COOL-FIT 4.0

Planning Fundamentals

Plan, Build, Operate

Design and Installation

COOL-FIT 4.0

Content

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1 COOL-FIT 4.0

1.1 General Information

COOL-FIT 4.0 is a pre-insulated piping system for the delivery of secondary refrigerants. The COOL-FIT 4.0 system is a completely pre-insulated plastic piping system for secondary refrigerant circuits that run with water, brine, or Glycol based solutions. Thanks to its insulation thickness of 40 mm, typical areas of application are industrial refrigeration systems with medium temperatures below 0 °C and chilled water systems for media above 0 °C.

COOL-FIT 4.0 is based on established, impact resistant and corrosion free PE pipe and fittings. The smooth inner surface of the fluid pipe provides minimal losses of pressure. The low thermal conductivity and high quality insulation guarantee low operating cost over the entire lifespan of the system. Thanks to the 3 in 1 design – Fluid pipe / Insulation / Robust jacket – installation time is kept very short.

All components are pre-insulated or supplied with mountable insulation shells.
The COOL-FIT 4.0 tools allow for fast and safe installation of the system.

The COOL-FIT 4.0 system is a completely pre-insulated plastic piping system for secondary refrigerant circuits that run with water, brine, or Glycol based solutions.

The COOL-FIT 4.0 system is suitable for use in applications like:

- Fruit and vegetable processing
- Bakeries
- Fish and meat processing
- Cold stores
- Breweries and wineries
- Air conditioning
- Airports
- Apartments
- Hospitals
- Industrial buildings
- Data centers
- Hotels
- Shopping centers
- Sports centre / leisure centre
- Universities
- Bank / public institutions

1.2 System Specification

Specification		COOL-FIT 4.0
Materials[1]	Pipe	PE100
	Insulation	GF-HE foam, halogen free, closed-porous
	Outer jacket	Pipe HDPE
		Fitting GF-HE
Size		d32DN25 - d450DN450
Jointing technology		Electrofusion
Nominal pressure[2]	16 bar, SDR11	d32DN25 – d110DN100
	10 bar, SDR17	d160DN150 – d450DN450
Temperature	Medium	-50 °C to +60 °C
	Environment	-30 °C to +60 °C
Insulation	Thermal conductivity $\lambda_{20°C}$ HE Foam PE jacket & inner pipe	0.022 W/mK (32-d110); 0.026 W/mK (d160-d450) 0.38 W/mK
	Density	≥ 70 kg/m^3
	Foam cell size	max. Ø 0.5 mm
	Nominal thickness GF-HE	40 mm
Mechanical strength (from insulation)	Axial shear strength 2)	≥ 0.12 N/mm^2
	Compressive strength	≥ 0.3 N/mm^2
Colour	Outer jacket	Black
Weight (without medium)	Pipe d32	1.41 kg/m
	Pipe d110	6.20 kg/m
	Pipe d225	16.6 kg/m
Oxygen diffusion at < 14.5° C	ISO 17455	≤ 0.32 mg/(m^2 d)
Fire classification		Normal combustibility
Environment	Stability	Moisture and vapor-tight
	Resistance	Weather resistant UV resistant
	Global warming potential GWP	≤ 0.01
	Ozone Depletion Potential ODP	Zero

1) All three materials are firmly bonded together.

2) at 20°C, Media Water

Specification		COOL-FIT 4.0
Standards and Guidelines	EN ISO 15494	Plastic piping systems for industrial applications – polybutene (PB), polyethylene (PE) and polypropylene (PP) – specifications for components and the piping system – metric series
	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
	EN ISO 13501-1	Fire classification of construction products and building elements
Product declarations	Greenbuildings	According to: DGNB 2015 DGNB 2012 BREEAM 2016 LEED 2009 LEED v4

1.3 Technical Details

1.3.1 COOL-FIT 4.0 Pipe and Fittings

COOL-FIT 4.0 Pipe

COOL-FIT 4.0 pipe are made from PE 100. The high efficiency GF-HE hard foam insulation exhibits a thermal conductivity λ of 0.022 W/mK (d32-d110) respectively 0.026 W/mK (d160-d450). The pipe are protected by an impact- and weather resistant PE jacket.

All three materials are firmly bonded in order to ensure good insulation properties and low thermal expansion or contraction for the system.

The pipe are available in 5 m lengths. The pipe have free, uninsulated ends, prepared already for the jointing with the COOL-FIT 4.0 fittings.

Pipe	Pipe	Outer jacket	Free pipe ends	Weight		Volume	Insulation thickness	Heat transfer coefficient (U)
				empty	with Water			
d x e (mm)	d_i (mm)	D x e1 (mm)	(mm)	(kg/m)	(kg/m)	(l/m)	(mm)	(W/m K)
32 x 2.9	26.2	90 x 3	36	1.41	1.95	0.54	26	0.13
40 x 3.7	32.6	110 x 3.4	40	2.05	2.88	0.83	31.6	0.14
50 x 4.6	40.8	110 x 3.4	44	2.22	3.53	1.31	26.6	0.18
63 x 5.8	51.4	125 x 3.8	48	2.99	5.06	2.07	27.2	0.21
75 x 6.8	61.4	140 x 4.0	55	3.76	6.72	2.96	28.5	0.23
90 x 8.2	73.6	160 x 4.0	62	4.82	9.07	4.25	31	0.24
110 x 10	90	180 x 4.0	72	6.50	12.86	6.36	31	0.28
160 x 9.5	141.0	250 x 5	90	9.95	25.56	15.61	40	0.37
225 x 13.4	198.2	315 x 6	110	16.60	47.45	30.85	39	0.50
250 x 14.8	220.4	355 x 5.1	123	18.18	56.31	38.13	47.4	0.49
280 x 16.6	246.8	400 x 6.3	126	22.63	70.44	47.81	53.7	0.48
315 x 18.7	277.6	450 x 6.4	133	28.41	88.9	60.49	61.1	0.48
355 x 21.1	312.8	500 x 7.4	148	35.36	112.17	76.81	65.1	0.49
400 x 23.7	352.6	560 x 8.4	150	44.06	141.66	97.60	71.6	0.50

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

Pipe	Pipe	Outer jacket	Free pipe ends	Weight		Volume	Insulation thickness	Heat transfer coefficient (U)
				empty	with Water			
d x e (mm)	d_i (mm)	D x e1 (mm)	(mm)	(kg/m)	(kg/m)	(l/m)	(mm)	(W/m K)
450 x 26.7	396.6	630 x 7.6	165	55.50	178.97	123.47	82.4	0.50

COOL-FIT 4.0 Fittings

General

The media fitting and insulation used for COOL-FIT 4.0 fittings fulfill the same specifications as the COOL-FIT 4.0 pipe. The COOL-FIT 4.0 fittings are based on ELGEF electrofusion fittings, which have been in use successfully for years. They provide an easy and safe connection.

The pre-insulated COOL-FIT 4.0 fittings are available in two types:

Type A

Electrofusion fitting with integrated heat coils for direct electrofusion pipe-to-fitting connections.

90° elbow and reducer as an example

Type B

Spigot fitting with free ends for electrofusion with COOL-FIT 4.0 electrofusion fittings.

Usefull functions

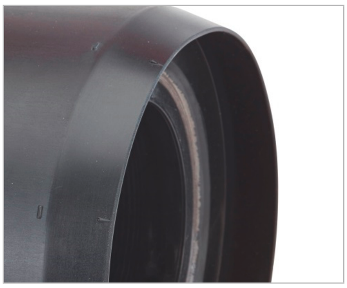
Fusion indicators

After the welding process, the indicator pin shows that energy has been applied to the welding zone.

Sealing lip at fittings Type A d32-d225

The sealing lip ensures a moisture-proof and vapour tight sealing of the insulation towards the outside.

On joining the fittings to the pipe, it's sealing mechanically. Due to this an additional sealing of the joints is not necessary.



Label

The fittings have abrasion-resistant marking.

Trace code

Relevant product data can be traced back to production via traceability codes.

Angle marking

By marking the ends of the fittings, connections between pipe and fittings can be optimally aligned.

Jointing

Pipe and Fitting

Type A fittings have integrated resistance wires, which are put under electric current during the welding operation through welding contacts on the fittings. This heats up the inside of the fitting and bonds the melting zone with the pipe.

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 4.0 fittings are usually connected by using a piece of COOL-FIT 4.0 pipe with free ends. For compact joints, the special COOL-FIT 4.0 barrel nipple with insulation can be used.

Two COOL-FIT 4.0 Type B fittings can be joined using an electrofusion fittings type A.

The direct connection of a COOL-FIT 4.0 fitting Type A and Type B is also possible.

Components

COOL-FIT 4.0 Electrofusion coupler

COOL-FIT 4.0 electrofusion couplers are used to connect pipe and components with free ends like type B fittings, valves and transition fittings.

COOL-FIT 4.0 Elbows 45° and 90°

(Refer to „General Information“ chapter above)

COOL-FIT 4.0 T90° equal and COOL-FIT T90° reduced

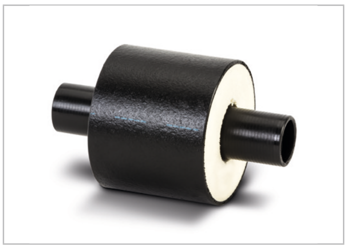
The equal and reduced type A 90° tees have, like the coupler, resistance wires for electrofusion. The central branches can be connected to the type A fitting, so all combinations are possible.

COOL-FIT 4.0 reducer

The COOL-FIT 4.0 reducer can be used to reduce the flow of the starting size by up to 3 to 5 sizes (e.g. from d225 up to d63).

COOL-FIT 4.0 barrel nipple (with insulation)

COOL-FIT 4.0 barrel nipple serves as a compact direct connector for type A fittings.



Combination of T90° and Reducer

If a reducer in a system is fitted behind a tee, either a COOL-FIT 4.0 T90° reduced or a COOL-FIT 4.0 T90° reduced/equal connected to a reducer should be used.

Run / Branch	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

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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 clamps

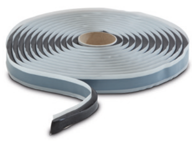
For vertical installations outdoors, sealing clamps mounted at the top lip of the fitting are recommended.

Sealing tape

As an alternative to the sealing clamps, the sealing tape with width 25mm is intended to be used for vertical installations outdoors, to seal the top lip of the fitting.

Transition of insulation

The Transition of insulation is used for a moisture-proof and vapour tight sealing of the interface of COOL-FIT 4.0 Fitting to COOL-FIT 2.0 pipe.

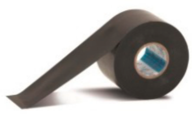


Cement

For frontal bonding of the insulations of transition fittings and flexible hoses.

Adhesive tape

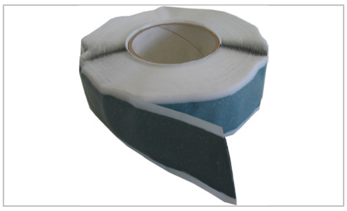
Optional for covering hand-cut faces as well as for bonding of the insulations of transition fittings to the insulation of flexible hoses.



Accessories for dimensions d250 - d450

Sealing tape

A roll of 40 mm wide butylene rubber-based sealing tape. For a water- and vapor-tight connection of inspection gaps with shrink sockets. The sealing tape is affixed to the circumference of the pipe or fitting.



Shrink socket

The shrink socket is used to water and vapor seal the inspection gap on the outer jacket and can seal only components with the same outside diameter. Functionality is ensured only in combination with the butylene-rubber sealing tape. This version provides additional mechanical strength with regard to bending forces. The socket shrinks uniformly, resulting in a good visual appearance. It can be shrunk with an open, soft flame.

End cap

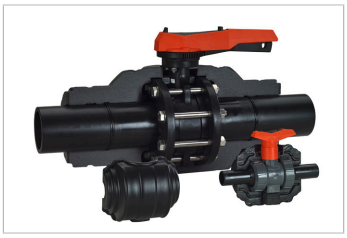
End caps are used to cap the pre-insulated system. They seal the PUR insulation and prevent moisture from entering. Sealing PUR is achieved by using a suitable sealant.

Sealant

The silicone-free sealant is used at the end of the pre-insulated system to seal the PUR insulation. It is used to cement the end caps.

COOL-FIT 4.0 Valves

The plastic valves designed for COOL-FIT 4.0 valves are based on Georg Fischer Piping Systems standard plastic valves. The valves are supplied including PE-/GF-HE insulation shells with a protective PE jacket. The sealing faces between the shells are vapor tight by their design. No additional tape or sealant is required.



