+GF+

Industry
Design & Installation

Plan, Build, Operate

How to Use

Content

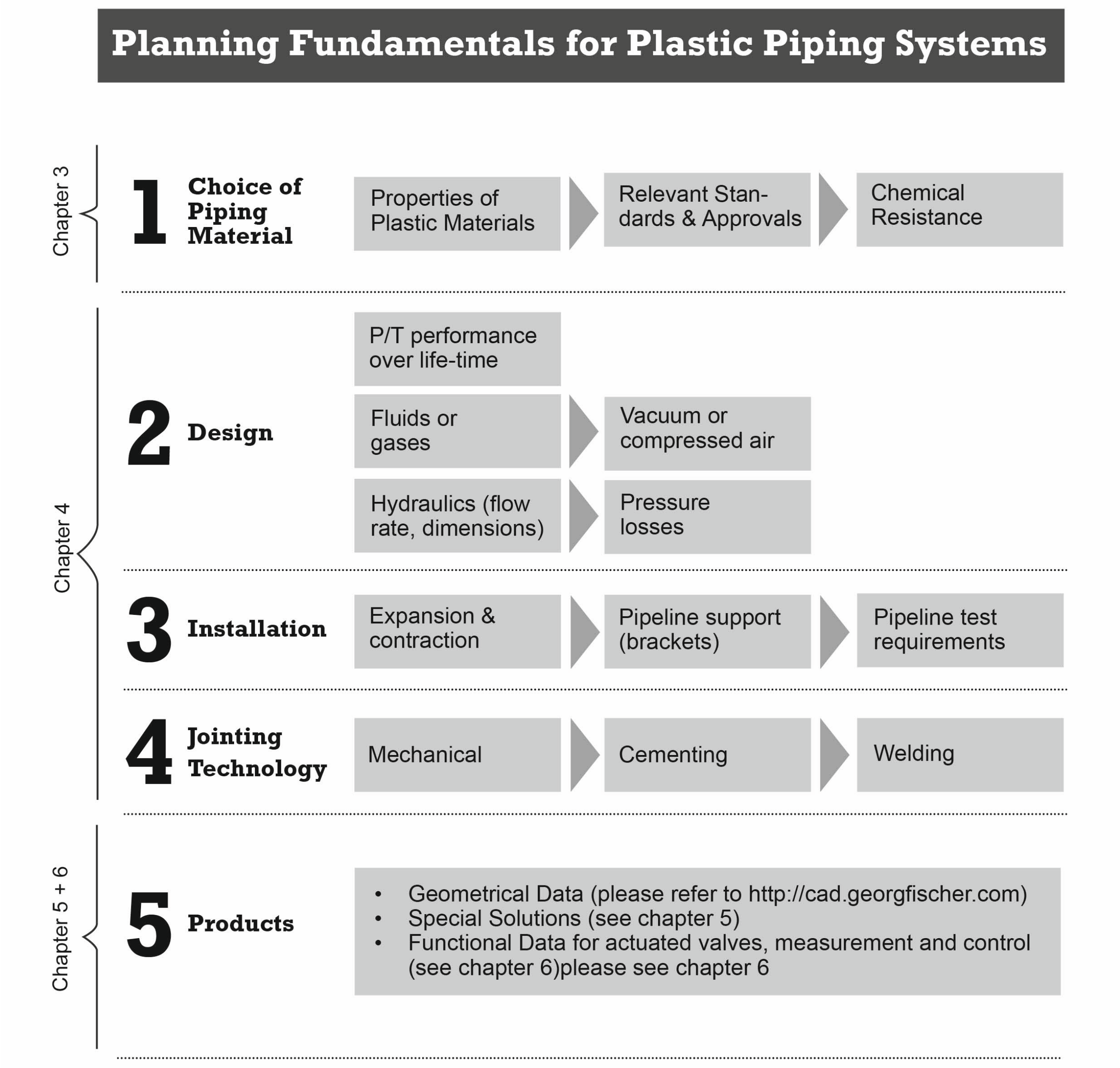
1 How to use

This handbook describes and explains the basic fundamentals for planning, product selection, processing and installation of pressure pipe in industrial applications.

It is suitable as a reference book as well as documents for training and education or to support the consultation. All specifications are based on the relevant international ISO and EN standards, on various national standards, DVS guidelines and additional information from raw material suppliers. In addition, the results of extensive internal investigations are incorporated. Thus the designer, engineer and installer should be given the necessary assistance to properly plan and install their plastic piping system.

Selection and weighting of the topics are focused on the explanation of the design-relevant areas. Detailed instructions of the products are to be taken from the corresponding installation and operating instructions.

Planning fundamentals for utility and building-technology systems are available in separate handbooks. For further information, please contact your local country representative or refer to: www.gfps.com



Overview of symbols

General symbols

	General information		Note
	Example		Online calculation tools and mobile applications

Symbols of materials

	Abrasion resistance		Application limits
	Combustion behavior		Mechanical characteristics
	Chemical resistance		Physiological properties
	High-purity properties		UV and weather resistance
	Application limits		

2 List of abbreviations

Abbreviations	Description
BGA	German health authority
BgVV	Federal Institute for Consumer health protection and veterinary medicine
DIBt	German Institute for construction technology
DVGW	German association of gas and water e.V.
DVS	German association of welding technology
EPDM	Ethylene propylene diene rubber
FAR	Federal Aviation Regulations
FDA	Food and Drug Administration
FKM	Fluororubber
GFK	Fiberglass reinforced plastics
KTW	Plastic drinking water recommendation by the Federal Health Office
MFR	Melt Flow Rate
MRS	Minimum Required Strength
NBR	Nitrile rubber (Buna-N)
NR	Natural rubber
PB	Polybutene
PE	Polyethylene
PE-X	Polyethylene
PP	Polypropylene
PTFE	Polytetrafluorethylene
PVC	Polyvinyl chloride
PVC-C	Polyvinyl chloride, chlorinated
PVC-U	Polyvinyl chloride, unplasticized
PVDF	Polyvinylidene fluoride
SDR	Standard Dimension Ratio
TG	Malleable iron
UP-GF	Unsaturated polyester resin, glass fiber reinforced

Planning Fundamentals

Industrial Piping Systems

Design and Installation

Planning Fundamentals

Industrial Piping Systems
Design and Installation

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Planning Fundamentals

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Preface

GF Piping Systems is a major global provider of complete piping solutions for many demanding applications in various market segments. Founded in 1802, Georg Fischer started the first production of malleable iron fittings in 1864 and today is recognized as the pioneer in the development of corrosion-free plastic piping systems for the safe and reliable conveyance of liquids and gases. This technical handbook reflects more than 60 years of our experience and know-how in the designing and manufacturing of plastic piping systems. Today, our product portfolio consists of more than 60'000 products and we are supporting our customers with products and services day to day around the globe.

The scope of these planning fundamentals is to offer a valuable support in planning selection of the proper materials and the most suitable product range for all main industrial applications. In addition, the handbook provides extensive information about all jointing technologies for plastic materials and gives technical advises in the installation of pipes, fittings, valves, measurements and control, as well as actuation.

We strongly believe that the professional planning and the proper use of our comprehensive product range are the base for reliability, safety and high quality of plastic piping systems.

We hope that, in this handbook, you will find the qualified support that you need for your daily work.

In case of special applications our worldwide technical engineers will be glad to assist you.

We would like to thank everyone, who continues to support GF Piping Systems in its mission to delivering more value to customers, through superior piping systems.

Schaffhausen, 10/2021

Introduction

Content

1 GF Piping Systems

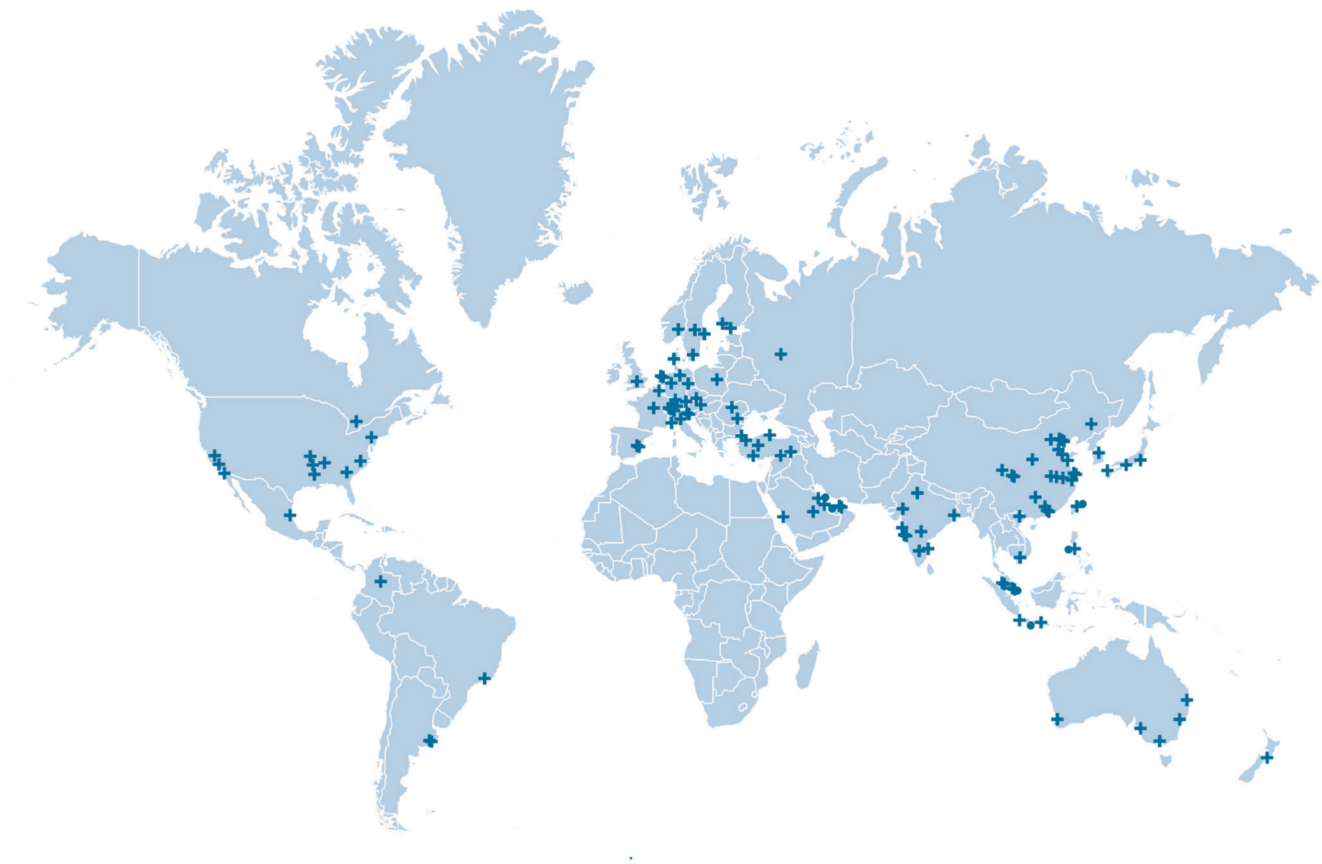
Global presence

Our global presence ensures customer proximity worldwide. Sales companies in over 25 countries and representatives in another 80 countries provide customer service around the clock. With 50 production sites in Europe, Asia and the USA we are close to our customers and comply with local standards. A modern logistics concept with local distribution centers ensures highest product availability and short delivery times. GF Piping Systems specialists are always close by.

Complete solutions provider

With over 60,000 products, we offer individual and comprehensive system solutions for a variety of industrial applications. Having the profitability of the projects in focus, we optimize processes and applications that are integrated into the complete systems. Continually setting standards in the market, we directly provide our customers with technological advantages. Due to our worldwide network of qualified contact partners, customers benefit directly from our 50 years+ experience in plastics.

From start to finish, we support our customers as a competent, reliable and experienced partner, actively contributing the know-how of an industrial company that has been successful in the market for over 200 years.



2 Quality

2.1 Quality assurance at all levels

Quality creates safety and is the basis for trust. In customer relationships as well as in project work, development, production and in the specific application of products, quality awareness and standards decide on sustainable success. The fundamental importance of quality determines our actions, shapes our understanding of quality, and is reflected in our own claim to quality.

The systematic integration of partners and suppliers is part of our comprehensive understanding of quality and guarantees the binding assurance of the quality standard along the entire value added chain.

GF Piping Systems is bound to the high quality standards of its customers and considers itself actively responsible for meeting the customer requirements as well as ensuring legal standards. The rigorous implementation of our quality policy represents an obligation for every single person. Consequently, the orientation towards quality when providing a service goes without saying for all employees working in the company.

2.2 Management systems

Quality, environment, occupational safety and health protection have always played a very important role in the Georg Fischer group. In line with that, all production companies as well as many sales companies of GF Piping Systems are certified in accordance with the ISO 9001 quality management system. Furthermore, all of our production sites are certified in accordance with ISO 14001. The standard defines criteria that are applicable throughout the world for efficient environmental management systems and, as a result, is considered to be the basis for optimizing environmentally relevant processes.

As part of our sustainability activities, all production sites have also been certified in accordance with OHSAS 18001, the international standard in the area of occupational health and safety. Newly acquired or newly founded production companies are bound to establish a quality, environmental and occupational safety management regime within a period of three years.

2.3 Accredited test center

The test center of GF Piping Systems is a test center accredited in accordance with ISO/IEC 17025 for components of piping systems. It inspects all types of pipe, pipe connections, connecting elements, fittings, manual and automatic valves as well as flow meters according to relevant standards and its own external as well as internal specifications.

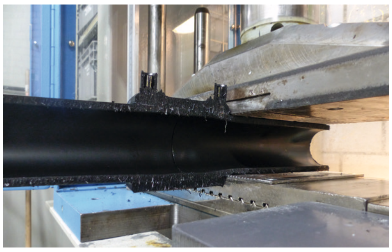
STS 094

Customers for test laboratory programs are the R&D departments, manufacturing plants, as well as end-users of GF Piping Systems components and other external customers.

Development and product release tests are completed for R&D departments (TT type testing, ITT initial type testing), batch release tests (BRT) and process verification tests (PVT) for our own production units as well as other tests for external customers.

The continuous training and specific experience of our employees, the technical state of our testing systems, as well as properly documented test sequences are basic prerequisites to accrediting the test center in accordance with ISO/IEC 17025. The accreditation by SAS (Swiss Accreditation Office) is confirmed in the form of a certificate. A verification takes place annually as well as a renewal of the accreditation every 5 years.

The SAS, which is responsible for GF and has issued our accreditation, is a member of the International Laboratory Accreditation Cooperation (ILAC). All laboratories accredited by the ILAC are obliged to formally recognize any test report issued by a fellow member. This permits us, and our customers, to use all accredited test reports originating from our laboratory to obtain product approvals and quality certificates, etc. Therefore, potential expenditure and time consumption is considerably reduced.



The accredited test program also includes:
- Long-term internal pressure testing (EN ISO 10931, EN ISO 15493, EN ISO 15494, ISO 9393)
- Burst tests on fittings and pipe
- Crush tests (ISO 9853)
- Impact resistance tests (ISO 13957)
- Decohesion test of polyethylene (PE) saddle fusion joints (ISO 13956)
- Decohesion test (ISO 13955)
- Peeling test (ISO 13954)
- Tensile strength and failure mode on butt-fused test specimens (ISO 13953)
- Pressure drop test (EN ISO 17778)
- Determination of density (EN ISO 1183)
- Melt flow rate (EN ISO 1133)
- Oxidation induction time OIT (EN ISO 11357-6)

A complete listing of accredited tests can be seen in a table. This table, which is constantly updated, can be referred to by consulting the following internet site:
www.sas.ch

▶ Accredited bodies

▶ Search

▶ STS 094.

3 Sustainability

As an internationally operating industrial group, GF is in the midst of society. It is, therefore, important to harmonize economy, ecology and social aspects. In accordance with this responsibility, our industrial and social activities carry a long-term and long-range orientation. It is our endeavor to anchor sustainability in all of our sales companies. Our sustainability goals, whose attainment we communicate regularly and transparently, drive our actions.

3.1 Environment

For GF Piping Systems, our own environmental responsibility is an integral aspect in all of our business activities. Because we regard environmental awareness as one of the most important values of our company, all internal structures and processes are oriented towards sustainability. We strive to save natural resources and work relentlessly on optimizing the eco-friendliness of our products and their applications. Outstanding material properties and innovative technologies form the basis of our environmentally friendly and energy-saving solutions. By supplying our customers with complete piping systems, we support and promote ecological and cost-efficient operating processes in many industries and in daily routine. To obtain detailed information about the environmental compatibility of our products, we monitor all phases of the product life cycle in detail, which also allows us ultimately to improve the life cycle assessment of our products.

3.2 Social aspects

Attractive workplaces, interesting tasks, a goal-oriented training and professional development, as well as a fair salary and good social benefits contribute to securing the future of the company. GF Piping Systems operates with this responsibility as its premise. With locations in over 30 countries, GF Piping Systems views the multitude of cultures, religions, nationalities, genders and age groups as a valuable source for talent, creativity and experience. This makes possible the extraordinary services performed by approximately 15,000 staff members employed by GF Piping Systems throughout the world.

Additional information about sustainability can be found at www.gfps.com/sustainability

4 Services

From planning support to implementation – our specialists are always close by

As a leading provider of piping systems in plastic, we offer our customers not only reliable products, but also a comprehensive package of services. Our support ranges from a comprehensive technical manual or the extensive CAD library to an international team of experts, who work closely together with local sales companies. And when it comes to implementing a project, our customers additionally benefit from a wide range of training courses, either on site or in our modern training centers worldwide.

1 Chemical resistance

Our specialist teams have decades of experience in the area of chemical resistance. They can offer individual support and advice in selecting the right material for the corresponding plastics system solution. On request, a team will examine and select the appropriate material for special applications.

2 CAD library

The extensive CAD library is the most frequently used planning tool at GF Piping Systems. The database comprises over 30,000 drawings and technical data regarding pipe, fittings, measurement and control technology as well as manual and actuated valves. The big advantage of the CAD library is that the data can be integrated directly in CAD models.

3 Technical support

Technical support and material selection are key factors for a successful installation. A team of specialists headquartered in Switzerland is available to support the GF Piping Systems sales companies around the world. For technical advice or for general information, our customers are supported individually by the specialist team in the corresponding sales company.

4 Online and mobile calculation tools

Our numerous, multilingual online calculation tools are very useful for configuring and calculating. By means of pressure/temperature diagrams, the pressure of liquid media recommended for pipe and fittings at various temperatures can be easily defined. FlowCalc App, the mobile application of GF Piping Systems, is an on-site planning tool for pipe diameter and flow velocity calculation to select the right dimension of piping systems.

5 On-site training

Our experts are available to support our customers locally and conduct training in diverse fusion and jointing techniques on location. The duration and structure of the training depends on the project and the system being installed.

6 Customizing

The customizing teams at GF Piping Systems work closely together around the globe. The focus of these teams is to manufacture custom parts for special systems. In addition, a variety of special solutions can be produced in small series. Standardized processes warrant the highest level of quality for the individual solutions of our customers.

7 Planning Fundamentals

For our customers, we have documented the extensive know-how of GF Piping Systems in planning and installing plastic piping systems in our technical manual. This detailed documentation is available in both printed and digital versions. The reference book is helpful in planning large and small projects.

8 Training courses

GF Piping Systems offers a wide range of training courses that allow participants to gain confidence in working with our products and proven jointing technologies. The practical training is clearly defined, structured and adapted to the various levels of experience of the participants.

5 Training

Qualified personnel is one of the key factors for the success of a company. Only highly motivated and well-trained employees with the appropriate know-how and customer focus are reliable partners.

GF Piping Systems, as a professional system and solution provider, offers you training courses with a focus on products, applications, sales arguments and different customer requirements.

The jointing technologies, as well as measurement and control technology are increasingly innovative. To stay up-to-date, you need continuing education.
GF Piping Systems makes an essential contribution to your know-how. No matter what your field of expertise may be – utilities, building technology or industrial applications – you can benefit from the training courses, which are adapted to the different market segments and applications.

We offer a customized program for sales personnel and occupational groups such as installers, planners and plant builders. Besides the theory, we attach great importance to hands-on practice. Our rooms are especially equipped for practical training. They are suitable for simultaneous training of up to 100 persons under ideal conditions. We work together closely with our sales personnel when selecting trainers. There are basic, advanced and master courses, which are all structured in a coordinated fashion.

For additional information about the current training program, visit www.gfps.com

Piping Solutions

of GF Piping Systems

Content

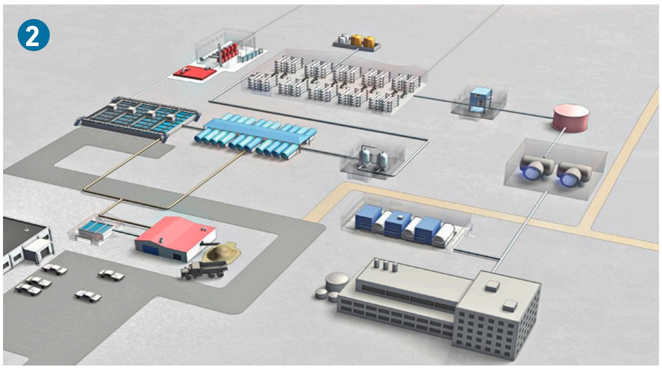
1 Market Segments

1.1 Water Treatment

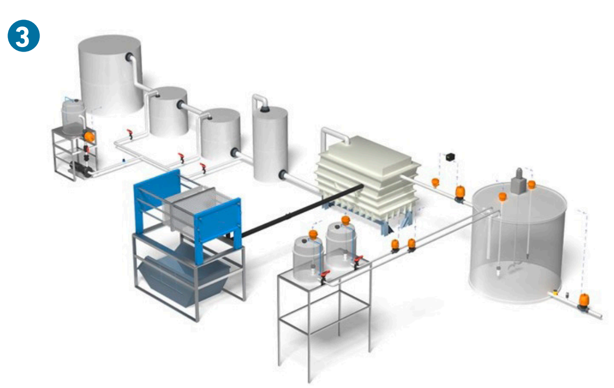
1.1.1 Overview

Since the late 90's, the water treatment business has been continuously growing. In water scarce countries, it is even regarded to be the most investment-intensive and important industry sector for the next decades. Depending on the application area, our customers have to face different challenges in water treatment processes ranging from securing high water quality up to providing reliable measurements to meet stringent regulations. GF Piping Systems steps up these challenges with a comprehensive system offering of pipe, fittings, valves and the ideal jointing technology as well as an optimally adapted selection of components for automation technology.

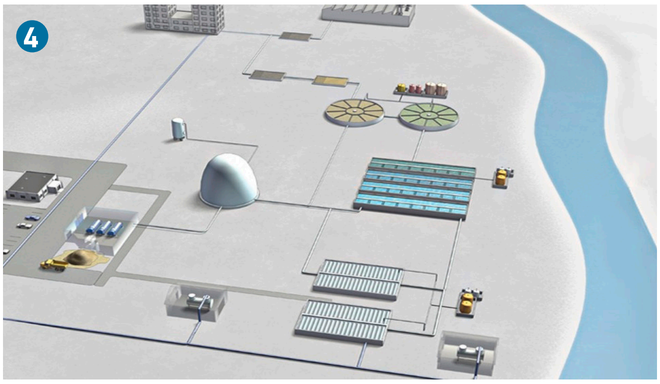
Drinking water



Industrial process water



Industrial waste water



Municipal waste water

❶ Drinking water

Producing drinking water is a demanding challenge which requires the right system behind the scenes. Depending on the application area, the choice of plastic material for pipe, valves and fittings is essential for a long-lasting system. With the high quality plastic solutions of GF Piping Systems the optimal compatibility of all components is warranted.

❷ Industrial process water

High water quality in terms of purity for steam boilers, cooling systems and production processes is the key requirement for industry today. Avoiding any form of contamination, scaling and corrosion is achieved through technologies as ion exchanging, ultrafiltration, reverse osmosis and electro deionization.

❸ Industrial waste water

Waste water treatment plants for inorganic caustics and acids are small chemical plants themselves. Corrosion resistance and staff safety are the top priority issues for hazardous waste containing lines. GF Piping Systems' philosophy for safe transport of liquids and gases meets these advanced process needs.

❹ Municipal waste water

Stringent regulations and binding laws demand state-of-the-art technologies in sewage plants today. Membrane technologies, chemical dosing systems and polymer preparation units are only some of the examples that require efficient and safe piping systems.

1.1.2 Leading Systems (Samples)

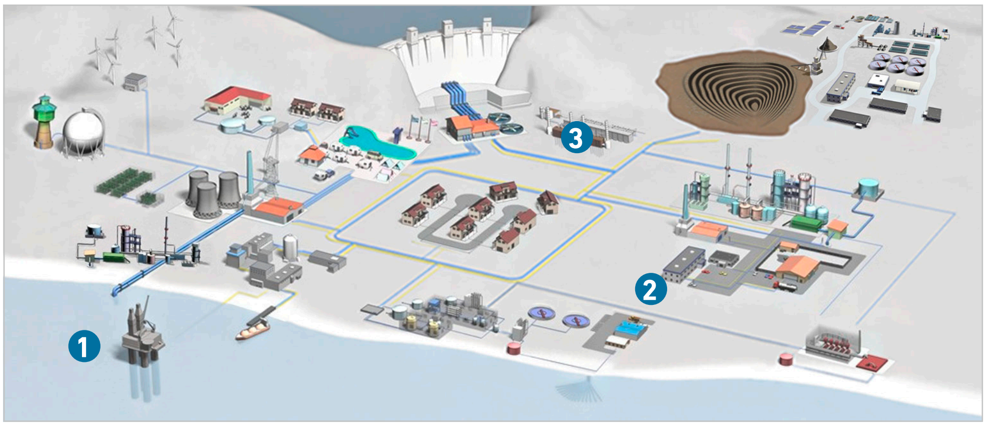
ecoFIT and ELGEF	PVC-U	PROGEF Standard	CONTAIN-IT Plus
			
d20 – d630 mm, PN10 – PN16	d6 – d400 mm, PN6 – PN16	d16 – d500 mm*, PN6 – PN10	d25 – d225 mm
-50 °C to +60 °C	+0 °C to +60 °C	+0 °C to +80 °C	-50 °C to +140 °C**
Automation Measurement – Control – Actuation			

*bigger sizes available for certain products
**acc. to primary pipe material

1.2 Chemical Process Industry

1.2.1 Overview

Chemical and Process Industry encompasses all the industrial activities related to the extraction of natural resources and their transformation into basic chemical products and specialties. Each chemical has a distinctive value chain, where careful material and components selection is a mandatory requisite for planners, designers and installers.
The harsh environment in most of the industrial plants, the strive for efficiency and the responsible care policies for chemical handling, drive high demands on piping systems in regard to health and safety, environmental standards compliance, reliability and maintenance.



1 Chemicals extraction from natural resources

Mining and minerals processing

Mining and mineral processing industry are among the most intensive users of water and chemicals, in harsh environment and with demanding tasks for installation, reliability and resistance to corrosion. GF Piping Systems products are used in the mines utilities and for several process steps from ore beneficiation to hydrometallurgy.

Oil and gas industry

Water cycle in oil and gas industry is complex and demanding: a multitude of chemical additives are used to enhance process performance and increase the efficiency of water treatment operations. Evolving frontiers in offshore and hydraulic fracturing techniques for unconventional resources are more and more welcoming GF plastic piping systems for their lightweight, modularity of installation and long lasting life in aggressive environment.

2 Chemicals production and distribution

Petrochemicals

Petrochemicals are the building blocks for most of the objects surrounding people's daily life, and their value chain is growing with new installations according to the increasing standards of life in emerging economies and urbanization megatrend. Olefin, aromatics and synthesis gas processing industrial plants have high complexity flow schemes for water and chemicals, used as process additives or catalysts and in several chemical injection skids.

Fertilizers

Like petrochemicals, fertilizer plants play a key role in the global chemical Industry, driven by the agro-industrial need for intensive food production and being an excellent platform for ammonia gas monetization into nitrogen based fertilizers. Fertilizer plants are cross-points in the value chain of the most used mineral acids worldwide in the industry, such as sulfuric acid and phosphoric acid.

Chlor-alkali

Chlor-alkali plants are the backbone of the basic industrial inorganic chemistry. GF plastic piping solutions find their ideal area of application in the dual laminate systems for brine electrolysis, while downstream the chlorine tree and the infinite caustic soda industrial usages offer the perfect environment for thermoplastic installations with GF Piping Systems. Electro chlorination and water disinfection are increasing practices worldwide, GF Piping Systems offer key components for the skid, low weight and top quality installations.

Basic inorganic chemicals, specialty chemicals, bio-chemicals

Whether there are basic substances like titanium dioxide or bromine, pigments or ingredients for pharmaceuticals, adhesives or chemicals for water treatment or electronic industry, GF Piping Systems products are employed nearly at all process stages. The same value chain as in the traditional chemical processing, is increasingly being replicated in the growing field of the bio-chemicals, where inorganic chemicals play a distinctive role as process additives or catalysts.

3 Chemicals used in manufacturing and process industries

Steel mills and metal industry

Metallic materials are the backbone of infrastructure construction and the platform for the majority of the engineered products of industry and everyday life. Steel mills and the base metal processing plants for operations of smelting, refining, recycling are intensive users of aggressive acids and alkalis, especially in the pickling process. In this area the thermoplastic piping systems play a key role, for example in the exhaust gases scrubbing.

Surface treatment, galvanization, batteries, painting and printing, glass industry

Driven primarily by transportation industry and household appliances, surface treatment of the metals is a widespread industrial practice, including demanding fine-tuned electrochemical applications such in case of galvanization of fashion accessories, including watches, treatment of steel tyre cord, etching of surfaces for electronics industry components. Preparation of metal surfaces for painting involves high complexity electro-dipping treatment stages, where the excellent material purity and leach-out behavior of GF Piping Systems components are proven benefits.

Pulp and paper, starch, yeast and sugar, cosmetic and detergents, textile industry

Globalization and urbanization driven, increasing standards of life place a demand to manufacturing industries for several products, with challenging quality and performance requirements and within strict regulations for environmental compliance and health and safety. High quality components, durable materials, precise process control are ensured by GF Piping Systems in a multitude of applications involving chemicals.

1.2.2 Leading Systems (Samples)

PVC-U	PVC-C	SYGEF Standard	SYGEF ECTFE	PROGEF Standard	CONTAIN-IT Plus
					
d6 – d400 mm, PN6 – PN16	d16 – d225 mm PN10 – PN16	d16 – d315 mm PN10 – PN16	d20 – d110 mm PN10	d16 – d500 mm**, PN6 – PN10	d25 – d225 mm
0 °C to +60 °C	0 °C to +80 °C	-20 °C to +140 °C	0°C bis +80 °C*	0 °C to +80 °C	-50 °C to +140 °C***
Automation Measurement – Control – Actuation					

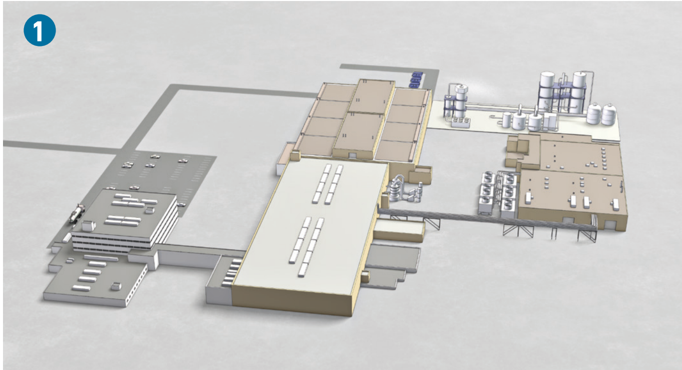
* proven for chemicals, on raw materials: -76 to +130 °C
**bigger sizes available for certain products
***acc. to primary pipe material

1.3 Microelectronics

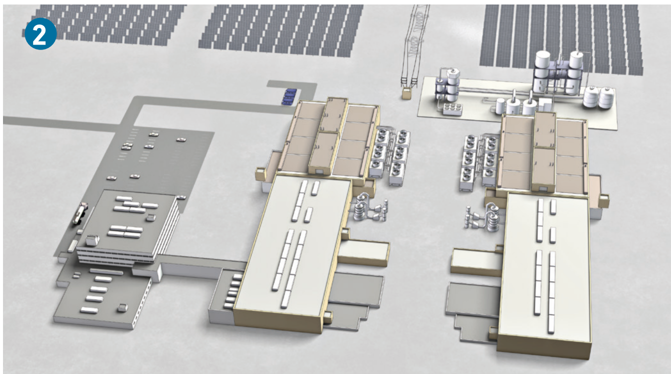
1.3.1 Overview

At GF Piping Systems we realize that your high tech production plants running 24/7. Having dependable, safe piping systems that can consistently deliver critical processing fluids is a must.

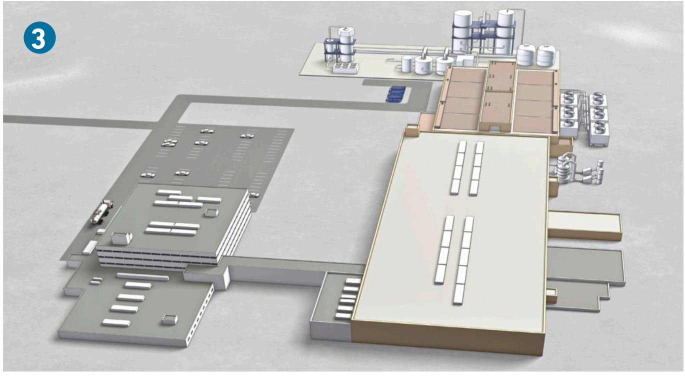
Avoiding unnecessary shutdowns is a common goal that we share. Our supply of quality plastic piping system products and jointing technologies coupled with our dedicated and knowledgeable engineering staff has kept factories like your own running 24/7 for more than two decades. During this time, end users like yourself have seen the added benefits of plastic piping systems and replaced other materials to achieve safety, quality and productivity.



