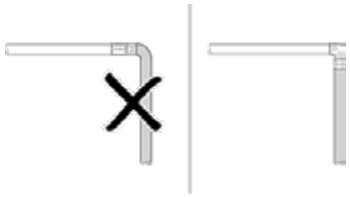
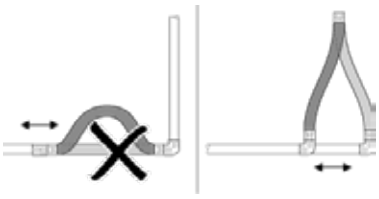
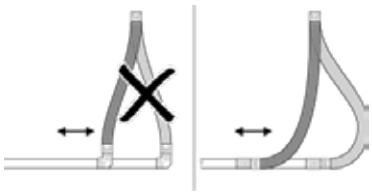
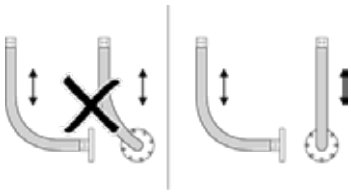
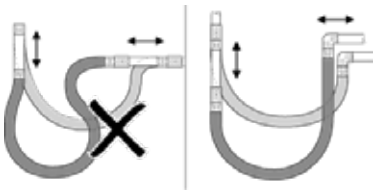
- Pressure: do not exceed maximum permitted working pressure and operating vacuum
- Temperature: do not exceed maximum permitted temperature for the medium

Storage

- Must be stored in a cool, dry, and dust-free area. Avoid direct sunlight or ultraviolet irradiation, and protect the hoses from nearby heat sources. Piping must not come into contact with substances that can cause damage.
- Hoses and hose assemblies must be stored horizontally, free of tension or bending forces.

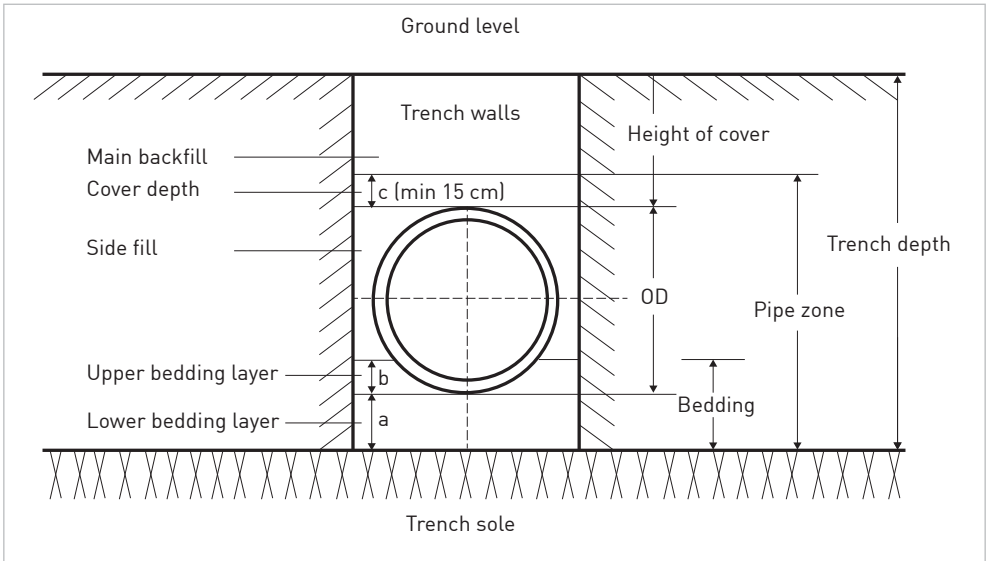
COOL-FIT® Hoses

In order to ensure the functionality of flexible hose joints following installation and handling instructions have to be considered.

Installation and handling instructions (false/correct)	Description
	Ensure hose is long enough to form an even curve radius.
	Avoid excessive bending or curving behind the fitting; use elbows.
	Where there is significant axial expansion, the direction of movement and hose axis must lie in the same plane in order to avoid torsion.
	Avoid excessive bending stress by using elbows.
	If the hose absorbs expansion, it must be installed transversally to the direction of expansion.
	For large lateral movements, a 90° angle should be allowed.
	Expansion take-up must be in the same direction of the pipe to avoid twisting
	For major axial expansion, the pipe must be installed in a U-shape to avoid twisting.

4.13 Underground installation

COOL-FIT PE Plus can be used underground. The corresponding national installation guidelines apply to building the pipe trenches and installing the pipe. In general, trenches should not be less than 1 meter deep; deeper depth recommended if frost is present. The sand bed must be built in such a way that the pipe is evenly supported. The pipe must be laid in a sand bed and protected against sharp stones and debris. The sand must be well compacted.



The pipe zone has to be designed according to planning requirements and static calculations. The area between trench sole and side fill is referred to as bedding. A load-carrying bedding must be created by using soil replacement. For regular soil conditions, EN 1610 specifies a minimum thickness of a = 5.9 (150 mm) in for the lower bedding. In addition to the minimum thickness, corresponding requirements are also imposed on the building materials that must be used for the bedding.