Releasable plastic bands for sizes d32DN25 – d63DN50 and metal straps with tension locks for sizes d75DN65 – d225DN200 permit the pre-insulated shells to be fitted to and removed from the valves easily, allowing easy maintenance.

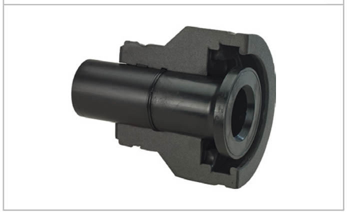
The insulated ball valve in ABS is available in sizes d32DN25 – d90DN80. For the sizes d110DN100 – d225DN125, butterfly valves kits are available that consist of butterfly valve, flange adaptor, backing flange PP-St, screw-kits and insulation half shells.
Both valve types are available either as manually operated or electric actuated version.

The electric actuators used feature following benefits:

- Position feedback via relais (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 4.0 transition fittings, flange joints

Transition fittings and flange connectors enable connections to different systems in either metal or plastic, such as the Georg Fischer systems iFIT or Sanipex MT. The components are supplied including PE- insulation half shells with a protective PE jacket. The sealing faces between the shells are vapor tight by their design. No additional tape or sealant is required.



	Size	Material	Thread type/ connector/bolt circle
Adaptor fitting to metal	d32 – d63 ½" – 2"	PE – stainless steel	male thread (R, NPT), female thread (Rp, NPT), loose nut (G)
Adaptor Fitting to iFIT or Sanipex MT	d32	Stainless steel / Brass	iFIT, Sanipex MT
Unions	d32 – d63 d32 – d110	PE – PE, PE – ABS	Welding spigots cementing sockets
Flange Adaptor (flange joints)	d32 – d225	PE	Suitable for Bolt circle PN 16/10

COOL-FIT 4.0 flex hoses

The flexible hoses in EPDM permit mobile access to devices such as chillers and fan coils. In addition to this the flex hose are compensating expansion or contraction within the system. The tear-resistant protective jacket and NBR insulation ($\lambda_{10°C}$ ≤ 0.035 W/mK) ensure the temperature of the cooling medium remains unchanged. Versatile connectivity options mean that system connection is ensured:
G thread (male thread + loose nut including gasket)

COOL-FIT 4.0 Installation fittings type 313

Installation fittings are used to install various types of sensors to the system. Pressure or temperature sensors can be connected using the ½ "or ¾" Rp or NPT female thread.

The insulation is comprised of highly efficient GF-HE foam with excellent insulating capabilities.

1.3.2 COOL-FIT Tools

Electrofusion Machines

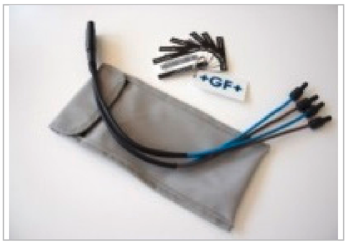
Electrofusion machines are required to join COOL-FIT 4.0 components. The range includes dedicated and multipurpose electrofusion machines which are reliable and easy to use.

Georg Fischer Piping Systems recommends: MSA-Series electrofusion machines.

Long Fusion adaptors

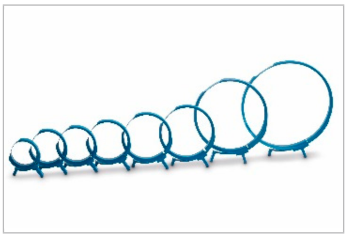
Long Fusion adaptors serve as an extension of the fusion plugs of electrofusion machines. Compared to standard adaptors, the longer adaptor length matches the insulation of the COOL-FIT 4.0 electrofusion Fittings. The long fusion adapters are needed for electrofusion of fittings
d ≥ d160/D250

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 4.0 assembly aids are used for an easy mounting of COOL-FIT 4.0 Fitting on COOL-FIT 4.0 pipe. The assembly aid splays the pre-stressed sealing lips of the fittings enabling the easy insertion of the COOL-FIT 4.0 pipe.

Foam removal tool and peeling tool – manually operated

The foam removal tool is used to prepare shortened COOL-FIT 4.0 pipe for electrofusion. The tool removes the foam and cuts outer jacket, and also peels the surface of the inner pipe. Any oxide layer present is removed when the welding zone is treated.The tool is available in two versions:

1. for sizes d32 – d90,
2. for sizes d110 – d225.
3. for sizes d250 – d450.

Powered foam removal and peeling tool

The powered foam removal tool is also used to prepare shortened COOL-FIT 4.0 pipe for electrofusion. Due to the compatibility to commonly used drill drivers, it serves a comfortable and powersaving supplement to the manually operated tool.

The tool is available as a kit for the sizes d32-d63.

Clamping tool

The fusion process gives rise to forces that can pull the pipe out of the coupler. Therefore it is recommended that the assembly should be fitted with COOL-FIT installation clamps. This prevents movement during the welding and cool-down process.
The central 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. The linkage is made of galvanized steel. Tension bands are included and a T-adapter is optional available.

1.4 Dimensioning and Design

1.4.1 General information about the dimensioning and installation of plastic piping

Plastics have different physical characteristics to metals. When designing and installing thermoplastic piping systems, this needs to be taken into account. Although PE and COOL-FIT 4.0 are very robust systems, 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 which are subjected to very rigorous demands, such as optimized insulation properties in 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 technical documentation. In the professional production of plastic piping systems, for example, piping systems must be able to move to accommodate changes in length caused by temperature and pressure changes. To allow for these changes in length, the use of pipe holders that permit this movement is vital.

The following technical information contains the basic information needed to ensure an economical and trouble-free installation. However, this chapter does not contain all of the details. For more information, or if you have specific questions, please call your local Georg Fischer Piping Systems representative. Additional information is available on the official Georg Fischer Piping Systems website.

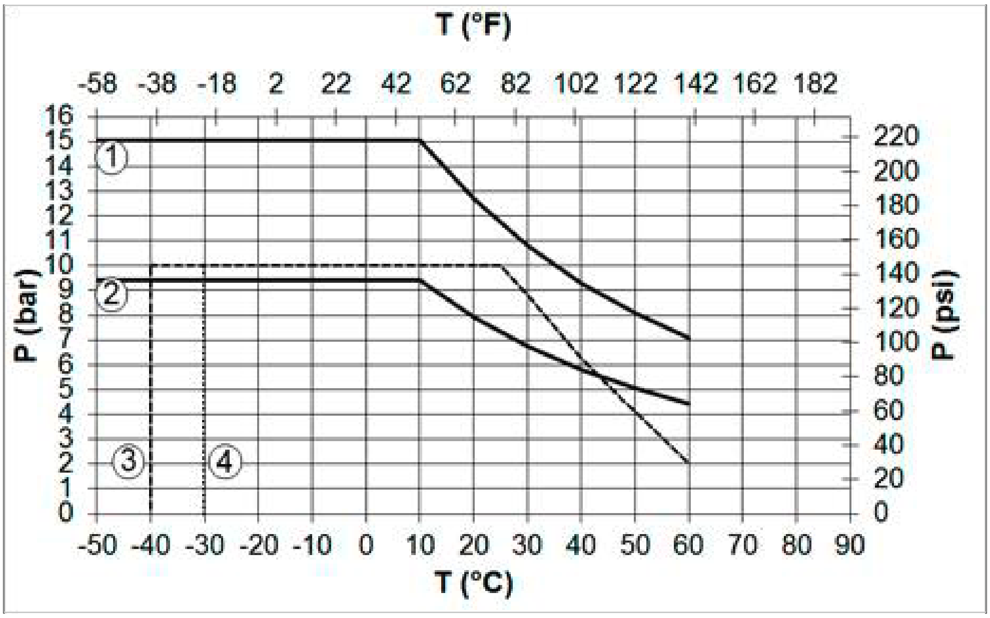
1.4.2 COOL-FIT 4.0 pressure-temperature diagram

The pressure resistance for thermoplastic pipe for water is always specified at +20 °C. At higher temperatures allowance must be made for a lower maximum operating pressure.

The graph shows the maximum permissible pressure for COOL-FIT 4.0 pipe and fittings at various temperatures, up to the maximum permissible media temperature of +60 °C. The graph is based on an ambient temperature of +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 4.0 pipe, fittings, valves – water as secondary refrigerant

Limits for COOL-FIT 4.0: 25-year values allowing for the safety factor 1.6 (with water as the secondary refrigerant).



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

① COOL-FIT 4.0 Pipe and fitting d32 – d110, C1.6, SDR11
② COOL-FIT 4.0 Pipe and fitting d160 – d450, C1.6, SDR17
③ COOL-FIT 4.0 Ball valve PN10
④ COOL-FIT 4.0 Butterfly valve PN10

Influence of secondary refrigerants with antifreeze additives

At media temperatures below 0 °C, antifreeze must be used in the water to prevent it from freezing during a plant shut-down.

COOL-FIT 4.0 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 4.0 Pipe and Fitting	COOL-FIT 4.0 Valves
Inorganic brine solutions	F = 1	F = 1
Organic salt solutions	F = 1	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 4.0 can be used with glycol solutions with concentrations up to 50%. The chemical resistance of COOL-FIT 4.0 systems is suitable for the following antifreeze 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 4.0 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 4.0 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 4.0 can be used with the media below. The manufacturer's instructions must be followed.

Brand name	Manufacturer	Type
Antifrogen KF	Clariant	Brine
Zytrec S-55	Frigol	Brine
Temper1)	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".

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1.4.3 Polyethylene (PE)

The dominant material for the COOL-FIT 4.0 system is polyethylene (PE). As the inner pipe which comes into contact with the media is made of PE-100, its properties are of particularly high relevance.

Properties of PE (approximate)

Property	PE 100-value[1]	Unit	Testing standard
Density	0.95	g/cm^3	EN ISO 1183-1
Yield stress at 23 ° C	25	N/mm^2	EN ISO 527-1
Tensile modulus at 23 ° C	900	N/mm^2	EN ISO 527-1
Charpy notched impact strength at 23 ° C	83	kJ/m^2	EN ISO 179-1/1 eA
Charpy notched impact strength at -40 ° C	13	kJ/m^2	EN ISO 179-1/1 eA
Crystallite melting point	130	°C	DIN 51007
Thermal conductivity at 23 ° C	0.38	W/m K	EN 12664
Water absorption at 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

All polymers made from hydrocarbons of the formula CnH2n are constructed with a double bond (ethylene, propylene, butene-1, isobutene) are referred to collectively as polyolefins. Among them is polyethylene (PE). It is a semi-crystalline thermoplastic. Polyethylene is probably the best known plastic. The chemical formula is: -(CH2-CH2)n. Polyethylene is an environmentally friendly hydrocarbon product. PE, like PP, is a non-polar material. Therefore, it is insoluble and scarcely swellable in conventional solvents. PE pipe cannot therefore be adhesively bonded to fittings. Welding is the appropriate connection method for the material.

The most widespread in piping system construction is PE for use in underground gas and water pipe. In this area polyethylene has become the dominant material in many countries. However, the advantages of this material mean that it is also used in domestic installations and industrial piping.

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

Because of the black pigments used, polyethylene is very weather resistant. Even at long exposure to direct sunlight, wind and rain the material can be used without restrictions.

Chemical resistance

Polyethylene exhibits good resistance to a wide range of media. For detailed information, please see the detailed chemical resistance list from Georg Fischer Piping Systems, or contact the person responsible at Georg Fischer Piping Systems directly.

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. For many applications, PE has proven especially advantageous with metals.

Thermal and electrical properties

Operating limits

The application limits of the material depend on both embrittlement and softening temperatures and on the manner and method of application. Details are provided in the relevant pressure-temperature charts.

Electrical properties

Polyethylene, 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.

V

1.4.4 Fire behavior and fire prevention measures

Polyethylene is a flammable plastic. The oxygen index is 17 %. PE drips and continues to burn without soot after the flame is removed. When PE burns, carbon dioxide, carbon monoxide and water are primarily formed.

GF HE foam foam will burn if exposed to flames. The combustibility characteristics vary with its chemical composition. Unlike expanded polystyrene (eps), GF HE does not melt. It ignites between 800 °C and 850°C, and chars. The charring may help protect adjacent foam.