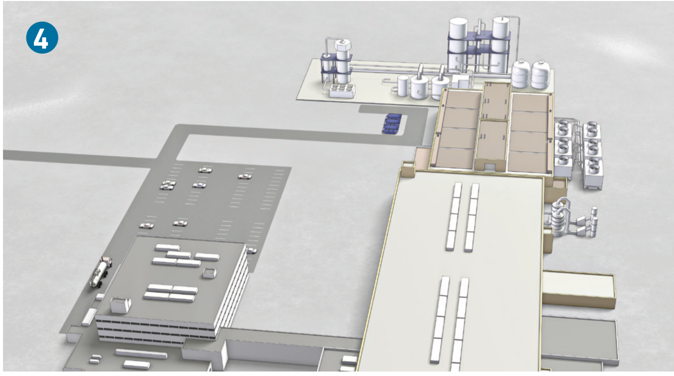
Semiconductor



Photovoltaic



TFT/HB-LED



Storage media

1 Semiconductor

Highly specialized facilities handle the complexity and sensitiveness of the processes and products in the semiconductor wafer production industry by operating in strictly controlled clean room environments. GF Piping Systems offers a portfolio of high purity plastic systems for the safe and reliable conveyance of critical processing fluids to and from your Fab processing equipment installed on production floor.

2 Photovoltaic

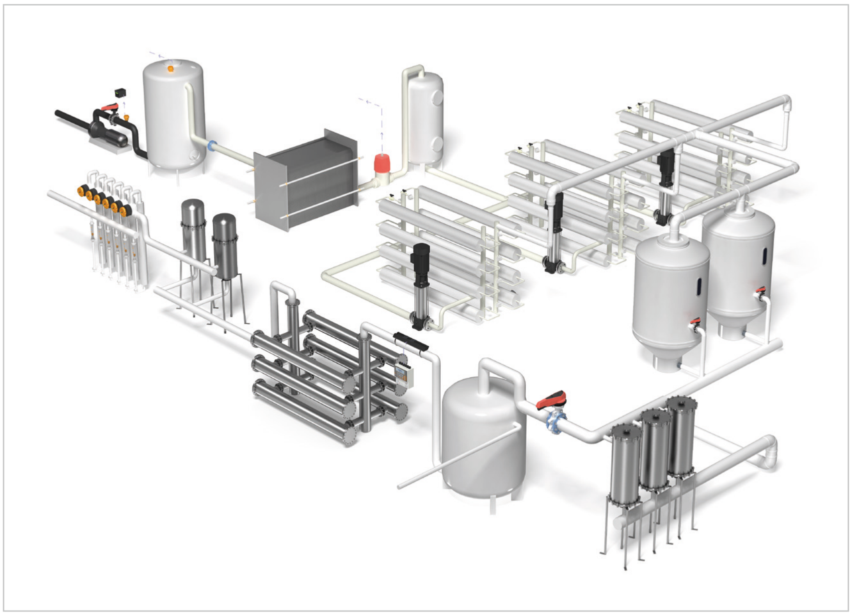
High demands regarding purity, safety and quality characterize production processes of photovoltaic systems. Reliable conveyance of media under clean conditions has to be assured and appropriately controlled. Whether it is process technology or the production flow, GF Piping Systems product portfolio covers all high end water applications in the photovoltaic industry.

❸ TFT/HB-LED

The manufacturing of TFT/LED technologies is structured in wafer cleaning and metallization steps, patterning and etching, mapped in typical applications such as neutralization and chemical distribution as well process cooling water for tools. GF Piping Systems offers the right solution according to process requirements, temperature conditions and chemical concentrations.

❹ Storage media

Since memory capacity per footprint is continuously increasing, producers of mechanical memory devices showing also an increased demands for pure and high purity materials of constructions for their facilities in various applications.



Applications
- Process- / Vacuum Solutions
- CMP / Slurry process
- UPW / Hot UPW
- Chemical distribution / Conveyance
- Process cooling water
- Specialty waste
- Industrial grade water
- DI water / Specified water
- Wet bench process tools (OEM)

1.3.2 Leading Systems (Samples)

SYGEF Plus	PROGEF Plus	SYGEF ECTFE	CONTAIN-IT Plus
			
d20 – d400 mm PN10 – PN16	d16 – d500 mm*, PN6 – PN10	d20 – d110 mm PN10	d20 – d630 mm, PN10 – PN16
-20 °C to +140 °C	0°C to +80 °C	0°C bis +80 °C**	-50 °C to +60 °C***
Automation Measurement – Control – Actuation			

*bigger sizes available for certain products
**proven for chemicals, on raw materials: -76 to +130 °C
***acc. to primary pipe material

1.4 Cooling

1.4.1 Overview

GF Piping Systems offers application orientated, value adding system solutions for the transport of chilled water at +6/+12°C in air-conditioning plants, industrial cooling water at +25/-35°C and heat pump combined cooling – heating installations as well as efficient energy saving transport of secondary refrigerants in refrigeration plants; for example in Breweries, Supermarkets, Cold Stores, Food and Beverage production factories.

Environmental regulations worldwide are restricting the use of high GWP (Global Warming Potential) refrigerant gases; this is driving the Cooling market towards ever increasing use of indirect or secondary systems to reduce the amount and leakages of man-made refrigerant gases. Efficient, economical transfer of the heat load in the secondary piping system is of vital importance to the efficiency of the complete plant.

GF Piping Systems offers a range of real value-adding systems for all types of cooling lines, all offering 100% corrosion resistance, optimum efficiency, thanks to factory made pre-insulation and simple time-saving installation on-site. Freon free and low carbon footprint expected life-span.

Cold stores

Commercial refrigeration

A/C Cooling: commercial - residential

F & B production

Cooling media > 0 °C / 32 °F

Air Conditioning

Chilled water +6/+12°C air-conditioning plants are common for larger cooling capacity installations: centralized cold water loops offer efficiency and flexible for contractor and end-user alike. GF Piping Systems offers within its systems also the necessary flexible hoses and fire-wall penetration solutions necessary for such installations.

Industrial Cooling Water

All industrial plants require cooling water both within the factory itself for cooling of machinery and also for external dry-cooler respectively cooling tower systems. GF Piping Systems offer all decision makers real added-value for such installations offering energy efficiency and real time savings compared with traditional solutions.

Data Centers

All sectors from banks to universities, insurance companies to communication providers, require centralized server storage of critical information. An effective way of removing heat is a water loop associated with a non-corroding, non-scaling, pressure-bearing, all-plastic piping system.

Cooling media < 0 °C / 32 °F

Commercial refrigeration

Supermarkets and groceries stores: medium temperature for fresh foods such as meat, fish and dairy products, and low temperature for frozen goods. Secondary refrigeration systems using glycol and salt solutions require smooth, non-corroding, non-dripping piping systems for an efficient transport of cooling capacity, keeping a low carbon footprint.

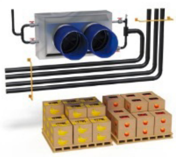
Cold stores

Preserving fruits or vegetables after harvest or storing dairy, meat and fish, these large installations require efficient, long lasting and maintenance-free cooling systems. Hydraulic loops using pre-insulated plastic piping systems provide the required accurate temperature and humidity control, with 25 years corrosion resistant life-span.

Food and Beverage Production

From ready-made meal production factories, to dairies, slaughter houses and meat production, to carbonated drinks, all forms of food and beverage production really heavily on a reliable efficient cooling plant. The safety of the workers, hygiene requirements and energy efficiency are the main drivers when designing the cooling plant. Low pressure glycol or salt solution secondary circuits with pre-insulated plastic pipe offer a simple and cost effective state-of-the-art solution for indirect refrigeration installations.

Applications

Air Conditioning +6/+12°C	Industrial Cooling Water	Data Centers	Commercial Refrige-ration	Cold Stores	Industrial Refrigeration
					

1.4.2 Leading Systems (Samples)

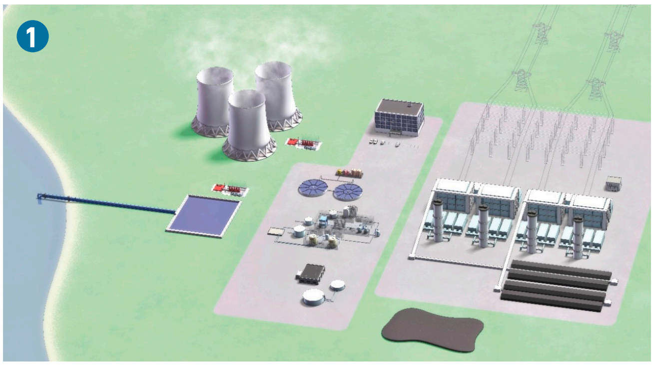
COOL-FIT 2.0 (pre-insulated)	COOL-FIT 4.0 (pre-insulated)	iFIT	ecoFIT and ELGEF
			
d32 – d140 mm, PN16	d32 – d450 mm, PN10/16	d16 - d32 mm, PN16	d20 – d630 mm, PN10 – PN16
0 °C to +60 °C	-50 °C to +60 °C	0 °C to +95 °C	-50 °C to +60 °C
Automation Measurement – Control – Actuation			

1.5 Energy

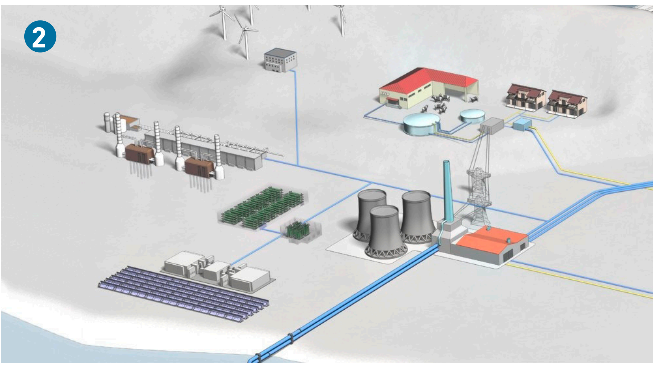
1.5.1 Overview

In the growing sense of sustainability, profound changes are beginning to transform the way energy is produced, delivered and used. GF Piping Systems provides intelligent corrosion resistant plastic solutions for successfully managing highly specialized water and chemical applications in today's and tomorrow's energy power generation.

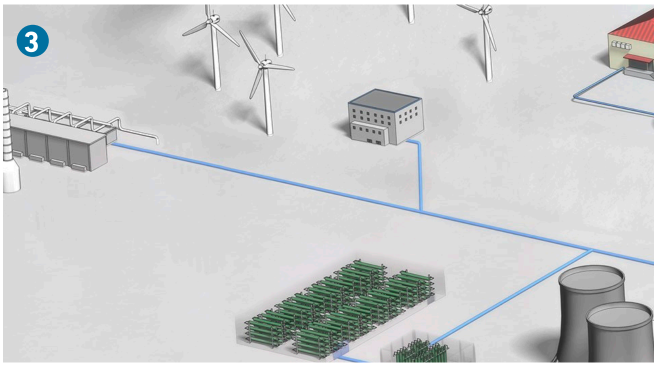
Corrosion is the biggest contributor to piping system failures in a power plant. With this in mind the goal is to replace metal piping with thermoplastic solutions. The result is corrosion resistance for up to 50 years, depending on the application.



Conventional power plants



Renewable energies



Pioneering green solutions

Energy production include coal, gas, nuclear, cogeneration waste to energy, biogas, biomass, algae, energy storage, carbon capture to name some examples.

1 Conventional Power Plants

Conventional power generation, using fossil fuels or nuclear sources to produce energy, still has a large worldwide market share and is extended by innovative new developments. Our solutions for cooling, waste and chemical lines are maximizing safety and are corrosion free.

2 Renewable Energies

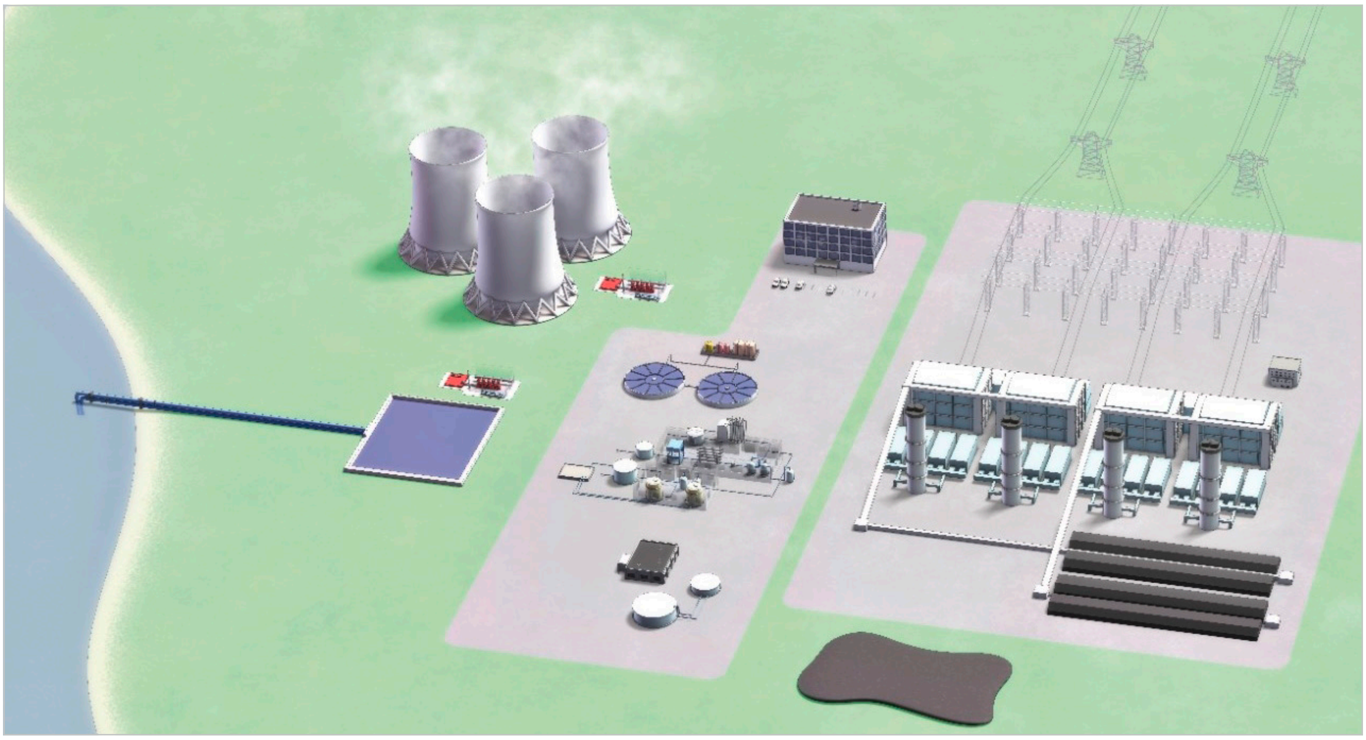
Generating energy by means of renewable natural resources is a dynamic sector with high growth rates, contributing to sustainable energy production for the future. Using intelligent cooling or containment system solutions from GF Piping Systems in water and chemical treatment reduces energy costs and potential environmental effects of leaks, maximizing safety on site at the same time.

3 Pioneering Green Solutions

The development of innovative green technologies for the intelligent utilization of alternative sources of energy is a highly promising market of the future. Providing state-of-the-art products and technologies in water and chemical media conveyance, GF Piping Systems offers cost efficient solutions that meet highest health, safety and environmental requirements.

Corrosion free piping systems for water and chemical applications in power generation

Industrial Cooling Water	Chemical Con-veyance	Water Intake Lines	Flue Gas Desulfurization	Water Distribution	Gas Distribution	Fire Fighting
						



Safety Showers	Slurry Transfer	Water Treatment	Desalination	Makeup Water	Compressed Air	Hot & Cold Water in Buildings
						

1.5.2 Leading Systems (Samples)

ecoFIT and ELGEF	PVC-U	PROGEF Standard	SYGEF Standard
			
d20 – d630 mm, PN10 – PN16	d6 – d400 mm, PN6 – PN16	d16 – d500 mm*, PN6 – PN10	d16 – d315 mm PN10 – PN16
-50 °C to +60 °C	0 °C to +60 °C	0 °C to +80 °C	-20 °C to +140 °C
Automation Measurement – Control – Actuation			

*bigger sizes available for certain products

1.6 Marine

1.6.1 Overview

Ships and platforms are exposed to the forces of nature. Wind, rain and saltwater can be harsh on structure, hulls, housing and supply lines. Preventing corrosion is more important here than anywhere else. With GF Piping Systems products corrosion is no longer an issue. The plastic piping systems reduce maintenance time and increase productivity.

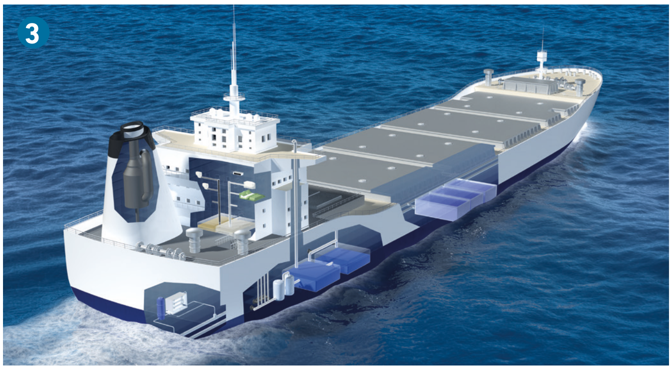
Plastic piping systems weight approx. 5 time less than metal. Using plastic components contribute to a lower carbon footprint of the total installation.

GF Piping Systems offers IMO compliant and fully approved piping systems for marine applications perfectly suitable for new build and retrofit.

Cruisers

Ferries

Offshore



Commercial vessels

① Cruise / ferries

Cruises and ferries are floating cities which need safe conveyance of drinking water, grey and black water together with high quality water treatment. Galley and laundry have to work 24/7 requiring corrosion resistant and reliable material. Air conditioning has become essential for onboard comfort. Pre-insulated piping can also ensure higher thermal efficiency.

② Offshore

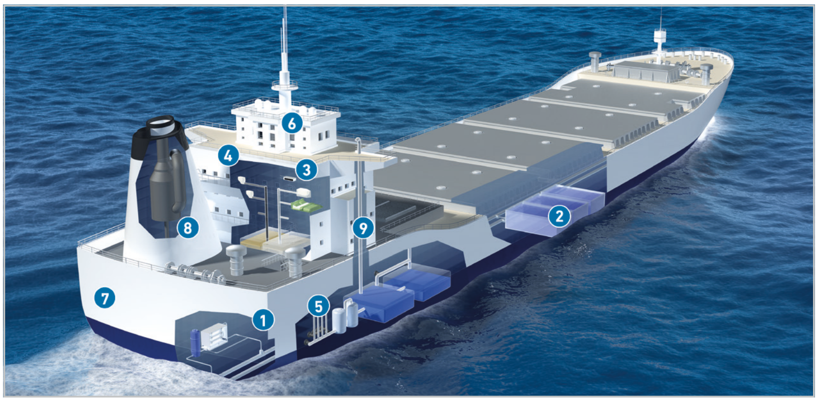
Flotels, accommodations and living barges need higher life standard onboard. Beside the hot and cold water distribution, rain catchment and chemical distribution are particularly affected internally and externally by corrosion and incrustation.

3 Commercial vessels

Commercial vessel fleets of large dimensions dominate today's worldwide maritime traffic. This trend is accompanied by rising environmental requirements and standards to counteract pollution resulting from the expanded trade and travel. Commercial vessels can benefit from lighter and corrosion resistant solutions on ballast piping system, water treatment, vent lines and gas scrubber effluents.

GF Piping Systems supports the industry to face these technical, operational and environmental challenges. The corrosion, abrasion and chemical resistant systems are ideally adapted to the extreme conditions on the high sea, offering outstanding cost-efficiency and a long system life cycle.

Applications



Description

1. Ballast Water Treatment
2. Ballast System
3. Hot & Cold Water
4. Grey and Black Water Ships
5. Water Treatment
6. AC Cooling
7. Compressed Air
8. Air Cleaning (Gas Scrubber)
9. Water Tank Venting

1.6.2 Leading Systems (Samples)

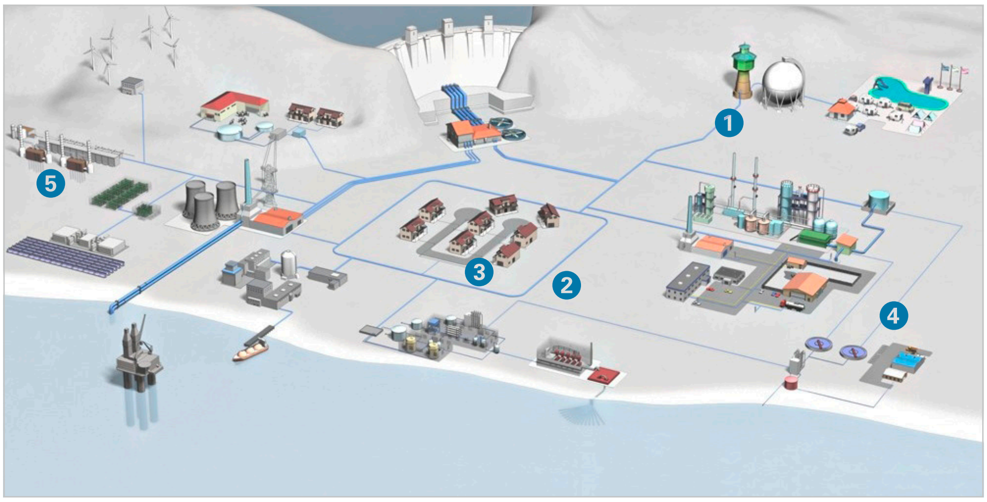
INSTAFLEX	JRG SANIPEX MT	SeaDrain	PVC-U	PVC-C	ecoFIT and ELGEF
					
d16 – d225 mm, PN16	d16 – d63 mm, PN10	1½" – 12" Schedule 40	d6 – d400 mm, PN6 – PN16	d16 – d225 mm, PN10 – PN16	d20 – d630 mm, PN10 – PN16
0 °C to +95 °C	0 °C to +95 °C	0 °C to +100 °C	0 °C to +60 °C	0 °C to +80 °C	-50 °C to +60 °C
Automation Measurement – Control – Actuation					

COOL-FIT 2.0 (pre-insulated)	COOL-FIT 4.0 (pre-insulated)	PROGEF Standard
		
d32 – d140 mm, PN16	d32 – d450 mm, PN10/16	d16 – d500 mm**, PN6 – PN10
0 °C to +60 °C	-50 °C to +60 °C	0 °C to +80 °C
Automation Measurement – Control – Actuation		

1.7 Water Utilities

1.7.1 Overview

Hygienic drinking water, pure in taste, smell and appearance is one of the fundamental health requirements. The demand for a secure supply of clean water is increasing worldwide. For the full spectrum of water supply, GF Piping Systems has a variety of innovative techniques and specialized products designed specifically for the water distribution industry. Our leading know-how and expertise for all water distribution applications helps finding the right solution for your application.



1 Water transportation lines

When transporting water, a safe and reliable connection is the key success factor. But at the same time it can be a challenging task, especially at large dimensions. GF Piping Systems understands the need for proper tooling, high performance jointing technologies and connection parts as well as expert support on site.

2 Water distribution lines

For the reliable, economical and sustainable water distribution it is essential that all piping components like pipe, fittings and valves are connected safe and reliable. GF Piping Systems offers a comprehensive range of jointing technologies. The electro fusion system ELGEF Plus ensures a material homogeneous connection of pipe and fitting that contributes to a reliable network. With the MULTI/JOINT system all kinds of materials can be connected in a quick, safe and simple way.

3 Water service lines and house connections

In the last stage of the water grid, service lines bring water to the meter. Due to its flexibility and material homogeneous jointing technologies, amongst many other positive characteristics, PE is today's main used material for new installations. Thanks to the modular ELGEF Plus electro fusion system an appropriate solution can be found for every application. Each individual ELGEF fitting and saddle is made to match and when put together they form reliable leak-proof connections. Many different combinations can be devised using just a few products. Also PE valves will contribute to a reliable and safe network as part of the ELGEF Plus system.

4 Pressure sewage lines

Rather than gravity, the pressure sewage system is using pumps to move the waste water along to the waste water treatment plant. Pressure sewage systems are using generally smaller diameter pipe that are less expensive and easier to install. Choosing here the GF PE system, a reliable network for 100 years can be built.

5 Irrigation

A growing world population and the changing climate enhance the food and water scarcity. More and more food production will be separated from the local weather by building large glass houses or doing extended irrigation increasing the output of food per m². Systems simple to install and ensuring a secure water distribution over the total product life span will become an important attribute. GF Piping Systems provides a comprehensive product range for irrigation as well as on the local training and fast deliveries.

1.7.2 Leading Systems (Samples)

ELGEF	MULTI/JOINT	iJOINT	Machines	Tools
				
d160 – d2000 mm, PN10 d20 – d1200 mm, PN16	DN50 – DN600 mm	d16 – d110 mm	**Butt fusion** d160 mm – d1600 mm (with CNC technology up to d630 mm) **Electrofusion** (Transformer) MSA 210, 230, 330, 340 **Electrofusion** (Inverter technology) MSA 2.0, 2.1, 4.0, 4.1	d20 – d2000 mm
Electro fusion fittings, spigot fittings, seamless bends and segmented fittings	Wide-range of couplings, restrained	couplings, tees, bends, reducers and saddles, transition fittings, universal fittings		A wide range of different installation tools enable easy installation and result in high quality joints

1.8 Gas Utilities

1.8.1 Overview

For decades, gas has been delivered through a network of buried transmission and distribution pipe to homes and industries throughout the world. It has grown to become the most dependable form of energy and being one of the cleanest, safest and most useful of all energy sources.

During recent years the gas supply industry has invested greatly to ensure and enhance consistent quality in the operation and maintenance of gas supply networks.
GF Piping Systems continues to provide high quality systems and services for building and maintaining these networks thus contributing to the transportation of gas in the safest, most secure and reliable way.

1 Gas transportation lines

When transporting gas, a safe and reliable connection is the key success factor. But at the same time it can be a challenging task, especially at larger dimensions. GF Piping Systems understands the need for proper tooling, high performance jointing technologies and connection parts as well as expert support on site.

2 Gas distribution lines

For the reliable, economical and sustainable gas distribution it is essential that all piping components like pipe, fittings and valves are connected safe and reliable. GF Piping Systems offers a comprehensive range of jointing technologies. The electro fusion system ELGEF Plus ensures a material homogeneous connection of pipe and fitting that contributes to a reliable network. With the MULTI/JOINT system all kinds of materials can be connected in a quick, safe and simple way.

3 Gas service lines and house connections

In the last stage of the gas grid, service lines bring gas to the meter. Due to its flexibility and material homogeneous jointing technologies, amongst many other positive characteristics, PE is today's main used material for new installations. Thanks to the modular ELGEF Plus electro fusion system an appropriate solution can be found for every application. Each individual ELGEF fitting and saddle is made to match and when put together they form reliable leak-proof connections. Many different combinations can be devised using just a few products. Also PE valves will contribute to a reliable and safe network as part of the ELGEF Plus system.

1.8.2 Leading Systems (Samples)

ELGEF	Valves	MULTI/JOINT	Machines	Tools
				
d160 – d2000 mm, PN10 d20 – d1200 mm, PN16	PE ball valves up to d225 mm	DN50 – DN600 mm	**Butt fusion** d160 mm – d1600 mm	d20 – d2000 mm
Electro fusion fittings, spigot fittings, seamless bends and segmented fittings	Pressure Tapping Valves up to d63 mm outlet , mains up to d400 mm	Wide-range of couplings, restrained	(with CNC technology up to d630 mm) **Electrofusion** (Transformer) MSA 210, 230, 330, 340 **Electrofusion** (Inverter technology) MSA 2.0, 2.1, 4.0, 4.1	A wide range of different installation tools enable easy installation and result in high quality joints.

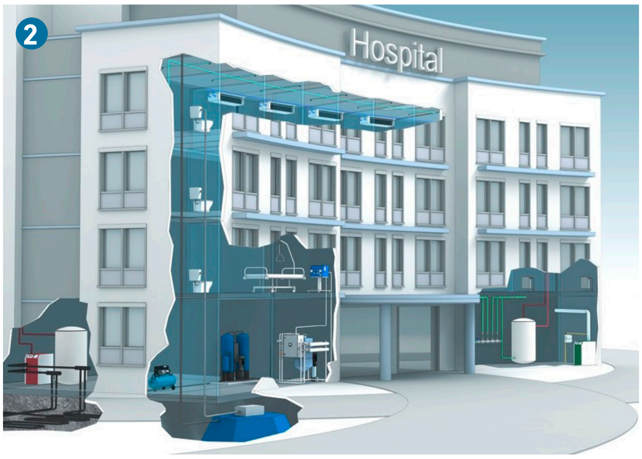
1.9 Building Technology

1.9.1 Overview

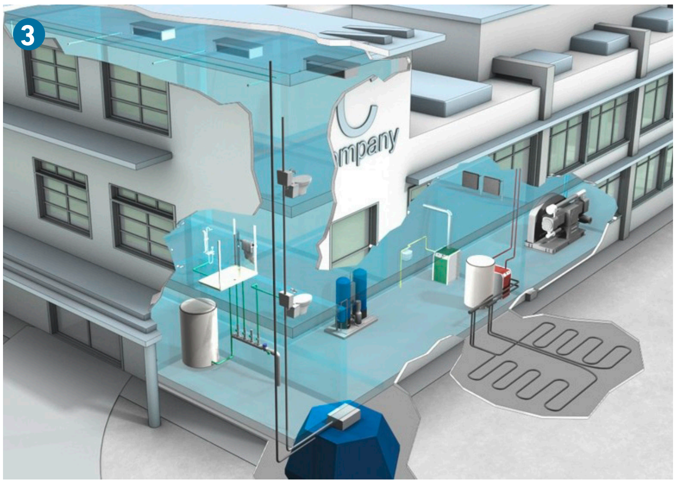
Sustainability, comfort and hygiene are at the top of the wish list for new building or renovation projects. Environment-friendly and cost-efficient piping systems make all the difference in terms of zero dead leg, noise reduction, corrosion resistance and prefabrication.

Prefabrication is big trend even including prefabricated bathroom units (PBU) which shorten the overall construction time due to factory proceedings in parallel and the 'Just-in-time' bathroom supply to the site. Incorporating design and the supply of a flexible and high quality plumbing and sanitary piping system makes all the difference.

Hotel



Hospital



Industrial buildings

Residential buildings

1 Hotels

Hotels are an oasis of comfort and calm. Guests expect first-class service which includes a perfectly functioning hygienic and environment-friendly piping system. Apart from providing water hygiene with a full hygienic concept, piping systems in a hotel provide optimized acoustic solutions for drainage and water supply systems. Energy saving piping solutions further contributes to a more sustainable building changeover.

2 Hospitals

Hospitals and healthcare facilities are a place of healing and convalescence. In such an environment water hygiene is of utmost importance where no compromises are allowed. Thus, drinking water installations in hospitals must be carefully planned, built and operated.

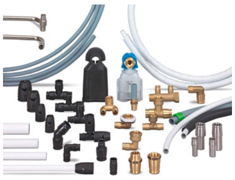
❸ Commercial and industrial buildings

Commercial and industrial buildings, as well as research facilities have one thing in common: they all need an environment-friendly heating and cooling system as well as a reliable, leak-free supply of drinking water, sprinkler water, gas and compressed air.

❹ Residential buildings / Green buildings

Comfort, hygiene and sustainability are the current key trends in modern living. In building, renovation or extension projects one relies on environment-friendly heating and cooling systems, durable, easy handling drinking water installations and leak-free gas piping systems.

1.9.2 Leading Systems (Samples)

iFIT	INSTAFLEX	JRG SANIPEX	JRG SANIPEX MT
			
d16 – d32 mm, PN16	d16 – d225 mm, PN16	d12 – d32 mm, PN16	d16 – d63 mm, PN10
0 °C to +95 °C	-10 °C to +90 °C	0 °C to +95 °C	0 °C to +95 °C

AQUASYSTEM (PP-R)	Silenta Premium	iLITE	GF Malleable Iron Fittings
			
d20 – d125 mm, PN20	d58 – d200 mm	d16 – 32 mm, PN10	1/8 to 4 inch, PN25
0 °C to +70 °C	+10 °C to +90 °C	0 °C to +95 °C	0 °C to +300°C

1.10 Application-System Overview

	ABS	AQUASYSTEM	CONTAIN-IT Plus	COOL-FIT	ecoFIT	ELGEF Plus	iFIT	iJOINT	INSTAFLEX	JRG Sanipex	JRG Sanipex MT	Malleable Fittings	PROGEF	PRIMOFIT	PVC-C	PVC-U	SeaCor	SeaDrain	Silenta Premium	SYGEF	WAGA
AC Cooling	✓	✓		✓	✓	✓	✓		✓		✓										
Advanced Water Processing on Ships					✓	✓															
Ballast Water					✓	✓															
Ballast Water Treatment on Ships	✓												✓		✓	✓	✓				
Biological Media																				✓	
Chemical Distribution / Conveyance			✓		✓								✓		✓	✓				✓	
Compressed Air					✓	✓			✓		✓	✓									
Cooling Towers				✓	✓								✓			✓					
District cooling / heating				✓		✓			✓												
Dosing / Dilution			✓		✓								✓		✓	✓				✓	
Drainage of Buildings																			✓		
Draw-off Station					✓								✓		✓	✓				✓	
Fire Fighting					✓	✓															
Fire Protection / Sprinkler Systems									✓	✓		✓		✓							
Fish Farms	✓				✓											✓					
Gas Distribution lines						✓															✓
Gas House Connections / Service Lines						✓								✓							✓
Gas Installations inside Buildings												✓		✓							
Gas Maintenance and Repair						✓								✓							✓
Gas Scrubber			✓		✓	✓							✓		✓	✓	✓			✓	
Gas Transport lines						✓															✓
Geothermal					✓	✓			✓				✓		✓	✓					
Grey and Black Water in Ships					✓	✓										✓	✓	✓	✓		
Heating							✓			✓	✓	✓		✓			✓				
Hot & Cold Water		✓					✓		✓	✓	✓				✓		✓				
Industrial Cooling Water	✓			✓	✓								✓		✓	✓	✓			✓	
Irrigation / Agriculture						✓		✓													
Ion Exchanger					✓										✓	✓					
Media Filtration			✓												✓	✓					
Mixing (Batching and Ratio Control)			✓		✓								✓		✓	✓				✓	
Neutralization			✓										✓		✓	✓					
Pressure sewage / Waste water						✓															✓
Process Cooling Water	✓			✓	✓								✓		✓	✓				✓	
Refrigeration	✓			✓	✓	✓	✓				✓										
Safety Showers		✓		✓								✓									
Seam Gas / LNG					✓	✓															✓
Surface Treatment			✓		✓								✓		✓	✓				✓	
Swimming Pools					✓	✓										✓					
Tank filling			✓		✓								✓		✓	✓				✓	
Ultrapure Water / Hot Ultrapure Water																				✓	
Water - Maintenance and Repair						✓		✓						✓							✓
Water Distribution lines					✓	✓										✓		✓			✓
Water House Connections / Service Lines						✓		✓					✓			✓		✓			✓
Water intake lines					✓	✓															
Water storage						✓															✓
Water Transport Lines					✓	✓															✓

Suitability of system solutions may differ acc. to respective local needs or regulation

2 System and Product Solutions

GF Piping Systems develops, produces and markets a comprehensive range of piping systems and components in a variety of materials used worldwide to transport water, gases and aggressive media. Our goal is to provide comprehensive system solutions, consisting of pipe, fittings, valves, tools, jointing technology and automation, for industrial applications and thus, fulfilling the expectation of our customers.