No building materials with components exceeding the following ranges may be used:

- 22 mm for (0.87")

The upper bedding layer b is derived from static calculations. It is also important to ensure that no cavities are created below the pipe. The bedding dissipates all loads from the pipe securely and evenly into the ground. For this reason, the COOL-FIT PE Plus pipe has to rest solidly on the bedding across its entire length. The upper end of the pipe zone is defined according to EN 1610 as 5.9 (150 mm) in above the pipe apex or 3.9 (100 mm) in above the pipe connection. Ensure that the pipe is not damaged when the cover and main backfill are filled and compacted.

The COOL-FIT PE Plus system has a higher degree of stiffness and a higher weight than the non-insulated pipe. For this reason, the pipe should always be connected in the trench. Unnecessary stress on the COOL-FIT PE Plus joining elements thus avoided. Under normal circumstances, it is not necessary to install expansion loops in the system.

A movement of the pipe before filling the pipe trench should be avoided. Please contact Georg Fischer Piping Systems concerning recommendations for underground installations.

4.14 COOLING Tool-Box

The Georg Fischer Piping Systems COOLING Tool-Box is used to help in the dimensioning and design of cooling systems.

The COOLING Tool-Box handles:

- Expansion, contraction
- Flexible section design
- Energy savings
- Pipe dimensioning
- Pressure loss
- Dew point/ insulation thickness
- Weight comparison
- CO_2 footprint

Data for the most commonly used secondary refrigerants are already stored in the calculation tool. It calculates all system components such as pipe, fittings and valves. The menu is available in several different languages. It allows system design to be efficient and optimized. With the function "comparison" a COOL-FIT system can be compared to a black steel, stainless steel or copper system.

COOLING Tool-Box: Get in contact with your Georg Fischer Piping Systems representative or visit www.gfps.com

5 Joining and Installation

5.1 Joining of COOL-FIT® PE Plus

For general information on electrofusion, see Planning Fundamentals chapter "Joining technology", section "Electrofusion joints".

General advice

The quality of a weld is largely determined by careful preparation. The welding surface must be protected from adverse weather conditions such as rain, snow, or wind. The permissible temperature range for fusion is 14°F (-10 °C) to 113°F (45 °C). National regulations must be observed. Indirect sunlight and shielding of the welding area can help create an even temperature profile around the whole circumference of the pipe. It is particularly important to ensure that the climate conditions are the same for both the electro fusion machine and the welding area.

Electrofusion Process

Protect the welding area

The surfaces to be welded on the pipe and the fitting must be carefully protected from dirt, grease, oils and lubricants. Minimum 90% Isopropyl Alcohol is the recommended solution for cleaning.

No fats (i.e. hand cream, oily rags, silicone, etc.) must be introduced into the fusion zone!

Joining d32 – d225

1. Without touching the surface, remove product immediately before the installation from packaging

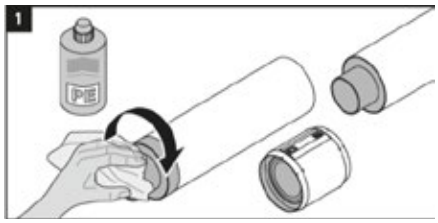
If necessary, prepare the pipe for fusion joints using the Foam removal tool (foam removal, cutting the jacket and peeling the media pipe) and check afterwards that the shaving thickness is 0.008 in - 0.016 in (0.2mm – 0.4mm) and that the minimum permissible external diameter after peeling is met:

- **COOL-FIT PE Plus Valves and COOL-FIT PE Plus Fittings d32 – d225 (Type B, barrel nipple and transition fittings) don't need to be peeled, just cleaned with minimum 90% Isopropyl Alcohol.**

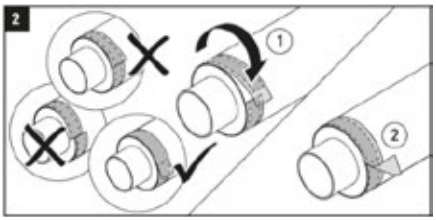
Minimum permitted pipe external diameter after peeling for COOL-FIT PE Plus

d/D (mm)	32/90	40/110	50/110	63/125	75/140	90/160	110/180	160/250	225/315
Min. d (in)	1.2	1.6	1.9	2.5	2.9	3.5	4.3	6.3	8.8

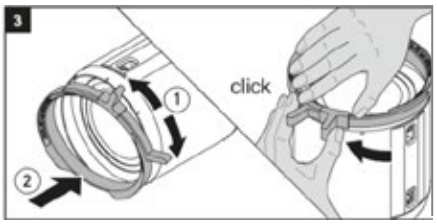
Mounting of sealing tape



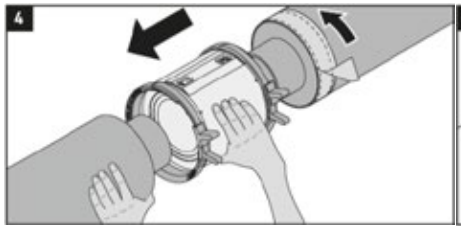
Step 1
In addition to the fusion zone, also clean the jacket of the pipe



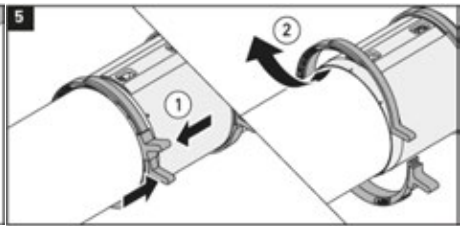
Step 2
Mount sealing tape end to end without offset and fold down liner