Fire load

d/D (mm)	32/90	40/110	50/110	63/125	75/140	90/160	110/180	160/250	225/315
Fire load COOL-FIT 4.0 Pipe (kWh/m)	15.1	21.9	24.3	33.1	41.8	53.7	69.7	110.4	188.5

d/D (mm)	250/355	280/400	315/450	355/500	400/560	450/360
Fire load COOL-FIT 4.0 Pipe (kWh/m)	208.16	258.57	324.32	404.58	504.27	634.82

Fire prevention classes EN13501-1 and British building codes

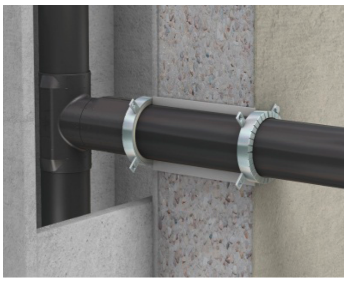
	COOL-FIT 4.0	COOL-FIT 4.0/mineral wool[2]
		
EN 13501-1	E	A2L
VKF	RF3cr*	RF1
BS 5422:2009[1]	National Class 3	National Class 0

1 Test method according to BS 476-6 and BS 476-7
2 Type: Rockwool 800
* RF3 for d>=d160mm

Fire collars

In order to carry flammable pipe through fire protection bulkheads without compromising its safety function, fire protection sleeves must be used in accordance with local requirements and legislation.

Following Fire collar solutions have an approval according to the European technical Approval ETA for COOL-FIT 4.0



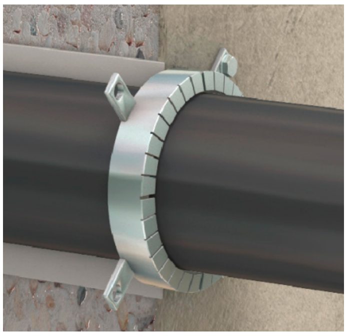
Fire collar	Manufacturer	Approval	Dimensions
ROKU ® AWM II	Rolf Kuhn GmbH	ETA 11/0208	d32 - d90
BIS Pacifyre ® AWM II	Walraven	ETA 11/0208	d32 - d90
CP644	Hilti	ETA 10/0404	will follow

System description

The above listed collars consist of a metal enclosure lined with multilayer, highly effective intumescent material. In the event of fire, the material expands with high pressure thus seals the opening hermetically against flames and smoke. For wall installations one pipe collar each side of the wall, for ceiling installations one collar at the underside of the collar must be provided.

Applications

- Sealing of plastic pipe up to max. 400 mm outside diameter in solid walls, drywall partitions and solid ceilings
- Sustainable for plastic pipe, fibre reinforced plastic-, and plastic multilayer pipe
- Suitable for insulated and uninsulated plastic pipe and sound-isolated wastewater pipe



Minimal distances

Opening size	≤ 20 x 20 cm	≤ 40 x 40 cm	> 40 x 40 cm
against other pipe penetration systems	10 cm	10 cm	20 cm
against other openings	10 cm	20 cm	20 cm

Solutions for emergency corridors

Within emergency corridors the use of only non-combustible materials is allowed. The supplier Rockwool offers with Rockwool 800 a protection sleeve, made of mineral wool, which allows the use of normal combustible pipe within emergency areas. This solution is approved on pipe outer diameters of up to 160 mm.

For detailed information about Rockwool 800 see: www.rockwool.de

V

1.4.5 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 4.0 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 power

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

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

di 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

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

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.

Liquids

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

di (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

1.4.6 Nomogram for easy calculation of diameter and pressure loss

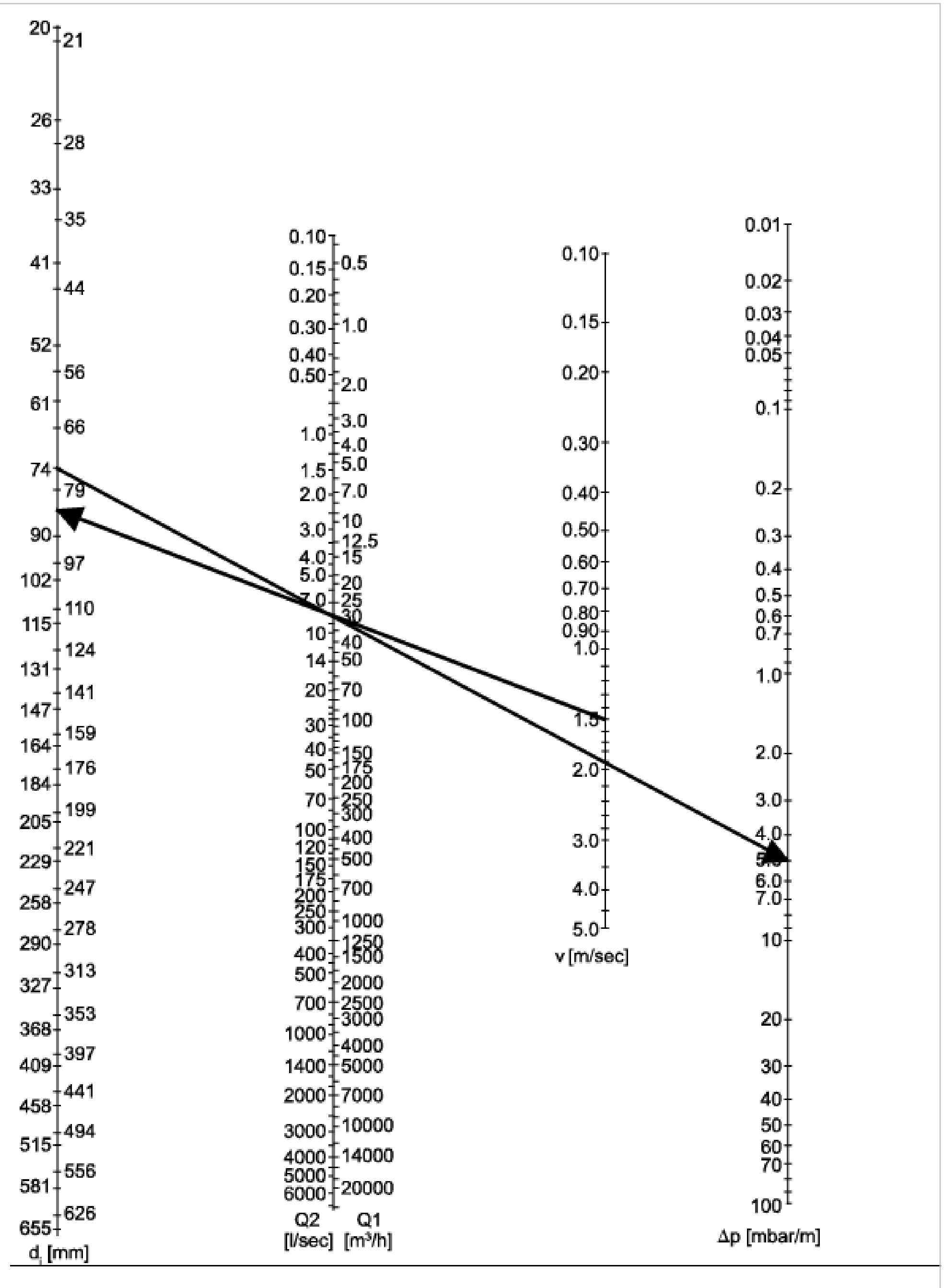
The nomogram below can be used to simplify the determination of the diameter required .The pressure loss in the pipe can be read off per meter of the pipe length.

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 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 di (≈ 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 4.0 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".

1.4.7 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 such as lubricating oils. In most applications, thus 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	
T-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. Usually the part of a T in the overall pressure loss is very small, therefore in most cases ζ = 1.3 can be used.

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/m^3 ($1\ g/cm^3 = 1000\ kg/m^3$)

Pressure losses 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:

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

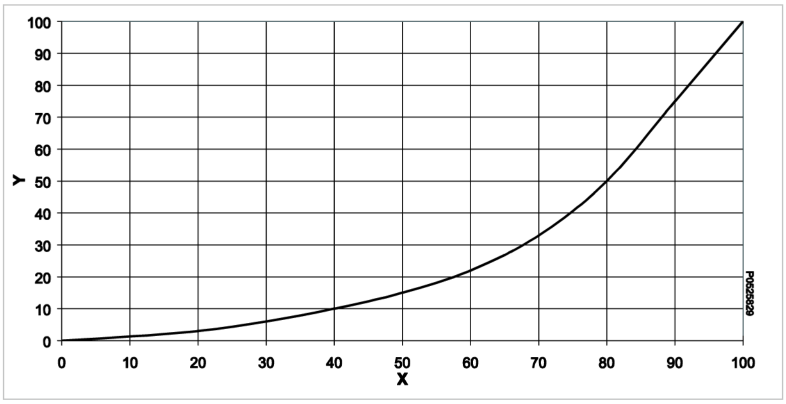
Δp_{Ar}	Pressure loss for the valve (bar)
Q	Flow rate (m^3/h)
ρ	Density of the conveyed medium (kg/m^3) ($1\ g/cc = 1000\ kg/m^3$)
k_v	Valve characteristic value (m^3/h)

k_v 100-Werte

DN (mm)	Zoll (inch)	d (mm)	k_v 100 (l/min)	Cv 100 (gal/min)	k_v 100 (m^3/h)
25[1]	1	32	700	49.0	42
32[1]	1 ¼	40	1000	70.0	60
40[1]	1 ½	50	1600	112.0	96
50[1]	2	63	3100	217.1	186
65[1]	2 ½	75	5000	350.0	300
80[1]	3	90	7000	490.0	420
100[2]	4	110	6500	455	390
150[2]	6	160	16600	1162	1000
200[2]	8	225	39600	2772	2380

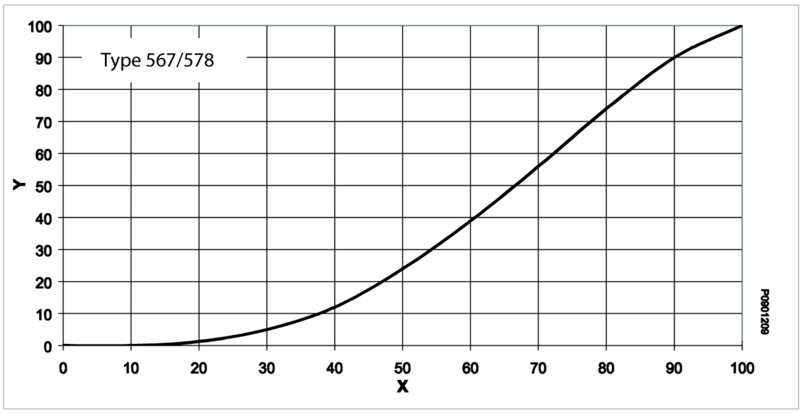
[1] COOL-FIT 4.0 Ball valve
[2] COOL-FIT 4.0 Butterfly valve

Flow characteristic Ball valve



X Opening angle (%)
Y k_v, Cv value (%)

Flow characteristic butterfly valve



X Opening angle (%)
Y k_v, Cv value (%)

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 4.0 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:

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

V

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

1.4.8 Dimension comparison COOL-FIT 4.0 metal

COOL-FIT 4.0			Stainless steel	
d (mm)	d_i (mm)	DN	inches	da (mm)
32	26.2	25	1	33.7
40	32.6	32	1 ¼	42.4
50	40.8	40	1 ½	48.3
63	51.4	50	2	60.3
75	61.4	65	2 ½	75.3
90	73.6	80	3	88.9
110	90	90	4	114.3
160	141.0	150	6	168.3
225	198.2	200	8	193.7
250	220.4	250	10	244.5
280	246.8	250	10	273.0
315	277.6	300	12	323.9
355	312.8	350	14	355.6
400	352.6	400	16	406.4
450	396.6	450	18	457.0

d Nominal external diameter of PE pipe
d_i Nominal internal diameter of pipe

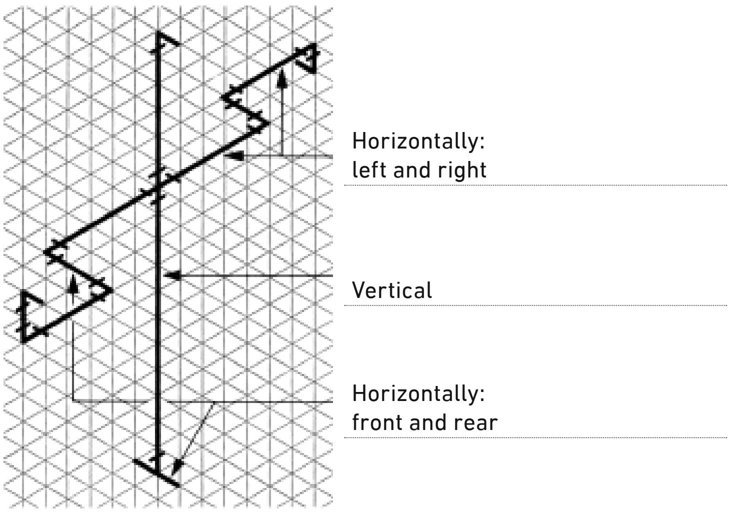
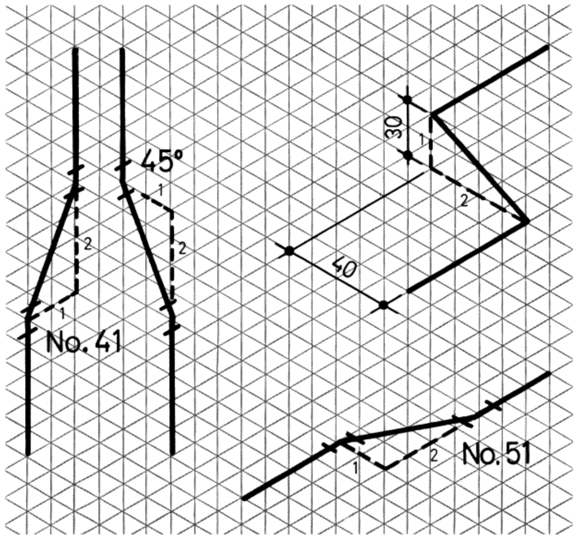
1.4.9 Z-dimension method

Overview

The pressure of competition and high wages makes it essential to install piping systems efficiently. The Georg Fischer Piping Systems method of assembly is highly suited to this task. It replaces the tedious and time-consuming cutting to size of one pipe at a time by a fast and precise way of preparing whole groups of pipe according to plans or jigs.