Our industrial system solutions are all based on certified raw materials, covering all requirements of the most significant international standards and offering high quality solutions to our customers.

2.1 Advantages of Industrial Plastic Piping Systems

Excellent Problem Solver

- Corrosion-free
- Good chemical and temperature resistance
- No electrical conductivity and low thermal conductivity
- Smooth inner surface
- Low weight and high flexibility

Economic efficiency

- Excellent price-performance ratio (in installation and operation)
- Low installation and maintenance costs
- System lifetime design over 25 years[1)]

Complete solutions

- High-quality system components
- Broad selection of valves with many connection options
- Proven jointing technologies
- Worldwide service: Customizing, engineering services, machine rental pool, training and sales suppor
- System life-time warranty [1)]

High quality

- Certified raw materials with many approvals
- 100 % traceability
- Low CO_2 footprint of plastic material

1) For detailed warranty terms and conditions, see www.gfps.com

2.2 Most Important Market Segments

Industrial Systems	Water treatment	Chemical process industry	Micro-electronics	Energy	Marine	Cooling
PVC-U	✓	✓	✓	✓	✓	
PVC-C		✓	✓	✓	✓	
ABS						✓
SYGEF PVDF		✓	✓	✓		
SYGEF ECTFE	✓	✓	✓			
PROGEF PP	✓	✓	✓	✓		
ecoFIT PE	✓	✓	✓	✓	✓	✓
COOL-FIT					✓	✓
CONTAIN-IT Plus	✓	✓	✓	✓		

2.3 PVC-U Piping System

The piping system made of PVC-U material can be used for operating temperatures in the range of 0 °C to +60 °C. Thanks to outstanding chemical resistance, PVC-U piping systems withstand demanding conditions, particularly during the transport of aggressive media, such as acids, bases and salts. The PVC-U system is widely used in the chemical and textile industry, in water treatment processes, for drinking water applications and vacuum lines.


Pipes


Fittings


Jointing technology


Automation


Valves

Essential system properties

- Food and drinking water approvals, proven physiological harmlessness
- First-class solution for aggressive media, such as acids, bases and salts
- Space-saving installation with PRO-FIT spigot-socket fittings
- Safe and simple joining technologies with low costs for tools and materials

Most important market segments

- Water treatment
- Chemical process industry
- Marine
- Microelectronics
- Energy

Technical data

Nominal pressure	Up to 16 bar
Temperature range	0 °C to +60 °C
Jointing technology	Solvent cementing
Standards and guidelines[1]	ISO, EN, ASTM, BS, JIS, CE, RoHS, DIN, DVS
Approvals[1]	DIBT, DVGW, GOST-R, DGS (ACS), WRAS, KIWA, CSTB, IIP, ABS, BV, CCS, DNV-GL, LR, RINA, RMROS

[1] For additional information about standards, guidelines and approvals, see www.gfps.com

PVC-U product overview

The following table uses metric units of measure.

Products	PN (bar)	d (mm)	6	8	10	12	16	20	25	32	40	50	63	75	90	110	125	140	160	180	200	225	250	280	315	355	400
		DN (mm)				8	10	15	20	25	32	40	50	65	80	100	100	125	150	150	200	200	250	250	300	355	400
Pipes	PN6-16	PVC-U System	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
		PVC-C System					■	■	■	■	■	■	■	■	■	■		■	■			■					
		ABS-System						■	■	■	■	■	■	■	■	■		■	■		■	■	■	■	■		
Fittings	PN6-16	PVC-U System	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■		■	■	■	■	■	■	■
		PVC-C System					■	■	■	■	■	■	■	■	■	■			■			■					
		ABS-System						■	■	■	■	■	■	■	■	■		■	■		■	■	■	■	■		
Ball valves	PN6-16	PVC-U System			■	■	■	■	■	■	■	■	■	■	■	■											
		PVC-C System					■	■	■	■	■	■	■	■	■	■											
		ABS-System					■	■	■	■	■	■	■	■	■	■											
Butterfly valves	PN6-10	PVC-U System											■	■	■	■	■	■	■	■	■	■	■	■	■		
		PVC-C System											■	■	■	■		■	■			■		■	■		
		ABS-System											■	■	■	■		■	■		■	■		■	■		
Check valves	PN6-16	PVC-U System					■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■		
		PVC-C System					■	■	■	■	■	■	■	■	■	■											
		ABS-System					■	■	■	■	■	■	■	■	■	■											
Diaphragm valves	PN6-16	PVC-U System					■	■	■	■	■	■	■	■	■	■			■								
		PVC-C System					■	■	■	■	■	■	■	■	■	■											
		ABS-System					■	■	■	■	■	■	■	■	■	■											
Flanges	PN 6-16	PVC-U System					■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
		PVC-C System					■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■					
		ABS-System					■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■		
Gaskets and pipe clips			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Automation			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

- PVC-U System
- PVC-C System
- ABS-System

For more information about the system specification of PVC-U, visit www.gfps.com

The following table uses units of measure based on the BS inch system.

Products	PN (bar)	d (mm)	3/8"	½"	¾"	1"	1 ¼"	1 ½"	2"	2 ½"	3"	4"	5"	6"	8"	10"-12"
Pipes	PN9-15		PVC-U	PVC-U	PVC-U	PVC-U	PVC-U	PVC-U	PVC-U	PVC-U	PVC-U	PVC-U	PVC-U	PVC-U	PVC-U	
			ABS	ABS	ABS	ABS	ABS	ABS	ABS	ABS	ABS	ABS	ABS	ABS	ABS	
Fittings	PN9-15		PVC-U	PVC-U	PVC-U	PVC-U	PVC-U	PVC-U	PVC-U	PVC-U	PVC-U	PVC-U	PVC-U	PVC-U	PVC-U	
			ABS	ABS	ABS	ABS	ABS	ABS	ABS	ABS	ABS	ABS	ABS	ABS	ABS	
Ball valves	PN16		PVC-U	PVC-U	PVC-U	PVC-U	PVC-U	PVC-U	PVC-U	PVC-U	PVC-U	PVC-U				
			ABS	ABS	ABS	ABS	ABS	ABS	ABS	ABS	ABS	ABS				
Butterfly valves	PN10								PVC-U	PVC-U	PVC-U	PVC-U	PVC-U	PVC-U	PVC-U	PVC-U
									ABS	ABS	ABS	ABS	ABS	ABS	ABS	ABS
Check valves	PN6-16		PVC-U	PVC-U	PVC-U	PVC-U	PVC-U	PVC-U	PVC-U	PVC-U	PVC-U	PVC-U				
			ABS	ABS	ABS	ABS	ABS	ABS	ABS	ABS	ABS	ABS				
Diaphragm valves	PN6-16			PVC-U	PVC-U	PVC-U	PVC-U	PVC-U	PVC-U	PVC-U	PVC-U	PVC-U	PVC-U	PVC-U		
				ABS	ABS	ABS	ABS	ABS	ABS	ABS	ABS	ABS				
Flanges	PN10-16			PVC-U	PVC-U	PVC-U	PVC-U	PVC-U	PVC-U	PVC-U	PVC-U	PVC-U	PVC-U	PVC-U	PVC-U	
				ABS	ABS	ABS	ABS	ABS	ABS	ABS	ABS	ABS	ABS	ABS	ABS	
Gaskets and pipe clips			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
Automation	-		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	

PVC-U System
ABS-System

For more information about the system specification of PVC-U, visit www.gfps.com

2.4 PVC-C Piping System

PVC-C piping systems, having an operational temperature range from 0 °C to 80 °C, are suitable for high temperature environments. The excellent mechanical properties such as a high tensile strength, stiffness and impact strength are evident even at increased temperatures. PVC-C systems are used wherever aggressive media such as mixed acid waste or acids at a high temperature are transported, for example, in the chemical, paper and pulp industry or in metal treatment and microelectronic production.

Pipes

Fittings

Jointing technology

Automation

Valves

Essential system properties

- Very good mechanical properties, even at higher temperatures
- Flame-retardant and self-extinguishing
- Safe and simple jointing technology with low costs for tools and materials

Most important market segments

- Chemical process industry
- Marine
- Microelectronics
- Energy

Technical data

Nominal pressure	Up to 16 bar
Temperature range	0 °C to 80 °C
Jointing technology	Solvent cementing
Standards and guidelines[1)]	ISO, EN, ASTM, BS, JIS, CE, RoHS, DIN, DVS
Approvals[1)]	DGS (ACS), WRAS, GOST-R, ABS, BV, CCS, DNV-GL, LR, RINA, RMROS

1) For additional information about standards, guidelines and approvals, see www.gfps.com

II

PVC-C product overview

The following table uses metric units of measure.

Products	PN (bar)	d (mm)	6	8	10	12	16	20	25	32	40	50	63	75	90	110	125	140	160	180	200	225	250	280	315	355	400
		DN (mm)				8	10	15	20	25	32	40	50	65	80	100	100	125	150	150	200	200	250	250	300	355	400
Pipes	PN6-16		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
							■	■	■	■	■	■	■	■	■	■		■	■			■					
								■	■	■	■	■	■	■	■	■		■	■		■	■	■	■	■		
Fittings	PN6-16		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■		■	■	■	■	■	■	■
							■	■	■	■	■	■	■	■	■	■			■			■					
								■	■	■	■	■	■	■	■	■		■	■		■	■	■	■	■		
Ball valves	PN6-16				■	■	■	■	■	■	■	■	■	■	■	■											
							■	■	■	■	■	■	■	■	■	■											
							■	■	■	■	■	■	■	■	■	■											
Butterfly valves	PN6-10												■	■	■	■	■	■	■	■	■	■	■	■	■		
													■	■	■	■		■	■			■		■	■		
													■	■	■	■		■	■		■	■		■	■		
Check valves	PN6-16						■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■		
							■	■	■	■	■	■	■	■	■	■											
							■	■	■	■	■	■	■	■	■	■											
Diaphragm valves	PN6-16						■	■	■	■	■	■	■	■	■	■			■								
							■	■	■	■	■	■	■	■	■	■											
							■	■	■	■	■	■	■	■	■	■											
Flanges	PN 6-16						■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
							■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■					
							■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■		
Gaskets and pipe clips			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Automation			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

PVC-U System
PVC-C System
ABS-System

For more information about the system specification of PVC-C, visit www.gfps.com

2.5 ABS Piping System

The outstanding characteristics of ABS allow its application in a wide temperature range between -50 ˚C to +60˚C. The exceptionally high notched impact strength values, even at low temperatures, indicate the material's high robustness and tolerance to surface damage. ABS systems offer an energy-efficient solution for industrial low temperature applications, refrigeration and cooling systems.

Pipes

Fittings

Jointing technology

Automation

Valves

Essential system properties

- Outstanding abrasion resistance
- Low thermal conductivity
- High impact strength even at low temperatures
- Halogen-free
- Safe and simple jointing technology with low costs for tools and materials

Most important market segments

- Cooling
- Water Treatment

Technical data

Nominal pressure	Up to 10 bar
Temperature range	-50 °C to +60 °C
Jointing technology	Solvent cementing
Standards and guidelines[1)]	ISO, EN, ASTM, BS, JIS, CE, RoHS, DIN, DVS
Approvals[1)]	GOST-R, ABS, BV, CCS, DNV-GL, LR, RINA, RMROS

1) For additional information about standards, approvals and guidelines, see www.gfps.com

ABS product overview

The following table uses metric units of measure.

Products	PN (bar)																										
		d (mm)	6	8	10	12	16	20	25	32	40	50	63	75	90	110	125	140	160	180	200	225	250	280	315	355	400
		DN (mm)				8	10	15	20	25	32	40	50	65	80	100	100	125	150	150	200	200	250	250	300	355	400
Pipes	PN6-16																										
Fittings	PN6-16																										
Ball valves	PN6-16																										
Butterfly valves	PN6-10																										
Check valves	PN6-16																										
Diaphragm valves	PN6-16																										
Flanges	PN6-16																										
Gaskets and pipe clips			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Automation			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

PVC-U System
PVC-C System
ABS-System

For more information about the system specification of ABS, visit www.gfps.com

The following table uses units of measure based on the BS inch system.

Produkte	PN (bar)	d (mm)	3/8"	1/2"	3/4"	1"	1 1/4"	1 1/2"	2"	2 1/2"	3"	4"	5"	6"	8"	10" - 12"
Pipes	PN9-15		PVC-U	PVC-U	PVC-U	PVC-U	PVC-U	PVC-U	PVC-U	PVC-U	PVC-U	PVC-U	PVC-U	PVC-U	PVC-U	
			ABS	ABS	ABS	ABS	ABS	ABS	ABS	ABS	ABS	ABS	ABS	ABS	ABS	
Fittings	PN9-15		PVC-U	PVC-U	PVC-U	PVC-U	PVC-U	PVC-U	PVC-U	PVC-U	PVC-U	PVC-U	PVC-U	PVC-U	PVC-U	
			ABS	ABS	ABS	ABS	ABS	ABS	ABS	ABS	ABS	ABS	ABS	ABS	ABS	
Ball valves	PN16		PVC-U	PVC-U	PVC-U	PVC-U	PVC-U	PVC-U	PVC-U	PVC-U	PVC-U	PVC-U				
			ABS	ABS	ABS	ABS	ABS	ABS	ABS	ABS	ABS	ABS				
Butterfly valves	PN10								PVC-U	PVC-U	PVC-U	PVC-U	PVC-U	PVC-U	PVC-U	PVC-U
									ABS	ABS	ABS	ABS	ABS	ABS	ABS	ABS
Check valves	PN6-16		PVC-U	PVC-U	PVC-U	PVC-U	PVC-U	PVC-U	PVC-U	PVC-U	PVC-U	PVC-U				
			ABS	ABS	ABS	ABS	ABS	ABS	ABS	ABS	ABS	ABS				
Diaphragm valves	PN6-16			PVC-U	PVC-U	PVC-U	PVC-U	PVC-U	PVC-U	PVC-U	PVC-U	PVC-U	PVC-U	PVC-U		
				ABS	ABS	ABS	ABS	ABS	ABS	ABS	ABS	ABS				
Flanges	PN10-16			PVC-U	PVC-U	PVC-U	PVC-U	PVC-U	PVC-U	PVC-U	PVC-U	PVC-U	PVC-U	PVC-U	PVC-U	
				ABS	ABS	ABS	ABS	ABS	ABS	ABS	ABS	ABS	ABS	ABS	ABS	
Gaskets and pipe clips			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
Automation	-		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	

PVC-U System
ABS-System

For more information about the system specification of ABS, visit www.gfps.com

2.6 SYGEF Piping Systems: Standard, Plus, and ECTFE

SYGEF Standard and Plus

The outstanding physical and mechanical properties of the SYGEF Standard and SYGEF Plus piping systems, made of polyvinylidene fluoride (PVDF), assure a superior performance for highly demanding applications in the industrial sector. SYGEF Standard combines the safe transport of water and aggressive chemicals with a very broad temperature range (-20 °C to +140 °C). In addition, SYGEF Plus, with its excellent surface roughness and purity, offers a benchmark solution for the supply of high-purity water in the microelectronics industry.

				
Pipes	**Fittings**	**Jointing technology**	**Automation**	**Valves**

Essential system properties

- Very high temperature range and chemical resistance
- Extremely smooth surface
- Excellent purity thanks to completely controlled cleanroom manufacturing

Most important market segments

- Chemical process industry
- Microelectronics
- Energy

Technical data

Nominal pressure	Up to 16 bar
Temperature range	-20 °C to +140 °C
Jointing technology	Socket fusion
	Butt fusion
	Infrared (IR) fusion
	Bead and crevice-free (BCF) fusion
Standards and guidelines[1)]	ISO, EN, ASTM, BS, JIS, CE, RoHS, DIN, DVS, SEMI
Approvals[1)]	DIBt, ASME BPE, FDA, EU 10/2011, USP 25 class VI, FM-4910

1) For additional information about standards, guidelines and approvals, see www.gfps.com

SYGEF Standard, SYGEF Plus product overview

The following table uses metric units of measure.

Products	PN (bar)	SDR)	d (mm)	16	20	25	32	40	50	63	75	90	110	125	140	160	200	225	250	280	315	355	400
			DN (mm)	10	15	20	25	32	40	50	65	80	100	100	125	150	200	200	250	250	300	350	400
Pipes	16	21		S+P	S+P	S+P	S+P	S+P	S+P	S+P	S+P	S+P	S+P		S+P	S+P	S+P	S+P	S+P	S+P	S+P		
	10	33										S+P	S+P	S+P	S+P	S+P	S+P	S+P	S+P	S+P	S+P	P	P
Socket fusion fittings	16			S	S	S	S	S	S	S													
Butt fusion fittings[1) IR and BCF-compatible	16	21			S+P	S+P	S+P	S+P	S+P	S+P	S+P	S+P	S+P		S+P	S+P	S+P	S+P	S+P	S+P	S+P		
	10	33										S+P	S+P	S+P	S+P	S+P	S+P	S+P	S+P	S+P	S+P	P	P
Ball valves	16			S	S	S	S	S	S	S	S	S	S										
	10			S	S	S	S	S	S	S	S	S	S										
Diaphragm valves	16				S+P	S+P	S+P	S+P	S+P	S+P On request	S+P	S+P	S+P	S+P									
	10				S+P	S+P	S+P	S+P	S+P	S+P	S+P	S+P	S+P	S+P			S+P						
Butterfly valves	10									S	S	S	S	S	S	S	S	S	S	S	S		
Check valves	16			S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S		
	10			S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S		
Pressure regulating valves	10				S+P	S+P	S+P	S+P	S+P	S+P	S+P	S	S	S									
Ventilating and bleed valves	16			S	S	S	S	S	S	S	S	S	S	S									
Flanges					S+P	S+P	S+P	S+P	S+P	S+P	S+P	S+P	S+P	S+P	S+P	S+P	S+P	S+P	S+P	S+P	S+P	P	P
Gaskets					S+P	S+P	S+P	S+P	S+P	S+P	S+P	S+P	S+P	S+P	S	S+P	S+P	S+P	S+P	S+P	S+P	P	P
Pipe Clips				S+P	S+P	S+P	S+P	S+P	S+P	S+P	S+P	S+P	S+P	S+P	S+P	S+P	S+P	S+P	S+P	S+P	S+P	P	P
Automation				S+P	S+P	S+P	S+P	S+P	S+P	S+P	S+P	S+P	S+P	S+P	S+P	S+P	S+P	S+P	S+P	S+P	S+P	P	P
IR-welding machine					S+P	S+P	S+P	S+P	S+P	S+P	S+P	S+P	S+P	S+P	S+P	S+P	S+P	S+P	S+P	S+P	S+P	P	P
BCF-welding machine					S+P	S+P	S+P	S+P	S+P	S+P	S+P	S+P	S+P										
Butt fusion machine[1)					S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S		
Socket fusion machine				S	S	S	S	S	S	S	S	S	S	S									

S = SYGEF Standard
P = SYGEF Plus

[1) Butt fusion for SYGEF Standard is technically possible, but not recommended; for SYGEF Plus it is not allowed.

SYGEF ECTFE

The ECTFE system made of ethylene-chlorotrifluoroethylene shows excellent physical properties and mechanical characteristics. The high-performance fluoropolymer material allows applications in a very broad temperature range of -76°C to +140°C [1], on a welded system approach for the use of aggressive chemicals approved between 0°C up to 80°C. Thanks to its extremely good chemical resistance, excellent abrasion resistance and high impact strength, ECTFE meets all requirements of demanding industrial environments. The SYGEF ECTFE system in combination with most advanced IR-jointing technology is dedicated for demanding applications in segments like Chemical Process Industry, Water Treatment and Microelectronics.

[1] on short term only

Pipes	Fittings	Jointing technology

Essential system properties

- Extremely resistant against high corrosive chemicals
- Unsuspicious towards stress cracking media
- Outstanding permeation resistance
- High temperature and UV-resistance

Most important market segments

- Chemical process industry
- Water treatment
- Microelectronics

Technical data

Nominal pressure	10 bar
Temperature range on chemicals	0 °C to +80 °C
Temperature range material	-76 °C to +130 °C (140 °C)[1]
Jointing technology	Infrared (IR) fusion
	Mechanical joints
Standards and guidelines[2]	ISO, EN, DIN, ASTM, DVS

[1] on short term only
[2] Further information on standards, directives and approvals at www.gfps.com

SYGEF ECTFE product overview

The following table uses metric units of measure, available in PN 10 (bar) and SDR 21.

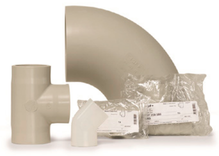
Products	d (mm)	20	25	32	40	50	63	75	90	110
	DN (mm)	15	20	25	32	40	50	65	80	100
Pipes		●	●	●	●	●	●	●	●	●
Fittings		●	●	●	●	●	●	●	●	●
Unions		●	●	●	●	●	●			
Flange rings		●	●	●	●	●	●	●	●	●
Gaskets		●	●	●	●	●	●	●	●	●
Valves [1)]		●	●	●	●	●	●	●	●	●
Automation		●	●	●	●	●	●	●	●	●
Pipe clips		●	●	●	●	●	●	●	●	●
IR fusion machines		●	●	●	●	●	●	●	●	●

1) on request (PVC/PVDF BV546 Pro with ECTFE valve ends, Type SDV SSt/PFA, BuV 065, etc.)

2.7 PROGEF Piping Systems: Standard, Plus, and Natural

PROGEF systems out of polypropylene show excellent physical properties and mechanical characteristics. The high-quality material allows applications in a very broad temperature range (0 °C to 80 °C). Thanks to its high chemical resistance, good abrasion resistance and high impact strength, PROGEF Standard meets all requirements of demanding industrial environments. Cleaned and packed in specified processes, the silicone-free or oil-free PROGEF Plus system has a high pureness factor. The system is widely used in demanding applications in microelectronics as well as in coating and surface treatment. PROGEF Natural is a translucent, unpigmented polypropylene that is wherever pure solutions are needed. Its beneficial properties, such as excellent clean, smooth surface, together with the bead and crevice-free welding, ensure the system quality.

Pipes



Fittings

Jointing technology

Automation

Valves

Essential system properties

- High impact strength
- High operating temperature range
- High surface quality for PROGEF Plus
- Highest cleanliness and protection against contamination for PROGEF Plus
- Bead and crevice-free jointing technology for PROGEF Natural

Most important market segments

- Water treatment
- Chemical process industry
- Microelectronics
- Energy

Technical data

Nominal pressure	Up to 10 bar
Temperature range	0 °C to 80 °C
Jointing technology	Socket fusion
	Butt fusion
	Infrared (IR) fusion
	Bead and crevice-free fusion (BCF) for PROGEF Natural
Standards and guidelines[1]	ISO, EN, DIN, DVS
Approvals[1]	FDA, USP 25 class VI, DIBt, DNV, Lloyd's Register

[1] For additional information about standards, guidelines and approvals, see www.gfps.com

PROGEF Standard, PROGEF Plus product overview

The following table uses metric units of measure.

d (mm)	16, 20, 25, 32, 40, 50, 63, 75, 90, 110, 125, 140, 160, 180, 200, 225, 250, 280, 315, 355, 400, 450, 450, 500, 560, 630
DN (mm)	10, 15, 20, 25, 32, 40, 50, 65, 80, 100, 100, 125, 150, 150, 200, 200, 250, 250, 300, 350, 400, 450, 500, 500, 500, 600

Products	SDR	PN (bar)
Pipes	7.4	16
	11	10
	17.	6
Socket fusion fittings	11	10
Butt fusion fittings, IR-compatible	11	10
	17.6	10
Ball valves	11	10
	17.6	10
Diaphragm valves	11	10
	17.6	10
Butterfly valves		10
Check valves	11/17.6	10
		6
	11	10
Pressure regulating valves	11	10
Ventilating and bleed valves		10
Flanges PP-V / PP-Steel		
Gaskets EPDM / FKM		
Pipe clips PP / PE		
Automation		

PROGEF Standard
PROGEF Plus

Product overview PROGEF Natural

Products	SDR	PN (bar)	d (mm)	20	25	32	40	50	63	75	90	110
			DN (mm)	15	20	25	32	40	50	65	80	100
Pipes	11	10		■	■	■	■	■	■			
	17.6	6								■	■	■
Butt fusion fittings, IR and BCF-compatible	11	10		■	■	■	■	■	■			
	17.6	6								■	■	■
Sanitary adapter	11	10		■	■	■	■	■	■			
Ball valves PP-H body/ PP-R	11	10		■	■	■	■	■	■			
Ball valves PP-H Flange connector		10								■	■	■
Diaphragm valves PP-R	11	10		■	■	■	■	■	■			
Diaphragm valves PP-H Flange connector		10								■	■	■
Butterfly valves PP-H		10							■	■	■	■
Cone check valves PP-H body/PP-R	11	10		■	■	■	■	■	■			
Cone check valves PP-H Flange connector		10								■	■	■
Flange PP-V / PP-Steel				■	■	■	■	■	■	■	■	■
Flange gaskets EPDM / FKM				■	■	■	■	■	■	■	■	■
Pipe clips PP / PE				■	■	■	■	■	■	■	■	■
Automation				■	■	■	■	■	■	**Upon request**		

For more information about the system specification of PROGEF Standard, Plus, Natural, visit www.gfps.com

2.8 ecoFIT Piping System

The ecoFIT piping system is based on the material polyethylene, which meets the highest requirements in the industrial environment. It allows applications in a broad temperature range (-50 °C to +60 °C) and features high UV resistance, good abrasion resistance and high impact strength. Valve bodies made of PVC-U or PP-H with PE end connections allow easy integration in the ecoFIT system. To provide a maximum of flexibility, the valves come with socket welding, butt welding spigots or flanges.

				
Pipes	**Fittings**	**Jointing technology**	**Automation**	**Valves**

Essential system properties

- UV and weather-resistant
- Outstanding abrasion resistance
- High impact strength, particularly at low temperatures
- High flexibility

Most important market segments

- Water treatment
- Chemical process industry
- Energy
- Marine
- Cooling
- Microelectronics

Technical data

Nominal pressure	Up to 16 bar
Temperature range	-50 °C to +60 °C
Jointing technology	Socket fusion
	Butt fusion
	Infrared (IR) fusion
	Electrofusion
Standards and guidelines[1]	ISO, EN, DVS
Approvals[1]	DIBt, FM, IIP, ABS, DNV, GL, RINA, RMROS, CCS, Nk approved

[1] For additional information about standards, guidelines and approvals, see www.gfps.com

ecoFIT product overview

The following table uses metric units of measure.

Products	Material	SDR	PN (bar)	d (mm)	20	25	32	40	50	63	75	90	110	125	140	160	180	200	225	250	280	315	355	400	450	450	500	560	630
				DN (mm)	15	20	25	32	40	50	65	80	100	100	125	150	150	200	200	250	250	300	350	400	450	500	500	500	600
Pipes	PE100	7.4	20		●	●																							
		11	16		●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●		
		17/17.6	10		●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●		
Socket fusion fittings	PE80	11	10		●	●	●	●	●	●	●	●	●																
Butt fusion fittings, IR-compatible	PE100	11	16		●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
		17/17.6	10						●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Electrofusion fittings (ELGEF)	PE100	11	16		●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
		17/17.6	10													●	●	●	●	●	●	●	●	●	●	●	●	●	●
Valves					●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Flanges	PP-V / PP-ST				●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Gaskets	EPFM/ FKM				●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Pipe clips	PP / PE				●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●					
Automation					●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●

Valve product range

Products	Valve bodies	d (mm)	20	25	32	40	50	63	75	90	110	125	140	160	180	200	225	250	280	315	355	400	450	450	500	560	630
		DN (mm)	15	20	25	32	40	50	65	80	100	100	125	150	150	200	200	250	250	300	350	400	450	500	500	500	600
Ball valves	PP-H, PVC-U		●	●	●	●	●	●	●	●	●			●													
Diaphragm valves	PP-H, PVC-U		●	●	●	●	●	●	●	●	●			●													
Butterfly valves	PP-H							●	●	●	●	●	●	●	●	●	●	●	●	●							
	PP-R																				●	●	●	●	●	●	●
	PVC-U							●	●	●	●	●	●	●	●	●	●	●	●	●	●	●					
	Metal							●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Cone check valves	PP-H, PVC-U		●	●	●	●	●	●	●	●	●																
Ventilating and bleed valves	PP-H, PVC-U		●	●	●	●	●	●	●	●	●																
Check valves	PP-H, PVC-U					●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●						
Pressure control valve	PP-H, PVC-U			●	●	●	●	●																			

For more information about the system specification of ecoFIT, visit www.gfps.com

2.9 CONTAIN-IT Plus Piping System

The CONTAIN-IT Plus piping system is used to minimize risks to humans, the environment and the plant. Existing legal regulations or ordinances could specify double containment piping systems. GF Piping Systems ensures excellent performance in transporting aggressive fluids or hazardous media in all types of different applications. The CONTAIN-IT Plus product range for media lines is available in a variety of plastics (PP, PE, PVDF, PVC-U, PVC-C and ECTFE). The protective line is made of PE, resulting in high UV and weather resistance. In addition, GF Piping Systems offers as well “PVC-U” or “transparent PVC-U” as outside piping.


Pipes


Fittings


Jointing technology


Leak monitoring


Valves

Essential system properties

- Suitable for visual inspection and identification
- Protection of personnel and the environment
- Adaptable leak monitoring system
- Compliance with legal regulations

Most important market segments

- Water treatment
- Chemical process industry
- Microelectronics
- Energy

Technical data

Nominal pressure	Up to 16 bar	
Temperature range	-50 °C to +140 °C (acc. to primary pipe material)	
Jointing technology	Inside pipe	Socket fusion
		Butt fusion
		Infrared (IR) fusion
		Solvent cementing
	Exterior line	Electrofusion / Mechanical joint with EPDM sleeve
Standards and guidelines[1]	ISO, EN ISO, ASTM, DIN, DVS	
Approvals[1]	Please refer to the PROGEF, ecoFIT, SYGEF, PVC-U and PVC-C	

[1] For additional information about standards, guidelines and approvals, see www.gfps.com

Product overview CONTAIN-IT Plus

The following table uses metric units of measure.

Material (inner/outer)	Products	PN_{inner} (bar)	PN_{outer} (bar)	d_o[1] (mm)	50	50	63	75	90	110	125	140	160	180	200	225	280	315
				d_i[1] (mm)	20	25	32	40	50	63	75	90	110	125	140	160	200	225
PP-H/PE100	Socket fusion fittings	10	16		■	■	■	■										
		10	10						■	■	■	■	■					
	Butt fusion fittings, infrared-compatible	10	16		■	■	■	■										
		10	10						■	■	■	■	■	■	■	■	■	■
	Ball valves	10	6		■	■	■	■	■	■								
	Diaphragm valves	10	6		■	■												
	Mechanical connection	10	6		■	■	■	■	■	■								
PE100/PE100	Butt fusion/IR fusion fittings	16	16		■	■	■	■										
		16	10						■	■	■	■	■	■	■	■	■	■
	Ball valves (housing: PVC-U)	10	6		■	■	■	■	■	■								
	Ball valves (housing: PP-H)	10	6		■	■	■	■	■	■								
	Mechanical connection	10	6		■	■	■	■	■	■								
PE80/PE100	Socket fusion fittings	10	16		■	■	■	■										
		10	10						■	■	■	■	■					
	Ball valves (housing: PVC-U, PP-H)	10	6		■	■	■	■	■	■								
	Mechanical connections	10	6		■	■	■	■	■	■								
PVDF/PE100	Socket fusion fittings	16	16		■	■	■	■										
		16	10						■	■								
	Butt fusion/IR fusion fittings	16	16		■	■	■	■										
		16	10						■	■	■	■	■					
		10	10											■	■	■	■	■
	Ball valves	16	6		■	■	■	■	■	■								
	Diaphragm valves	10	6		■	■												
	Mechanical connection	16	6		■	■	■	■	■	■								
PVC-U/PE100	Cemented sockets fittings	16	16		■	■	■	■										
		16	10						■	■	■	■	■	■	■	■		
		10	10														■	■
	Ball valves	16	6		■	■	■	■	■	■								
	Diaphragm valves	10	6		■	■												
	Mechanical connection	16	6		■	■	■	■	■	■								
PVC-C/PE100	Adhesive fittings	16	16		■	■	■	■										
		16	10						■	■	■	■	■					
	Ball valves	16	6		■	■	■	■	■	■								
	Diaphragm valves	10	6		■	■												
	Mechanical connection	16	6		■	■	■	■	■	■								
ECTFE/PE100	IR fusion fittings	10	10		■	■	■	■	■	■	■	■	■					
	Mechanical connection	10	10		■	■	■	■	■	■								
Leak monitoring					■	■	■	■	■	■	■	■	■	■	■	■	■	■

[1] d_o Dimension of the outer pipe
d_i Dimension of the inner pipe

For more information about the system specification of CONTAIN-IT Plus, visit www.gfps.com and see the planning fundamentals in chapter „Double containment piping system – CONTAIN-IT Plus".

2.10 COOL-FIT Piping Systems

Cooling in general can be divided into basic application areas, one is typically below 0°C (32°F) called industrial refrigeration and the other one is above 0°C (32°F) with applications such air-conditioning systems or process cooling.

GF Piping Systems offers the pre-insulated COOL-FIT range to cover all cooling applications. COOL-FIT 2.0 is based on the PE Electrofusion Technology for the primary pipe and targets above 0°C (32°F) applications. The COOL-FIT 2.0 is extended to below 0°C (32°F) applications having a thicker insulation, named COOL-FIT 4.0.

2.10.1 COOL-FIT 4.0

COOL-FIT systems are completely pre-insulated plastic piping systems for secondary cooling circuits that are operated with water, brine or glycol solutions as well as slurry ice. Typical application areas are industrial refrigeration systems with medium temperatures far below 0 °C and air-conditioning systems for media above 0 °C.