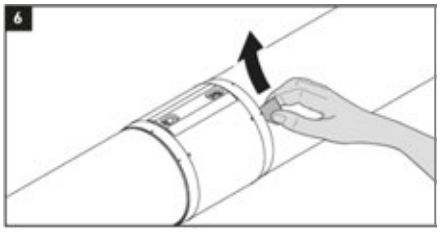
Step 3
Mount the assembly aids on the sealing lips of the COOL-FIT PE Plus fitting



Step 4
On pushing together, slightly turn either fitting or pipe assembled with sealing tape/ transition of insulation

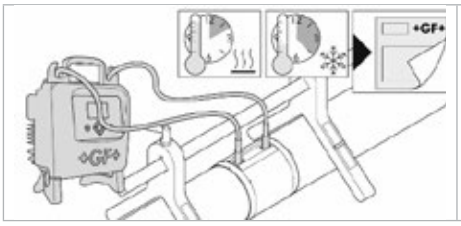


Step 5
Remove the assembly aids

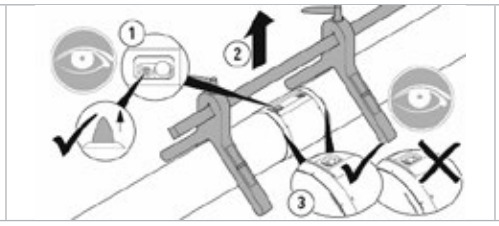


Step 6
Pull off the liner after removal of assembly aids

3. Welding process

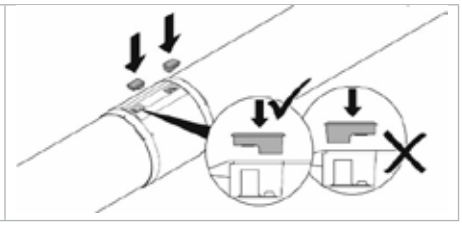


Step 1
Power the machine on, and follow the screen step-by-step fusion process. Use long fusion adaptors (790128035). Pay attention to fusion and cooling time.

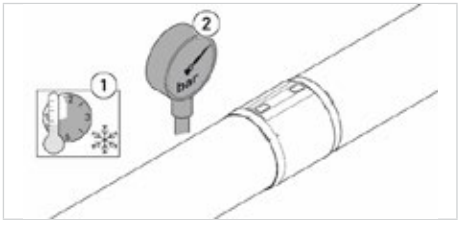


Step 2
After fusion, check fusion indicators on the electrofusion fitting and note the messages on the display of the electrofusion machine.
Mark the fitting with following information
- Date
- Welder/ Weld number
- Time at the end of cooling time

Remove the clamping tool after cooling time



Step 3
Fit the insulation of the weld pins onto the fusion contacts



Step 4
After cooling perform pressure tests as per table.

Cooling Time Table

d (mm)	Cooling time before Remove clamping tool [min.]	Cooling time before internal pressure test at 6 bar ≤ 87 psi [min.]	Cooling time before internal pressure test at 18 bar ≤ 261 psi [hours]
32	10	15	3.0
40	10	20	5.0
50	10	20	5.0
63	10	20	5.0
75	15	25	6.0
90	20	35	8.0
110	30	50	8.0
160	45	90	8.0
225	45	90	9.5

The values are valid for pressure tests using water or a liquid compatible with PE (check chemical resistance table or contact GF technical support) at ≤ 68°F (20 ° C). For testing with nitrogen (do not use comptressed air) a cooling time of 12 hours is recommended.

Joining d250 – d450

Preparing for fusion

Step 1	Step 2	Step 3
		
Clean the welding surfaces of the COOL-FIT PE Plus fittings and pipes	Check the pipe outer diameter before and after peeling with a circumferential measuring tape.	Check the free spigot length.

Overview of pipe outer diameter and insulation free spigot length

Dimension (mm)	Minimum permissible pipe outer diameter after peeling (mm)	Factory-set spigot length (mm)	Minimum permissible pipe outer diameter after peeling (in)	Factory-set spigot length (in)
d250	249.3	113 – 123	9.8	4.4 - 4.8
d280	279.3	116 – 126	11.0	4.6 - 5.0
d315	314.3	123 – 133	12.4	4.8 - 5.2
d355	354.3	135 – 145	13.9	5.3 - 5.7
d400	399.3	137 – 147	15.7	5.4 - 5.8
d450	449.3	153 – 163	17.7	6.0 - 6.4

Cleaning

Step 1	Step 2	Step 3
		
Peel the outer jacket and foam with the peeling tool	Clean peeled pipe section with PE cleaner and lint-free cloth and allow to air out.	Clean fusion area of the electrofusion coupler with PE cleaner and lint-free cloth and allow to air out.