The respective pipe group with the corresponding design dimensions and cut lengths can be entered in the isometric paper of Georg Fischer Piping Systems, see Measuring SheetSeite 32.

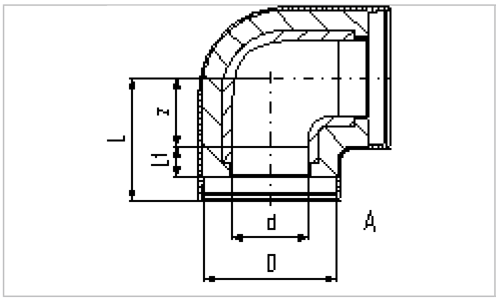
Please adhere to the following guidelines for drawing:

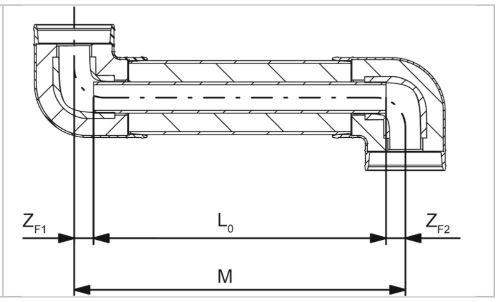
Pipe running perpendicular to one another	Pipe running diagonally
	

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 catalogues 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.

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

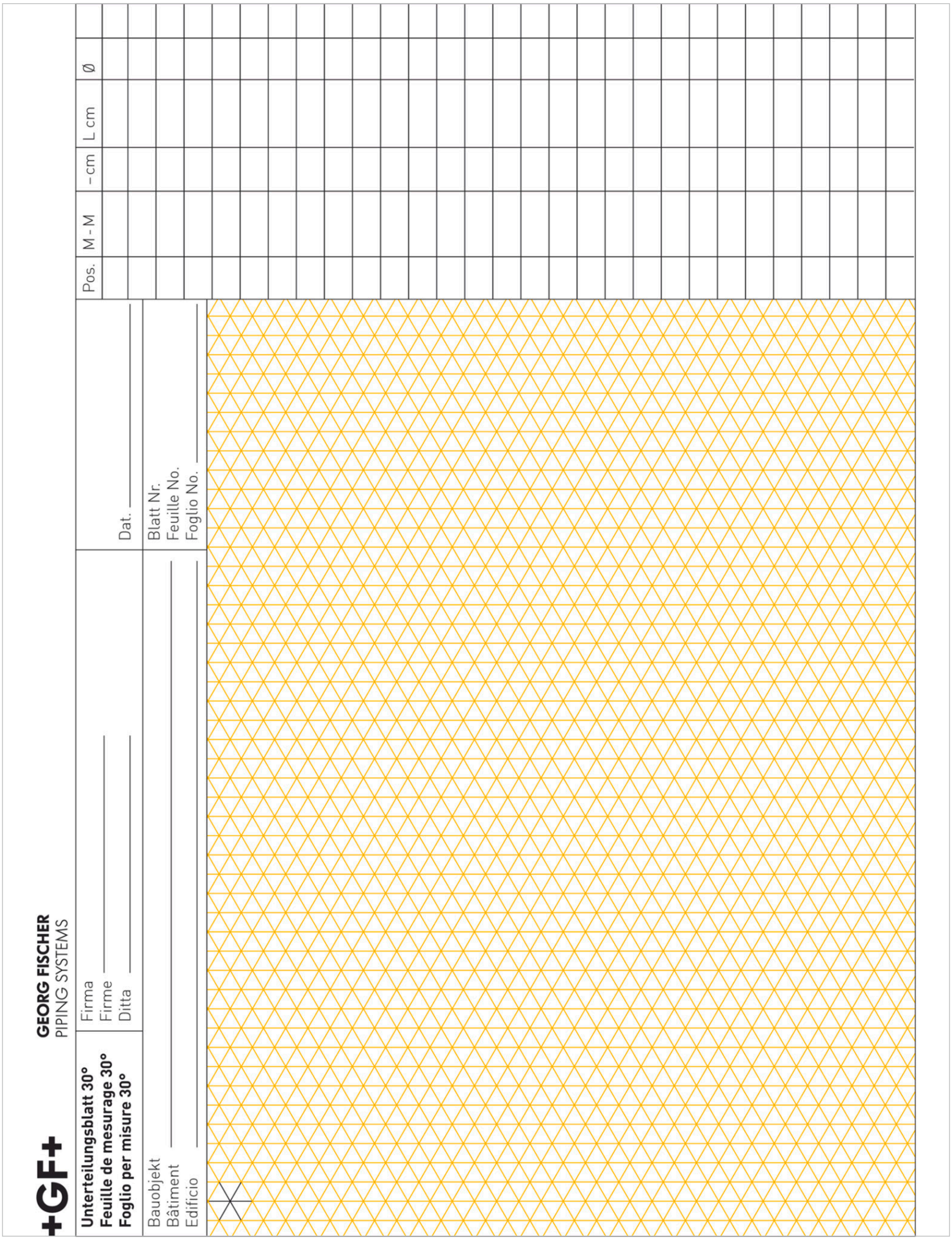
Example

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



1.4.10 Length changes and flexible sections

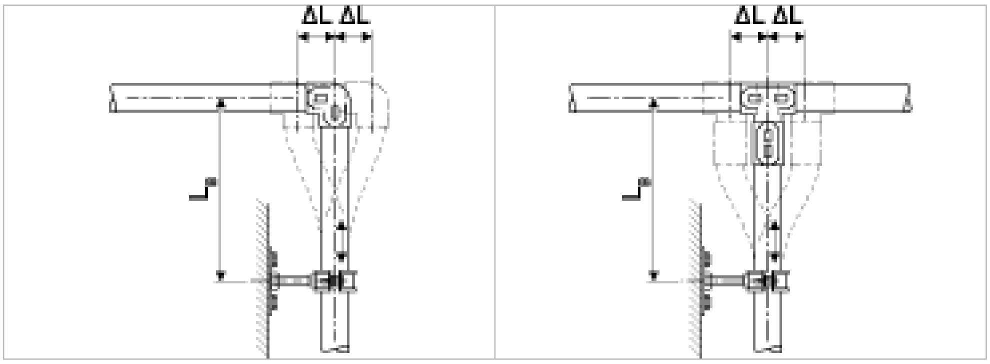
Overview

Length changes ΔL and expansion bend L_B – General

Thermoplastics are subject to greater thermal expansion and contraction than metallic materials. Pipe installed above ground, against walls or in ducts, require changes in length to be taken up in order to prevent any superimposed extra strain on the pipe. This applies especially to pipe exposed to operating temperature variations.

To accommodate a change in length, the following options can be considered:
A Flexible sections
B Flexible hoses
C Compensators

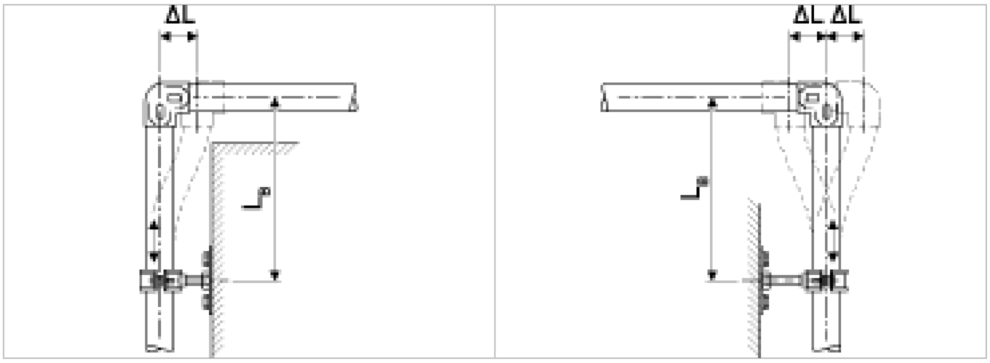
Flexible sections are the most common, the simplest and the most economical solution. The calculations for and the positioning of flexible sections are therefore described in detail.



ΔL Change in length
L_B Flexible section

Fundamentals

The low elasticity of thermoplastics allows changes in length to be taken up by special pipe sections, where pipe supports are positioned so that they can take advantage of the natural flexibility of the material. The length of such sections is determined by the diameter of the piping system and the extent of the thermal expansion to be compensated.



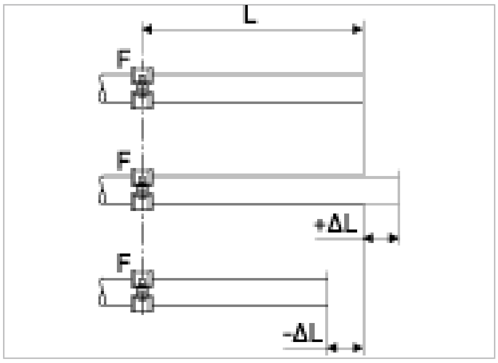
Flexible sections arise naturally at any branching or change in direction of the piping system. The movement L_B of the flexible section as a result of a change ΔL in the length must not be restrained by fixed pipe brackets, wall protrusions, girders or the like.