The COOL-FIT 4.0 media pipe is made of PE and is covered by high-quality GF HE insulation as well as a robust and UV-resistant jacket pipe. The smooth inside surface of the media pipe ensures very low pressure losses. The low thermal conductivity of the plastic and the insulation are a guarantee for life-long low energy and operating costs. In addition, the 3-in-1 design limits the installation time to a minimum.

COOL-FIT 4.0 is well suited for use in cold storage, in food production (e.g. in breweries, dairies and slaughterhouses), in supermarkets as well as for industrial cooling water systems for process cooling and in computing centers.

COOL-FIT systems	Compatible components		
			
COOL-FIT 4.0	Jointing technology	Automation	Valves

Essential system properties

- 3-in-1 system: media pipe, insulation and protective outer sheath in one product
- Quick connection
  - COOL-FIT 4.0: pre-insulated electrofusion fittings
- Uses approx. 50 % less energy in operation compared to post-insulated copper systems
- UV and weather-resistant, steam jet-compatible

Most important market segments

- Cooling
- Marine

Technical data

Nominal pressure	Up to 16 bar for COOL-FIT 4.0
Temperature range	-50°C to +60°C for COOL-FIT 4.0
Jointing technology	Electrofusion for COOL-FIT PE Plus
Standards and guidelines[1]	ISO, EN ISO, ASTM, DIN, DVS
Approvals[1]	Please refer ecoFIT

[1] For additional information about standards, guidelines and approvals, see www.gfps.com

COOL-FIT 4.0 product overview

Products	PN (bar)																
		D[1] (mm)	90	110	110	125	140	160	180	250	315	355	400	450	500	560	630
		DN (mm)	25	32	40	50	65	80	100	150	200	250	250	300	350	400	450
		d (mm)	32	40	50	63	75	90	110	160	225	250	280	315	355	400	450
Pipes, pre-insulated	16		■	■	■	■	■	■	■								
	10									■	■	■	■	■	■	■	■
Elbows 45 /90 , pre-insulated	16		■	■	■	■	■	■	■	■	■						
	10											■	■	■	■	■	■
T-90 equal, pre-insulated	16		■	■	■	■	■	■	■	■	■						
	10											■	■	■	■	■	■
T-90 reduced, pre-insulated	16					■	■	■	■	■	■						
	10											■ on request	■	■	■	■	■
Reducers, pre-insulated	16		■	■	■	■	■	■	■	■	■						
	10											■	■	■	■	■	■
Installation fittings, pre-insulated	16		■	■	■	■	■	■	■	■	■						
	10											■ on request	■	■	■	■	■
Flange joints, insulated	10/16		■	■	■	■	■	■	■	■	■	■ non-insulated	■	■	■	■	■
Ball valves, insulated	16		■	■	■	■	■	■									
Butterfly valves, insulated	10								■	■	■	■ non-insulated	■	■	■	■	■
Transition fittings, insulated	16		■	■	■	■	■	■	■	■	■						
Fixed points	-		■	■	■	■	■	■	■	■	■	■ on request	■	■	■	■	■

[1] Diameter of the protective sleeve

For more information about the system specification of COOL-FIT, visit www.gfps.com and see the planning fundamentals chapter "System COOL-FIT".

2.10.2 COOL-FIT 2.0

COOL-FIT 2.0 is a pre-insulated piping system for the delivery of refrigerants. Thanks to its insulation thickness of 22 mm, the system can be used in air-conditioning systems with coolants temperatures above 0 °C. COOL-FIT 2.0 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 / Jacket tube – installation time is kept very short.

The system consists of pipe, fittings, valves, flexible hoses and transition fittings. All components are pre-insulated or supplied with mountable insulation shells. The COOL-FIT 2.0 tools allow for fast and safe installation of the system.

COOL-FIT Systems	Compatible components		
			
COOL-FIT 2.0	COOL-FIT 4.0	ecoFIT PE	iFIT

Essential system properties

- 3-in-1 system: media pipe, insulation and protective outer jacket
- 50% faster installation than conventional systems
- 30% better insulation performance than post insulated metal systems
- Corrosion free

Most important market segments

- Cooling (> 0°C / 32°F)
- Marine

Technical data

Nominal pressure	16 bar, SDR 11
Temperature range **Medium** **Environment**	 0°C to +60 °C 0°C to +55 °C
Jointing technology	Electrofusion
Standards and guidelines[1]	ISO, EN ISO
Approvals[1]	Fire classes, please see chapter "Approvals of products" or at www.gfps.com with up-to-date listings

[1] For additional information about standards, guidelines and approvals, see www.gfps.com

COOL-FIT 2.0 product overview

The following table uses metric units of measure

Products d (mm)	25	32	40	50	63	75	90	110	140
Pipes PN 16		■	■	■	■	■	■	■	■
Couplers		■	■	■	■	■	■	■	■
Elbows 90° / 45°		■	■	■	■	■	■	■	■
T-90° equal		■	■	■	■	■	■	■	■
T-90° reduced					■	■	■	■	■
Reducers			■	■	■	■	■	■	■
Flexible hoses	■	■	■	■					
Ball valves		■	■	■	■	■	■		
Butterfly valves								■	■
Transition fittings		■	■	■	■	■	■	■	■
Fixed points		■	■	■	■	■	■	■	■

2.11 Automation

2.11.1 Overview

The automation closed control loop consists of three elements: measurement, control and actuation/valves. The measurement element includes a number of measuring technologies for capturing all types of parameters. Most of the sensors are available in plastic and are offered together with the corresponding fittings, which ensure a perfect integration into the piping system. The control element contains various control functions – from simple relays up to PID controllers – and common communication technologies. Actuation includes pneumatic, electrical and magnetic actuating elements, which can be combined with many different valves and accessory parts.

2.11.2 Measurement

Product overview

Product categories
Flow measurement (ultrasound, paddlewheel, electromagnetic, turbine, float)
pH/ORP
Conductivity/resistivity
Pressure/fill level
Temperature
Clouding
Chlorine/chlorine dioxide
Dissolved oxygen

2.11.3 Control

Product overview

Product categories
Multi-parameter transmitter
Special transmitter (e.g. batch, PID controller)
Multi-channel transmitter
Modular functionalities (e.g. Hart, additional relays, additional 4 to 20 mA outputs)

2.11.4 Actuation

Product overview

Product categories
Electrical and pneumatic actuators
Positioners and actuator accessories
AS interface

2.11.5 Valves

Product overview

Product categories
Manual valves
Magnetic pilot valves
Pressure regulating valves

Plastic Piping Materials

Content

1 Introduction to Plastics Materials

1.1 Plastics in general

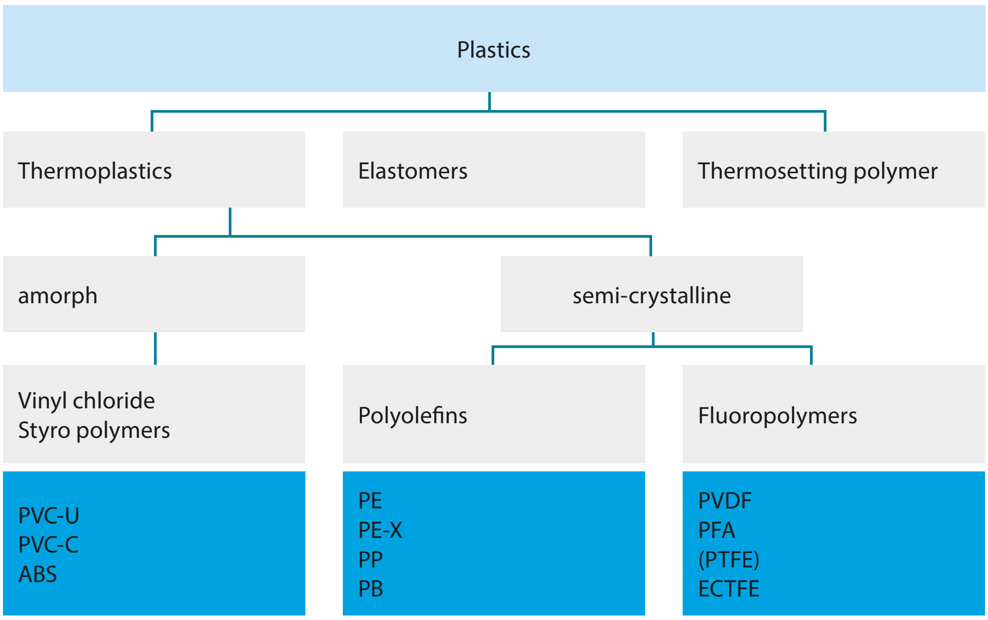
1.1.1 History

As early as 1838, Victor Regnault succeeded in manufacturing polyvinyl chloride in the laboratory by exposing vinyl chloride to sunlight. In 1912 Fritz Klatte discovered the fundamental principle for the technical manufacture of PVC. In their early years during the war from 1914 to 1918, the plastics had to replace other scarce materials and were thereby partly overwhelmed in terms of their applicability. Therefore, plastics had to be improved. To do this, it was necessary to investigate the inner structure of these new materials in more detail. After the versatile application possibilities were recognised, in 1938 the large-scale production of plastics began.

1.1.2 Structure and properties

Polymers are organic compounds that are obtained either by the conversion of natural products (e.g. natural rubber, cellulose), or by synthesis from petroleum derivatives. Polymer chains, together with additives such as stabilisers and processing aids, produce the actual material – referred to as plastic. These chains consist mainly of carbon and hydrogen. Depending on the type, halogens (chlorine, fluorine), oxygen, nitrogen and sulphur can also be incorporated into the polymer chain. Polymers are also referred to as macromolecules, that is to say, a single polymer chain consists of more than 1,000 basic building blocks, the monomers.

In plastic piping design, mainly thermoplastics are used, which are processed into fittings, valves and pipe with a technical processes referred to as **injection moulding** and **extrusion**. Elastomers are used as sealing material in unions, flanges and push-fit fitting. For example, thermosetting polymer are used as insulation foams or in glass-fibre reinforced liners.



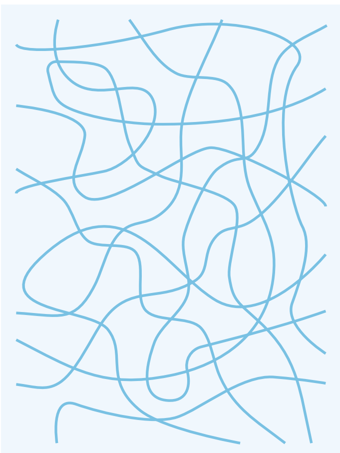
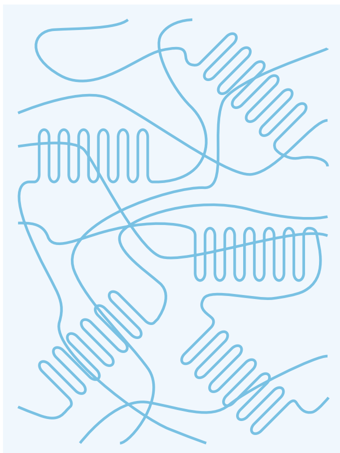
Materials for piping systems – Overview

Plastics – Main groups

Main group		Property
Thermoplastics e.g. PE, PVC		• Linear or branched • Meltable • Soluble, swellable • Plastic mouldable
Elastomer e.g. NBR, EPDM		• Poorly linked • Not meltable • Not soluble, not swellable • Not plastically mouldable
Thermosetting plastics e.g. PUR, Epoxy		• Strongly linked • Not meltable • Not soluble, not swellable • Not plastically malleable

The thermoplastics, the fusible agents of plastics, are subdivided into two groups:

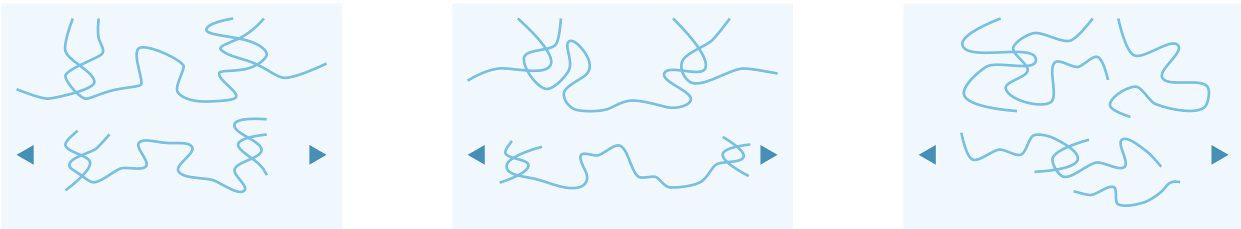
Subdivision of the Thermoplastics

Amorphous thermoplastics	Semi-crystalline thermoplastics
In the case of the amorphous (Greek "without form") thermoplastics, the polymer chains are present as disordered, intertwined bundles. Typical representatives of this group are, for example, PVC and ABS. These plastics dissolve and swell easily by adding solvents. Therefore, they are solvent cemented together when used in piping installations.	The semi-crystalline thermoplastics contain not only the disordered, amorphous but also highly ordered regions in which the chains are arranged into crystalline structures. Representatives of this group are for example polyolefins such as polyethylene (PE), polypropylene (PP) and polybutene (PB). Due in part to the semi-crystalline structure, these plastics do not swell and are not soluble in solvents. Piping systems made of semi-crystalline materials are therefore usually connected by welding.
	

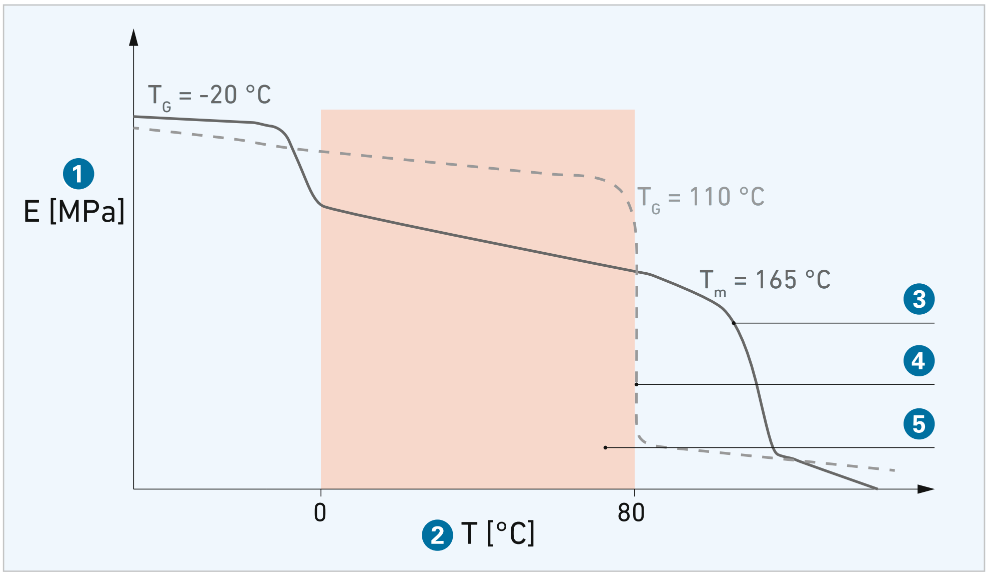
1.1.3 Mechanical properties

The mechanical properties of plastics, especially thermoplastics, are temperature-dependent. At low temperatures below the glass-transition temperature T_g the chains become immobile and brittle, which leads to increased fragility. At higher temperatures ($T_g < T < T_m$), the chains become more mobile, causing semi-crystalline materials to gain toughness, but lose strength and rigidity. At this stage, amorphous plastics are already softening. Both the embrittlement and softening temperatures are characteristic of the individual types of plastic and dependent on their molecular structure. If the temperature continues to rise ($T > T_m$), the semi-crystalline thermoplastic is also present as a melt.

Glassy state (energy-elastic)	Rubber-elastic state (entropy-elastic)	Melt (liquid)



⇒ Rising temperature⇒



Application temperature

1. Modulus of elasticity (rigidity)
2. Temperature
3. Semi-crystalline, here PP-H
4. Amorph, here PVC-C
5. Application temperature

The application temperatures for semi-crystalline and amorphous thermoplastics vary due to their different properties. Semi-crystalline materials are preferably used at temperatures above their glass transition temperature. However, amorphous thermoplastics are used below the glass transition point.

Plastics also tend to creep to progressive deformation under load. Their mechanical properties are not only temperature-dependent but also time-dependent. For use in piping system construction, the materials are therefore tested for their creep internal compressive strength in accordance with ISO 1167 and ISO 9080 in order to determine the maximum operating temperatures and pressure for a service life of 50 years.

The characteristic values for mechanical properties of GF pipe materials can be found in the relevant raw materials chapter.

1.1.4 Advantages

Compared to metallic materials, the following general advantages for plastics result:

Properties and advantages of plastics

Property	Advantage
Low density (Plastic: 0.9 to 1.8 g/cm^3)	Very light-weight
Chemical resistance	No corrosion as with metals
Low thermal conductivity	• Minimum heat loss • Low condensation • Plastics are poor heat conductors, but good insulators Thermal conductivity: • PB: 0,19 W/(m·K) • PE: 0,38 W/(m·K) • PVC: 0,15 W/(m·K)
Tight connections due to a variety of connection technologies	Plastics can be welded, glued and clamped
Smooth surface	The smooth surface causes low pressure losses

1.2 Plastic in the environment

The world is facing big challenges in the energy sector. These challenges include increasing energy consumption, the finite nature of fossil resources, rising energy prices and climate change. In order to satisfy the needs not only of today but also of future generations, sustainable development is essential. Plastics help to meet these challenges.

The products of GF Piping Systems are used by customers for years, sometimes decades. Even the smallest increases in efficiency – such as a suitable design – can significantly affect the environmental performance. GF Piping Systems therefore pursues a holistic approach in the development of piping systems. Sustainable solutions are only possible if the entire life cycle of the applications and products is considered.

Plastics save energy

In addition to the well-known technical advantages such as corrosion resistance, plastics also characterised by their ecological advantages. Its light weight and insulating properties make it suitable for a variety of energy-efficient applications: in vehicles, packaging, insulation and piping systems. Plastics are mainly made from crude oils. About four percent of the world's oil is processed into plastic. The efforts to reduce the consumption of oil and other fossil fuels, however, do not mean a renouncement of plastic – on the contrary: The use of plastics saves energy!

In a study, Plastics Europe has quantified how energy consumption and greenhouse gas emissions affect plastic products by replacing them with other materials.

Results

- Plastic products enable significant savings in energy and reduce greenhouse gas emissions.
- Replacing plastic products with other materials will in most cases increase energy consumption and greenhouse gas emissions.

Replacing as many plastic products as possible with other materials would require over 50% more energy than is consumed today throughout the life cycle of all plastic products. In other words: The plastic products on the market today have enabled energy savings of 2,400 million GJ per year. This is equal to an amount of 50 million tons of oil, spread over 200 very large oil tankers.

i Additional information on sustainability and life cycle assessment see: www.gfps.com/gfps-sustainability > materials.

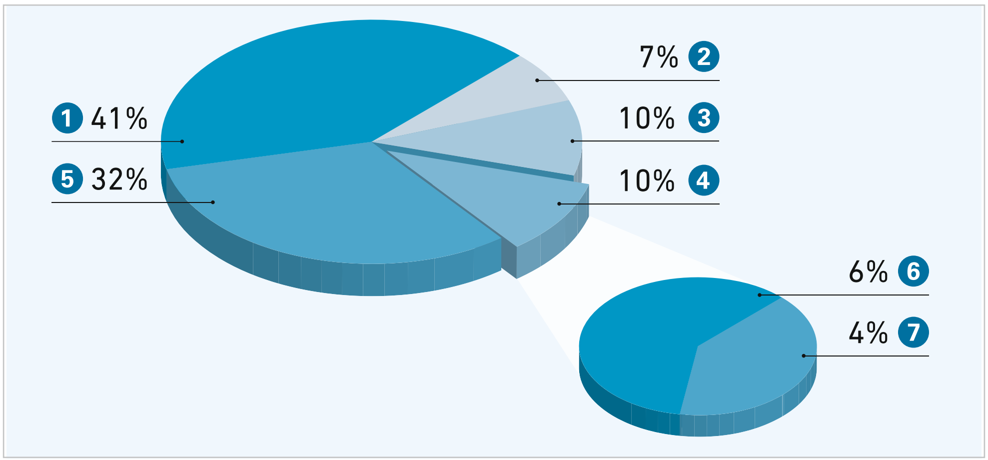
1.3 Manufacturing and processing methods

1.3.1 Raw materials

Raw materials required for the production of plastics are natural products such as cellulose, coal, crude oil and natural gas. At the refinery, crude oil is separated by distillation it into several components. It is separated into boiling ranges, distillation results in gas, petrol, petroleum and gasoil. The residue is bitumen. All components consist of hydrocarbons, which differ in size and shape of the molecules. The most important component for the production of plastics is naphtha. Naphtha is broken up and converted into ethylene, propylene, butylene and other hydrocarbon compounds in a thermal cracking process.

1.3.2 Manufacturing

Plastics are formed by connecting a large number of similar basic building blocks (monomers), using a chemical bond. The majority of the raw materials required for this purpose comes from the processing of crude oil, but in some cases raw materials from renewable sources are also used. Contrary to expectations, only about 4% of crude oil products coming from the refinery go to the plastics industry. The chemical industry accounts for around 10% of total crude oil consumption in Germany, including 6% for plastics production. In the production of plastics, three different methods are used.



Use of petroleum in production areas
1. Traffic
2. Miscellaneous
3. Industry
4. Chemistry
5. Heater
6. of this 6% plastic
7. other materials

T3.1 Manufacturing of plastics

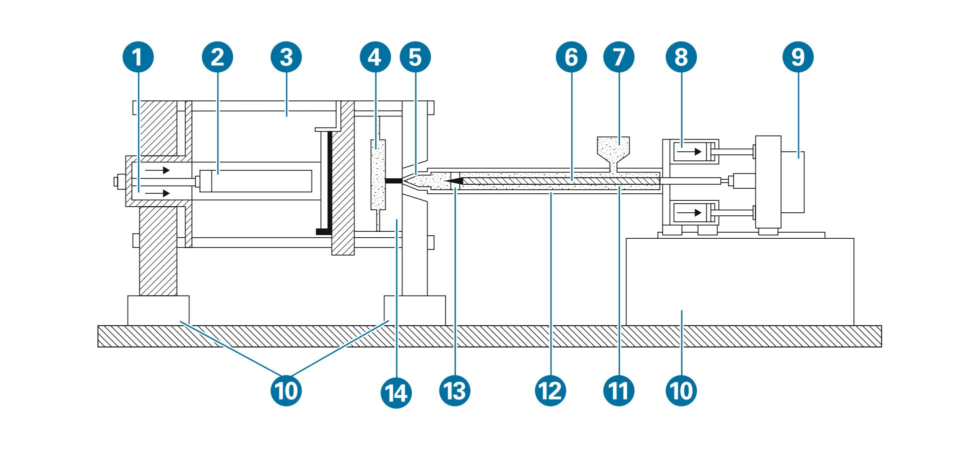
Polymerisation	Polycondensation	Polyaddition
Polymerisation is the most widely used process in the synthesis of plastics. Polymerisation refers to the attachment of monomers to macromolecule chains without elimination of foreign substances. When using e.g. polymerisation, polyethylene, polybutene, polypropylene, polyvinyl chloride are formed.	In the polycondensation process, equal and dissimilar monomers are arranged in a macromolecule chain with simultaneous elimination of a by-product, e.g. water, hydrochloric acid. Polycondensation is used, for example, in the manufacturing of phenolic resins and polyamides.	When using polyaddition, macromolecules are formed from molecules of different chemical structure, but without elimination of a by-product. This process is used in the manufacturing of polyurethanes and epoxy resin, for example, araldite.

1.3.3 Processing

GF Piping Systems uses a variety of plastic processing techniques. A distinction is made between injection moulding, extrusion and foaming. The injection moulding process is used to produce fittings and valves; pipe are extruded. Pipes are pre-insulated with foam.

Injection moulding

An injection moulding machine is used to melt (plasticise) the respective material and injected into a mould—the moulding tool—under pressure. Inside the mould tool, the material is cooled and thus reverts to its solid state. The resulting volume shrinkage is compensated by very high pressures. By rotating the plasticising screw, material for the next component is prepared. After opening the tool, the finished part is removed. The void (the cavity) of the tool determines the shape and the surface structure of the finished part.



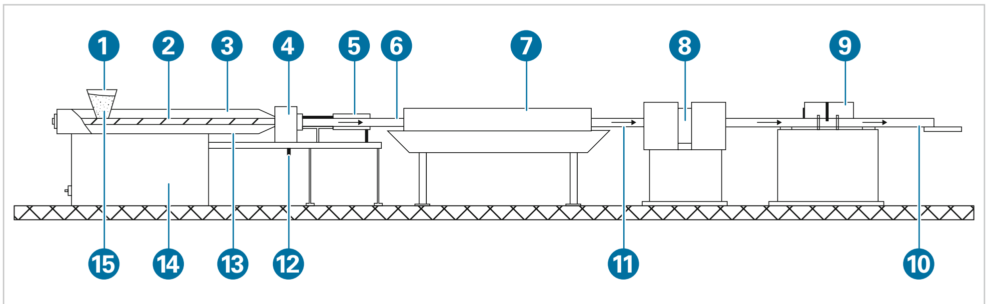
Components of a typical plasticising/injection unit

1. Locking cylinder
2. Opening cylinder
3. Opening and locking cylinder
4. Workpiece
5. Injection nozzle
6. Plasticising screw
7. Plastic pellets
8. Injection cylinder
9. Worm gear drive
10. Machine bed
11. Plasticising cylinder
12. Heater
13. Non-return valve
14. Moulding tool

Extrusion

An extrusion machine integrates the following process steps:

1. Extrusion
2. Shaping
3. Calibrating
4. Cooling
5. Removing
6. Separating



Components of a typical extrusion system

1. Hopper
2. Plasticising screw
3. Heater
4. Moulding tool (profile nozzle)
5. Calibration distance
6. Pipe
7. Cooling section
8. Haul-off/pulling machine
9. Device for cutting into lengths
10. Hollow section
11. Pipe
12. Compressed air
13. Plasticising cylinder
14. Extruder
15. Plastic pellets

The extruder system consists of the hopper, the plasticising cylinder, one or two plasticising screw(s) and the drive. The tasks of the extruder's components are the same as in the injection unit during injection moulding.

The extruder tool rests directly against the extruder, guiding the mass around a mandrel and shaping the profile of the pipe. For pipe under d400 mm, tools with sieve rings or multiple webs are used for fixing. For larger pipe over d400 mm, spiral distribution tools are used. The cooling section and calibration section are connected in the manufacturing of the pipe. This is possible by using vacuum tank calibration with multiple water showers. A caterpillar haul-off/pulling machine is used to handle the pulling in pipe manufacturing. The speed of the haul-off/pulling machine is adapted to the performance of the extruder. The separating unit must move with the extruded pipe during cutting process.

2 Properties of Plastic Piping Materials

2.1 Acrylonitrile-butadiene-styrene (ABS)

ABS properties (reference values)

Property	Value[1]	Units	Test standard
Density	0.925	g/cm³	EN ISO 1183-1
Yield stress at 23 °C	20	N/mm²	EN ISO 527-1
Tensile modulus at 23 °C	450	N/mm²	EN ISO 527-1
Charpy notched impact strength at 23 °C	20	kJ/m²	EN ISO 179-1/1eA
Charpy notched impact strength at -40 °C	≥ 10	kJ/m²	EN ISO 179-1/1eA
Heat distortion temperature HDT A 1.80 MPa	≥ 74	°C	EN ISO 75-2
Vicat-heat distortion temperature B/50N	≥ 94	°C	ISO 306
Thermal conductivity at 23 °C	0.19	W/m K	ASTM E1530
Water absorption at 23 °C	≤ 0.45	%	EN ISO 62
Color	similar 7001	-	RAL
Limiting oxygen index (LOI)	19	%	ISO 4589-1

[1] Typical characteristics measured at the material should not be used for calculations.

General

Acrylonitrile-butadiene-styrene (ABS) is a versatile polymer. In addition to its application in piping systems, ABS is mainly common in automotive applications and in high-quality household devices. The wide area of application relates to the versatile characteristic profile of ABS which can be adapted to the respective application by taking advantage of the variable composition of the components acrylonitrile, styrene and polybutadiene.

ABS belongs to the amorphous thermoplastics. While acrylonitrile provides strength to the material and contributes to an improved chemical resistance relative to polystyrene, the styrenic component provides both strength and a quality surface finish. On the other hand, the chemically bound polybutadiene rubber components give the material its impact strength, even at very low temperatures. The ABS used by GF Piping Systems shows a good balance between toughness and strength, making it especially suitable for low temperature applications. Accordingly, the areas of application are mainly refrigeration and air-conditioning systems as well as water treatment.

Advantages of ABS

- High impact strength even at low temperatures
- Corrosion resistance
- Simple installation via solvent cement joints
- Low thermal conductivity
- Halogen free
- Low weight
- Low pressure losses due to smooth surfaces
- Good abrasion resistance
- Trouble-free recycling

UV and weather resistance

If the ABS piping system is exposed to direct sunlight over a long period, its surface loses its shine and the colour shifts to light grey. Due to the very high impact strength of ABS, the resulting loss of toughness generally causes no problems in moderate climate zones. For extreme weather conditions or very high loads on the piping system, we nevertheless recommend protecting the surface from direct sunlight.

Chemical resistance

ABS shows a good resistance against a broad range of media. For detailed information, observe the comprehensive list of chemical resistance from GF Piping Systems or contact an authorized GF Piping Systems representative.

Abrasion resistance

In addition to the excellent impact strength, the butadiene rubber components in ABS effect an outstanding resistance to abrasion. Because of this property, piping systems made of ABS have been used for solids and slurries, such as those found in mining, for a long time.
ABS offers significant advantages for many of such applications compared to metals.

Application limits

The application limits of the material on the one hand depend on embrittlement and softening temperatures and on the other hand on the nature and the expected service life of the application. The pressure-temperature diagrams give details on application temperatures and pressures.

Combustion behavior

ABS self-ignites at temperatures exceeding 450 °C. ABS burns when exposed to an open flame, after removing the flame, the material continues burning. The oxygen index amounts to 19 %. (Materials that burn with less than 21 % of oxygen in the air are considered to be flammable).

Basically toxic substances are released though all burning processes. Carbon monoxide is generally the combustion product most dangerous to humans. When ABS burns, primarily carbon dioxide, carbon monoxide and water are formed. Tests have shown that the relative toxicity of the products of combustion are similar or even lower than those of natural products such as wood, wool and cotton. ABS combustion gases are not corrosive. Nevertheless, the burning forms soot. Because of this, smoke develops during combustion.

Water, foam and carbon dioxide are suitable fire-fighting agents.

Electrical properties

Like most thermoplastics, ABS is not conductive. This means that no electrochemical corrosion takes place in ABS systems. However, the non-conductive properties have to be taken into account because an electrostatic charge can develop in the piping. ABS provides good electrical insulation properties. The specific volume resistance is 3.5×10^{16} Ωcm, the specific surface resistance is 10^{13} Ω. These figures have to be taken into account wherever there is a danger of fires or explosion.

Physiological properties

Formulations of ABS used by GF Piping Systems are in general non toxic and biologically inert. For details regarding existing approvals for applications with drinking water or food stuff, please contact your GF Piping Systems representative.

2.2 Polyethylene (PE)

PE properties (reference values)

Property	PE 80-Value[1]	PE 100-Value[1]	Units	Test standard
Density	0.93	0.95	g/cm^3	EN ISO 1183-1
Yield stress at 23 °C	18	25	N/mm^2	EN ISO 527-1
Tensile modulus at 23 °C	700	900	N/mm^2	EN ISO 527-1
Charpy notched impact strength at 23 °C	110	83	kJ/m^2	EN ISO 179-1/1eA
Charpy notched impact strength at -40 °C	7	13	kJ/m^2	EN ISO 179-1/1eA
Thermal conductivity at 23 °C	0.43	0.38	W/m K	EN 12664
Water absorption at 23 °C	0.01 - 0.04	0.01 - 0.04	%	EN ISO 62
Color	9005	9005	RAL	
Limiting oxygen index (LOI)	17.4	17.4	%	ISO 4589-1

[1] Typical characteristics measured at the material should not be used for calculations.

General

Polymers which consist of hydrocarbons with formula C_nH_{2n} with a double bond (ethylene, propylene, butene-1, isobutene) are collectively referred as polyolefins. Polyethylene (PE) belongs to this group. It is a semi-crystalline thermoplastic. Polyethylene is the best known polymer. The chemical formula is: $-(CH_2-CH_2)_n$, making polyethylene an environmentally friendly hydrocarbon product. PE as well as PP belong to the non-polar materials. Because of this, it does not dissolve in common solvents and hardly swells. As a result, PE pipe cannot be solvent cemented. The appropriate jointing method for this material is welding.

High molecular PE grades of medium to high density have become state of the art for industrial piping installations. The grades are classified in accordance with their internal pressure resistance in PE80 (MRS 8 MPa) and PE100 (MRS 10 MPa). In this context, we also talk about PE grades of the 3rd generation, while PE80 grades belong, in most cases, to the 2nd generation. PE grades of the 1st generation – PE63 according to current classifications – have practically no application anymore. The internal pressure resistance is tested according to ISO1167 and calculated in compliance to ISO 9080.

In piping construction, PE is mostly used for buried gas and water lines. For this range of applications, polyethylene has become the dominant material in numerous countries. But also building technology and industrial piping installations make use of the advantages of this material.

Advantages of PE

- Low weight
- Outstanding flexibility
- Good abrasion resistance (abrasion resistance)
- Corrosion resistance
- Ductile breaking properties
- High impact strength even at low temperatures
- Good chemical resistance
- Fusible

UV and weather resistance

Because of the black pigments used, polyethylene is very weather-resistant. Even longer exposure to direct sunlight, wind and rain hardly causes any damage to the material.

Chemical resistance

Polyethylene shows a good resistance against a broad range of media. For detailed information, observe the list of chemical resistance from GF Piping Systems or contact the responsible GF Piping Systems representative.

Abrasion resistance

Polyethylene has excellent resistance against abrasion. As a result, PE piping systems are used in numerous applications for transporting solids and slurries. Experience has shown that PE offers considerable advantages over metal for many such applications.

Application limits

The application limits of the material on the one hand depend on embrittlement and softening temperatures and on the other hand on the nature and the expected service life of the application. The pressure-temperature diagrams give details on application temperatures and pressures.