Fusion process

Step 1	Step 2	Step 3
		
Slide on the electrofusion socket up to the insulation without touching the fusion area. Slide on the shrink socket and fix the components stress-free[1].	Power the machine on, and follow the screen step-by-step fusion process. Use long fusion adaptors (790128035). Pay attention to fusion and cooling time	After fusion, check fusion indicators on the electrofusion fitting and note the messages on the display of the electrofusion machine. Mark the fitting with following information • Date • Welder/ Weld number • Time at the end of cooling time Remove the clamping tool after cooling time

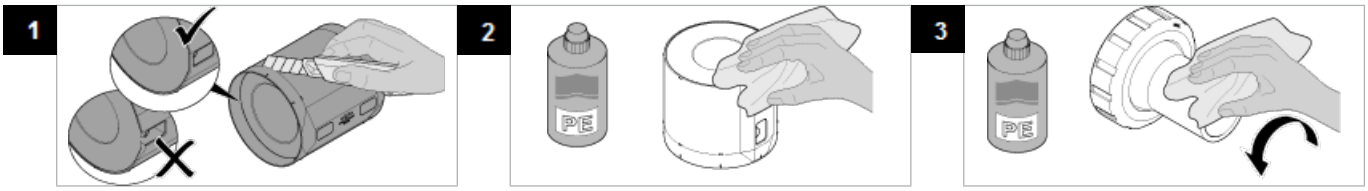
1) The use of suitable fixing devices is recommended.

Sealing

Step 1	Step 2	Step 3
		
Place the sealing tape centered over the gap and overlap it at the end. Press it on well and smooth out folds.	Position the shrink socket centered.	Using a roofers torch (yellow flame), strike the shrink socket as vertically as possible. keep the flame moving over the shrink socket to maintain an uniform heating process. Avoid applying unnecessary heat to the fittings.

Valves and flange joints

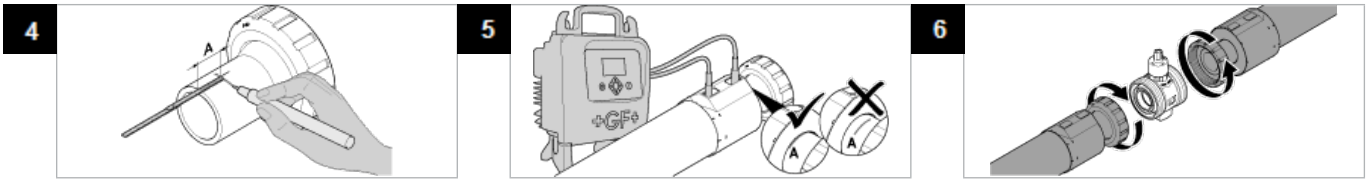
1. Preparation of fitting – cut the sealing lip flush on one side, clean the sealing surfaces



For joining the valve or flange adaptor, the sealing lip of the fitting has to be removed on the side that will be joining with the valve or flange adaptor. The sealing and fusion areas need to be cleaned.

2. Standard fusion

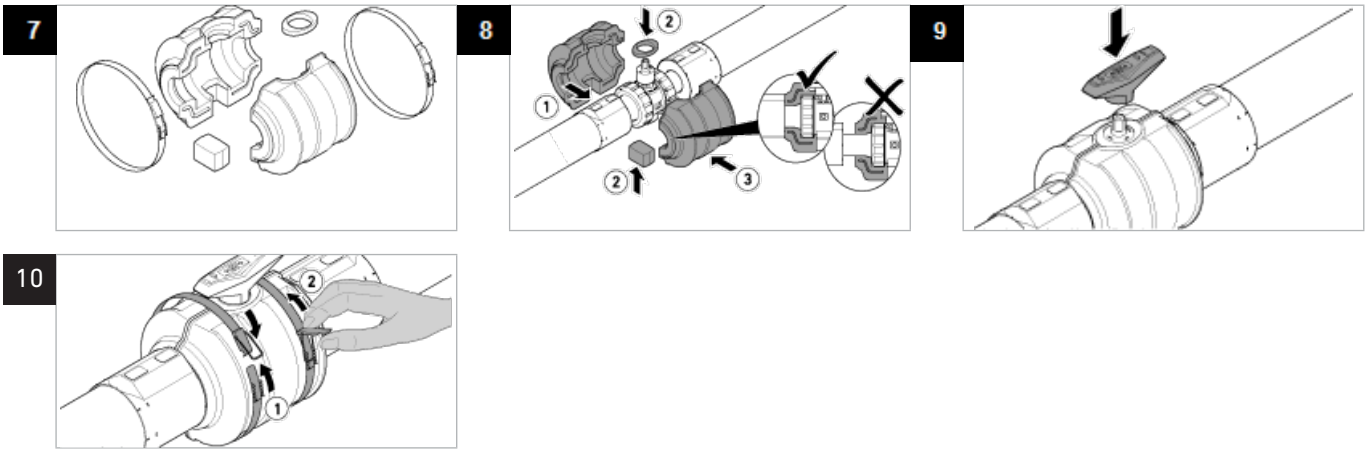
Fuse both valve ends without valve mounted.



Following insertion depths A are valid for COOL-FIT PE Plus components:

d/D (mm)	32/90	40/110	50/110	63/125	75/140	90/160	110/180	160/250	225/315
L1 (in)	1.4	1.6	1.7	1.9	2.2	2.4	2.8	3.5	4.3
L1 (mm)	35.6	40.6	43.2	48.3	55.9	61.0	71.1	88.9	109.2

3. Assembling the valve/flange insulation



Further information can be found in the assembly instructions "COOL-FIT / COOL-FIT PE Plus insulation for Ball Valve and Butterfly Valve".

It's recommended to re-tighten the bolts of COOL-FIT PE Plus butterfly valves and flange joints at operating temperature.