Calculation of length changes

To determine the **change in length due to temperature** ΔL (mm) of COOL-FIT 4.0 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	25 °C
Min. ambient temperature	25 °C constant
Max. ambient temperature	25 °C constant
Min. flow temperature	See table
Max. flow temperature	25 °C

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

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

L Laid pipe length

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

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

L Laid pipe length

Length change ΔL (mm) at 0° C flow temperature					Length change ΔL (mm) at -5° C flow temperature				
L (m)	**25**	**50**	**100**	**150**	**L (m)**	**25**	**50**	**100**	**150**
d32 mm	-30	-60	-121	-181	d32 mm	-37	-75	-150	-225
d40 mm	-33	-65	-131	-196	d40 mm	-41	-81	-162	-243
d50 mm	-42	-85	-169	-254	d50 mm	-52	-104	-208	-313
d63 mm	-47	-95	-190	-285	d63 mm	-58	-116	-233	-349
d75 mm	-51	-102	-205	-307	d75 mm	-63	-125	-250	-375
d90 mm	-56	-112	-224	-336	d90 mm	-68	-137	-273	-410
d110 mm	-62	-124	-247	-371	d110 mm	-75	-150	-300	-449
d160 mm	-58	-115	-230	-346	d160 mm	-70	-140	-280	-421
d225 mm	-63	-127	-254	-381	d225 mm	-77	-154	-307	-461

L Laid pipe length

Length change ΔL (mm) at -10° C flow temperature					Length change ΔL (mm) at -15° C flow temperature				
L (m)	**25**	**50**	**100**	**150**	**L (m)**	**25**	**50**	**100**	**150**
d32 mm	-45	-90	-180	-270	d32 mm	-53	-106	-211	-317
d40 mm	-49	-97	-195	-292	d40 mm	-57	-114	-228	-342
d50 mm	-62	-124	-245	-373	d50 mm	-72	-145	-289	-434
d63 mm	-69	-138	-276	-414	d63 mm	-80	-160	-320	-481
d75 mm	-74	-148	-296	-445	d75 mm	-86	-171	-343	-514
d90 mm	-81	-161	-322	-483	d90 mm	-93	-186	-372	-558
d110 mm	-88	-176	-352	-528	d110 mm	-101	-202	-405	-607
d160 mm	-83	-165	-331	-496	d160 mm	-95	-190	-381	-571
d225 mm	-90	-180	-361	-541	d225 mm	-104	-207	-414	-621

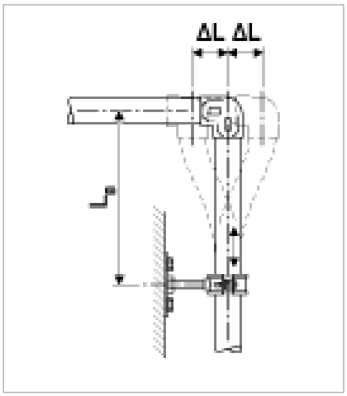
L Laid pipe length

COOL-FIT 4.0 Flexible sections for COOL-FIT 4.0

Flexible Section L_B

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

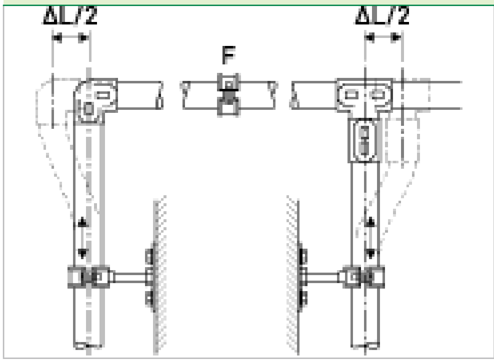
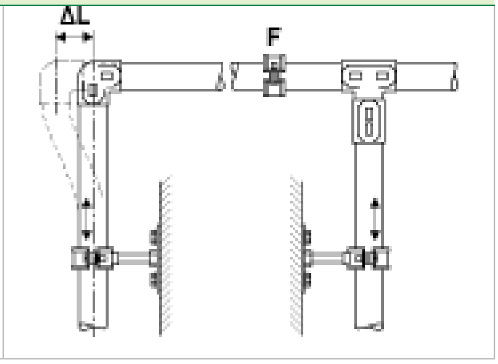
Flexible section L_B (cm)													
ΔL (mm)	**10**	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**100**	**150**	**200**	**300**
d32 mm	78	110	135	156	174	191	206	221	234	247	302	349	427
d40 mm	86	122	149	172	193	211	228	244	259	273	334	386	472
d50 mm	86	122	149	172	193	211	228	244	259	273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



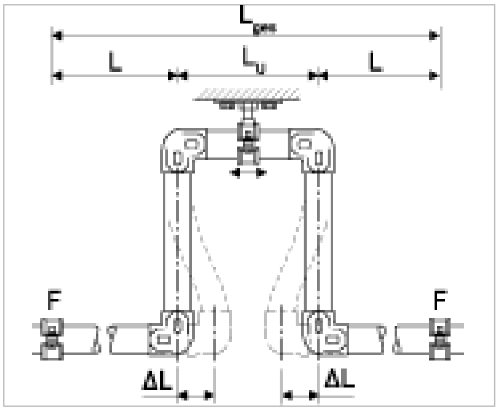
1.4.11 Installation

Recommendations for installation

Length changes in pipe sections should always be accommodated through the arrangement of fixed brackets. 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 take up 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 taken up. 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-tensioning

In particularly difficult situations with large changes in one direction only, it is possible to pre-tensioning the flexible section during installation and thereby shorten its length LB, as illustrated in the next example:

Example

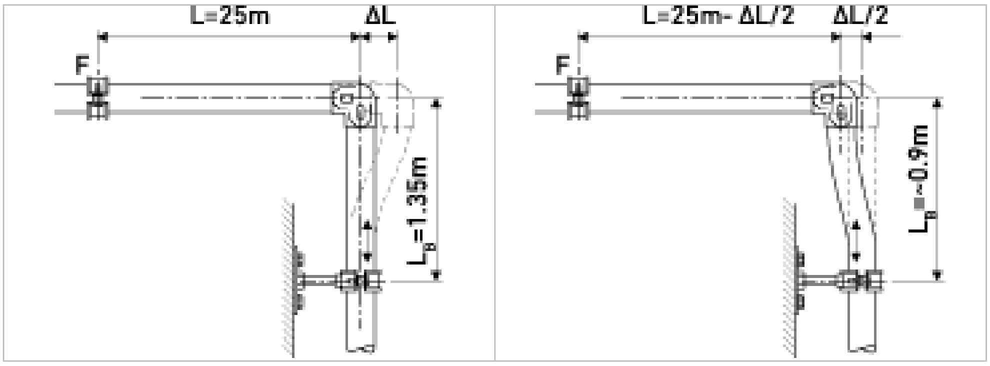
Pipe length L	25 m
Diameter	d225/D315 mm
Installation temperature	25 °C
Min ambient temperature	25 °C constant
Max ambient temperature	25 °C constant
Min flow temperature	10 °C
Max flow temperature	25 °C

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-tensioned to ΔL/2, the flexible section required is reduced to ~2060 mm. The change in length starting from the 0 position is then +/- ΔL/2 = 39/2 = 19.5 mm.

By pre-tensioning 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.



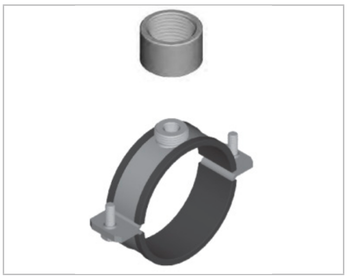
1.4.12 Pipe bracket spacing and support of piping systems

Overview

Installation of plastic pipe

COOL-FIT 4.0 pipe should be installed using supports designed for use with plastics and should then be installed taking care not to damage or overstress the pipe. Specifically COOL-FIT 4.0 must be installed in order to allow stress-free operation.

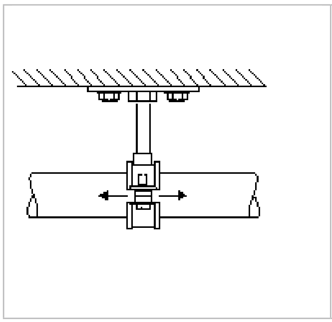
Thanks to the excellent insulating properties of the COOL-FIT 4.0 pipe and its hard, impact resistant outer jacket, standard pipe clamps with hard plastic inlay may be used. Special insulation pipe clamps or cold clamps are not necessary.



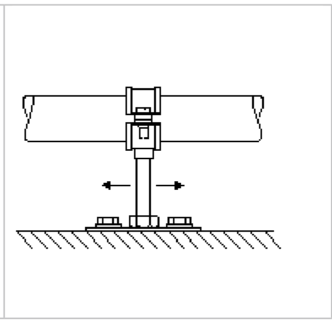
Arranging loose brackets

What is a loose bracket?

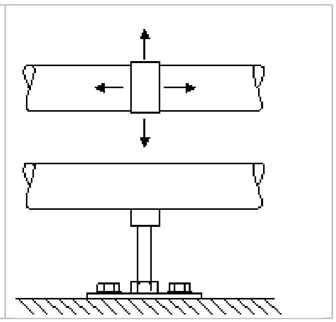
A loose bracket is a pipe bracket which allows axial movement of the pipe. This allows stress-free compensation of temperature changes and compensation of any other operating condition changes.



Axial displacement of the pipe in the clamp.



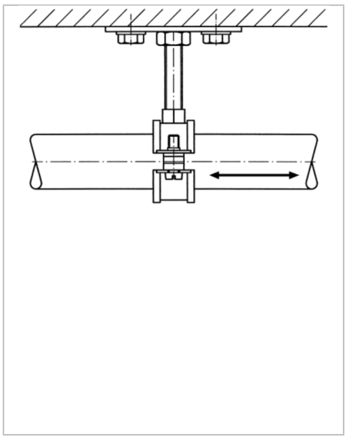
Pipe clamp fitted rigidly to the pipe, axial displacement in the suspension of the pipe clamp.



Displacement of the pipe in 2 axes.

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.

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



Spacers prevent pinching the pipe

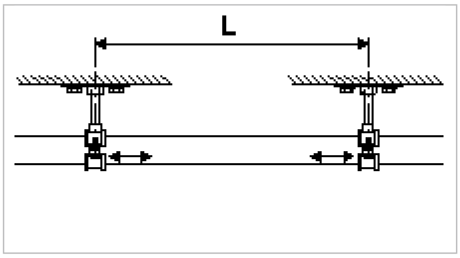
The axial movement of the piping may not be hindered by fittings arranged next to the pipe bracket or other diameter changes.

Sliding brackets and hanging brackets permit the pipe to move in different directions. Attaching a sliding block to the base of the pipe bracket permits 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.

Pipe bracket spacing

The pipe bracket spacing have been determined for conveying water on the basis of a specific deflection of the pipe between two clamps considered acceptable.

The pipe bracket spacing for COOL-FIT 4.0 pipe is always consistent independent of pressure and temperature.



L Pipe bracket spacing

Pipe bracket intervals L for COOL-FIT 4.0

d/D (mm)	32/90	40/110	50/110	63/125	75/140	90/160	110/180	160/250	225/315
L (mm)	1800	1950	1950	2000	2100	2150	2300	2600	2850

d/D (mm)	250/355	280/400	315/450	355/500	400/560	450/630
L (mm)	3300	3500	3700	3900	4100	4300

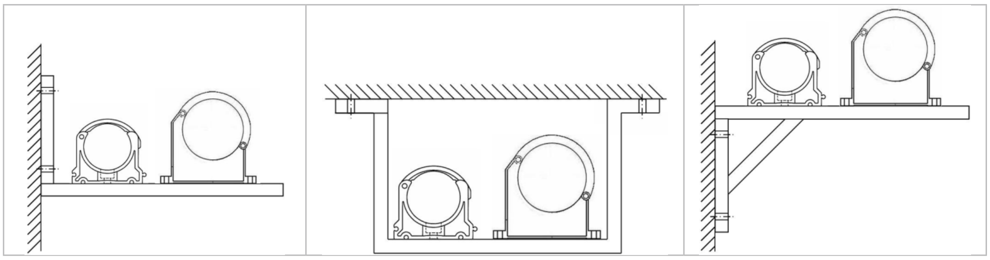
The pipe clamp intervals from the table can be increased by 30% for vertical pipe. Multiply the values given by 1.3 in this case.

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!

From d90 upwards KLIP-IT pipe clamps must be mounted upright, as in the installation examples below.



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 elongation 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 mounted firmly to be able to take up the forces arising from changes in length in the piping system. Hanging brackets or KLIP-IT pipe brackets are unsuitable for use as fixed points.

COOL-FIT 4.0 Fixpoint

Fixed points for COOL-FIT are established with the special COOL-FIT fixed points. The product consists of fusion tapes and pipe brackets. Electrofusion bands as permanent joints transmit the forces that occur in the pipe to the fixed point. The supplied pipe brackets serve to build up the fusion pressure during installation of the fusion bands and provide stability during operation. For fusion, use an MSA 2.x, MSA 4.x, MSA 250, 300, 350, 400 or commercially available 220-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.

Please take note of the maximum allowed forces in the table below.

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 (kN)	2.0	3.0	5.0	8.0	10	10	10	10.0	10.0	10.0

COOL-FIT 4.0 fixed points must be calculated on the basis of the application. Fixed point brackets and cross braces are not included.

Scope of delivery

① Clamps to maintain fusion pressure
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 tapes always come in pairs, Y-cables allow for a simultaneous fusion process, cutting fusion time in half.

Rigidly fixed installations

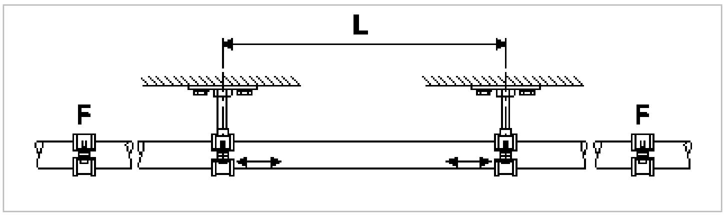
Pipe which are axially clamped and rigidly fixed must be tested for their resistance to kinking. In most cases, this test results in a reduction of the maximum internal pressure and more tightly spaced supports. The forces acting on the fixed points should be considered.