Combustion behavior

Polyethylene belongs to the flammable plastics. The oxygen index amounts to 17 %. With an oxygen index below 21 %, a plastic material is considered to be flammable. PE drips and continues to burn without soot after removing the flame. Basically toxic substances are released through all burning processes, particularly carbon monoxide. When PE burns, primarily carbon dioxide, carbon monoxide and water are formed.

Electrical properties

Like most thermoplastics, polyethylene is non-conductive. This means that no electrochemical corrosion takes place in PE systems.

However, the non-conductive properties have to be taken into account because an electrostatic charge can build up in the pipe. Polyethylene provides good electrical insulation properties. The specific volume resistance is $3.5 \times 10^{16}\ \Omega\text{cm}$ and the specific surface resistance is $10^{13}\ \Omega$. These figures have to be taken into account wherever there is a hazard of ignition or explosion.

Physiological properties

The black polyethylene materialsfrom GF Piping Systems are authorized for use in food applications. The organoleptic properties of the fittings are in accordance to the relevant standards. Usage in all related areas is thus possible. For details regarding existing approvals for applications with drinking water or foodstuffs, please contact the responsible GF Piping Systems representative.

2.3 Polypropylene (PP)

PP properties (reference values)

Property	PP-R value[1]	β PP-H-value[1]	Units	Test standard
Density	0.90 - 0.91	0.90 - 0.91	g/cm³	EN ISO 1183-1
Yield stress at 23 °C	25	31	N/mm²	EN ISO 527-1
Tensile modulus at 23 °C	900	1300	N/mm²	EN ISO 527-1
Charpy notched impact strength at 23 °C	20	50	kJ/ m²	EN ISO 179-1/1eA
Charpy notched impact strength at 0 °C	3.4	4.8	kJ/m²	EN ISO 179-1/1eA
Heat distortion temperature HDT B 0.45 MPa	75	95	°C	EN ISO 75-2
Water absorption at 23 °C	0.1	0.1	%	EN ISO 62
Color	Neutral/ 7032	7032		RAL
Limiting oxygen index (LOI)	19	19	%	ISO 4589-1

[1] Typical characteristics measured at the material should not be used for calculations.

General

Polypropylene (PP) is a semi- crystalline thermoplastic belonging to the polyolefins. Its density is lower than that of other thermoplastics. Its mechanical characteristics, its chemical resistance and especially its relatively high heat deflection temperature have made polypropylene one of the most important materials used in piping installations today. PP is formed by the polymerisation of propylene (C_3H_6) using Ziegler-Natta catalysts.

There are three different material types which are conventionally supplied for piping installations:

- Isotactic PP-homopolymer (PP-H)
- PP block copolymer (PP-B)
- PP random copolymer (PP-R)

Because of its high long-term behavior, PP-H types are preferred for industrial applications. The more flexible PP-R is used predominantly in plumbing applications because of its low tensile modulus and high long-term creep resistance at high temperature. PP-B is mainly used for sewage piping systems because of its high impact strength especially at low temperatures and its relatively low resistance to elevated temperatures. Most of the PP grades are offered with nucleating agents because PP crystallizes at least 10 times slower than PE. This way, we achieve lower internal stress and a more homogenous morphology. It is differentiated between α and β nucleation. Nucleation is realized by adding only few ppm (parts per million) of nucleating agents. PP, just like PE, belongs to the non-polar materials. For this reason, PP does not dissolve in common solvents and, in addition, hardly swells. As a result, PP pipe cannot be solvent-cemented. The appropriate jointing method for this material is welding. For industrial applications, GF Piping Systems uses beta nucleated PP-H (PROGEF Standard, PROGEF Plus) and PP-R (PROGEF Standard, PROGEF Natural). The long-term behavior was tested in long-term tests according to ISO 1167 and calculated according to ISO 9080. According to ISO 12162, our industrial materials are classified as MRS 10.

Advantages of PP

- Low weight
- Good abrasion resistance (abrasion resistance)
- Corrosion resistance
- Balanced ratio of stiffness and toughness
- Good chemical resistance
- Weldable
- High temperature resistance

UV and weather resistance

PP is sensitive to UV radiation, particularly the non pigmented PROGEF Natural system, so that prolonged exposure to direct sunlight should be avoided. In outside applications, it can be advantageous to protect the material from direct sunlight exposure. Contact the responsible GF Piping Systems representative for suitable protective measures.

Chemical resistance

Polypropylene shows a good resistance against a broad range of media. For detailed information, observe the list of chemical resistance from GF Piping Systems or contact the responsible GF Piping Systems representative.

Abrasion resistance

PP has a good resistance against abrasion. For many applications, PP demonstrates similar or better properties than metals.

Application limits

The application limits of the material on the one hand depend on embrittlement and softening temperatures and on the other hand on the nature and the expected service life of the application. The pressure-temperature diagrams give details on application temperatures and pressures.

Combustion behavior

Polypropylene is a flammable plastic. The oxygen index amounts to 19 %. With an oxygen index below 21 %, a plastic material is considered to be flammable PP drips and continues to burn without soot after removing the flame. Basically toxic substances are released by all burning processes, while carbon monoxide is generally the combustion product most dangerous to humans. When PP burns, primarily carbon dioxide, carbon monoxide and water are formed.

Electrical properties

Like most thermoplastics, polypropylene is non-conductive. This means that no electrochemical corrosion takes place in PP systems.

However, the non-conductive properties have to be taken into account because an electrostatic charge can build up in the pipe. Polypropylene provides good electrical insulation properties. The specific volume resistance is at least 10^{16} Ωcm, the dielectric strength is 75 kV/mm. Because of the possible development of electrostatic charges, caution is recommended when using PP in applications where there is a hazard of ignition or explosion.

Physiological properties

Formulations used by GF Piping Systems are generally non-toxic and biologically inert. For details regarding existing approvals for applications with drinking water or foodstuffs, please contact the responsible GF Piping Systems representative.

2.4 Polyvinyl chloride, unplasticized (PVC-U)

PVC-U properties (reference values)

Property	Value[1]	Units	Test standard
Density	1.38	g/cm^3	EN ISO 1183-1
Yield stress at 23 °C	≥ 54	N/mm^2	EN ISO 527-1
Tensile e-modulus at 23 °C	≥ 2700	N/mm^2	EN ISO 527-1
Charpy notched impact strength at 23 °C	≥ 8	kJ/m^2	EN ISO 179-1/1eA
Charpy notched impact strength at 0 °C	≥ 3	kJ/m^2	EN ISO 179-1/1eA
Vicat-heat distortion temperature B/50N	≥ 76	°C	ISO 306
Thermal conductivity at 23 °C	0.15	W/m K	EN 12664
Water absorption at 23 °C	≤ 0.1	%	EN ISO 62
Color	7011		RAL
Limiting oxygen index (LOI)	42	%	ISO 4589-1

[1] Typical characteristics measured at the material should not be used for calculations.

General

Polyvinylchloride (PVC) is one of the most important and oldest plastics. Worldwide consumption of PVC is exceeded only by PE and PP. PVC was produced for the first time as early as the middle of the 19th century. An industrial manufacturing process was not patented until the year 1913. Nowadays, PVC plays an important role in many industrial and consumer good applications.

PVC is a polymer containing approximately 56 % by weight of chlorine. The PVC resin becomes a processable and usable material only by using additives. The choice of the additives allows a wide variation of its characteristics and an adjustment to the planned application. There are two classes of PVC materials. Soft PVC (PVC-P) which is created by adding plasticizers (e.g. phthalates). This type is not used at GF Piping Systems. Hard PVC, also called unplasticized PVC (PVC-U), is used for piping system construction.

PVC-U is an amorphous thermoplastic. The properties of PVC-U molded parts are strongly dependent on the composition of the individual components, but also on the processing. Because of our 50 years of experience in PVC processing and the continuous advancement of our own formulation of materials, GF Piping Systems has become a benchmark in the field of PVC-U piping. The long-term behavior was tested in long-term tests according to ISO 1167 and calculated according to ISO 9080. According to ISO 12162, our PVC-U types are classified as MRS 25.

Advantages of PVC-U

- Versatility of use
- Very good chemical and corrosion resistance
- Proven physiological interness and thus usable for food applications
- No influence on the drinking water quality
- Biologically inert, no support of microbiological growth
- Excellent mechanical properties
- Safe cementing, e.g. with Tangit

UV and weather resistance

PVC-U is very weather-resistant. Even longer exposure to direct sunlight, wind and rain does hardly any damage to the material. Despite its very good resistance to UV radiation, PVC-U loses some of its impact strength. In extreme applications, it can be advantageous to protect the material from direct sunlight exposure. Contact the responsible GF Piping Systems representative for suitable protective measures.

Chemical resistance

PVC-U shows a good resistance against a broad range of media. For detailed information, observe the list of chemical resistance from GF Piping Systems or contact the responsible GF Piping Systems representative.

Abrasion resistance

As a relatively hard thermoplastic, the resistance of PVC-U against abrasion is lower than those of other pipe materials. For this reason, it is rarely used for transporting solids.

Application limits

The application limits of the material on the one hand depend on embrittlement and softening temperatures and on the other hand on the nature and the expected service life of the application. The pressure-temperature diagrams give details on application temperatures and pressures.

Combustion behavior

The high chlorine content of PVC-U causes an advantageous combustion behavior. Self-ignition resulting from temperature influences occurs only at 450 °C. PVC-U burns when exposed to an open flame, but extinguishes immediately after removing the flame. The oxygen index (LOI) amounts to 42 %. With an oxygen index below 21 %, a plastic material is considered to be flammable.

Because the combustion of PVC-U produces hydrogen chloride, which forms a corrosive acid in connection with water, immediate cleaning of areas susceptible to corrosion is necessary after a fire. Danger to personnel from hydrochloric acid (HCl) is minimal because its pungent odor allows early escape from toxic combustion gases, mainly from the odorless carbon monoxide. There are no restrictions for the choice of firefighting agents.

Electrical properties

PVC-U, like all unmodified thermoplastics, is non-conductive. This means that no electrochemical corrosion takes place in PVC-U systems. On the other hand, these non-conductive properties have to be taken into account because an electrostatic charge can develop in the piping.

Special attention must be paid to this fact in environments in which explosive gases may occur. Various methods are available to prevent the occurrence of electrostatic charges. GF Piping Systems representatives can provide support a correct installation.

The specific volume resistance is at least 10^{15} Ωcm.

Physiological properties

The PVC-U formulas were developed by GF Piping Systems for use with drinking water and food. All PVC-U product offered by GF Piping Systems are free of lead and cadmium. The residual monomer content of vinyl chloride lies below the detection limit of modern analytical methods.

For details regarding existing approvals for applications with drinking water or foodstuffs, please contact your authorized GF Piping Systems representative.

2.5 Polyvinyl chloride, chlorinated (PVC-C)

PVC-C properties (reference values)

Property	Value[1]	Units	Test standard
Density	1.5	g/cm^3	EN ISO 1183-1
Yield stress at 23 °C	≥ 53	N/mm^2	EN ISO 527-1
Tensile e-modulus at 23 °C	≥ 2700	N/mm^2	EN ISO 527-1
Charpy notched impact strength at 23 °C	≥ 8	kJ/m^2	EN ISO 179-1/1eA
Charpy notched impact strength at 0 °C	≥ 4	kJ/m^2	EN ISO 179-1/1eA
Heat distortion temperature HDT A 1.80 MPa	≥ 102	°C	EN ISO 75-2
Vicat-heat distortion temperature B/50N	≥ 103	°C	ISO 306
Thermal conductivity at 23 °C	0.15	W/m K	EN 12664
Water absorption at 23 °C	0.1	%	EN ISO 62
Color	7038		RAL
Limiting oxygen index (LOI)	60	%	ISO 4589-1

[1] Typical characteristics measured at the material should not be used for calculations.

General

The abbreviation PVC-C stands for chlorinated polyvinyl chloride (also referred to as chlorinated PVC or PVC-C), a material in use since 1958. PVC-C is an amorphous thermoplastic that is created by postchlorinating PVC. During this process, chlorine is chemically bonded to the PVC chain. Thus, PVC-C is a PVC-U-related material which, because of its chemical structure, is characterized by a higher temperature resistance than PVC-U with other properties such as the high tensile strength, good impact resistance and the exceptional chemical resistance remain unaffected. Its flame resistance is better than that of PVC-U.

These properties have made PVC-C a preferred material for piping and fabrication of devices in the chemical industry as well as for several other industrial applications with demanding requirements (e.g. the aircraft industry). In pressure piping systems, PVC-C is suitable for strongly corrosive environments, where materials such as stainless steel or even glass-fiber reinforced plastics only reach a short service life time. PVC-C is used for semi-finished products, pumps, valves as well as for the entire range of accessories associated with transport of liquids.

Advantages of PVC-C

- Very good mechanical properties, even at elevated temperatures
- Excellent chemical resistance
- No electrochemical corrosion
- Long service life, even under intensely corrosive conditions
- Simple installation using solvent cementing
- Smooth inner surface
- Very low thermal conductivity
- Exceptional fire resistance

UV and weather resistance

PVC-C is very weather-resistant. Even longer exposure to direct sunlight, wind and rain does hardly any damage to the material. Despite its very good resistance to UV radiation, PVC-C loses some of its impact strength. In extreme applications, it can be advantageous to protect the material from direct sunlight exposure. Contact the responsible GF Piping Systems representative for suitable protective measures.

Chemical resistance

PVC-C shows a good resistance against a broad range of media. For detailed information, observe the list of chemical resistance from GF Piping Systems or contact the responsible GF Piping Systems representative.

Abrasion resistance

As a relatively hard thermoplastic, the resistance of PVC-C against abrasion is lower than those of other pipe materials. For this reason, it is rarely used for transporting solids.

Application limits

The application limits of the material on the one hand depend on embrittlement and softening temperatures and on the other hand on the nature and the expected service life of the application. The pressure-temperature diagrams give details on application temperatures and pressures.

Combustion behavior

Due to its high chlorine content, PVC-C shows an exceptionally good combustion behavior without the addition of flame retardants.

PVC-C self-ignites at temperatures exceeding 400 °C. PVC-C burns when exposed to an open flame, but immediately extinguishes when the flame is removed. The oxygen index amounts to 60 % (with less than 21 % of oxygen, the plastic is considered to be flammable).

Since the combustion of PVC-C produces hydrogen chloride, which forms a corrosive acid in connection with water, immediate cleaning of areas susceptible to corrosion with water containing detergent is necessary after a fire. Danger to personnel from hydrochloric acid is minimal because its pungent odor allows recognition even in lowest concentrations (1 ppm to 5 ppm), thereby allowing an early escape from toxic combustion gases, mainly from the odorless carbon monoxide.

Recommended fire-fighting agents are water, carbon dioxide or foam.

Electrical properties

PVC-C is, like all unmodified thermoplastics, non-conductive. This means that no electrochemical corrosion takes place in PVC-C systems. On the other hand, these non-conductive characteristics have to be taken into account because an electrostatic charge can develop in the piping.

Special attention must be paid to this fact in environments in which explosive gases may occur. Various methods are available to prevent the occurrence of electrostatic charges. GF Piping Systems representatives can provide support in selecting the right one.

The specific volume resistance is at least 10^{15} Ωcm.

Physiological properties

For details regarding existing approvals for applications with drinking water or foodstuff, please contact your GF Piping System representative.

2.6 Polyvinylidenefluoride (PVDF)

PVDF properties (reference values)

Property	Value[1]	Units	Test standard
Density	1.78	g/cm³	EN ISO 1183-1
Yield stress at 23 °C	≥ 48	N/mm²	EN ISO 527-1
Tensile e-modulus at 23 °C	≥ 1800	N/mm²	EN ISO 527-1
Charpy notched impact strength at 23 °C	≥ 8	kJ/m²	EN ISO 179-1/1eA
Charpy notched impact strength at 0 °C	≥ 7	kJ/m²	EN ISO 179-1/1eA
Heat distortion temperature HDT A 1.80 MPa	≥ 104	°C	EN ISO 75-2
Crystallite melting point	≥ 168	°C	ISO 11357-3
Thermal conductivity at 23 °C	0.19	W/m K	EN 12664
Water absorption at 23 °C / 24 h	≤ 0.04	%	EN ISO 62
Color	opaque		
Limiting oxygen index (LOI)	≥ 43	%	ISO 4589-1

[1] Typical characteristics measured at the material should not be used for calculations.

General

Polyvinylidenefluoride (PVDF) is a semi-crystalline thermoplastic with outstanding mechanical, physical and chemical properties. These result from the chemical structure of PVDF. PVDF belongs to the class of fluorinated polymers, whose best-known representative is polytetrafluoroethylene (PTFE). PTFE is characterized by an extreme heat resistance and the best chemical resistance of all polymers. A great disadvantage is that it cannot be processed like other thermoplastics, e.g. injection molding into fittings. PVDF, on the other hand, combines various advantages of PTFE with good processability into structural parts. The fluorine content in PVDF amounts to 59 % by weight.

PVDF from GF Piping Systems used in the SYGEF system is characterized by a very good mechanical behavior and high temperature resistance. Because of the exceptionally wide pressure-temperature range in which SYGEF PVDF can be used, it has opened, in connection with the specific properties of the PVDF material, completely new areas of application in plastic piping. This includes the semiconductor industry, the chemical and pharmaceutical industry, electroplating technology, the pulp and paper industry, the automotive industry and water treatment. Pipes, fittings and valves are not pigmented and opaque (milky, translucent). By avoiding the addition of any additives, the purity as well as the outstanding chemical resistance and physiological inertness of the material remain completely unaffected.

Advantages of PVDF

- Outstanding mechanical properties, even at elevated temperatures
- No electrochemical corrosion
- Long service life, even under intensely corrosive conditions
- Outstanding resistance against UV and γ-radiation
- Very pure material by avoiding the use of additives
- No support of microbiological growth
- Secure jointing by high-quality fusioning technology
- Very low thermal conductivity
- Excellent flame retardant properties

UV and weather resistance

PVDF is very weather-resistant. Even longer exposure to direct sunlight, wind and rain causes no damage to the material. Contact the responsible GF Piping Systems representative for more detailed information.

Chemical resistance

PVDF shows a good resistance against a broad range of media. For detailed information, observe the list of chemical resistance from GF Piping Systems or contact the responsible GF Piping Systems representative.

Abrasion resistance

PVDF has an excellent resistance against abrasion. For many applications, PVDF demonstrates similar or better properties than metals.

Application limits

The application limits of the material on the one hand depend on embrittlement and softening temperatures and on the other hand on the nature and the expected service life of the application. The pressure-temperature diagrams give details on application temperatures and pressures.

Combustion behavior

PVDF displays an exceptionally good combustion behavior without the addition of fire protection additives. Material decomposition starts at 380 °C. The oxygen index amounts to 44 % (with less than 21 %, the material is considered to be flammable). Since the combustion of PVDF produces hydrogen fluoride, which forms a corrosive acid in connection with water, immediate cleaning of areas susceptible to corrosion with water containing detergent is necessary after a fire. Additional combustion products are carbon monoxide and carbon dioxide. Suitable fire-fighting agents are sand and extinguishing foam. The use of water can lead to corrosive acids.

Electrical properties

PVDF is, like all unmodified thermoplastics, non-conductive. This means that no electrochemical corrosion takes place in PVDF systems. On the other hand, these non-conductive characteristics have to be taken into account because an electrostatic charge can develop in the piping. Special attention must be paid to this fact in environments in which explosive gases may occur. Various methods are available to prevent the occurrence of electrostatic charges. GF Piping Systems representatives can provide support in selecting the right one. The specific volume resistance is greater than 10^{14} Ωcm and the specific surface resistance is 10^{14} Ωcm

Physiological properties

PVDF is physiologically non-toxic as long as it is used at temperatures up to a maximum of 150 °C. During processing, adequate ventilation must be ensured and developing gases must be extracted.

High-purity properties

As is can be processed and utilized without the use of additives (no pigments, thermo-stabilizers, processing aids or fillers), PVDF is particularly suited for applications that require the highest degree of purity. The PVDF raw materials used by GF Piping Systems fulfil the requirements of the semiconductor and pharmaceutical industries. In addition, products made of PVDF exhibit a very smooth surface. Leach-out tests according to SEMI F57 are done regularly for quality control.

2.7 Ethylene-Chlorotrifluoroethylene (ECTFE)

ECTFE properties (reference values)

Property	Value[1]	Units	Test standard
Density	1.68	g/cm³	EN ISO 1183-1 ASTM D792
Yield stress at 23 °C	≥ 30	N/mm²	EN ISO 527-1
Tensile e-modulus at 23 °C	≥ 1600	N/mm²	EN ISO 527-1
Charpy notched impact strength at 23 °C	no break	kJ/m²	EN ISO 179-1/1eA
Charpy notched impact strength at 0 °C	≥ 6	kJ/m²	EN ISO 179-1/1eA
Heat distortion temperature HDT A 1.80 MPa	≥ 65	°C	ASTM D648
Crystallite melting point	≥ 240	°C	ISO 11357-3 DSC / ASTM D3418
Thermal conductivity at 23 °C	0.20	W/m K	ASTM C177
Water absorption at 23 °C / 24 h	≤ 0.07	%	EN ISO 62
Color	opaque		
Limiting oxygen index (LOI)	≥ 50	%	ASTM D 2863

[1] Typical characteristics measured at the material should not be used for calculations.

General

As raw material for pipes only HALAR 901S ECTFE from Solvay may be used, HALAR 350LC ECTFE for fittings.

Advantages of ECTFE

- Outstanding chemical resistance
- Long service life, even under intensely corrosive conditions
- Outstanding resistance against UV and γ-radiation
- Reliable jointing by high-quality jointing technology
- Very low thermal conductivity
- Excellent flame retardant properties

UV and weather resistance

ECTFE is very weather-resistant. Even longer exposure to direct sunlight, wind and rain causes very little change in properties or appearance of the material. Contact the responsible GF Piping Systems representative for more detailed information.

Chemical resistance

ECTFE shows an outstanding resistance against a broad range of media. For detailed information, observe the list of chemical resistance from GF Piping Systems or contact the responsible GF Piping Systems representative.

Abrasion resistance

For the use of ECTFE in abrasive applications please contact your GF Piping Systems representative.

Application limits

The application limits of the material on the one hand depend on embrittlement and softening temperatures and on the other hand on the nature and the expected service life of the application. The pressure-temperature diagrams give details on application temperatures and pressures.

Combustion behavior

ECTFE displays an exceptionally good combustion behavior without the addition of fire protection additives. Material decomposition starts at 300 °C, heating above 350°C must be strictly avoided. The oxygen index is 52 % (with less than 21 %, the material is considered to be flammable). Since the combustion of ECTFE produces hydrogen fluoride and hydrogen chloride, which form corrosive acids in connection with water, immediate cleaning of areas susceptible to corrosion with water containing detergent is necessary after a fire. Additional combustion products are carbon monoxide and carbon dioxide. Suitable fire-fighting agents are sand and extinguishing powder. The use of water can lead to corrosive acids.

Electrical properties

ECTFE is, like all unmodified thermoplastics, non-conductive. This means that no electrochemical corrosion takes place in ECTFE systems. On the other hand, these non-conductive characteristics have to be taken into account because an electrostatic charge can develop in the piping. Special attention must be paid to this fact in environments in which explosive gases may occur. Various methods are available to prevent the occurrence of electrostatic charges. GF Piping Systems representatives can provide support in selecting the right one.

The specific volume resistance is greater than 10^{15} Ω cm and the specific surface resistance is above 10^{14} Ω cm.

Physiological properties

ECTFE is physiologically non-toxic as long as it is used at temperatures up to a maximum of 140 °C. During processing, adequate ventilation must be ensured and developing gases must be vented. Approvals and Standards

3 Approvals and standards

3.1 Approvals of products

Various approvals are in place for all piping systems from GF Piping Systems. The most important approvals are listed in the following overview. The current status of the approvals can be obtained from an authorized GF Piping Systems representative.

Abbreviation	Approval authority	Approved product range	Material
ABS	American Bureau of Shipping	Pipes, fittings, valves	ABS, PE100, PVC-U, PVC-C
AVS	Attestation de Conformité Sanitaire	Gaskets	EPDM
BSI	British Standard Institution	Fittings	PVC-U
BV	Bureau Veritas	Pipes, fittings, valves	ABS, PE100, PP-H, PVC-C, PVC-U
CCS	China Classification Society	Pipes, fittings, valves	PE100, PVC-C
CSTB	Centre Scientifique et Technique du Bâtiment	Fittings	PVC-U
DIBt	Deutsches Institut für Bautechnik	Pipes, fittings, valves	PVC-U, PP-H, PVDF, PE (Fittings)
DNV	Det Norske Veritas	Pipes, fittings, valves	ABS, PE100, PP-H, PVC-C, PVC-U
DVGW	Deutscher Verein des Gas- und Wasserfaches	Dichtungen	EPDM
		Rohre, Fittings, Ventile	PE, PP-H, PVC-C, PVC-U
FDA	Food and Drug Administration	Gaskets	FKM
GL	Germanischer Lloyd	Pipes, fittings, valves	ABS, PE100, PP-H, PVC-C, PVC-U
GOST-R	Rosstandart	Pipes, fittings, valves	ABS, PB, PE, PP, PVC-C, PVC-U, PVDF
IIP	Instituto Italiano dei Plastici	Fittings	PE, PVC-U
KIWA	Keuringsinstituut voor Waterleidings-artikelen	Fittings	PE, PVC-U
KTW	Kunststoff-Trinkwasser-Bewertungs-grundlagen und Leitlinien	Gaskets	EPDM
		Fittings	PE, PVC-U
LNE	Laboratoire Nationale d' Essais	Pipes	PVC-U
LR	Lloyd's Register of Shipping	Pipes, fittings, valves	ABS, PE100, PVC-U, PVC-C, PP-H
NAMSA	North American Science Associates	Gaskets	EPDM, FKM, PTFE
NK	Nippon Kaiji Kyokai	Pipes, fittings, valves	ABS, PB, PE, PP, PVC-C, PVC-U
NSF	National Sanitary Foundation		
ÖVGW	Austrian Association for Gas and Water	Gaskets	EPDM
		Pipes, fittings, valves	PE, PP, PVDF
PZH	Panstwowy Zaklad Higieny	Fittings, valves	ABS, PP-H, PVC-U
RINA	Registro Italiano Navale	Pipes, fittings, valves	ABS, PE100, PP-H, PVC-C, PVC-U
RMROS	Russian Maritime Register of Shipping	Pipes, fittings, valves	ABS, PE100, PVC-C, PVC-U
RTN	ROSTECHNADZOR	Pipes, fittings, valves	ABS, PB, PE, PP, PVC-C, PVC-U, PVDF
SVGW	Swiss Association for Gas and Water	Gaskets	EPDM
		Fittings, valves	PB, PE, PP
TSSA	Technical Standards & Safety Authority	Pipes, fittings, valves	PVC-U, PVC-C, PP-H
WRAS	Water Regulations Advisory Scheme Water Byelaws Scheme	Gaskets	EPDM
		Pipes, fittings	ABS, PE, PVC-U, PVC-C

Abbreviations of approvals (edition: July 2015)

3.2 Standards and guidelines

3.2.1 Relevant standards and standards met for valves

Standards for valves (edition: July 2015)

Standard	Name
ISO 9393-2	Thermoplastics valves for industrial applications - Pressure test methods and requirements - Part 2: Test conditions and basic requirements
ISO 9393-1	Thermoplastics valves for industrial applications - Pressure test methods and requirements - Part 1: General
ISO 14617-8	Graphical symbols for diagrams - Part 8: Valves and dampers
EN ISO 5211	Industrial valves - Part-turn actuator attachments
EN ISO 16135	Industrial valves - Ball valves of thermoplastic materials
EN ISO 16136	Industrial valves - Butterfly valves of thermoplastic materials
EN ISO 16137	Industrial valves - Check valves of thermoplastic materials
EN ISO 16138	Industrial valves - Diaphragm valves of thermoplastic materials
EN ISO 16139	Industrial valves - Gate valves of thermoplastic materials
EN ISO 21787	Industrial valves - Valves of thermoplastic materials
EN 593	Industrial valves - Metallic butterfly valves
EN 12266-2	Industrial valves - Testing of metallic valves - Part 2: Tests, test procedures and acceptance criteria - Supplementary requirements
EN 12266-1	Industrial valves - Testing of metallic valves - Part 1: Pressure tests, test procedures and acceptance criteria - Mandatory requirements
EN 12516-2	Industrial valves - Shell design strength - Part 2: Calculation method for steel valve shells
EN 13774	Valves for gas distribution systems with maximum operating pressure less than or equal to 16 bar - Performance requirements
EN 14141	Valves for natural gas transportation in piping systems - Performance requirements and tests
EN 15389	Industrial valves - Performance characteristics of thermoplastic valves when used as construction products
ASME B 16.10	Face-to-face and end-to-end dimensions of valves
DIN 3202-4	Face-to-face and center-to-face dimensions of valves; Valves with internal thread connection
DIN 3202-5	Overall lengths of valves; Valves with pipe union connections
DIN 3230-4	Technical conditions of delivery for valves; Valves for potable water service, requirements and testing
DIN 3230-5	Technical conditions of delivery of valves - Valves for gas installations and gas piping systems - Requirements and tests
DIN 3230-6	Technical delivery conditions for valves; requirements and methods of test for valves for use with flammable liquids
DIN 3266	Valves for drinking water installations on private premises - Anti-vacuum valve types D and E - Requirements and tests
DIN 3292-1	Fittings for domestic installation; nonferrous metal union nuts
DIN 3500	Stop valves for domestic water supply - Piston type gate valves - PN 10
DIN 3512	Stopvalves for domestic water supply - Two-way valves - Vertical bonnet type PN 10; Straight pattern globe valve; Technical rule of the DVGW / Caution: Applies in connection with DIN EN 1213
DIN 3537-1	Gas stop valves for domestic gas installations up to 5 bar - Requirements and tests
DIN 3544-1	High-density polyethylene (HDPE) valves; tapping valves; requirements and test
DIN 32676	Fittings for the food, chemical and pharmaceutical industries - Clamp connections for stainless steel tubes - Fusion type
DIN 28000-4	Chemical apparatus - Documentation in the life cycle of process plants - Part 4: Graphical symbols of valves, pipe and actuators
JIS B 2002	Face-to-face and end-to-end dimensions of valves
JIS B 2003	General rules for inspection of valves

3.2.2 Relevant standards and guidelines for flanges

Standards for flanges (edition: July 2015)

Standard	Name
ISO 5752	Metal valves for use in flanged pipe systems - Face-to-face and center-to-face dimensions
ISO 7005-3	Metallic flanges - Part 3: Copper alloy and composite flanges
ISO 7005-2	Metallic flanges - Part 2: Cast iron flanges
ISO 7005-1	Pipe flanges - Part 1: Steel flanges for industrial and general service piping systems
ISO 7483	Dimensions of gaskets for use with flanges to ISO 7005
ISO 7483 Technical Corrigendum 1	Dimensions of gaskets for use with flanges to ISO 7005; Technical Corrigendum 1
ISO 8483	Plastics piping systems for pressure and non-pressure drainage and sewerage - Glass-reinforced thermosetting plastics (GRP) systems based on unsaturated polyester (UP) resin - Test methods to prove the design of bolted flange joints
ISO 9624	Thermoplastics pipe for fluids under pressure - Mating dimensions of flange adapters and loose backing flanges
EN ISO 10931	Plastics piping systems for industrial applications - Poly(vinylidene fluoride) (PVDF) - Specifications for components and the system
EN ISO 15493	Plastics piping systems for industrial applications - Acrylonitrile-butadiene-styrene (ABS), unplasticized poly(vinyl chloride) (PVC-U) and chlorinated poly(vinyl chloride) (PVC-C) - Specifications for components and the system - Metric series
EN ISO 15494	Plastics piping systems for industrial applications - Polybutene (PB), polyethylene (PE) and polypropylene (PP) - Specifications for components and the system - Metric series
EN 558+A1	Industrial valves - Face-to-face and center-to-face dimensions of metal valves for use in flanged pipe systems - PN and Class designated valves
EN 1092-1+A1	Circular flanges for pipe, valves, fittings and accessories, PN designated – Part 1: Steel flanges
EN 1092-2	Flanges and their joints - Circular flanges for pipe, valves, fittings and accessories, PN designated - Part 2: Cast iron flanges
EN 1514-8	Flanges and their joints - Dimensions of gaskets for PN-designated flanges Part 8: Polymeric O-ring gaskets for grooved flanges
EN 1515-1	Flanges and their joints - Bolting - Part 1: Selection of bolting
EN 1759-3	Flanges and their joints - Circular flanges for pipe, valves, fittings and accessories, Class designated. - Part 3: Copper alloy flanges
EN 1759-1	Flanges and their joints - Circular flanges for pipe, valves, fittings and accessories, Class designated - Part 1: Steel flanges, NPS 1/2 to 24
ASME B16.5	Pipe flanges and flanged fittings: NPS 1/2 through NPS 24 metric/inch standard
ASTM D4024	Standard specification for machine made “fiberglass” (glass-fiber-reinforced thermosetting resin) flanges
ASTM D5421	Standard specification for contact molded “fiberglass” (glass-fiber-reinforced thermosetting resin) flanges
BS 10:2009	Specification for flanges and bolting for pipe, valves and fittings
BS 1560-3.2:1989	Circular flanges for pipe, valves and fittings (Class designated). Steel, cast iron and copper alloy flanges. Specification for cast iron flanges
DIN 16831-7	Pipe fittings and joint assemblies for polybutene pressure pipe - Type PB 125 - Part 7: Dimensions of bushings, flanges and sealing elements for socket fusioning
DIN 16966-7	Pipe joints and their elements of glass fiber reinforced polyester resins - Part 7: Bushings, flanges, flanged and butt joints; general quality requirements and test methods
DIN 16966-6	Glass fiber reinforced polyester resin (UP-GF) pipe fittings and joint assemblies; collars, flanges, joint rings, dimensions
DIN 28000-4	Chemical apparatus - Documentation in the life cycle of process plants - Part 4: Graphical symbols of valves, pipe and actuators
DIN 28403	Vacuum technology; quick release couplings; clamped type couplings

Standard	Name
DIN 28404	Vacuum technology; flanges; dimensions
DVS 2205-4	Calculation of thermoplastic tanks and apparatuses - Flanged joints
DVS 2205-4 Supplement 4	Calculation of thermoplastic tanks and apparatuses - Fusioned flanges, fusioned collars - Constructive details
DVS 2210-1 Supplement 3	Industrial piping made of thermoplastics - Design and execution - Above-ground pipe systems - Flange connections: Description, requirements and assembly
JIS B 2220	Steel pipe flanges
JIS B 2239	Cast iron pipe flanges