Compact connection fitting-to-fitting

For compact connections between fittings and pipe, the foam removal tool enables pipe lengths as short as 4.33 in (~110 mm) for the dimensions d32-d90 (2"-3"), and 6.69 in (~170 mm) for the dimensions d110-d225 (4" -8").

For compact fitting-to-fitting joints, COOL-FIT PE Plus barrel nipple can be used.

For shorter fitting to pipe connections (d75), an uninsulated PE100 SDR11 pipe with a piece of insulation can be used. After peeling the outer layer of the uninsulated pipe, the sealing lip is pulled over the pipe and then welded with the fitting.

d	d75	d90	d110	d160	d225
L (mm)	165	186	216	270	330

d	d75	d90	d110	d160	d225
L (in)	6.5	7.3	8.5	10.6	13.0

L) Length of un-insulated PE100 SDR11 pipe needed

Transition Fittings

The Georg Fischer Piping Systems range of fittings provides a variety of transitions and threaded fittings to connect plastic piping components to pipe, fittings or valves in metal (or vice versa). The metal threads Rp, R or NPT can be sealed with a PTFE tape as long as the counterpart is not made of plastic. Male and female G threads must be sealed with flat gaskets. The advantage of a threaded G connection is radial and torsion-free possibility for installing and uninstalling.

To prevent electrochemical corrosion, stainless steel connecting elements should preferably be used for steel transitions.

Combining G and R threads

The connection of an external parallel pipe thread G in accordance with EN ISO 228-1, with an internal parallel pipe thread Rp in accordance with ISO 7-1 is not intended according to standards. A tight connection is possible under favorable conditions, but cannot be established reliably.

Mounting the insulation half shells of Transition Fittings

Following the joining of the COOL-FIT PE Plus Transition Fittings with the COOL-FIT PE Plus Fitting Type A, and the mechanical joining of the threaded components, the insulation half shells can be mounted. Assembling of the shells can be done in the same way like for the COOL-FIT PE Plus valves. With the exception of COOL-FIT unions, the sealing lip of the type A fitting must not be cut off on mounting the insulation half shells of transition fittings.

Further information can be found in the assembly instructions "COOL-FIT PE Plus insulation for transition fittings".

Connecting the flexible hose insulation to the Transition Fittings

The radial joining of the joining face of the NBR insulation of flexible hoses to the insulation of transition fittings can be applied either by adhesive cement or by adhesive tape.

Joining Instructions for the adhesive cement

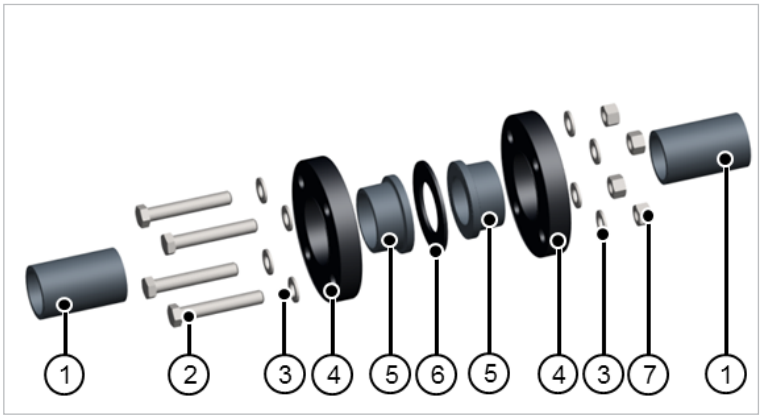
The adhesive should be thoroughly stirred before use. A thin film is applied using the brush to both surfaces to be bonded. The open joint time is about 3 to 15 minutes depending on temperature and humidity of surrounding air.

Before the coated surfaces are bonded together, the adhesive must still be wet but should not transfer to the skin when touched. The surfaces should be brought together quickly and firmly and should be held together for a few seconds.

The recommended temperature for storage and processing is in the range between 59°F (+15 °C) and 77°F (25 °C). The adhesive should not be used below 50°F (+10 °C).

Flange joints

The gasket dimensions must match the outer and inner diameter of the flange adaptor or valve end. Differences between the inner diameters of gasket and flange that are greater than 0.93" (10 mm) may result in malfunctioning flange connections.



Recommended backing flange of COOL-FIT PE Plus flange joints

1) Pipe
2) Bolt
3) Washer
4) Backing Flange
5) Flange Adaptor/ Valve End
6) Flange Gasket
7) Nut

Tightening the Bolts

To ensure even distribution of stresses in the fully-installed flange, tighten the bolts in a star pattern as described in ANSI B16.5.

- Tighten the bolts by using a torque wrench.
- The bolts must be tightened diagonally and evenly: First, tighten the bolts by hand so that the gasket is evenly contacting the joining faces. Then tighten all bolts diagonally to 50 % of the required torque, followed by 100 % of the required torque. The recommended bolt tightening torques are listed in the table.