COOL-FIT 4.0 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	25 °C
Min. ambient temperature	25 °C constant
Max. ambient temperature	25 °C constant
Min. flow temperature	See table
Max. flow temperature	25 °C



Fixpoint forces F and maximal pipe bracket spacing L at 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 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 -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
Fixoint forces F and maximal pipe bracket spacing L at -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

1.4.13 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 hindered.
- During operation, hose loines 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 screwed together.

Proper use of the hose line

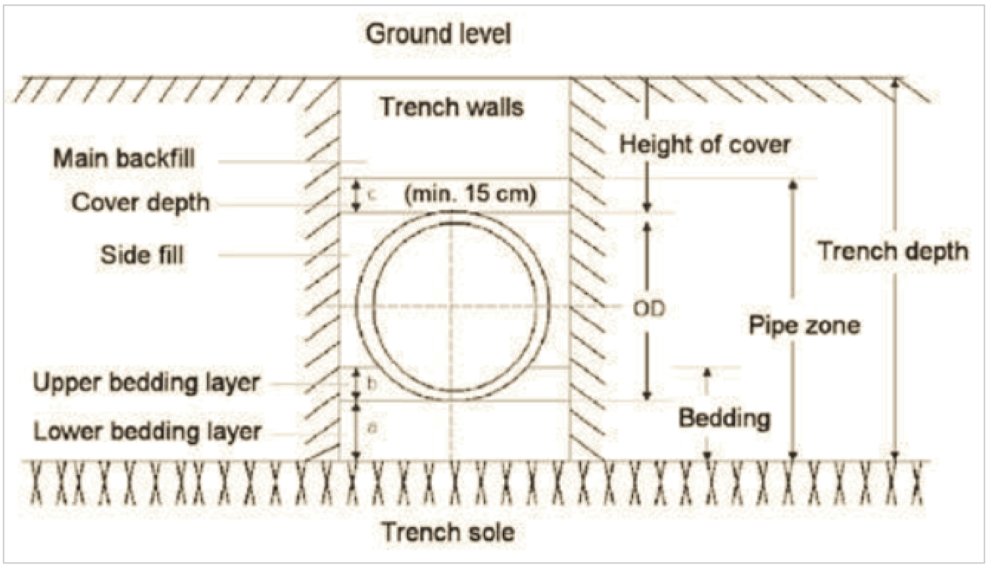
- Pressure: do not exceed maximum permitted working pressure and operating vacuum
- Temperature: do not exceed maximum permitted temperature for the medium

Storage

- Store in a cool, dry and dust-free area; avoid direct sunlight or ultraviolet irradiation; protect 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.

1.4.14 Underground installation

COOL-FIT 4.0 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 if there is a risk of frost. 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 = 150 mm 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 DN ≤ 200

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 4.0 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 150 mm above the pipe apex or 100 mm above the pipe connection. Ensure that the pipe is not damaged when the cover and main backfill are filled and compacted.

COOL-FIT 4.0 pipe have a higher degree of stiffness and a higher weight than non-insulated pipe. For this reason, the pipe should always be connected in the trench. Unnecessary stress on the COOL-FIT 4.0 jointing elements is 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.

1.4.15 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 exterior temperature
- Pipe dimensioning
- Pressure loss
- Dew point/ insulation thickness
- Pipe bracket spacing
- Freezing time
- 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

1.5 Jointing and Installation

1.5.1 Jointing of COOL-FIT 4.0

For general information on electrofusion, see Planning Fundamentals chapter "Jointing 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 -10 °C to 45 °C. National regulations must be observed. In direct sunlight, shielding of the welding area can help to 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 electrofusion machine and the welding area.

Executing electrofusion

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. Only Tangit PE cleaner must be used for cleaning.

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

Jointing d32 – d225

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

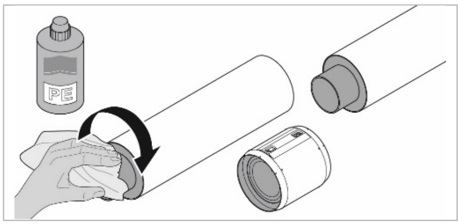
If necessary, prepare the pipe for fusion joints using the Foam removal tool (foam removal, cutting the jacket and peeling the media pipe) and check afterwards that the shaving thickness is 0.2 – 0.4 mm and that the minimum permissible external diameter after peeling is met:

- **COOL-FIT 4.0 Valves und COOL-FIT 4.0 Fittings d32 – d225 (Type B, barrel nipple and transition fittings) don't need to be peeled.**

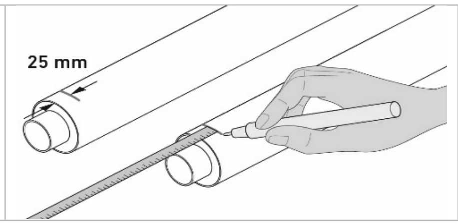
Minimum permitted pipe external diameter after peeling for COOL-FIT 4.0

d/D (mm)	32/90	40/110	50/110	63/125	75/140	90/160	110/180	160/250	225/315
Min. d (mm)	31.5	39.5	49.5	62.5	74.4	89.4	109.4	159.4	224.4

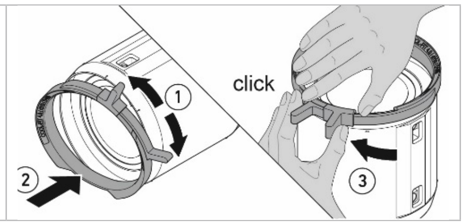
2. Cleaning and installation for welding preparation



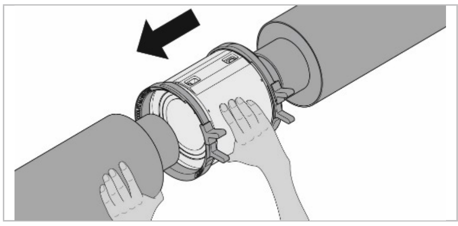
Step 1
Clean the fusion area of the components with Tangit PE cleaner and lintfree colourless and clean cloth in circumferential direction.



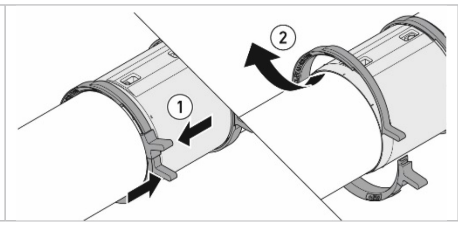
Step 2
Mark the jacket pipe at a distance of 25 mm



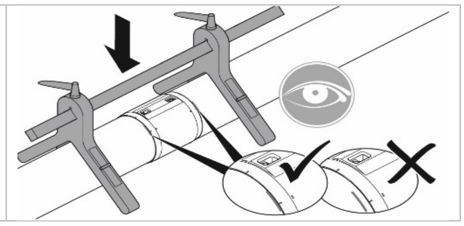
Step 3
Mount the assembly aids on the sealing lips of the COOL-FIT 4.0 fitting



Step 4
Insert pipe in pipe brackets and align free of stress. Push fitting up to the limit stop on the pipe.

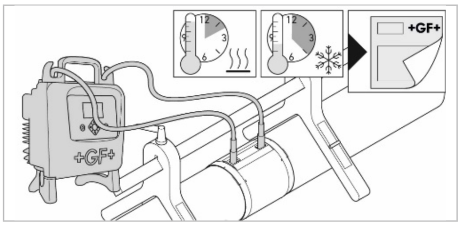


Step 5
Remove the assembly aids

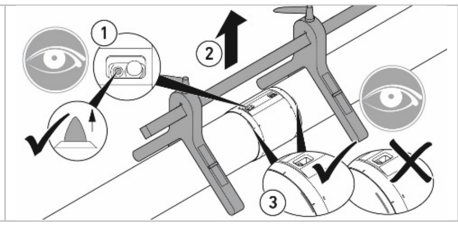


Step 6
Take care for low stress installation and secure the pipe and fitting against dislocation. Check insertions depths of both pipe into the fitting

3. Schweissprozess

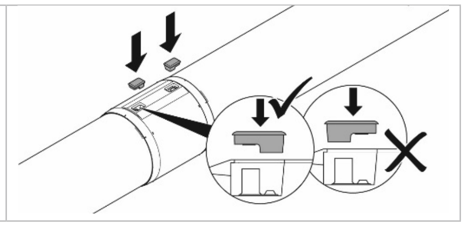


Step 1
Fuse in accordance to the operating instructions of the fusion unit. Use long fusion adaptors (790128035). Pay attention to fusion and cooling time.

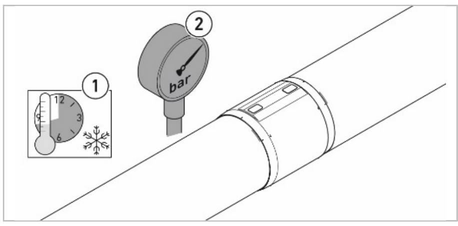


Step 2
After fusion, check fusion indicators on the electrofusion fitting and note the messages on the display of the electrofusion machine.
Mark the fitting with following information
- Date
- Welder/ Weld number
- Time at the end of cooling time

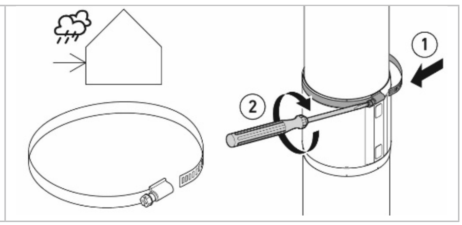
Remove the clamping tool after cooling time



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



Step 4
After cooling perform pressure tests as per table.



Step 5 (optional)
For vertical installations outside, mount sealing clamps tightly at the top lip of the fitting.
Alternatively to sealing clamps, sealing tapes, 25 mm width can be mounted underneath the top lip of the fittings.

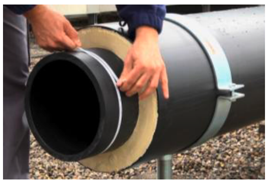
Cooling times before removing clamping tool and pressure/leak testing

d (mm)	Cooling time before Remove clamping tool [min.]	Cooling time before internal pressure test at ≤ 6 bar [min.]	Cooling time before internal pressure test at ≤ 18 bar [hours]
32	10	15	3
40	10	20	5
50	10	20	5
63	10	20	5
75	15	25	6
90	20	35	8
110	30	50	8
160	45	90	8
225	45	90	9.5

The values are valid for pressure tests using a liquid at ≤ 20 ° C. For testing with gas a cooling time of 12 hours is recommended.

Jointing d250 – d2450

1 Preparing for fusion

Step 1	Step 2	Step 3
		
Perform a preliminary cleaning of the media pipe, deburr at a right angle using the pipe cutter, if necessary.	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 open spigot length

Dimension (mm)	Minimum permissible pipe outer diameter after peeling (mm)	Factory-set spigot length (mm)
d250	249.3	113 – 123
d280	279.3	116 – 126
d315	314.3	123 – 133
d355	354.3	135 – 145
d400	399.3	137 – 147
d450	449.3	153 – 163

2 Cleaning

Step 1	Step 2	Step 3
		
Peel the media pipe and fitting type B with the peeler. Observe min. peel removal of 0.2 mm.	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.

V

3 Fusion process

Step 1

Slide on the electrofusion socket up to the insulation without touching the fusion area. Slide on the shrink coupler and fix the components stress-free[1)].

Step 2

Connect the fusion device with fusion adaptors and fuse according to the operating instructions of the fusion device. Check and monitor the fusion process[1)].

Step 3

After the fusion process, the coupler is marked with the following information.
- Date
- Fusion number
- Cooling time

1) The use of suitable fixing devices is recommended..

4 Sealing

Step 1

Affix the sealing tape centered over the gap and overlap it at the end. Press it on well and smooth out folds.

Step 2

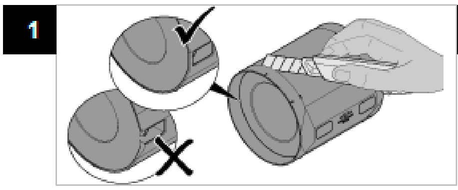
Position the shrink socket centered.

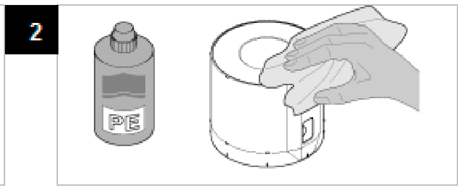
Step 3

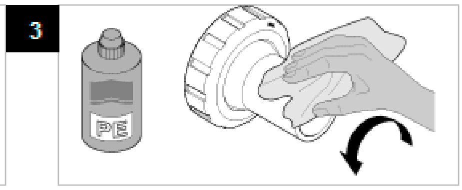
The flame or hot-air stream must strike the shrink socket as vertically as possible. Avoid applying unnecessary heat to the fittings.