3.2.3 Relevant standards for threads

Standards for threads (edition: July 2015)

Standard	Name
ISO 7-1	Pipe threads where pressure-tight joints are made on the threads - Part 1: Dimensions, tolerances and designation
ISO 7-2	Pipe threads where pressure-tight joints are made on the threads - Part 2: Verification by means of limit gauges
ISO 68-1	ISO general purpose screw threads - Basic profile - Part 1: Metric screw threads
ISO 1502	ISO general-purpose metric screw threads - Gauges and gauging
EN ISO 228-1	Pipe threads where pressure-tight joints are not made on the threads - Part 1 : Dimensions, tolerances and designation
EN ISO 228-2	Pipe threads where pressure-tight joints are not made on the threads - Part 2: Verification by means of limit gauges
EN ISO 228-1 addendum 1	Pipe threads where pressure-tight joints are not made on the threads - Part 1: Dimensions, tolerances and designation; Limits of size
EN 10226-1	Pipe threads where pressure tight joints are made on the threads - Part 1: Taper external threads and parallel internal threads - Dimensions, tolerances and designation
EN 10226-3	Pipes threads where pressure tight joints are made on the threads - Part 3: Verification by means of limit gauges
ASME B1.20.1	Pipe Threads, general purpose, inch
ASTM F1498	Standard specification for taper pipe threads 60° for thermoplastic pipe and fittings
BS 21:1985	Specification for pipe threads for tubes and fittings where pressure-tight joints are made on the threads
DIN 103-1	ISO metric trapezoidal screw thread; Profiles
DIN 103-2	ISO metric trapezoidal screw thread; General plan
DIN 103-3	ISO metric trapezoidal screw thread; Allowances and tolerances for trapezoidal screw threads of general purpose
DIN 103-4	ISO metric trapezoidal screw thread; Nominal dimensions
DIN 103-5	ISO metric trapezoidal screw threads; Limiting sizes for nut threads from 8 to 100 mm nominal diameter
DIN 103-6	ISO metric trapezoidal screw threads; Limiting sizes for nut threads from 105 to 300 mm nominal diameter
DIN 103-7	ISO metric trapezoidal screw threads; Limiting sizes for bolt threads from 8 to 100 mm nominal diameter
DIN 103-8	ISO metric trapezoidal screw threads; Limiting sizes for bolt threads from 105 to 300 mm nominal diameter
DIN 103-9	ISO metric trapezoidal screw threads; gauging of external and internal threads; gauge dimensions and design features
DIN 405-1	General purpose knuckle threads - Part 1: Profiles, nominal sizes
DIN 405-2	General purpose knuckle threads - Part 2: Deviations and tolerances
DIN 513-1	Metric buttress threads; thread profiles
DIN 513-2	Metric buttress threads; general plan
DIN 513-3	Metric buttress threads; deviations and tolerances
DIN 3852-2	Stud ends and ports of fittings, valves and plug screws - Part 2: Dimensions for pipe thread
DIN 40430	Steel conduit thread; Dimensions

Standard	Name
DIN 28000-4	Chemical apparatus - Documentation in the life cycle of process plants - Part 4: Graphical symbols of valves, pipe and actuators
JIS K 6743	Unplasticized poly (vinyl chloride) (PVC-U) pipe fittings for water supply

3.2.4 Relevant standards for pipe and fittings made of ABS

Standards for pipe and fittings made of ABS (edition: July 2015)

Standard	Name
ISO 727-1	Fittings made from unplasticized poly(vinyl chloride) (PVC-U), chlorinated poly (vinyl chloride) (PVC-C) or acrylonitrile/butadiene/styrene (ABS) with plain sockets for pipe under pressure - Part 1: Metric series
ISO 727-2	Fittings made from unplasticized poly(vinyl chloride) (PVC-U), chlorinated poly (vinyl chloride) (PVC-C) or acrylonitrile/butadiene/styrene (ABS) with plain sockets for pipe under pressure - Part 2: Inch-based series
ISO 8283-4	Plastics pipe and fittings - Dimensions of sockets and spigots for discharge systems inside buildings - Part 4: Acrylonitrile/butadiene/styrene (ABS)
EN ISO 15493	Plastics piping systems for industrial applications - Acrylonitrile-butadiene-styrene (ABS), unplasticized poly(vinyl chloride) (PVC-U) and chlorinated poly(vinyl chloride) (PVC-C) - Specifications for components and the system - Metric series
ASTM D3965	Standard specification for rigid acrylonitrile-butadiene-styrene (ABS) materials for pipe and fittings
BS 5391-1:2006	Acrylonitrile-butadiene-styrene (ABS) pressure pipe. Specification
BS 5392-1:2006	Acrylonitrile-butadiene-styrene (ABS) fittings for use with ABS pressure pipe. Specification
DIN 28000-4	Chemical apparatus - Documentation in the life cycle of process plants - Part 4: Graphical symbols of valves, pipe and actuators
DVS 2210-2	Industrial piping made of thermoplastics - Design, structure and installation of two-pipe systems

3.2.5 Relevant standards and guidelines for pipe and fittings made of PE

Standards for pipe and fittings made of PE (edition: July 2015)

Standard	Name
ISO 3458	Plastics piping systems - Mechanical joints between fittings and pressure pipe - Test method for leak-tightness under internal pressure
ISO 3459	Plastic piping systems - Mechanical joints between fittings and pressure pipe - Test method for leak-tightness under negative pressure
ISO 3501	Plastics piping systems - Mechanical joints between fittings and pressure pipe - Test method for resistance to pull-out under constant longitudinal force
ISO 3503	Plastics piping systems - Mechanical joints between fittings and pressure pipe - Test method for leak-tightness under internal pressure of assemblies subjected to bending
ISO 4437-1	Plastics piping systems for the supply of gaseous fuels - Polyethylene (PE) - Part 1: General
ISO 4437-2	Plastics piping systems for the supply of gaseous fuels - Polyethylene (PE) - Part 2: Pipes
ISO 4437-3	Plastics piping systems for the supply of gaseous fuels - Polyethylene (PE) - Part 3: Fittings
ISO 4437-4	Plastics piping systems for the supply of gaseous fuels - Polyethylene (PE) - Part 4: Valves
ISO 4437-5	Plastics piping systems for the supply of gaseous fuels - Polyethylene (PE) - Part 5: Fitness for purpose of the system
ISO 9623	PE/metal and PP/metal adaptor fittings for pipe for fluids under pressure - Design lengths and size of threads - Metric series
ISO/TS 10839	Polyethylene pipe and fittings for the supply of gaseous fuels - Code of practice for design, handling and installation
ISO 12176-3	Plastics pipe and fittings - Equipment for fusioning jointing polyethylene systems - Part 3: Operator's badge

Standard	Name
ISO 14236	Plastic pipe and fittings - Mechanical compression joints for polyethylene pressure pipe in the water supply
EN ISO 15494	Plastics piping systems for industrial applications - Polybutene (PB), polyethylene (PE) and polypropylene (PP) - Specifications for components and the system - Metric series
EN 12201-1	Plastics piping systems for water supply - Polyethylene (PE) - Part 1: General
EN 12201-2+A1	Plastics piping systems for water supply - Polyethylene (PE) - Part 2: Pipes
EN 12201-3+A1	Plastics piping systems for water - Polyethylene (PE) - Part 3: Fittings
EN 12201-4	Plastics piping systems for water supply - Polyethylene (PE) - Part 4: Valves
EN 12201-5	Plastics piping systems for water supply, and for drainage and sewerage under pressure - Polyethylene (PE) - Part 5: Fitness for purpose of the system
EN 1555-1	Plastics piping systems for the supply of gaseous fuels - Polyethylene (PE) - Part 1: General
EN 1555-2	Plastics piping systems for the supply of gaseous fuels - Polyethylene (PE) - Part 2: Pipes
EN 1555-3+A1	Plastics piping systems for the supply of gaseous fuels - Polyethylene (PE) - Part 3: Fittings
EN 1555-4	Plastics piping systems for the supply of gaseous fuels - Polyethylene (PE) - Part 4: Valves
EN 1555-5	Plastics piping systems for the supply of gaseous fuels - Polyethylene (PE) - Part 5: Fitness for purpose of the system
EN 12007-2	Gas infrastructure - Piping systems for maximum operating pressure up to and including 16 bar - Part 1: General functional requirements; German version EN 12007-1:2012
CEN/TS 12201-7	Plastics piping systems for water supply, and for drainage and sewerage under pressure - Polyethylene (PE) - Part 7: Guidance for the assessment of conformity
CEN/TS 1555-7	Plastics piping systems for the supply of gaseous fuels - Polyethylene (PE) - Part 7: Guidance for assessment of conformity
ASTM D2657	Standard practice for heat fusion joining of polyolefin pipe and fittings
ASTM D3261	Standard specification for butt heat fusion polyethylene (PE) plastic fittings for polyethylene (PE) plastic pipe and tubing
DIN 3544-1	High-density polyethylene (HDPE) valves; tapping valves; requirements and test
DIN 8074	Polyethylene (PE) - Pipes PE 80, PE 100 - Dimensions
DIN 8075	Polyethylene (PE) pipe - PE 80, PE 100 - General quality requirements, testing
DIN 8076	Pressure piping systems made from thermoplastics materials - Metal and plastics compression fittings for polyethylene (PE) pipe - General quality requirements and testing
DIN 19537-3	Prefabricated high density polyethylene (PE-HD) manholes for use in sewerage systems; dimensions and technical delivery conditions
DIN 28000-4	Chemical apparatus - Documentation in the life cycle of process plants - Part 4: Graphical symbols of valves, pipe and actuators
DVGW VP 302	Gas-Absperrarmaturen aus Polyethylen (PE 80 und PE 100) - Anforderungen und Prüfungen (Gas valves made of polyethylene [PE 80 and PE 100] - Requirements, testing)
DVS 2205-1 Supplement 6	Calculation of tanks and apparatus made of thermoplastics - Welding factors
DVS 2207-1	Fusioning of thermoplastics - Heated tool fusion of pipe, piping system components and sheets made of PE
DVS 2210-1	Industrial piping systems made of thermoplastics - Planning and execution - Above-ground pipe systems
DVS 2210-1 Supplement 1	Industrial piping made of thermoplastics - Design and execution - Above-ground pipe systems - Calculation example

Standard	Name
DVS 2210-1 Supplement 2	Industrial piping made of thermoplastics - Design and execution - Above-ground pipe systems - Recommendations for the internal pressure and leak tests
DVS 2210-1 Supplement 3	Industrial piping made of thermoplastics -Design and execution - Above-ground pipe systems - Flange connections: Description, requirements and assembly
DVS 2210-2	Industrial piping made of thermoplastics - Design, structure and installation of two-pipe systems
JIS K 6774	Polyethylene pipe for the supply of gaseous fuels

3.2.6 Relevant standards and guidelines for pipe and fittings made of PP

Standards and guidelines for pipe and fittings made of PP (edition: July 2015)

Norm	Bezeichnung
ISO 3213	Polypropylene (PP) pipe - Effect of time and temperature on the expected strength
ISO 9623	PE/metal and PP/metal adaptor fittings for pipe for fluids under pressure - Design lengths and size of threads - Metric series
EN ISO 15494	Plastics piping systems for industrial applications - Polybutene (PB), polyethylene (PE) and polypropylene (PP) - Specifications for components and the system - Metric series
DIN 8077	Polypropylene (PP) pipe - PP-H, PP-B, PP-R, PP-RCT - Dimensions
DIN 8078	Polypropylene (PP) pipe - PP-H, PP-B, PP-R, PP-RCT - General quality requirements and testing
DIN 8078 Supplement 1	Pipes of polypropylene (PP); chemical resistance of pipe and fittings
DIN 28000-4	Chemical apparatus - Documentation in the life cycle of process plants - Part 4: Graphical symbols of valves, pipe and actuators
DVS 2207-6	Fusioning of thermoplastics - Non-contact heated tool butt fusion of pipe, piping system components and sheets - Methods, equipment, parameters
DVS 2207-11	Fusioning of thermoplastics - Heated tool fusioning of pipe, piping parts and panels made of PP
DVS 2210-1	Industrial piping systems made of thermoplastics - Planning and execution - Above-ground pipe systems
DVS 2210-1 Supplement 1	Industrial piping made of thermoplastics - Design and execution - Above-ground pipe systems - Calculation example
DVS 2210-1 Supplement 2	Industrial piping made of thermoplastics - Design and execution - Above-ground pipe systems - Recommendations for the internal pressure and leak tests
DVS 2210-1 Supplement 3	Industrial piping made of thermoplastics -Design and execution - Above-ground pipe systems - Flange connections: Description, requirements and assembly
DVS 2210-2	Industrial piping made of thermoplastics - Design, structure and installation of two-pipe systems

3.2.7 Relevant standards and guidelines for pipe and fittings made of PVC-C

Standards for pipe and fittings made of PVC-C (edition: July 2015)

Standard	Name
ISO 727-1	Fittings made from unplasticized poly(vinyl chloride) (PVC-U), chlorinated poly(vinyl chloride) (PVC-C) or acrylonitrile/butadiene/styrene (ABS) with plain sockets for pipe under pressure - Part 1: Metric series
ISO 727-2	Fittings made from unplasticized poly(vinyl chloride) (PVC-U), chlorinated poly(vinyl chloride) (PVC-C) or acrylonitrile/butadiene/styrene (ABS) with plain sockets for pipe under pressure - Part 2: Inch-based series
EN ISO 15493	Plastics piping systems for industrial applications - Acrylonitrile-butadiene-styrene (ABS), unplasticized poly(vinyl chloride) (PVC-U) and chlorinated poly(vinyl chloride) (PVC-C) - Specifications for components and the system - Metric series
ASTM F437	Standard specification for threaded chlorinated poly (vinyl chloride) (PVC-C) plastic pipe fittings, Schedule 80
ASTM F441/F441M	Standard specification for chlorinated poly(vinyl chloride) (PVC-C) plastic pipe, Schedules 40 and 80
ASTM F1970	Standard specification for special engineered fittings, appurtenances or valves for use in poly (vinyl chloride) (PVC) or chlorinated poly (vinyl chloride) (PVC-C) systems
DIN 8079	Chlorinated polyvinyl chloride (PVC-C) pipe - Dimensions
DIN 8080	Chlorinated polyvinyl chloride (PVC-C) pipe - General quality requirements, testing
DIN 8080 Supplement 1	Chlorinated polyvinyl chloride (PVC-C) pipe, PVC-C 250 - General quality requirements and testing; chemical resistance
DIN 28000-4	Chemical apparatus - Documentation in the life cycle of process plants - Part 4: Graphical symbols of valves, pipe and actuators
DVS 2204-5	Adhesive bonding of pipe and fittings made of thermoplastics - Chlorinated polyvinyl chloride (PVC-C)
DVS 2204-5	Adhesive bonding of pipe and fittings made of thermoplastics - Chlorinated polyvinyl chloride (PVC-C)
DVS 2210-1	Industrial piping systems made of thermoplastics - Planning and execution - Above-ground pipe systems
DVS 2210-1 Supplement 1	Industrial piping made of thermoplastics - Design and execution - Above-ground pipe systems - Calculation example
DVS 2210-1 Supplement 2	Industrial piping made of thermoplastics - Design and execution - Above-ground pipe systems - Recommendations for the internal pressure and leak tests
DVS 2210-1 Supplement 3	Industrial piping made of thermoplastics -Design and execution - Above-ground pipe systems - Flange connections: Description, requirements and assembly
DVS 2210-2	Industrial piping made of thermoplastics - Design, structure and installation of two-pipe systems

3.2.8 Relevant standards and guidelines for pipe and fittings made of PVC-U

Standards and guidelines for pipe and fittings made of PVC-U (edition: July 2015)

Standard	Name
ISO 265-1	Pipe and fittings of plastics materials - Fittings for domestic and industrial waste pipe - Basic dimensions: Metric series - Part 1: Unplasticized poly(vinyl chloride) (PVC-U)
ISO 727-1	Fittings made from unplasticized poly(vinyl chloride) (PVC-U), chlorinated poly(vinyl chloride) (PVC-C) or acrylonitrile/butadiene/styrene (ABS) with plain sockets for pipe under pressure - Part 1: Metric series
ISO 727-2	Fittings made from unplasticized poly(vinyl chloride) (PVC-U), chlorinated poly(vinyl chloride) (PVC-C) or acrylonitrile/butadiene/styrene (ABS) with plain sockets for pipe under pressure - Part 2: Inch-based series
ISO 4132	Unplasticized polyvinyl chloride (PVC) and metal adaptor fittings for pipe under pressure - Laying lengths and size of threads - Metric series
EN ISO 13783	Plastics piping systems - Unplasticized poly(vinyl chloride) (PVC-U) end-load-bearing double-socket joints - Test method for leak-tightness and strength while subjected to bending and internal pressure
EN ISO 1452-1	Plastics piping systems for water supply and for buried and above-ground drainage and sewerage under pressure - Unplasticized poly(vinyl chloride) (PVC-U) - Part 1: General
EN ISO 1452-2	Plastics piping systems for water supply and for buried and above-ground drainage and sewerage under pressure - Unplasticized poly(vinyl chloride) (PVC-U) - Part 2: Pipes
EN ISO 1452-3	Plastics piping systems for water supply and for buried and above-ground drainage and sewerage under pressure - Unplasticized poly(vinyl chloride) (PVC-U) - Part 3: Fittings
EN ISO 1452-4	Plastics piping systems for water supply and for buried and above-ground drainage and sewerage under pressure - Unplasticized poly(vinyl chloride) (PVC-U) - Part 4: Valves
EN ISO 1452-5	Plastics piping systems for water supply and for buried and above-ground drainage and sewerage under pressure - Unplasticized poly(vinyl chloride) (PVC-U) - Part 5: Fitness for purpose of the system
EN ISO 15493	Plastics piping systems for industrial applications - Acrylonitrile-butadiene-styrene (ABS), unplasticized poly(vinyl chloride) (PVC-U) and chlorinated poly(vinyl chloride) (PVC-C) - Specifications for components and the system - Metric series
ASTM D1784	Standard specification for rigid poly(vinyl chloride) (PVC) compounds and chlorinated poly(vinyl chloride) (PVC-C) compounds
ASTM D1785	Standard specification for poly(vinyl chloride) (PVC) plastic pipe, Schedules 40, 80, and 120
ASTM D2464	Standard specification for threaded poly(vinyl chloride) (PVC) plastic pipe fittings, Schedule 80
ASTM D2466	Standard specification for poly(vinyl chloride) (PVC) plastic pipe fittings, Schedule 40
ASTM F1970	Standard specification for special engineered fittings, appurtenances or valves for use in poly (vinyl chloride) (PVC) or chlorinated poly (vinyl chloride) (PVC-C) systems
BS 3506:1969	Specification for unplasticized PVC pipe for industrial uses
BS 4346-1:1969	Joints and fittings for use with unplasticized PVC pressure pipe. Injection molded unplasticized PVC fittings for solvent fusioning for use with pressure pipe, including potable water supply
DIN 8061	Unplasticized polyvinyl chloride (PVC-U) pipe - General quality requirements
DIN 8061 Supplement 1	Unplasticized polyvinyl chloride pipe; chemical resistance of pipe and fittings of (PVC-U)
DIN 16450	Fittings for pressure pipe made of plasticizer-free polyvinylchloride (PVC-U); Names, symbols, simplified presentations
DIN 28000-4	Chemical apparatus - Documentation in the life cycle of process plants - Part 4: Graphical symbols of valves, pipe and actuators
DVS 2204-4	Adhesive bonding of pipe and piping parts made of thermoplastics - Polyvinyl chloride (PVC-U)

Standard	Name
DVS 2210-1	Industrial piping systems made of thermoplastics - Planning and execution - Above-ground pipe systems
DVS 2210-1 Supplement 1	Industrial piping made of thermoplastics - Design and execution - Above-ground pipe systems - Calculation example
DVS 2210-1 Supplement 2	Industrial piping made of thermoplastics - Design and execution - Above-ground pipe systems - Recommendations for the internal pressure and leak tests
DVS 2210-1 Supplement 3	Industrial piping made of thermoplastics -Design and execution - Above-ground pipe systems - Flange connections: Description, requirements and assembly
DVS 2210-2	Industrial piping made of thermoplastics - Design, structure and installation of two-pipe systems
JIS K 6741	Unplasticized poly (vinyl chloride) (PVC-U) pipe
JIS K 6742	Unplasticized poly (vinyl chloride) (PVC-U) pipe for water supply
JIS K 6743	Unplasticized poly (vinyl chloride) (PVC-U) pipe fittings for water supply

3.2.9 Relevant standards and guidelines for pipe and fittings made of PVDF

Standards and guidelines for pipe and fittings made of PVDF (edition: July 2015)

Standard	Name
ISO 10931	Plastics piping systems for industrial applications - Poly (vinylidene fluoride) (PVDF) - Specifications for components and the system
EN ISO 10931	Plastics piping systems for industrial applications - Poly (vinylidene fluoride) (PVDF) - Specifications for components and the system
ASTM F1673	Standard specification for polyvinylidene fluoride (PVDF) corrosive waste drainage systems
ASTM D3222	Standard specification for unmodified poly(vinylidene fluoride) (PVDF) molding extrusion and coating materials
DIN 28000-4	Chemical apparatus - Documentation in the life cycle of process plants - Part 4: Graphical symbols of valves, pipe and actuators
DVS 2205 Supplement 4	Calculation of tanks and apparatus made of thermoplastics - Characteristic values of the PVDF pipe
DVS 2207-6	Fusioning of thermoplastics - Non-contact heated tool butt fusion of pipe, piping system components and sheets - Methods, equipment, parameters
DVS 2207-15	Fusioning of thermoplastics - Heated tool fusion of pipe, piping system components and sheets made of PVDF
DVS 2210-1	Industrial piping systems made of thermoplastics - Planning and execution - Above-ground pipe systems
DVS 2210-1 Supplement 1	Industrial piping made of thermoplastics - Design and execution - Above-ground pipe systems - Calculation example
DVS 2210-1 Supplement 2	Industrial piping made of thermoplastics - Design and execution - Above-ground pipe systems - Recommendations for the internal pressure and leak tests
DVS 2210-1 Supplement 3	Industrial piping made of thermoplastics -Design and execution - Above-ground pipe systems - Flange connections: Description, requirements and assembly
DVS 2210-2	Industrial piping made of thermoplastics - Design, structure and installation of two-pipe systems

3.2.10 Relevant standards and guidelines for pipe and fittings made of ECTFE

Standard	Name
ISO 10931 (ECTFE in compliance)	Plastic piping systems for industrial applications – Poly (vinylidene fluoride) (PVDF) – Specifications for components and the system
EN ISO 10931 (ECTFE in compliance)	Plastic piping systems for industrial applications – Poly (vinylidene fluoride) (PVDF) – Specifications for components and the system
ASTM D3275-18	Standard Classification System for E-CTFE-Fluoroplastic Molding, Extrusion, and Coating Materials
DIN 28000-4	Chemical apparatus - Documentation in the life cycle of process plants- Part 4: Graphical symbols of valves, pipe and actuators
DIN EN 12814-6	Testing of welded joints of thermoplastics semi-finished products - Part 6: Low temperature tensile test
DVS 2203-1	Testing of welded joints of thermoplastic sheets and pipes – Test methods - Requirements
DVS 2205-1 Supplement 4	Calculation of tanks and apparatus made of thermoplastics – Characteri-stic values of the fluoropolymer material group
DVS 2207-6	Fusioning of thermoplastics – Non-contact heated tool butt fusion of pipe, piping system components and sheets – Methods, equipment, parameters
DVS 2210-1	Industrial piping systems made of thermoplastics - Planning and execu¬-tion - Above-ground pipe systems
DVS 2210-1 Supplement 1	Industrial piping made of thermoplastics - Design and execution - Abo-ve-ground pipe systems - Calculation example
DVS 2210-1 Supplement 2	Industrial piping made of thermoplastics - Design and execution - Abo-ve-ground pipe systems - Recommendations for the internal pressure and leak tests
DVS 2210-1 Supplement 3	Industrial piping made of thermoplastics -Design and execution - Abo-ve-ground pipe systems - Flange connections: Description, requirements and assembly
DVS 2210-2	Industrial piping made of thermoplastics - Design, structure and installa¬-tion of two-pipe systems

III

3.2.11 Relevant standards for GRP pipe

Standards for GRP pipe (edition: July 2015)

Standard	Name
ISO 10466	Plastics piping systems - Glass-reinforced thermosetting plastics (GRP) pipe - Test method to prove the resistance to initial ring deflection
ISO 10468	Glass-reinforced thermosetting plastics (GRP) pipe - Determination of the long-term specific ring creep stiffness under wet conditions and calculation of the wet creep factor
ISO 10471	Glass-reinforced thermosetting plastics (GRP) pipe - Determination of the long-term ultimate bending strain and the long-term ultimate relative ring deflection under wet conditions
ISO 10928	Plastics piping systems - Glass-reinforced thermosetting plastics (GRP) pipe and fittings - Methods for regression analysis and their use / Caution: Intended replacement by ISO/DIS 10928 (2006-03).
ISO 1172	Textile-glass-reinforced plastics - Prepregs, molding compounds and laminates - Determination of the textile-glass and mineral-filler content - Calcination methods
ISO 14828	Glass-reinforced thermosetting plastics (GRP) pipe - Determination of the long-term specific ring relaxation stiffness under wet conditions and calculation of the wet relaxation factor
ISO 15306	Glass-reinforced thermosetting plastics (GRP) pipe - Determination of the resistance to cyclic internal pressure
ISO 7432	Glass-reinforced thermosetting plastics (GRP) pipe and fittings - Test methods to prove the design of locked socket-and-spigot joints, including double-socket joints, with elastomeric seals
ISO 7509	Plastics piping systems - Glass-reinforced thermosetting plastics (GRP) pipe - Determination of time to failure under sustained internal pressure
ISO 7511	Plastics piping systems - Glass-reinforced thermosetting plastics (GRP) pipe and fittings - Test methods to prove the leak-tightness of the wall under short-term internal pressure
ISO 7685	Plastics piping systems - Glass-reinforced thermosetting plastics (GRP) pipe - Determination of initial specific ring stiffness
ISO 8483	Plastics piping systems for pressure and non-pressure drainage and sewerage - Glass-reinforced thermosetting plastics (GRP) systems based on unsaturated polyester (UP) resin - Test methods to prove the design of bolted flange joints
ISO 8513	Plastics piping systems - Glass-reinforced thermosetting plastics (GRP) pipe - Test methods for the determination of the apparent initial longitudinal tensile strength
ISO 8521	Plastics piping systems - Glass-reinforced thermosetting plastics (GRP) pipe - Test methods for the determination of the apparent initial circumferential tensile strength
ISO 8533	Plastics piping systems for pressure and non-pressure drainage and sewerage - Glass-reinforced thermosetting plastics (GRP) systems based on unsaturated polyester (UP) resin - Test methods to prove the design of cemented or wrapped joints
ISO 8639	Glass-reinforced thermosetting plastics (GRP) pipe and fittings - Test methods for leak-tightness of flexible joints
ISO/TS 10465-1	Underground installation of flexible glass-reinforced pipe based on unsaturated polyester resin (GRP-UP) - Part 1: Installation procedures
EN 637	Plastics piping systems - Glass-reinforced plastics components - Determination of the amounts of constituents using the gravimetric method
EN 705	Plastics piping systems - Glass-reinforced thermosetting plastics (GRP) pipe and fittings - Methods for regression analyses and their use
EN 761	Plastics piping systems - Glass-reinforced thermosetting plastics (GRP) pipe - Determination of the creep factor under dry conditions
EN 1394	Glass-reinforced thermosetting plastics (GRP) pipe - Determination of the long-term specific ring relaxation stiffness under wet conditions and calculation of the wet relaxation factor
EN 1447+A1	Plastics piping systems - Glass-reinforced thermosetting plastics (GRP) pipe - Determination of time to failure under sustained internal pressure

Standard	Name
AD 2000 Code HP 110 R	Construction regulations; Piping made of glass reinforced thermosetting plastics (GRP) with and without liner
BS 7159:1989	Code of practice for design and construction of glass-reinforced plastics (GRP) piping systems for individual plants or sites
BS 8010-2.5:1989	Code of practice for piping systems. Piping systems on land: design, construction and installation. Glass reinforced thermosetting plastics
DIN 16867	Glass fiber reinforced polyester resin (UP-GF) pipe, fittings and joints for use in chemical piping systems; Technical delivery conditions
DIN 16871	Centrifugally cast glass fiber reinforced epoxy resin (EP-GF) pipe; Dimensions
DIN 16964	Wound glass fiber reinforced polyester resins (UP-GF) pipe; general quality requirements and testing
DIN 16965-1	Wound glass fiber reinforced polyester resin (UP-GF); pipe, Type A pipe, dimensions
DIN 16965-2	Wound glass fiber reinforced polyester resin (UP-GF); pipe, Type B pipe, dimensions
DIN 16965-4	Wound glass fiber reinforced polyester resin (UP-GF); pipe, Type D pipe, dimensions
DIN 16965-5	Wound glass fiber reinforced polyester resin (UP-GF); pipe, Type E pipe, dimensions
DIN 16966-1	Glass fiber reinforced polyester resin (UP-GF) pipe fittings and joint assemblies; fittings; general quality requirements and testing
DIN 16966-2	Glass fiber reinforced polyester resin (UP-GF) pipe fittings and joints; Elbows, Dimensions
DIN 16966-4	Glass fiber reinforced polyester resin (UP-GF) pipe fittings an joints; Tees, Nozzles, Dimensions
DIN 16966-5	Glass fiber reinforced polyester resin (UP-GF) pipe fittings and joints; Reducers, Dimensions
DIN 16966-6	Glass fiber reinforced polyester resin (UP-GF) pipe fittings and joint assemblies; collars, flanges, joint rings, dimensions
DIN 16966-7	Pipe joints and their elements of glass fiber reinforced polyester resins - Part 7: Bushings, flanges, flanged and butt joints; general quality requirements and test methods
DIN 16966-8	Glass fiber reinforced polyester resin (UP-GF) pipe fittings and joints; Laminated joints; Dimensions
DIN 16967-2	Glass fiber reinforced epoxy resin (EP-GF) pipe fittings and joints; Elbows, Tees, Dimensions
DIN 53769-1	Testing of glass fiber reinforced plastics pipe; determination of the longitudinal shear strength of type B pipe fittings

4 Material Selection – Chemical Resistance

4.1 Introduction

Pipes made from plastics are used not only for drinking water, water for general use and wastewater, but also for transporting aggressive liquids and gases. Today expensive pipe designs, such as lined metal, ceramic or glass pipe can in many cases be replaced by plastic systems. Questions regarding the chemical resistance of piping materials to media are as important as the mechanical parameters for the installation of the piping system.

GF Piping Systems attempts to present resistance statements in order to identify the best suitable material for your application.

The recommendations given in the ChemRes Plus database are not only based upon the long and extensive applicational experience of GF but origin as well from tests in GF-own laboratories. Such tests may have been initiated by particular customer or general market demands.

Data can furthermore derive from national or international cooperations with scientific institutes and, if necessary, ISO or standardization authorities.

In any case we seek to give our recommendations as close to the individual application as possible. This includes statements to long-term stability, nature of media impact, hints to static and dynamic utilization, limits of process conditions and e.g. the impact of single, alternating or mixed media.

GF Piping Systems' service comprises personal contact on site at the customer as well as by phone, email or via web pages as the ChemRes Plus database. Statements about the chemical resistance of plastics to media and materials not listed in the ChemRes Plus database can be requested from GF Piping Systems.

The GF ChemRes Plus database for the chemical resistance of plastic piping materials is subject to frequent updating and addition. Please be aware that the chemical resistance statements cannot consider the following aspects:

- Influence of synergistic effects
- Influence of dynamic effects
- Influence of long-term effects
- Behavior of media mixtures or alternating filling of piping systems
- Type of corrosion/damage

Information about the permissible operating pressure

Guarantee and liability claims

The statements in this chapter concerning chemical resistance of materials must be validated for any specific use case and do not allow any inference of guarantee and/or liability claims. The function of valves depends not only on the chemical resistance of the material and the gaskets, but on a number of additional factors. For this reason, it is not possible to unrestrictedly apply this information to valves made of the same material.

GF Piping Systems refers to the General Terms and Conditions of Sale. Subject to change without notice.

4.1.1 General information regarding chemical resistance

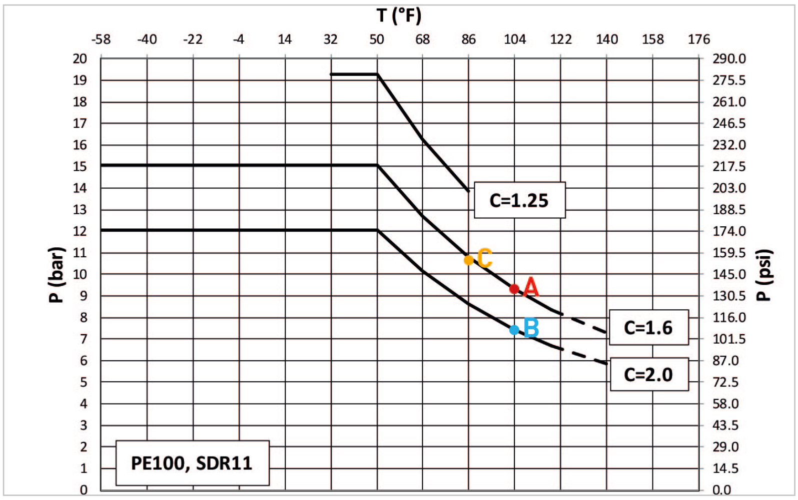
De-rating factor

The pressure-temperature diagrams of GF Piping Systems cover a service life of 25 years. They apply to water or aqueous solutions that do not impact the material properties.

Some media can affect the mechanical stability of piping materials without chemically attacking the material, e.g. through permeation or swelling. If pipe are exposed to elevated pressure and temperatures, the service life of the system may be reduced. A de-rating factor reduces the maximum pressure or temperature of a system.

Reduction factors are > 1, generally between 1.1 and 1.3, in a few cases higher.

Example



An aqueous medium in a PE piping system can be operated with a maximum of 9 bar at a temperature of 40 °C (point A in the pressure-temperature diagram) at a service life of 25 years.

37 % hydrochloric acid has a reduction factor of 1.2 for PE. The maximum operating pressure at 40°C for the same service life (point B) can be calculated:

$$\frac{9}{1.2} = 7.5 \text{ bar}$$

Conversely, the maximum operating temperature can be determined at a given pressure (point C):

$9 \cdot 1.2 = 10.8$ bar

A pressure of 10.8 bar on the SDR11 line corresponds to a temperature of approx. 30 °C.