Selecting and handling bolts

- The length of the bolts should be in such a way that the bolt thread does not extend beyond 2-3 turns of the thread at the nut. Washers must be used at the bolts as well as the nut. If bolts are too long it's not possible to mount the insulation half shells afterwards.
- To ensure that the connecting bolts can be easily tightened and removed after a lengthy period of use, the thread should be lubricated, e.g. with molybdenum sulphide.
- However, deviations may occur in practice, e. g. through the use of stiff bolts or pipe axes that are not aligned. The Shore hardness of the gasket can also influence the necessary tightening torque.
- We recommend checking the tightening torques 24 hours after assembly according to the specified values and, if necessary, retighten them. Always tighten diagonally here, as well.
- After the pressure test, the tightening torques must be checked in any case and, if necessary, retightened.
- If a flange leaks when pressure tested, retighten the bolts to the full recommended torque and retest. Do not exceed the recommended torque before consulting GF Technical support.

In the area of flexible sections and expansion loops, no mechanical joints should be used since the bending stress may cause leaks.

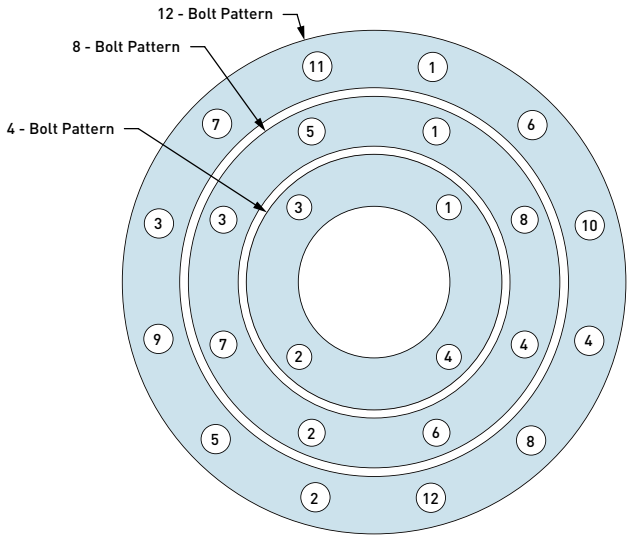


Figure 1 Recommended Bolt Tightening Sequence

Bolt tightening torque guidelines for metric flange connections

The indicated torques are recommended by Georg Fischer Piping systems. These torques already ensure a sufficient tightness of the flange connection. They deviate from the data in the DVS 2210-1 Supplement 3, which are to be understood as upper limits. The individual components of the flange connection (valve ends, flange adaptors, flanges) by Georg Fischer Piping systems are dimensioned for these upper limits.

Maximum operating pressure 87.01 psi (6 bar)

Bolt tightening torque guidelines for ISO flange connections

Pipe outside diameter d (mm)	Tightening torque MD (ft/lbs)		
	Flat ring maximum pressure 150 psi (10 bar)/ 104°F (40 °C)	Profile seal maximum pressure 232 psi (16 bar)	O-ring maximum pressure 232 psi (16 bar)
d32	11.1	7.38	2.38
d40	14.8	11.1	11.1
d50	18.4	11.1	11.1
d63	25.8	14.8	14.8
d75	36.9	18.4	18.4
d90	22.1	11.1	11.1
d110	25.8	14.8	14.8
d160	33.2	18.4	18.4
d225	51.6	33.2	25.8
d250	47.9	25.8	-
d280	47.9	25.8	-
d315	66.4	36.9	-
d355	66.4	36.9	-
d400	73.8	44.3	-
d450	140.0	51.6	-

Length of bolts

In practice, it is often difficult to determine the correct bolt length for flange joints. It can be derived from the following parameters:

- Thickness of the washer (2x)
- Thickness of the nut (1x)
- Thickness of the gasket (1x)
- Flange thickness (2x)
- Thickness of flange collar (valve end or flange adaptor) (2x)
- Valve installation length, if applicable (1x)

In order to ensure the fitting of the insulation half shells of the COOL-FIT PE Plus flange adaptors the used bolts must not be too long.

The following table is useful in determining the necessary bolt length.

Online "Lengths of bolts and tightening torques" tool on www.gfps.com/tools

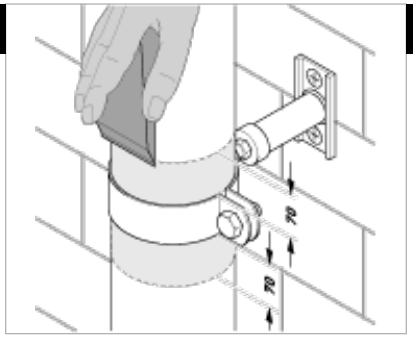
For COOL-FIT PE Plus Flange adaptors used together with PP-Steel backing flanges, the following bolt lengths can be used:

Dimension	d32	d40	d50	d63	d75	d90	d110	d160	d225
Bolts	M12x80	M16x80	M16x90	M16x90 or M16x100	M16x100	M16x100	M16x100	M16x200	M20x220

COOL-FIT® PE Plus Installation of fixed points

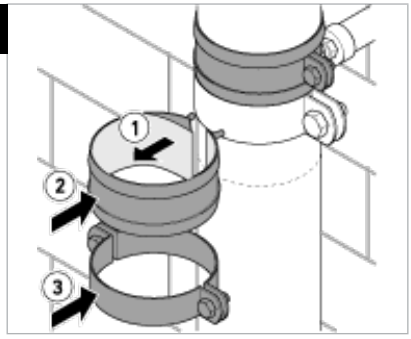
The COOL-FIT piping system must me mounted in final position in the regular fixpoint clamp.