Valves and flange joints

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



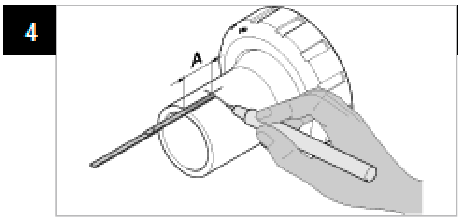


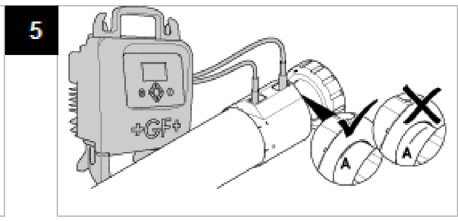


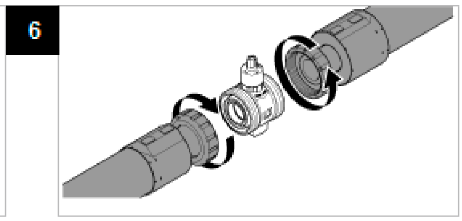
For the jointing to a valve or flange adaptor, the sealing lip of the fitting has to be removed at the valve or flange adaptor side and sealing and fusion surfaces have to be cleaned.

2. Standard fusion

Fuse both valve ends without valve mounted.



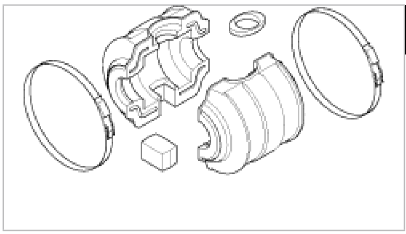




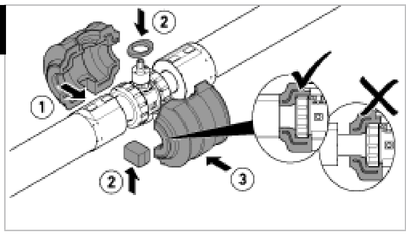
Following insertion depths A are valid for COOL-FIT 4.0 components:

d/D (mm)	32/90	40/110	50/110	63/125	75/140	90/160	110/180	160/250	225/315
L1 (mm)	36	40	44	48	55	62	72	90	110

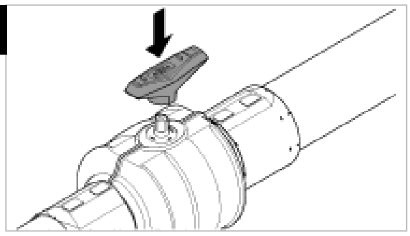
3. Mounting the valve/flange insulation



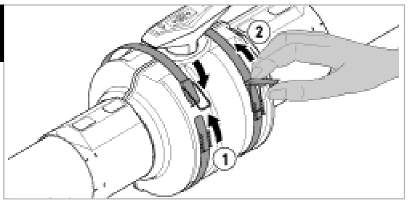
7



8



9



Further information can be found in the assembly instructions "COOL-FIT 2.0 / COOL-FIT 4.0 insulation for Ball Valve and Butterfly Valve".

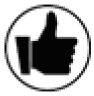
It's recommended to re-tighten the bolts of COOL-FIT 4.0 butterfly valves and flange joints at operating temperature.

Compact connection fitting-to-fitting

When there is enough space, Fitting-to-Pipe-to-Fitting connections can be realized using a short COOL-FIT 4.0 pipe. The foam removal tool enables the foam removal of pipe lengths of ~110 mm for the dimensions d32-d90, or respectively ~170 mm for the dimensions d110-d225.

For compact fitting-to-fitting joints, COOL-FIT 4.0 barrel nipple can be used.

- **Shorter connections Fitting-to-Pipe-to-Fitting as of sizes d75mm can be realized using an un-insulated PE100 SDR11 pipe in combination with a piece of insulation that results of an foam removal process of the foam removal tool.**
  After the peeling of the oxid layer of the un-insulated PE pipe, the insulation ring is pulled over the pipe and the pipe is welded with the fitting.

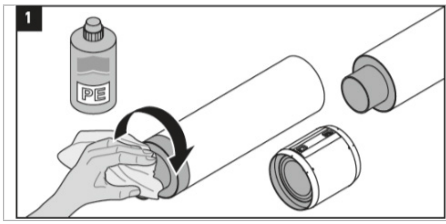


d	d75	d90	d110	d160	d225
L (mm)	165	186	216	270	330

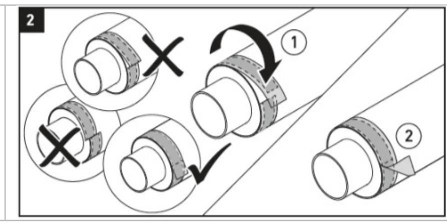
L: Length of un-insulated PE100 SDR11 pipe needed

V

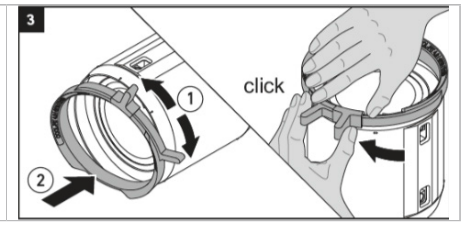
Mounting of sealing tape and transition of insulation



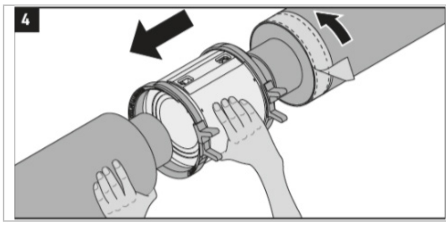
Step 1
In addition to the fusion zone, also clean the jacket of the pipe



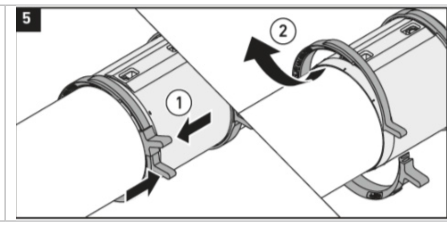
Step 2
Mount sealing tape/ transition of insulation, end to end without offset and fold down liner



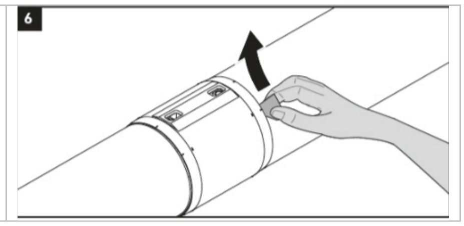
Step 3
Mount the assembly aids on the sealing lips of the COOL-FIT 4.0 fitting



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



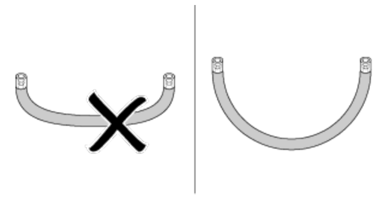
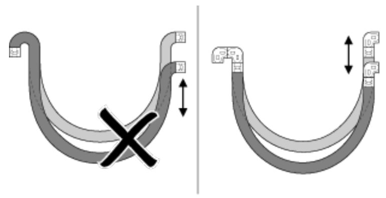
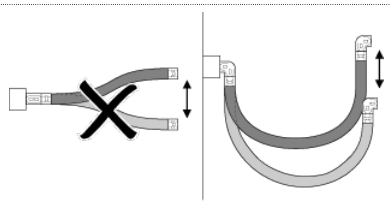
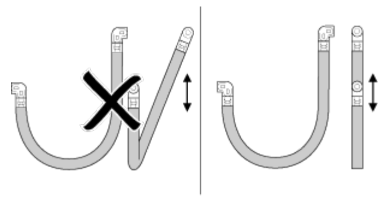
Step 5
Remove the assembly aids

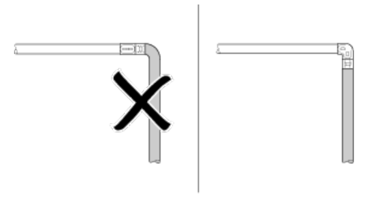
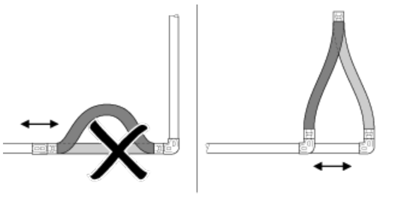
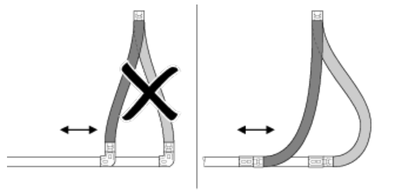
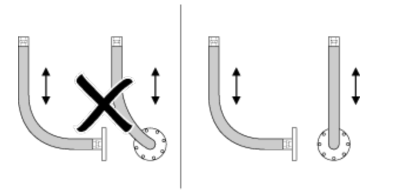
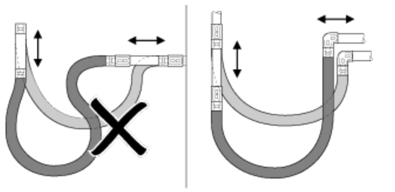


Step 6
Pull off the liner after removal of assembly aids

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 observe the minimum radius of curvature.
	Avoid excessive bending of hoses, use elbows.
	Avoid fluctuating bending stress and excessive curvature 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.

Installation and handling instructions (false/correct)	Description
	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 plane of the pipe; torsion should be avoided.
	For major axial expansion, the pipe must be installed in a U-shape to avoid kinking.

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 hemp or 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.

Next to the traditional transition to metal piping, these fittings can also be used to connect a manometers.

⚠ **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 establis-hed reliably.

Mounting the insulaton half shells of Transition Fittings

Following the jointing of the COOL-FIT 4.0 Transition Fittings with the COOL-FIT 4.0 Fitting Typ A, and the mechanical jointing 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 4.0 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 4.0 insulation for transition fittings".

Connecting the insulations of Transition Fittings with the insulaiton of Flexible Hoses

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

Jointing Instructions for the adhesive cement

The adhesive should be thoroughly stirred before use. A thin film is applied by means of the brush to both surfaces to be bonded. Doing this, the consumption is ~0.2 – 0.25 kg/m^2.

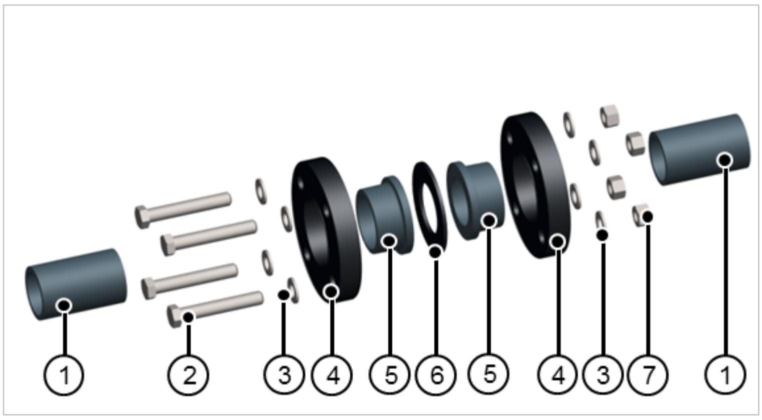
The open joint time is about 3 to 15 minutes depending on temperature and humidity of air.

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

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

Flange joints

Flanges with sufficient thermal and mechanical stability must be used. The different flange types by Georg Fischer Piping Systems fulfill these requirements. The gasket dimensions must match the outer and inner diameter of the flange adapter or valve end. Differences between the inner diameters of gasket and flange that are greater than 10 mm may result in malfunctioning flange connections.