Solvent cement joints with Tangit / DTX cement

Piping systems of ABS, PVC-U and PVC-C are preferentially cemented with Tangit. Some aggressive media at higher concentrations do, however, require DTX as a cement with a higher chemical resistance.

The use of DTX results in a few limitations:

- De-rating factor of 1.6 as specified in the data table
- Maximum application temperature

The following media or concentrations require a cement joint with DTX:

Medium	Concentration	De-rating factor	Temperature
Sulfuric acid	> 70 - 93 % H_2SO_4	AF: 1.6 (> 70 - 78 %) AF = 2 (> 78 %)	max. 60 °C max. 40 °C
Hydrochloric acid	> 25 - 37 % HCl	AF: 1.6	max. 60 °C
Nitric acid	> 20 – 55 % HNO_3	AF: 1.6	max. 60 °C (> 20 – 30 %) max. 40 °C (>30 %)
Sodium- / Potassium hypochlorite	> 6 – 15 % NaOCl / KOCl	AF: 1.6	max. 40 °C
Hydrogen peroxide	> 5 – 70 % H_2O_2	AF: 1.6	max. 40 °C
Hydrofluoric acid	</= 40% HF	AF: 1.6	max. 40 °C

Dytex is recommended exclusively for sulfuric acid > 93 – 98 %, chromic acid ≥ 10 % CrO_3, chromium sulfuric acid ≥ 70 % H_2SO_4 +5 % $K_2Cr_2O_7$/$Na_2Cr_2O_7$, and nitric acid > 55 – 65 %. The maximum temperature for Dytex adhesives is 40 °C.

The de-rating factor 1.6 reduces the maximum stress of a pressure level of PN16 to PN10, i.e. maximum 10 bar at a given temperature. For pressure levels of PN10 or lower, the reduction factor is no longer applied.

! Due to the unique properties of DTX, a special processing technique is required. For additional information, see Planning Fundamentals, chapter 12, "Jointing technology".

Gaskets

Below are general guidelines for the use of sealing materials for this purpose:

Material	Composition	Remarks	Maximum temperature	
			Constant	Short term
EPDM	Ethylene-propylene-co-polymer	• Generally applicable for alkaline and weak acidic media • Good resistance to aggressive media • Unsuitable for oils and greases	90 °C	120 °C
FKM, FFKM	Fluorine elastomers (Viton, Kalrez)	• Generally applicable for acidic media • High resistance to many solvents	150 °C	200 °C
NBR	Nitrile butadiene elastomer	• Good resistance to oils and fuels • Unsuitable for oxidizing substances	90 °C	120 °C
PTFE	Polytetrafluoroethylene	• Resistant to all chemicals in this list	250 °C	300 °C

The selection of the sealing material depends not only on aspects of chemical resistance, but also on mechanical influences.

Easily flammable substances

Besides questions concerning the chemical resistance many organic media require special safety measures when dimensioning piping systems due to their high flammability.

The recommendations of the ChemRes Plus database refer exclusively to the chemical resistance of the media with the corresponding materials and in no way replace technical instructions or safety guidelines for the design of piping systems. Corresponding explanations can be found, e.g., in the ATEX, ASME, ASTM or NFPA guidelines.

i For general notes see Planning Fundamentals, chapter 4 "Dimensioning", section 2.5 "Plastic piping systems in highly combustible locations/transport of explosive media". However, these do not replace the detailed expertise of planning companies.

Fusion joints

Fusion joints of the semi-crystalline thermoplastics PE, PP and PVDF have basically the same chemical resistance as the respective material. However, fusion joints can exhibit elevated pressure levels due to processes which can lead to smaller or larger cracks when exposed to crack-inducing media. To minimize these risks professional execution of the fusion is essential.

For more information see the corresponding fusion technologies in Planning Fundamentals, chapter 4, section 5 "Jointing technology".

Compressible media

Particular consideration and care is demanded for the design of plastic piping systems for gases or liquids with a considerable amount of dissolved gases with high vapour pressure.

Suitable materials for compressible media are not prone to brittle fracture . The materials of choice are ductile materials like PE and ABS. PP-H, PVC-U, PVC-C and PVDF are limited to process pressures ≤ 0.5 bar. Higher pressures are possible if secondary containment piping systems are applied, the outer piping of which provides protection against fragments from fractures.

Low boiling media or fluids with dissolved gases may generate considerable pressure increases under unfavourable operation conditions. Typical examples are hydrochloric acid or ammonium hydroxide at critical pH. Those pressures may exceed the maximum pressure values for the given piping system and need to be prevented by suitable process conditions (e.g. adaption of the temperature profile).

Under conditions of high flow speeds several non-aqueous media may generate electrostatic charge. In combination with flammable media this can provide additional hazards to the layout of the piping systems. Experienced engineering companies are able to meet these challenges.

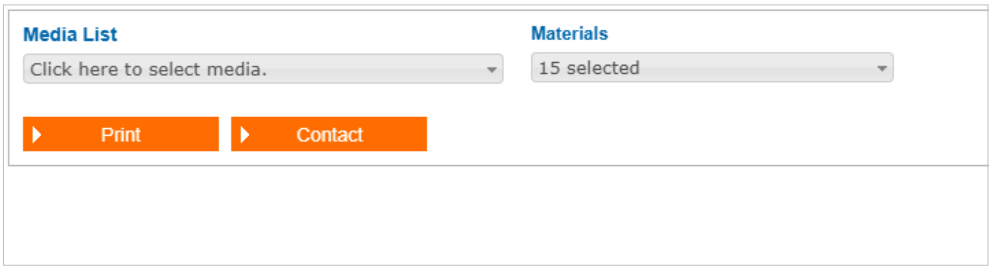
4.2 ChemRes Plus online database

4.2.1 General information

The ChemRes Plus database is supposed to serve as an orientation for the choice of a suitable piping material. Since the suitability of a material is not only determined by the pure chemical resistance profile but also by process details which are usually not referred to in lists, it is always recommended to contact the GF specialists for an individual and more detailed assessment.

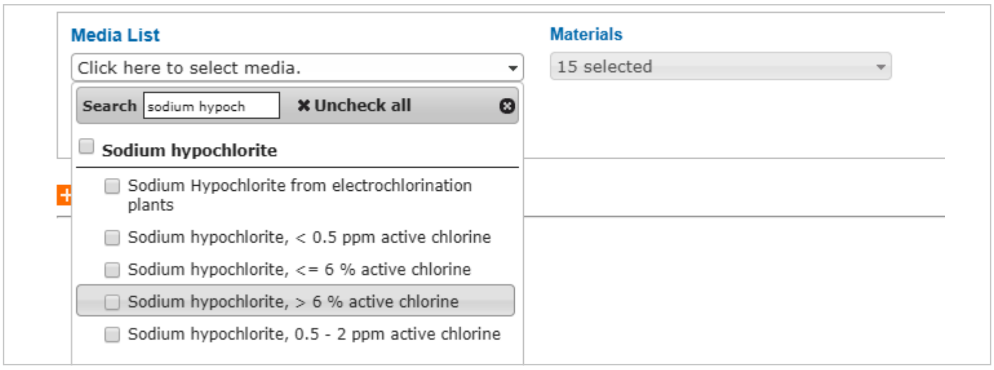
The ChemRes Plus database is available at www.gfps.com/tools

Call up the database at www.gfps.com/tools under Chemical Resistance.

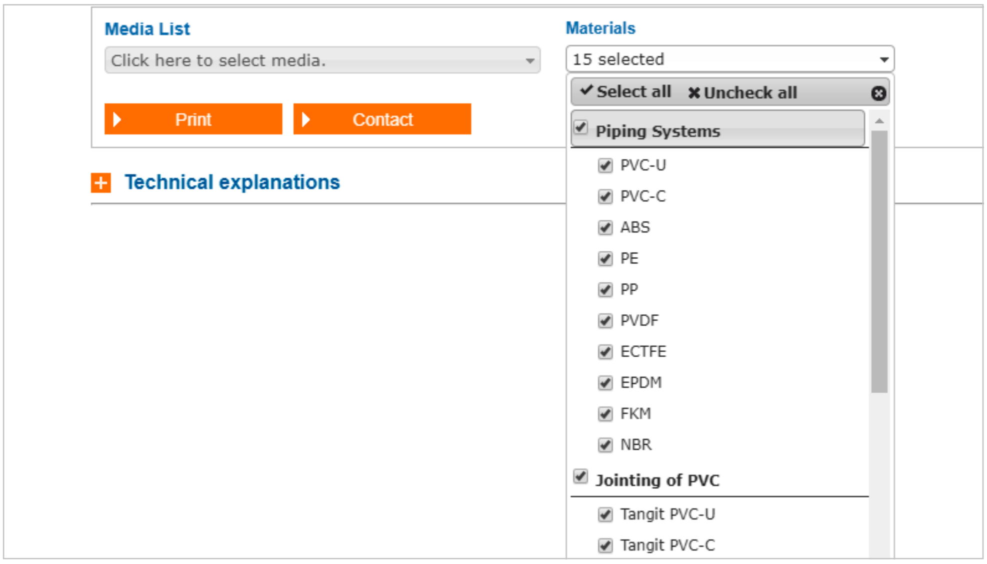


In order to locate a specific medium, click on the grey bar of the **Media List** and enter the corresponding name, e.g. sodium hypochlorite.

Synonyms can also be entered as an alternative, e.g. chlorine bleach.



To track the resistance profile of one or several materials choose the appropriate sections in the list **Materials**. The groups Piping Systems and Jointing of PVC are pre-selected.



After selecting the required materials and media the resistance profiles of the chosen materials are shown.

Media List 1 selected

Materials 15 selected

Print | Contact

Sodium hypochlorite, > 6 % active chlorine

Formula: NaOCl **Synonyme:** Eau de labarraque, Eau de javelle

Comments: PVC: DTX Solvent cement. De-Rating factor: 1.6. Unprofessional cementing can reduce the service life of the pipeline especially for aggressive media. You may contact GF for additional information.

Piping Systems	20 °C	40 °C	60 °C	80 °C	100 °C	120 °C	140 °C
PVC-U	+ (1.1)	+ (1.1)	O				
PVC-C	O						
ABS	-						
PE	O						
PP	-						
PVDF	-						
ECTFE	++	++	++	O	O	-	
EPDM	++	++	O	O	O	-	
FKM	O	O					
NBR							

Jointing of PVC	20 °C	40 °C	60 °C	80 °C	100 °C	120 °C	140 °C
Tangit PVC-U	O	-					
Tangit PVC-C	-						
Tangit DTX	+ (1.6)	+ (1.6)	-				
Tangit RAPID							
Tangit Plus							

Classification

The chemical resistance of materials in the ChemRes Plus database is classified by using the following symbols:

Symbol	Meaning	Description
++	Recommended	The material is unrestrictedly suitable for the medium within the temperature limits applicable for the medium. There is no or only a very small negative effect on the material properties.
+ (AF)	Recommended with restrictions	The material is suitable for the medium; however, the maximum temperature or pressure is subject to reduction by an individual de-rating factor. See the section "De-rating factor". Alternatively a flat maximum pressure or temperature may apply.
O	Consultation with GF Piping Systems	Starting at this temperature, the use of the material is limited. We recommend consulting GF to obtain an individual assessment of the conditions.
-	Not suitable	The material is not suitable for the application or only under special conditions since the medium considerably impacts material properties.

Design and Installation

of Plastic Piping Systems

Content

IV

1 Symbols, SI-Units and Conversion Tables

1.1 Metric and British system of units

The metric system uses both the pipe outside diameter (d in mm) and the nominal diameter (DN in mm) for the size definition. The pipe outside diameter is the specified real outside diameter of the pipe. The nominal diameter classifies the inner diameter and makes it comparable with metal pipe. The DN numbers of metal and plastic pipe are the same.

Inch systems are only designated by the nominal diameter (in inches and fractions of it). The dimensions of the imperial pipe (to BS) and the American pipe (to ANSI / ASME) are very similar, but not identical.

Metric and inch pipe of same nominal size can be connected by adaptors.

Comparison of metric and Inch based pipe sizes

Metric sizes		Inch sizes
Pipe outer diameter d (mm)	Nominal diameter DN (mm)	Nominal diameter DN (Inch)
10	6	⅛
12	8	¼
16	10	⅜
20	15	½
25	20	¾
32	25	1
40	32	1¼
50	40	1½
63	50	2
75	65	2½
90	80	3
110	100	4
125	100	
125[1)]	125	
140	125	5
160	150	6
180[2)]	150	
200	200	8
225	200	8
250	250	
280	250	10
315	300	12
355	350	14
400	400	16
450	450	18
450	500	
500	500	20
560	600	
630	600	24
710	700	28
800	800	32
900	900	36
1000	1000	40

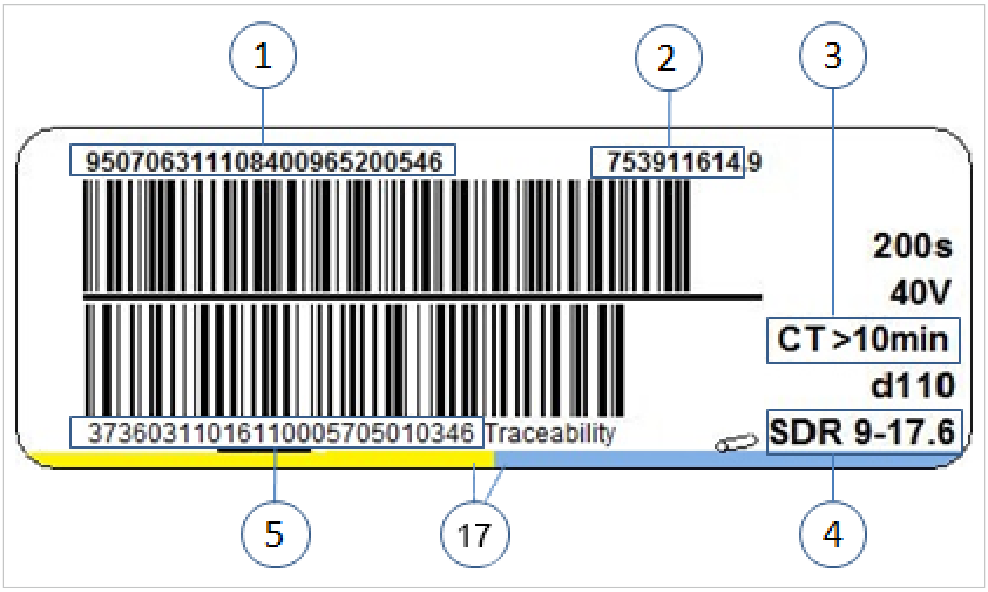
1) Solvent cement socket systems only
2) Butt fusion systems only

1.2 Identification

1.2.1 Fittings

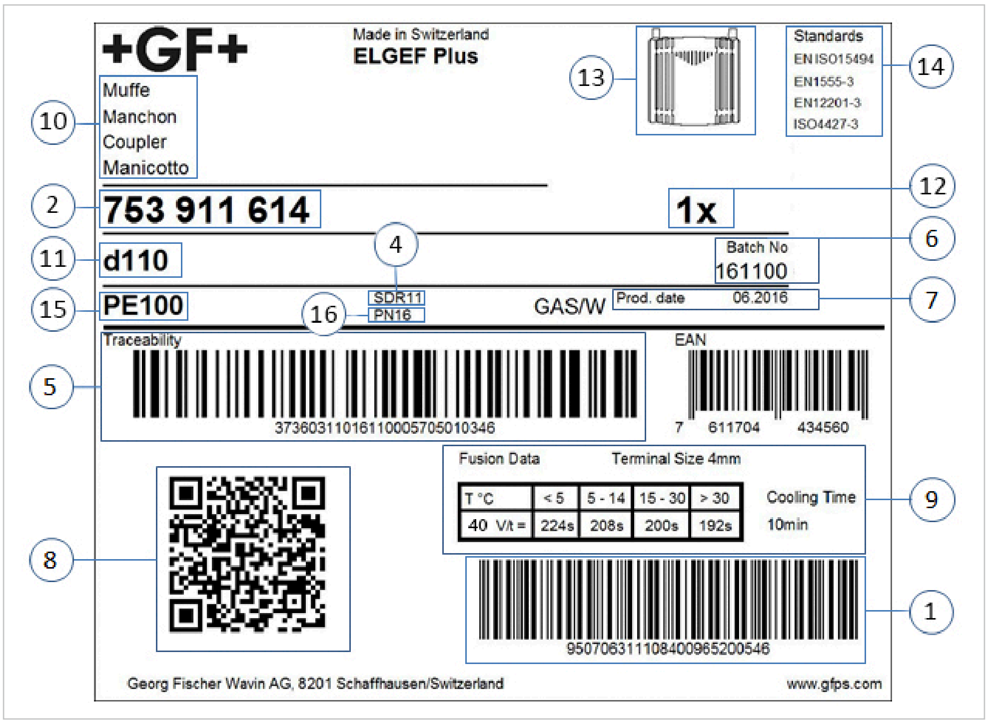
Packaging label using PE electrofusion fitting with the most comprehensive content as an example

Barcode label



① Welding-Barcode, ISO 13950
② Item number
③ Cooling time
④ SDR-Class of the Pipe
⑤ Traceability code, ISO 12176
⑥ Batch-Nr.
⑦ Production month and year YY.XXX
⑧ Unitary QR-Code
⑨ Manual Welding data
⑩ Product name
⑪ Dimension
⑫ Number of items
⑬ Product picture
⑭ Approval/Norms
⑮ Material
⑯ Max. bleed pressure
⑰ Color bar: yellow = Gas, blue = Water

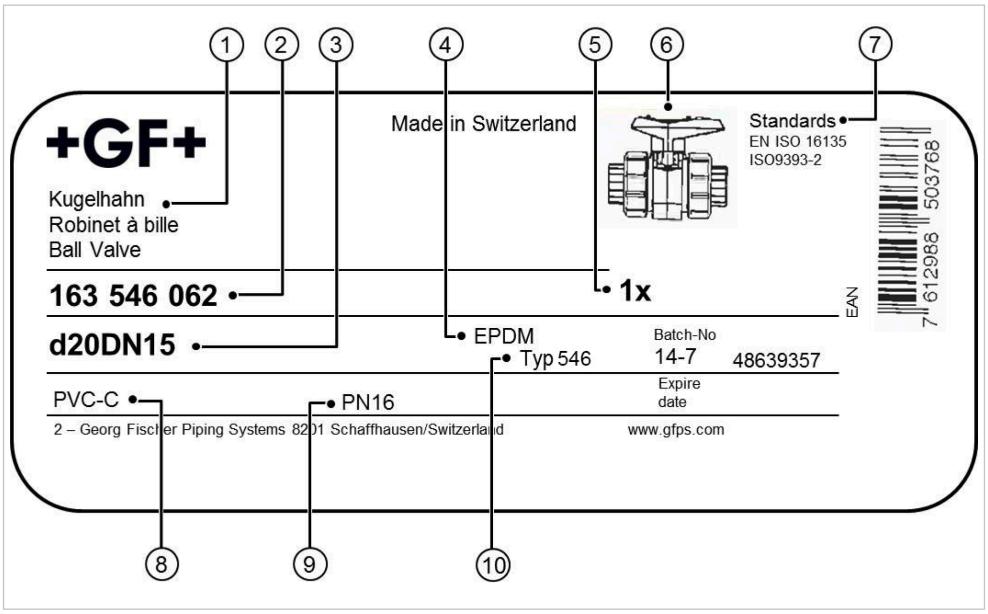
Bag label



Further information to each product can be downloaded with the unitary QR-Codes from the database of our online-services. In this way a consolidation of all information from production and installation is possible in order to generate complete network documentation.

1.2.2 Valves

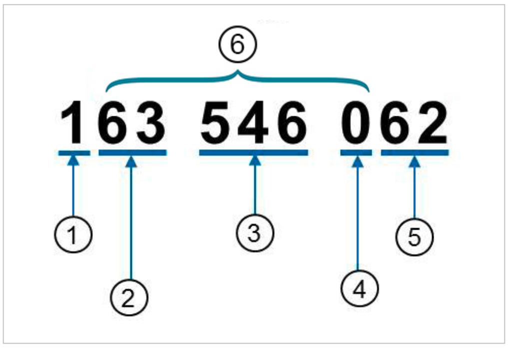
Packaging label using ball valve type 546 as an example



① Product name
② Code number
③ Dimension
④ Gasket material
⑤ Packaged number of units
⑥ Product image
⑦ Approvals/standards
⑧ Valve material
⑨ Nominal pressure
⑩ Type

Code numbers

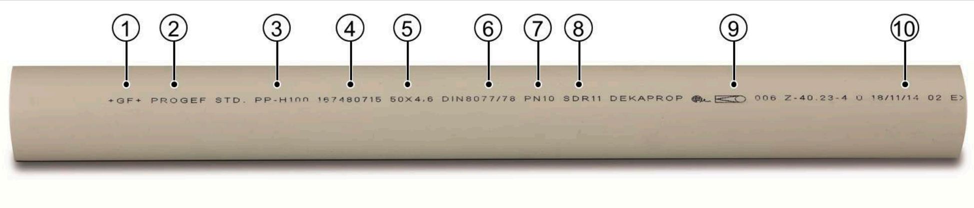
The code numbers typicially consist of the following:

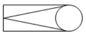


① Class
② Material
③ Type
④ Variant
⑤ Size

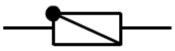
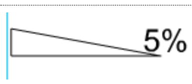
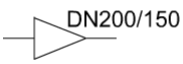
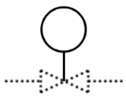
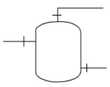
IV

1.2.3 Pipe



Nr.	Designation type	Example
①	Manufacturer's logo	+GF+
②	Name of piping system	PROGEF
③	Material	PP-H
④	Code number	167480715
⑤	Outside diameter (d) x wall thickness (e)	50 x 4.6
⑥	Standard/approval	DIN 8077/78
⑦	Pressure (PN)	PN10
⑧	SDR	11
⑨	Approval symbol	
⑩	Date of manufacture (DD/MM/YY)	16/11/14

1.3 Symbols (DIN 2429, ISO 14617)

Symbols	Connection	Symbols	Valves
	Pipe		Valve, general
	Pipe, insulated		Ball valve
	Crossing without connection		Diaphragm valve
	Tee		Flap trap
	Flange connection		Pump
	Hose		Valve, flanged
	Slope		Butterfly valve
	Connection		Check valve
	Reduction		Actuator
	Container, flanged		

1.4 Abbreviations and units of measure

1.4.1 Abbrevitations for materials

Abbreviation	Name
ABS	Acrylonitrile-butadiene-styrene
CR	Chloroprene rubber, e.g. neoprene
ECTFE	Ethylene-chlorotrifluoroethylene
EPDM	Ethylene propylene rubber
FKM	Fluorinated rubber, e.g. Viton
GRP	Glass-fiber reinforced plastics
Ms	Brass
NBR	Nitrile rubber
NR	Natural rubber
PB	Polybutylene
PE	Polyethylene
PE-X	Crosslinked polyethylene
PP	Polypropylene
PTFE	Polytetrafluorethylene
PVC	Polyvinylchloride
PVC-C	Polyvinylchloride postchlorinated (increased chlorine content)
PVC-U	Polyvinylchloride unplasticised
PVDF	Polyvinylidenefluoride
MCI	Malleable cast iron
UP-GF	Unsaturated polyester resin, fiberglass-reinforced

1.4.2 Abbreviations for procedures

Abbreviation	Name	
C	Design factor	Consideration of variations in material composition and pipe manufacturing
S	Pipe series	Wall thickness of a pipe with a given outer diameter
SDR	Standard dimension ratio	Ratio of diameter to wall thickness
MFR	Melt flow rate	Viscosity of the molten plastic material
MRS	Minimum required strength	Pressure resistance of a pipe material

1.4.3 Dimensions and units

Abkürzung	Bezeichnung
d, d1, d2, d3, d4	Outer diameter
DN	Nominal diameter
SC	Size of hexagon head bolts
AL	Number of bolt holes
s	Wrench size
g	Weight in grams
SP	Number of items per standard package
GP	Number of items per large package
e	Wall thickness of pipe
PN	Nominal pressure at 20 °C, water (50 years)
Rp	Cylindrical inner pipe thread acc. to ISO 7-1
R	Conical outer pipe thread acc. to ISO 7-1
ppm	Parts per million
1 bar	= 0.1 N/mm^2 = 0.1 Mpa = 14.504 psi

Dimensions must be listed in mm and/or inch and refer to nominal or standard dimension. Subject to construction and design changes.

1.5 SI units

1.5.1 SI base units

Base size		SI base units	
Name	Sign	Name	Sign
Length	l	Meter	m
Mass	m	Kilogram	kg
Time	t	Second	s
Electric current	I	Ampere	A
Thermodynamic temperature	T	Kelvin	K
Amount of substance	n	Mole	mol
Luminous intensity	ln	Candela	cd

1.5.2 Internationally defined prefixes

Meaning	Prefix Name	Sign	Factor as Decimal power	Decimal number
Quintillion	exa	E	10^{18}	= 1 000 000 000 000 000 000
Quadrillion	peta	P	10^{15}	= 1 000 000 000 000 000
Trillion	tera	T	10^{12}	= 1 000 000 000 000
Billion	giga	G	10^{9}	= 1 000 000 000
Million	mega	M	10^{6}	= 1 000 000
Thousand	kilo	k	10^{3}	= 1 000
Hundred	hecto	h	10^{2}	= 100
Ten	deka	da	10^{1}	= 10
Tenth	deci	d	10^{-1}	= 0.1
Hundredth	centi	c	10^{-2}	= 0.01
Thousandth	milli	m	10^{-3}	= 0.001
Millionth	micro	µ	10^{-6}	= 0.000 001
Billionth	nano	n	10^{-9}	= 0.000 000 001
Trillionth	pico	p	10^{-12}	= 0.000 000 000 001
Quadrillionth	femto	f	10^{-15}	= 0.000 000 000 000 001
Quintillionth	atto	a	10^{-18}	= 0.000 000 000 000 000 001

1.5.3 Units

Size	Sign	SI unit	Permissible units outside of SI	Conversion into corresponding SI unit and relationships	Units and conversions no longer permissible
Length	l	m			1" = 0.0254 m 1 Sm = 1852 m
Area	A	m^2			1 b = 10^{-28} m^2 1 a = 10^2 m^2 1 ha = 10^4 m^2 qm, qdm, qcm
Volume	V	m^3	l	1 l = 10^{-3} m^3	
Solid angle	Ω	SR		1 sr = 1 m^2/m^2	1° = 3.046 • 10^{-4} sr 1 g = 2.467 • 10^{-4} sr
Time	t	s	min h d	1 min = 60 s 1 h = 3600 s 1 d = 86 400 s	
Frequency	f	Hz		1 Hz = 1/s	
Speed, rotational frequency	n	s^{-1}	min^{-1} U/min	1 min^{-1} (1/60) s^{-1} 1 U/min = 1 (1/min)	
Velocity	v	m/s	km/h	1 km/h = (1/3.6) m/s	
Acceleration	g	m/s^2		Normal-Fallbeschleunigung g_n = 9.80665 m/s^2	1 Gal = 10^{-2} m/s^2
Mass	m	kg	t	1 t = 10^3 kg	1 q = 50 kg
Density	ρ	kg/m^3	t/m^3 kg/l	1 t/m^3 = 1000 kg/m^3 1 kg/l = 1000 kg/m^3	
Moment of inertia	J	kg • m^2			1 kp • m s^2 = 9.81 kg • m^2
Force	F	N		1 N = 1 kg • m/s^2	1 dyn = 10^{-5} N 1 p = 9.80665 • 10^{-3} N 1 kp = 9.80665 N
Torque	M	N • m			1 kpm = 9.80665 Nm 1 Nm = 0.7375 lb-ft
Pressure	p	Pa	bar	1 Pa = 1 N/m^2 1 bar = 10^5 Pa	1 atm = 1.01325 bar 1 at = 0.980665 bar 1 Torr = 1.333224 • 10^{-3} bar 1 m WS = 98.0665 • 10^{-3} bar 1 mm Hg = 1.333224 • 10^{-3}bar
Stress	σ	N/m^2 Pa		1 N/m^2 = 1 Pa	1 kp/m^2 = 9.80665 N/m^2 1 kp/cm^2 = 98.0665 10^{-3} N/m^2 1 kp/mm^2 = 9.80665 • 10^{-6} N/m^2
Dynamic viscosity		Pa • s		1 Pa • s = 1 N • s/m^2	1 P (Poise) = 10^{-1} Pa • s
Kinematic viscosity		m^2/s		1 m^2/s = 1 Pa • s • m^3/kg	1 St (Stokes) = 10^{-4} m^2/s
Work, energy	W E	J	eV W • h	1 J = 1 Nm = 1 WS 1 W • h = 3.6 KJ	1 cal = 4.1868 J 1 kpm = 9.80665 J 1 erg = 10^{-7} J
Electric charge	Q	C		1 C = 1 A • s	
Electric voltage	U	V		1 V = 1 W/A	
Electric current	I	A			
Electric resistance	R	Ω		1 Ω = 1 V/A	1 Ω abs = 1 Ω
Power	P	W		1 W = 1 J/s = 1 Nm/s 1 W = 1 V • A	1 PS = 735.498 W 1 kcal/h = 1.163 W 1 kpm/s = 10 W
Electric capacitance	C	F		1 F = 1 C/V	
Magnetic field strength	H	A/m			1 Oe = 79.5775 A/m
Magnetic flux	Φ	Wb		1 Wb = 1 V • s	1 Mx = 10^{-8} Wb
Magnetic flux density	B	T		1 T = 1 Wb/m^2	1 G = 10^{-4} T
Inductance	L	H		1 H = 1 Wb/A	
Electric conductance	G	S		1 S = 1/Ω	
Thermodynamic temperature	T	K		Δ 1 °C = Δ 1 K 0 °C = 273.15 K	
Celsius; temperature	t, δ	°C		Δ 1 °C = Δ 1 K 0 K = -273.15 °C	
Thermal capacity	C	J/K			1 Kcl/grad = 4.1868 10^{-3} J/K 1 Cl = 4.1868 J/K

1.6 Conversion tables

1.6.1 Viscosities

Kinematic viscosity Centistokes density	Absolute viscosity centipoise	Degree Engler	Saybolt Universal second (SSU)	Redwood 1 second (standard)	Saybolt Furol second	Ford Cup no. 4 second	Degree Barbey	Cup no. 15 second	Absolute viscosity poise density 1.0	Kinematic viscosity m^2/s
1.0	1.0	1.0	31	29					0.01	1.0×10^{-6}
2.0	2.0	1.1	34	30			3640		0.02	2.0×10^{-6}
3.0	3.0	1.2	35	33			2426		0.03	3.0×10^{-6}
4.0	4.0	1.3	37	35			1820			4.0×10^{-6}
5.0	5.0	1.39	42	38			1300		0.05	5.0×10^{-6}
6.0	6.0	1.48	45.5	40.5			1085		0.06	6.0×10^{-6}
7.0	7.0	1.57	48.5	43			930		0.07	7.0×10^{-6}
8.0	8.0	1.65	53	46			814		0.08	8.0×10^{-6}
9.0	9.0	1.74	55	48.5			723		0.09	9.0×10^{-6}
10	10	1.84	59	52			650		0.10	1.0×10^{-5}
20	20	2.9	97	85	15		320		0.2	2.0×10^{-5}
40	40	5.3	185	163	21		159		0.4	4.0×10^{-5}
60	60	7.9	280	245	30	18.7	106	5.6	0.6	6.0×10^{-5}
80	80	10.5	370	322	38	25.9	79	6.7	0.8	8.0×10^{-5}
100	100	13.2	472	408	47	32	65	7.4	1.0	1.0×10^{-4}
200	200	26.4	944	816	92	60	32.5	11.2	2.0	2.0×10^{-4}
400	400	52.8	1888	1632	184	111	15.9	18.4	4.0	4.0×10^{-4}
600	600	79.2	2832	2448	276	162	10.6	26.9	6.0	6.0×10^{-4}
800	800	106	3776	3264	368	217	8.1	35	8.0	8.0×10^{-4}
1000	1000	132	7080	4080	460	415	6.6	68	10	1.0×10^{-3}
5000	5000	660	23 600	20 400	2300	1356	1.23	240	50	5.0×10^{-3}
10 000	10 000	1320	47 200	40 800	4600	2713		481	100	1.0×10^{-2}
50 000	50 000	6600	236 000	204 000	23 000	13 560		2403	500	5.0×10^{-2}

Absolute viscosity (centipoise) = kinematic viscosity (centistokes) • density over 50 centistokes - conversion to SSU à SSU = centistokes • 4.62

1.6.2 Flow volume

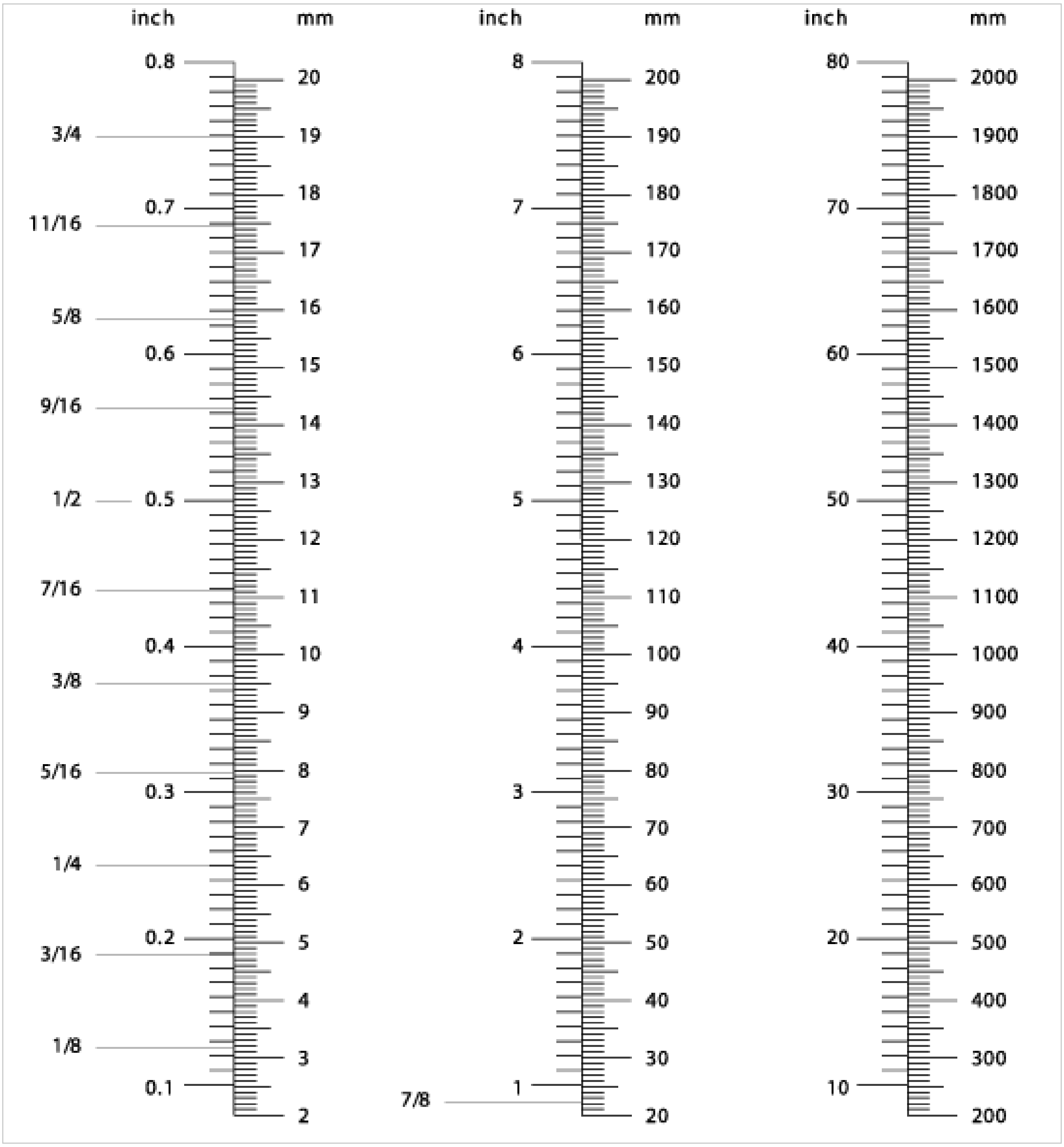
m^3/h	l/min	l/s	m^3/s	Imp. gal/min	US gal/min	cu. ft./h	cu. ft./s
1.0	16.67	0.278	$2.78 \cdot 10^{-4}$	3.667	4.404	35.311	$9.81 \cdot 10^{-3}$
0.06	1.0	0.017	$1.67 \cdot 10^{-5}$	0.220	0.264	2.119	$5.89 \cdot 10^{-4}$
3.6	60	1.0	$1.00 \cdot 10^{-3}$	13.20	15.853	127.12	$3.53 \cdot 10^{-2}$
3 600	60 000	1000	1.0	13 200	15 838	127 118	35.311
0.2727	4.55	0.076	$7.58 \cdot 10^{-5}$	1.0	1.201	9.629	$2.67 \cdot 10^{-3}$
0.2272	3.79	0.063	$6.31 \cdot 10^{-5}$	0.833	1.0	8.0238	$2.23 \cdot 10^{-3}$
0.0283	0.47	0.008	$7.86 \cdot 10^{-6}$	0.104	0.125	1.0	$2.78 \cdot 10^{-4}$
101.94	1 699	28.32	$2.83 \cdot 10^{-2}$	373.77	448.8	3 600	1.0

1.6.3 Pressure and pressure heads

bar	kg/cm^2	lbf/in^2	atm	ft H_2O	m H_2O	mm Hg	in. Hg	kPa
1.0	1.0197	14.504	0.9869	33.455	10.197	750.06	29.530	100
0.9807	1.0	14.223	0.9878	32.808	10	735.56	28.959	98.07
0.0689	0.0703	1.0	00609	2.3067	0.7031	51.715	2.036	6.89
1.0133	1.0332	14.696	1.0	33.889	10.332	760.0	29.921	101.3
0.0299	0.0305	0.4335	0.0295	1.0	0.3048	22.420	0.8827	2.99
0.0981	0.10	1.422	0.0968	3.2808	1.0	73.356	2.896	9.81
$13.3 \cdot 10^{-4}$	0.0014	0.0193	$13.2 \cdot 10^{-4}$	0.0446	0.0136	1.0	0.0394	0.133
0.0339	0.0345	0.4912	0.0334	1.1329	0.3453	25.40	1.0	3.39
$1.0 \cdot 10^{-5}$	$10.2 \cdot 10^{-6}$	$14.5 \cdot 10^{-5}$	$9.87 \cdot 10^{-6}$	$3.34 \cdot 10^{-4}$	$10.2 \cdot 10^{-5}$	$75.0 \cdot 10^{-4}$	$29.5 \cdot 10^{-5}$	1.0

atm International standard atmosphere
kg/cm^2 Metric atmosphere

1.6.4 Conversion inch/mm



IV

2 Pipeline Design

2.1 Long-term behavior of thermoplastic materials

One of the most important characteristics of plastic pipe is the realistic service life of a pipe that is subjected to internal pressure. This characteristic is referred to as long-term behavior. When determining the long-term behavior, the temperature and the flow medium play an essential role.