1



Step 1
Remove the outer layer of the PE jacket with a pipe scraper.

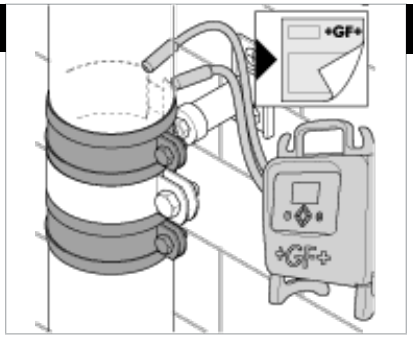
2



Step 2
Remove the yellow protection band from the welding bands and place them on the COOL-FIT pipe. Fix the welding bands with the metal clamps provided.

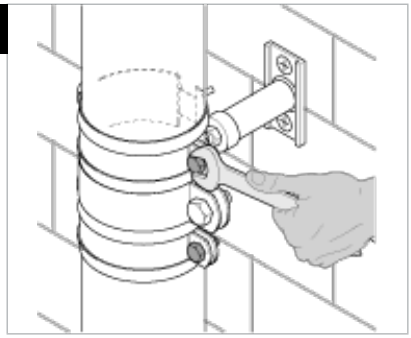
Note: The necessary welding pressure on the clean and dry COOL-FIT pipe is achieved by tightening the metal clamps. Take care that between the metal clamps and weld band there are no visible holes.

3



Step 3
Fuse the welding band with the COOL-FIT pipe in accordance with the operating instructions of the electrofusion machine. Use the COOL-FIT Y cables with integrated welding adaptors for the fusion.

4



Step 4
Retighten the pipe clips after 10 minutes

5.2 Pressure test

Internal pressure test

For internal pressure testing and commissioning, the same conditions apply for COOL-FIT PE Plus as for the non-insulated ecoFIT system (PE).

5.3 Internal pressure and leak testing

Introduction to the pressure test

Overview of the various test methods

Test methods	Inner Pressure test		Leak test
Medium	Water	Gas[1]	Gas
Type	Incompressible	Compressible	Compressible
Test pressure (overpressure)	$P_{p\,(perm)}$ or $0.85 \cdot P_{p\,(perm)}$	Operating pressure 29 psi (2 bar)	7.2 psi (0.50 bar)
Potential risk during the pressure test	Low	High	Low
Significance	High: Proof of pressure resistance incl. impermeability to test medium	High: Proof of pressure resistance incl. impermeability to test medium	Low

1) Follow the applicable safety precautions. More information is available in DVS 2210-1 addendum 2.

A number of international and national standards and guidelines are available for leak and pressure tests. Therefore, it is often not easy to find the applicable test procedure and for example the test pressure.

The purpose of a pressure test is:

- Ensure the resistance to pressure of the piping system, and
- Show the leak-tightness against the test medium

Usually, the internal pressure test is done as a water pressure test and only in exceptional cases (under consideration of special safety precautions) as a gas pressure test with nitrogen.

Water is an incompressible medium. In case of a leakage during the pressure test relative low energy is set free. Therefore the hazard potential is significantly lower compared to testing with a compressible medium.

Internal pressure test with water or similar incompressible test medium

The internal pressure test is done when installation work is completed, the fixed points (if required) re-installed and presumes operational requirements are satisfied. The test pressure load should provide preliminary proof of operational safety.

Test parameters

The following table provides recommendations on the performance of the internal pressure test

Purpose	Preliminary Review	Main examination
Test pressure pp (depends on the pipe wall temperature and the permitted test pressure of the installed components, see "determination of the test pressure")	≤ $P_{p\ (perm)}$	≤ 0.85 $P_{p\ (perm)}$
Test duration (depends on the length of the pipe sections)	L ≤ 328ft (100 m): 3 h 328ft (100 m) < L ≤ 1640ft (500 m): 6 h	328ft (L ≤ 100 m): 3 h 328ft (100 m) <L ≤ 1640ft (500 m): 6 h
Checks during the test (test pressure and temperature curves must be recorded)	At least 3 checks distributed across the test period with test pressure restored	At least 3 checks distributed across the test period without restoring the test pressure

Pre-test

The pre-test serves to prepare the piping system for the actual test (main test). In the course of pre-testing, a tension-expansion equilibrium in relation to an increase in volume will develop in the piping system. A material related drop in pressure will occur which will require repeated pumping to restore the test pressure and also frequently a re-tightening of the flange connection bolts.

The guidelines for an expansion-related pressure decrease in pipe are:

Material	Pressure drop (bar/h)	Pressure drop (psi/h)
COOL-FIT PE Plus	1.2	17.4

Main test

In the context of the main test, a much smaller drop in pressure can be expected at constant pipe wall temperatures so that it is not necessary to pump again. The checks can focus primarily on leak detection at the flange joints and any position changes of the pipe.

Observe if using compensators

If the piping system to be tested contains compensators, it has an influence on the expected axial forces on the fixed points of the piping system. Because the test pressure is higher than the operating pressure, the axial forces on the fixed points increase proportionately. This has to be taken into account when designing the fixed points.

Observe if using valves

When using a valve at the end of a piping system (end or final valve), the valve and the pipe end should be closed by a cap. This prevents an accidental opening of the valve and release of the medium.