1. Pipe
2. Bolt
3. Washer
4. Backing Flange
5. Flange Adaptor/ Valve end
6. Flange gasket
7. Nut

Recommended backing flange of COOL-FIT 4.0 flange joints

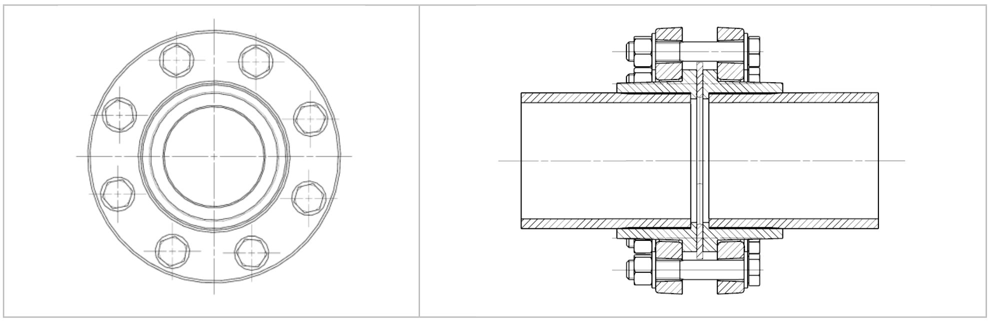
Flange	Properties
PP-steel flange	• Very robust and stiff due to the steel inlay • Corrosion-free plastic flange made of polypropylene PP-GF30 (fiber-glass reinforced) with steel inlay • High chemical resistance (hydrolysis-resistant) • UV-stabilized

Creating flange joints

When executing flange joints, the following points should be noted:

Orientation of bolts beyond the two main axes

- For horizontal piping systems, the orientation shown of the bolts beyond the main axes (see the following figure) is preferred since possible leaks at the flange connection do not cause the medium to run directly onto the bolts.



Flange with main axes (centered crosswise)

- Flange adaptor, valve end or fixed flange, seal and loose flange must be aligned centrally on the pipe axis.
- Before tightening the screws, the sealing surfaces must be aligned parallel and snug against the seal. Tightening misaligned flanges with the resulting tensile stress is to be avoided at all costs.

Selecting and handling bolts

- The length of the bolts should be in such a way that the bolt thread does not protrude more than 2-3 turns of the thread at the nut. Washers must be used at the bolts as well as the nut. If too long bolts are used 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.
- Tightening 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 jointing 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.
- 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.

> **For more information on flanges, see DVS 2210-1 supplement 3.**

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

Bolt tightening torque guidelines for metric (ISO) flange connections with PP- steel flanges

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 adapters, flanges) by Georg Fischer Piping systems are dimensioned for these upper limits.

Pipe outside diameter d (mm)	Nominal Diameter DN (mm)	Tightening torque MD (Nm)		
		Flat ring maximum pressure 10 bar / 40 °C	Profile seal maximum pressure 16 bar	O-ring maximum pressure 16 bar
d32	DN25	15	10	10
d40	DN32	20	15	15
d50	DN40	25	15	15
d63	DN50	35	20	20
d75	DN65	50	25	25
d90	DN80	30	15	15
d110	DN100	35	20	20
d160	DN150	45	25	25
d225	DN200	70[1)]	45	35
d250	DN250	65	35	-
d280	DN250	65	35	-
d315	DN300	90	50	-
d355	DN350	90	50	-
d400	DN400	100	60	-
d450	DN450	190	70	-

1) Maximum operating pressure 6 bar

Bolt tightening torque guidelines for ISO flange connections

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 4.0 flange adaptors the used bolts must not be too long.

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

Under DVS 2210-1, the screw length should be such that it extends 2 to 3 threads beyond the nut.

Online "screw lengths and tightening torques" tool on www.gfps.com/tools

For COOL-FIT 4.0 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
Screws	M12x80	M16x80	M16x90	M16x90 or M16x100	M16x100	M16x100	M16x100	M16x200	M20x220

Installation fittings (for sensors)

Transitions and threaded plastic fittings should first be screwed finger tight. The fittings are then screwed in using an appropriate tool until 1 or 2 threads remain visible.

Georg Fischer Piping Systems recommends using PTFE tape to seal transitions and threaded plastic fittings. Alternatively, Henkel Tangit Uni-Lock or Loctite 55 thread seal or Loctite 5331 thread sealant gel can be used. Follow the manufacturer's instructions. When using other sealants, you must check compatibility with the plastic used.

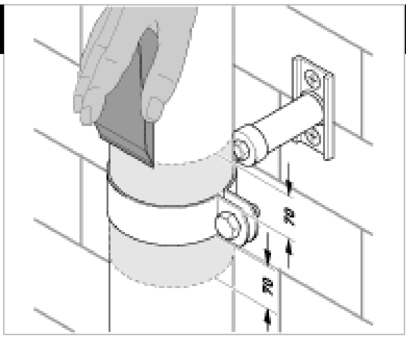
On installing Installation fittings in horizontal piping systems, the sensors should be in 1 – 5 or 7 – 11 clock position.

⚠ **Do not use hemp! It may swell up, putting force on the plastic fittings and damaging plastic threads. Hemp is also not resistant to chemicals used in some media.**

COOL-FIT 4.0 Installation of fixed points

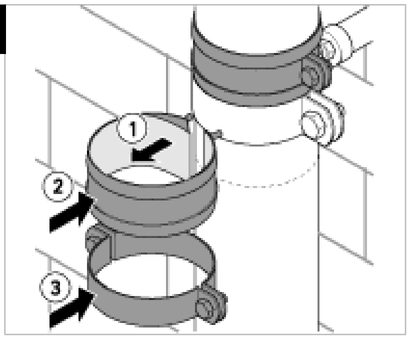
The COOL-FIT piping system must me mounted in final position in the regular fixpoint clamp.

1



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

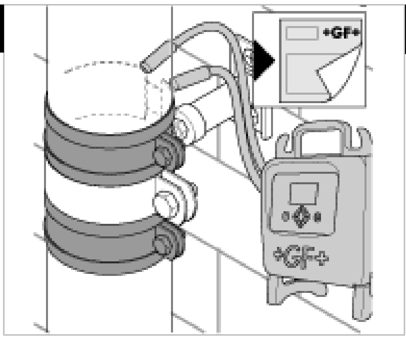
2



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 pipe clips provided.

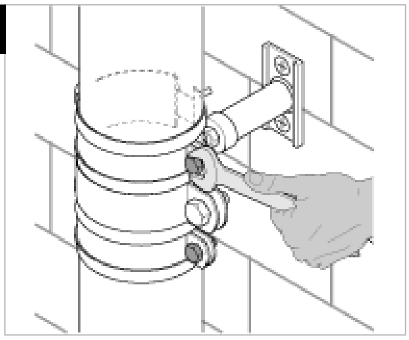
Note: The necessary welding pressure on the clean and dry COOL-FIT pipe is achieved by tightening the pipe clips. Take care that between fixed point clip and weld band there are no visible holes.

3



Step 3
Bond the welding band with the COOL-FIT pipe in accordance with the operating instructions of the electrofusion machine. Use welding adaptors of the y-cable with integrated welding adaptors for the bonding.

4



Step 4
Retighten the pipe clips after 10 minutes

1.5.2 Pressure test

Internal pressure test

For internal pressure testing and commissioning, the same conditions apply for COOL-FIT 4.0 as for the non-insulated ecoFIT system (PE).

1.5.3 Internal pressure and leak testing

Introduction to the pressure test

Overview of the various test methods

Test methods	Inner Pressure test			Leakage test
Medium	Water	Gas[1]	Compressed air[1]	Gas/air (oil-free)
Type	Incompressible	Compressible	Compressible	Compressible
Test pressure (overpressure)	$P_{p\ (perm)}$ or $0.85 \bullet P_{p\ (perm)}$	Operating pressure + 2 bar	Operating pressure + 2 bar	0.5 bar
Potential risk during the pressure test	Low	Hoch	High	Low
Significance	High: Proof of pressure resistance incl. impermeability to test medium	High: Proof of pressure resistance incl. impermeability to test medium	High: Proof of pressure resistance incl. impermeability to test medium	Low

1 Observe 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 air or 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 like e.g. compressed air.

Internal pressure test with water or similar incompressible test medium

The internal pressure test is done when installation work has been completed and presupposes an operational piping system or operational test sections. The test pressure load is intended to furnish experimental proof of operational safety. The test pressure is not based on the operating pressure, but rather on the internal pressure load capacity, based on the pipe wall thickness.

Addendum 2 of DVS 2210-1 forms the basis for the following information. This replaces the data in DVS 2210-1 entirely. The modifications became necessary because the reference value "nominal pressure (PN)" is being used less and less to determine the test pressure (1.5 x PN, or 1.3 x PN) and is being replaced by SDR. In addition, a short-term overload or even a reduction in the service life can occur if the pipe wall temperature TR = 20 °C is exceeded by more than 5 °C in the course of the internal pressure test based on the nominal pressure.

Test pressures are, therefore, determined in relation to SDR and the pipe wall temperature. The 100-h value from the long-term behavior diagram is used for the test pressure.

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 ≤ 100 m: 3 h 100 m < L ≤ 500 m: 6 h	L ≤ 100 m: 3 h 100 m <L ≤ 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)
COOL-FIT 4.0	1.2

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 dummy flange or cap. This prevents an inadvertent 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 or bond has been observed

Now the piping system can be filled from the geodetic 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 1 m/s.

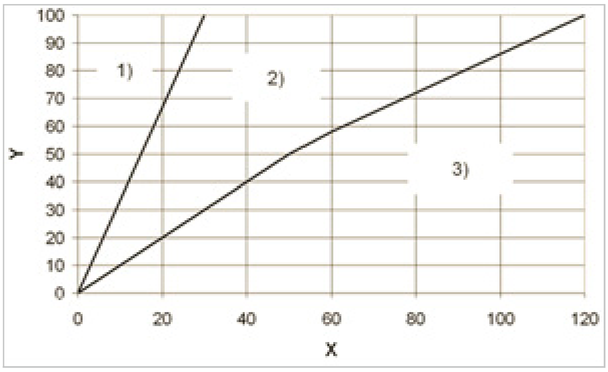
Reference values for the filling volume are given in the table below:

d (mm)	V (l/s)
≤ 90	0.15
110	0.3
160	0.7
225	1.5
250	2.0
315	3.0
400	6.0

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 DN100 mm
2)	Range of pressure increase rates between DN100 and DN400 mm
3)	Guideline rate of pressure increase for DN500 and higher: 500/DN (bar/10 min)

Determination of the test pressure

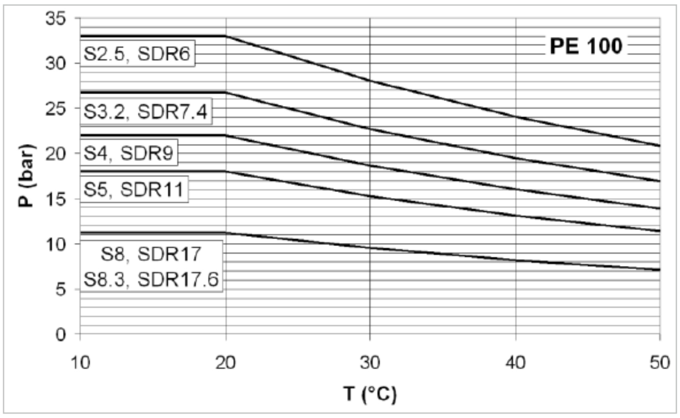
The permissible test pressure is calculated using the following formula:

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

$\sigma_{v(T,\,100\,h)}$	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 4.0 Pipe and Fittings (PE100)	1.25
COOL-FIT 4.0 Valves (ABS)	1.6

To make things easier, the permissible test pressures can be taken directly from the following diagrams.



P permitted test pressure (bar)
T pipe wall temperature (°C)

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

1.5.4 Start-up with secondary refrigerants

Secondary refrigerants such as glycol solutions must only introduced in liquid, pre-mixed form into COOL-FIT 4.0 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

V

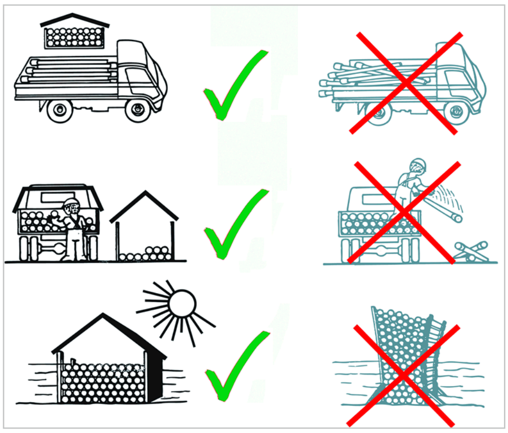
1.6 Transport, Handling and Storage

1.6.1 Transport

On trucks/in crates, manual transport

1.6.2 Storage

All plastic pipe including pre-insulated plastic pipe such as COOL-FIT 4.0 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.



1.6.3 Environment

The materials used for COOL-FIT 4.0 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 4.0.

For more information at www.coolfit.georgfischer.com