Filling the pipe

Before starting the pressure test, the following points should be checked:

1. The installation has been carried out in accordance with its plans.
2. All pressure relief and check valves are fitted in the direction of flow.
3. All end valves have been closed.
4. All valves for devices have been closed to secure against pressure.
5. A visual inspection has been made of all connections, pumps, measurement devices and tanks.
6. The waiting time after the last weld

Now the piping system can be filled from the lowest point. Special attention should be given to the air vent. If possible, vents should be provided at all the high points of the piping system and these should be open when filling the system. Flushing velocity should be at least 3.3 ft/s (1 m/s.)

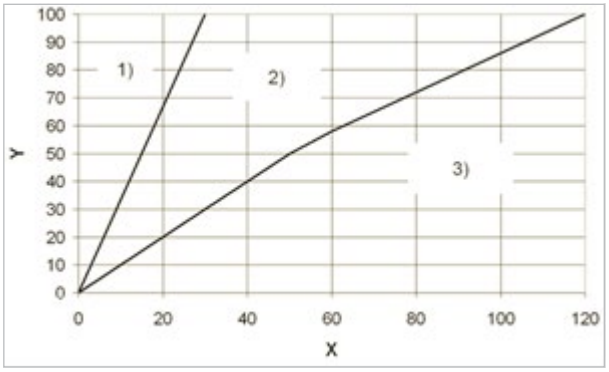
Reference values for the filling volume are given in the table below:

d (mm)	V (gal/s)	V (l/s)
≤ 90	3.96	15
110	7.93	30
160	18.5	70
225	39.6	150
250	52.8	200
315	79.3	300
400	158.5	600

Allow sufficient time to pass between filling and testing the pipe for the air in the piping system to escape through the vents: about 6 to 12 hours, depending on nominal diameter.

Applying the test pressure

The test pressure is applied in accordance with this diagram. It is important to ensure that the rate of pressure increase does not cause any water hammers.



Y) Test pressure (%)
X) Time of test pressure increase (min)
1) Rate of pressure increase up to 4"
2) Range of pressure increase rates between 4" and 16"
3) Guideline rate of pressure increase for 20" and higher: 20" psi/10 min (bar/10 min)

Determination of the test pressure

The permissible test pressure is calculated using the following formula:

$$P_{p(zul)} = \frac{1}{SDR} \cdot \frac{20 \cdot \sigma_{v(T,\,100\,h)}}{S_p \cdot A_G}$$

$\sigma_{v(T,\,100\,h)}$	Creep strength for the pipe wall temperature (at t= 100h)
S_p	Minimum safety factor for creep strength
A_G	Processing method or geometry specific factor which reduces the permissible test pressure
T_R	Pipe metal temperature: mean temperature of test medium and pipe surface

Material	Sp minimum safety factor
COOL-FIT PE Plus Pipe and Fittings (PE100)	1.25
COOL-FIT PE Plus Valves (ABS)	1.6

Checks during testing

The following measurement values must be recorded consistently during testing:

1. Internal pressure at the absolute lowest point of the piping system
2. Medium and ambient temperature
3. Water volume input
4. Water volume output
5. Pressure drop rates

5.4 Start-up with secondary refrigerants

Secondary refrigerants in pre-mixed solutions should be introduced into COOL-FIT PE Plus piping systems. Filling should be performed slowly from the lowest point of the system to allow the piping system to vent at its highest point.

Filling and de-aeration

It is important to vent air from all piping systems. This is particularly important with saline solutions, because of their corrosive properties. Venting process:

- The system must be filled slowly.
- Manual or automatic venting devices must be fitted at the highest point of the system.
- Long horizontal lines should be installed at a slight gradient.
- The piping layout should be chosen in such a way as to prevent the formation of air pockets.
- Installation of an air vent with a medium column as a reserve.
- Follow the specific manufacturer instructions for the liquids as regards filling

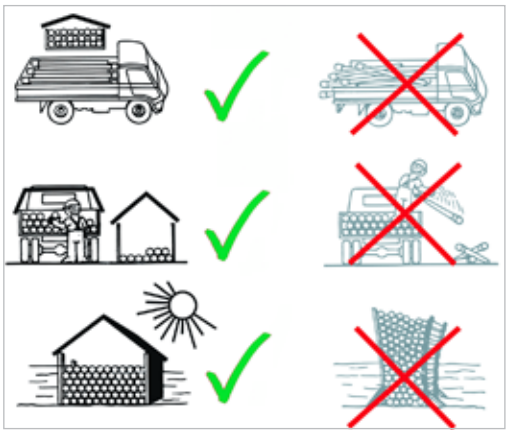
6 Transport, Handling and Storage

6.1 Transport

On trucks/in crates, manual transport

6.2 Storage

All plastic pipe including pre-insulated plastic pipe such as COOL-FIT PE Plus must be stacked on a flat surface with no sharp edges. During handling, care must be taken to avoid damage to the external surface of the pipe (i.e. by dragging along the ground). Pipe should not cross over each other in storage as this is likely to cause bending.



6.3 Environment

The materials used for COOL-FIT PE Plus are suitable for recycling. Georg Fischer Piping Systems aims to satisfy its customer's wishes concerning environmental aspects. TEWI, ODP and GWP values and test reports are available for COOL-FIT PE Plus.

For more information at www.gfps.com