2.1.1 MRS values

The following table shows the MRS values (Minimum Required Strength) for thermoplastic materials used in the construction of industrial piping systems.

The values are based on these standards:
- EN ISO 15493 (ABS, PVC-U, PVC-C)
- EN ISO 15494 (PB, PE, PP)
- EN ISO 10931 (PVDF; ECTFE in compliance)

Material	MRS value (MPa)
ABS	14
PE80	8
PE100	10
PP-H	10
PP-B	8
PP-R	8
PVC-U	25
PVC-C (pipe)	25
PVC-C (fitting)	20
PVDF	25
ECTFE	18

2.1.2 Long-term behavior of ABS

Calculation (based on EN ISO 15493:2015)

The following loop stress oliagram shows the long-term behavior of ABS. For the temperature range from +10 °C to +60 °C, fracture lines are displayed. These are called LPL curves (Lower Predictable Limit); this means according to the definition that 97.5 % of all fracture points are on or above the corresponding curve.

Typically for amorphous thermoplastics like ABS, the long-term behavior shows straight lines. The curves are plotted in a double logarithmic diagram (i.e. not linear). Please take this into account when reading values for stress or time.

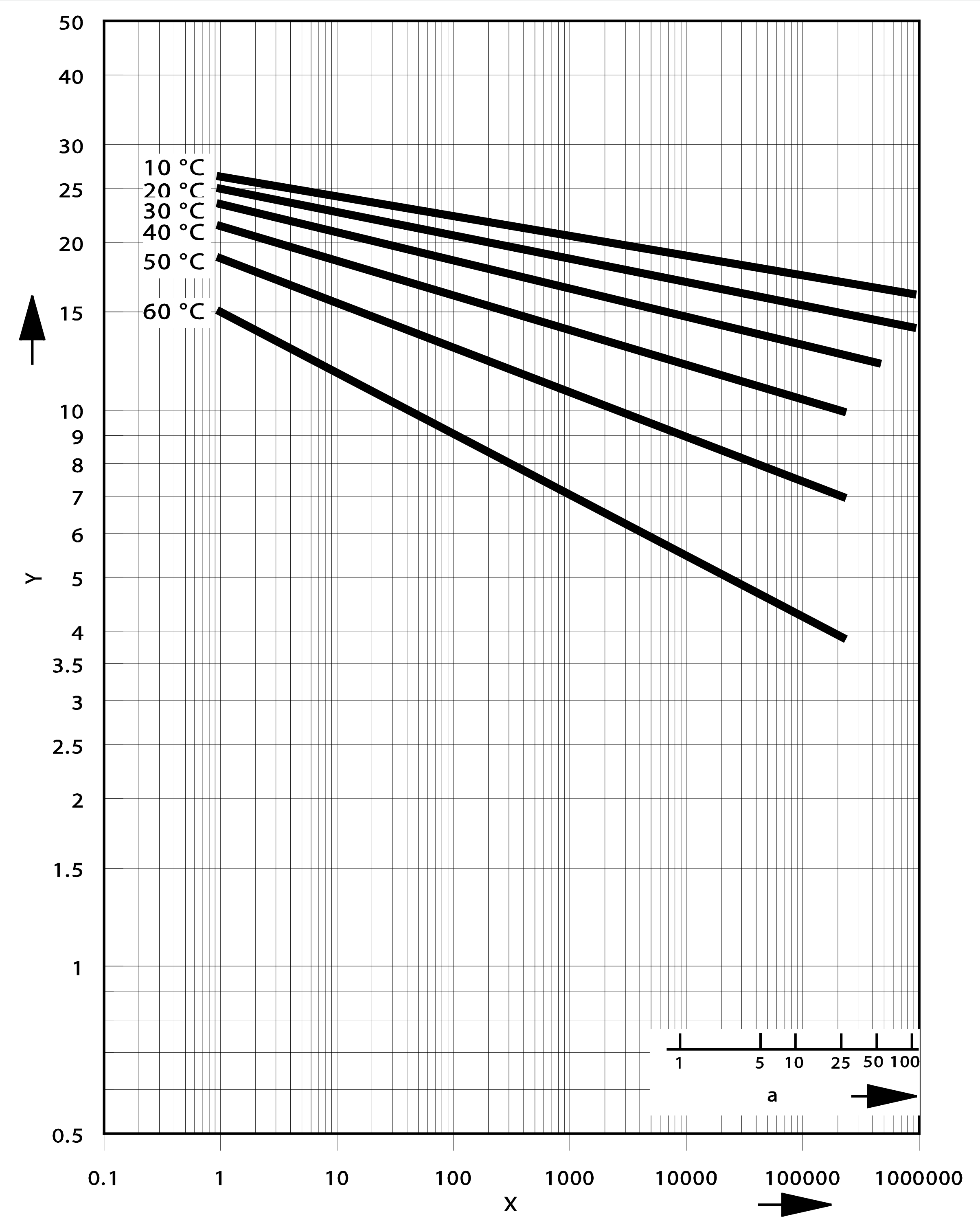
The long-term behavior was calculated by using the extrapolation method according to EN ISO 9080. With the following equation (4-parameter model), which was derived from that diagram, stress, temperature or time can be calculated for the temperature range of +10 °C to +60 °C.

$$\log t = -154.8961 - 35935.57 \cdot \frac{\log \sigma}{T} + 55180.34 \cdot \frac{1}{T} + 98.73749 \cdot \log \sigma$$

t Time to failure (h)
T Medium temperature (K)
σ Hoop stress (MPa) (1 MPa = 1 N/mm^2)

The pressure-temperature diagram shown for pipe and fittings made of ABS is derived from the long-term behavior, including the design factor, for a service life of 25 years.

Long-term behavior ABS (based on EN ISO 15493:2015)



Y Hoop stress (MPa) (1 MPa = 1 N/mm²)
X Time to failure (h)
a Years

2.1.3 Long-term behavior of PE

Calculation (based on EN ISO 15494:2015)

The following repeat of long-term behaviors of PE80 and PE100. For the temperature range from +10 °C to +80 °C, lines of fracture are displayed. These are called LPL curves (Lower Predictable Limit); this means according to the definition that 97.5 % of all fracture points are on or above the corresponding curve.

Straight lines represent the long term properties of PE in the hoop stress diagram.

The curves are plotted in a double logarithmic diagram (not linear), please take this into account when reading values for stress or time.

The long-term values have been calculated by using the extrapolation method according to EN ISO 9080. With the following equation (3-parameter model), which was derived from that diagram, stress, temperature or time can be calculated for the temperature range of +10 °C to 80 °C.

First branch (left-hand portion of the curves as shown in the following long-term behaviors)

PE100

$$\log t = -45.4008 + 28444.734 \cdot \frac{1}{T} - 45.9891 \cdot \log \sigma$$

PE80

$$\log t = -42.5488 + 24078.8 \cdot \frac{1}{T} - 37.5758 \cdot \log \sigma$$

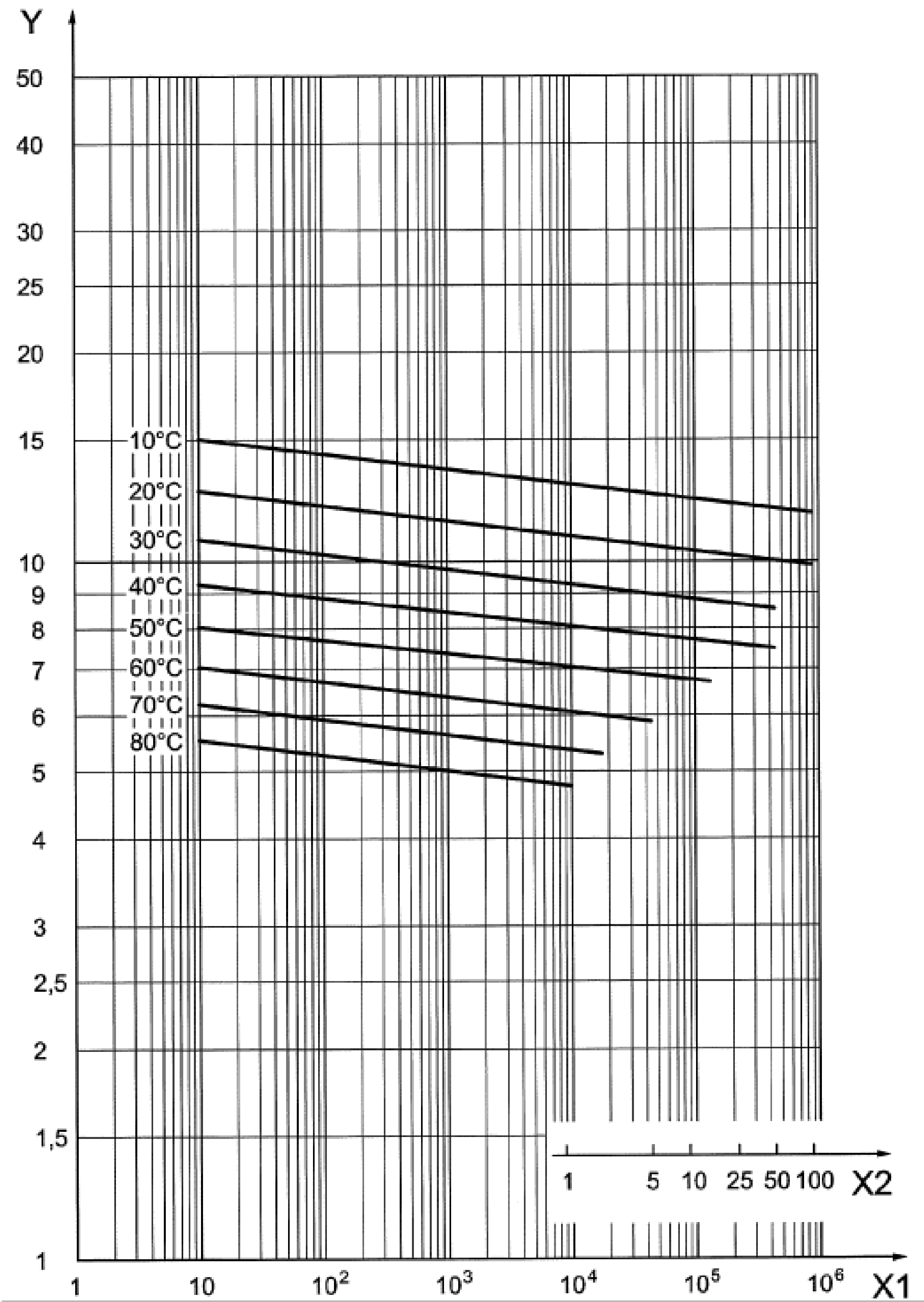
PE63

$$\log t = -19.8823 + 8619.357 \cdot \frac{1}{T} - 3.039 \cdot \log \sigma$$

t Time to failure (h)
T Medium temperature (K)
σ Hoop stress (MPa) (1 MPa = 1 N/mm^2)

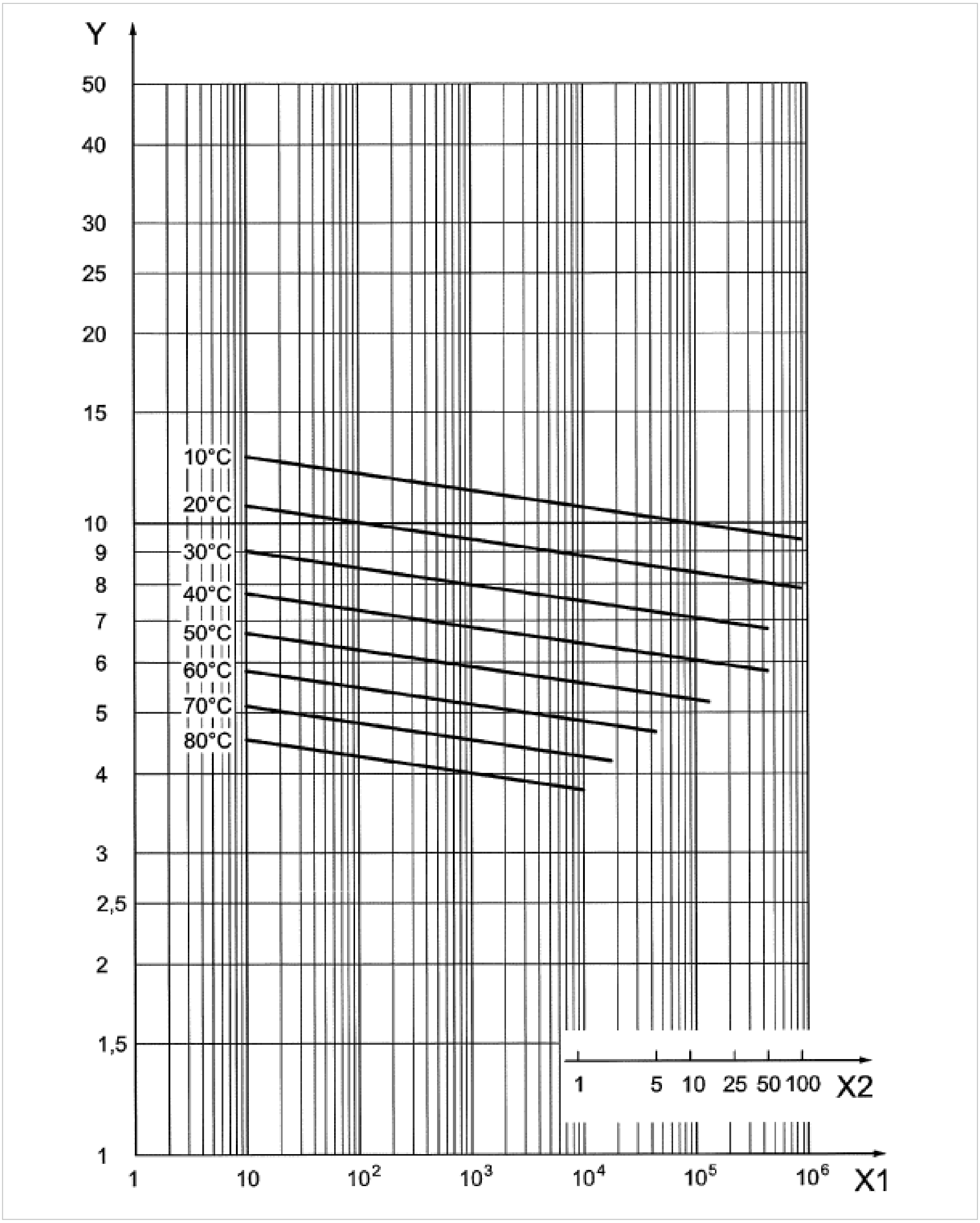
The pressure-temperature diagram that we provide for pipe and fittings made of PE80 and PE100 is derived from the long-term behavior, including the design factor, for a service life of 25 years.

Long-term behavior PE100 (EN ISO 15494:2015)



Y Hoop stress (MPa) (1 MPa = 1 N/mm^2)
X1 Time to failure (h)
X2 Years

Long-term behavior PE80 (EN ISO 15494:2015)



Y Hoop stress (MPa) (1 MPa = 1 N/mm^2)
X1 Time to failure (h)
X2 Years

2.1.4 Long-term behavior of PP

Calculation (based on EN ISO 15494:2015)

The following long-term behaviors show the long-term behavior of PP-H, PP-B and PP-R. For the temperature range from +10 °C to +110 °C, fracture lines are displayed. These are called LPL curves (Lower Predictable Limit); this means according to the definition that 97.5 % of all fracture points are on or above the corresponding curve.

Typically for semi-crystalline plastics like PP, the long-term curves show a knee. The curves are plotted in a double logarithmic diagram (i.e. not linear). Please take this into account when reading values for stress or time.

The long-term behavior was calculated by using the extrapolation method according to EN ISO 9080. With the following equation (4-parameter model), which was derived from that diagram, stress, temperature or time can be calculated for the temperature range of +10 °C to +95 °C.

The dotted lines of the curves apply if tests with longer testing times are carried out at 90 °C, 95 °C and 110 °C.

⚠ The 110 °C curve has been determined separately by using water inside and air outside; it cannot be calculated with the formulas below.

First branch (left-hand portion of the curves as shown in the following long-term behaviors)

PP-H

$$\log t = -46.346 - 9601.1 \cdot \frac{\log \sigma}{T} + 20381.5 \cdot \frac{1}{T} + 15.24 \cdot \log \sigma$$

PP-B

$$\log t = -56.086 - 10157.8 \cdot \frac{\log \sigma}{T} + 23971.7 \cdot \frac{1}{T} + 13.32 \cdot \log \sigma$$

PP-R

$$\log t = -55.725 - 9484.1 \cdot \frac{\log \sigma}{T} + 25502.2 \cdot \frac{1}{T} + 6.39 \cdot \log \sigma$$

Second branch (right-hand portion of the curves as shown in the following long-term behaviors)

PP-H

$$\log t = -18.387 + 8918.5 \cdot \frac{1}{T} - 4.1 \cdot \log \sigma$$

PP-B

$$\log t = -13.699 + 6970.3 \cdot \frac{1}{T} - 3.82 \cdot \log \sigma$$

PP-R

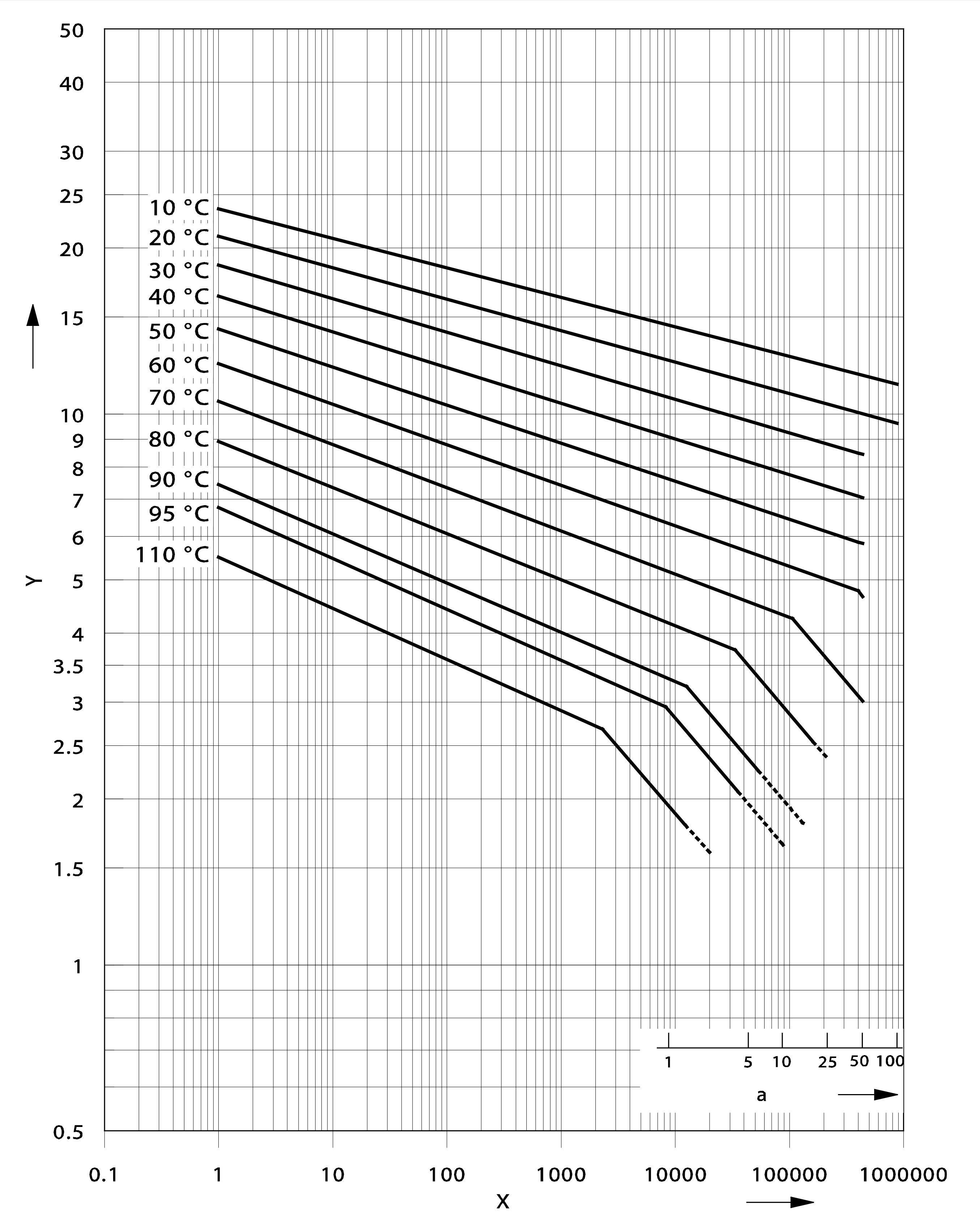
$$\log t = -19.98 + 9507 \cdot \frac{1}{T} - 4.11 \cdot \log \sigma$$

t Time to failure (h)
T Medium temperature (K)
σ Hoop stress (MPa) (1 MPa = 1 N/mm^2)

The pressure-temperature diagram that we provide for pipe and fittings made of PP-H and PP-R is derived from the long-term behavior, including the design factor, for a service life of 25 years.

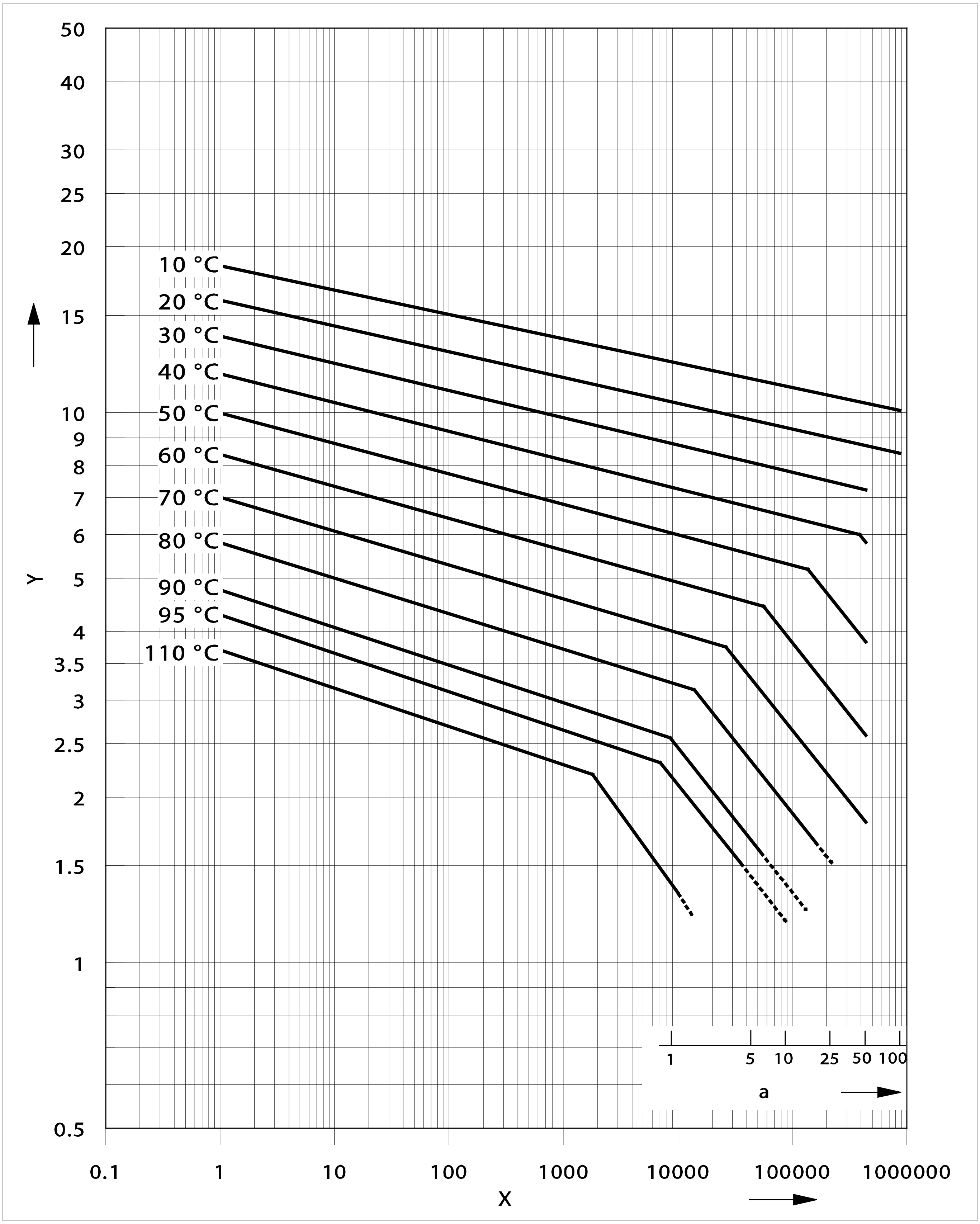
IV

Long-term behavior PP-H (according EN ISO 15494:2015)



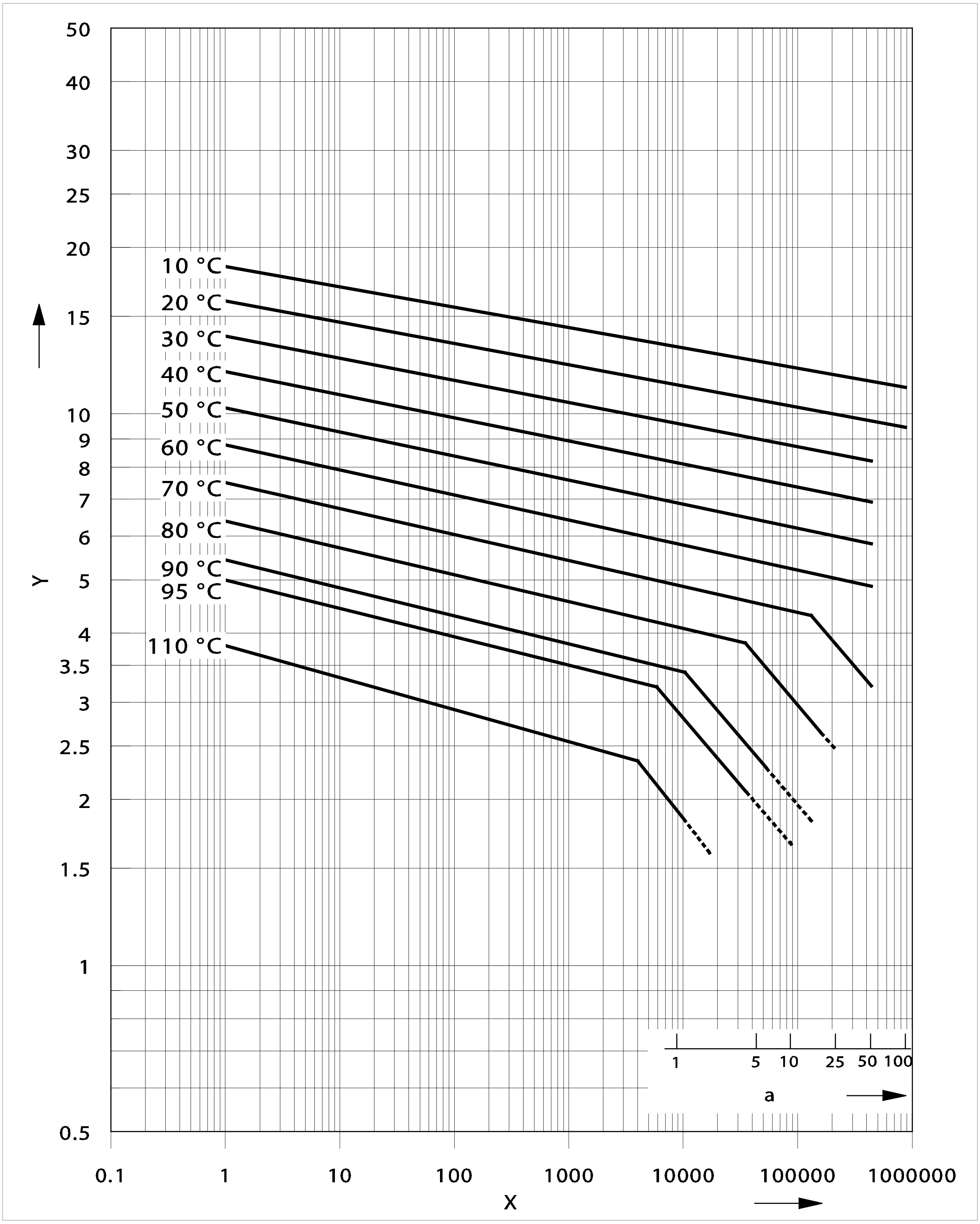
Y Hoop stress (MPa) (1 MPa = 1 N/mm²)
X Time to failure (h)
a Years

Long-term behavior PP-B (according EN ISO 15494:2015)



Y Hoop stress (MPa) (1 MPa = 1 N/mm^2)
X Time to failure (h)
a Years

Long-term behavior PP-R (according EN ISO 15494:2015)



Y Hoop stress (MPa) (1 MPa = 1 N/mm²)
X Time to failure (h)
a Years

2.1.5 Long-term behavior of PVC-U

Calculation (based on EN ISO 15493:2015)

The following long-term behavior shows the long-term behavior of PVC-U. For the temperature range from +20 °C to +60 °C, fracture lines are displayed. These are called LPL curves (Lower Predictable Limit); this means according to the definition that 97.5 % of all fracture points are on or above the corresponding curve.

Typically for amorphous thermoplastics like PVC-U, the long-term properties are represented by straight lines. The curves are plotted in a double logarithmic diagram (i.e. not linear). Please take this into account when reading values for stress or time.

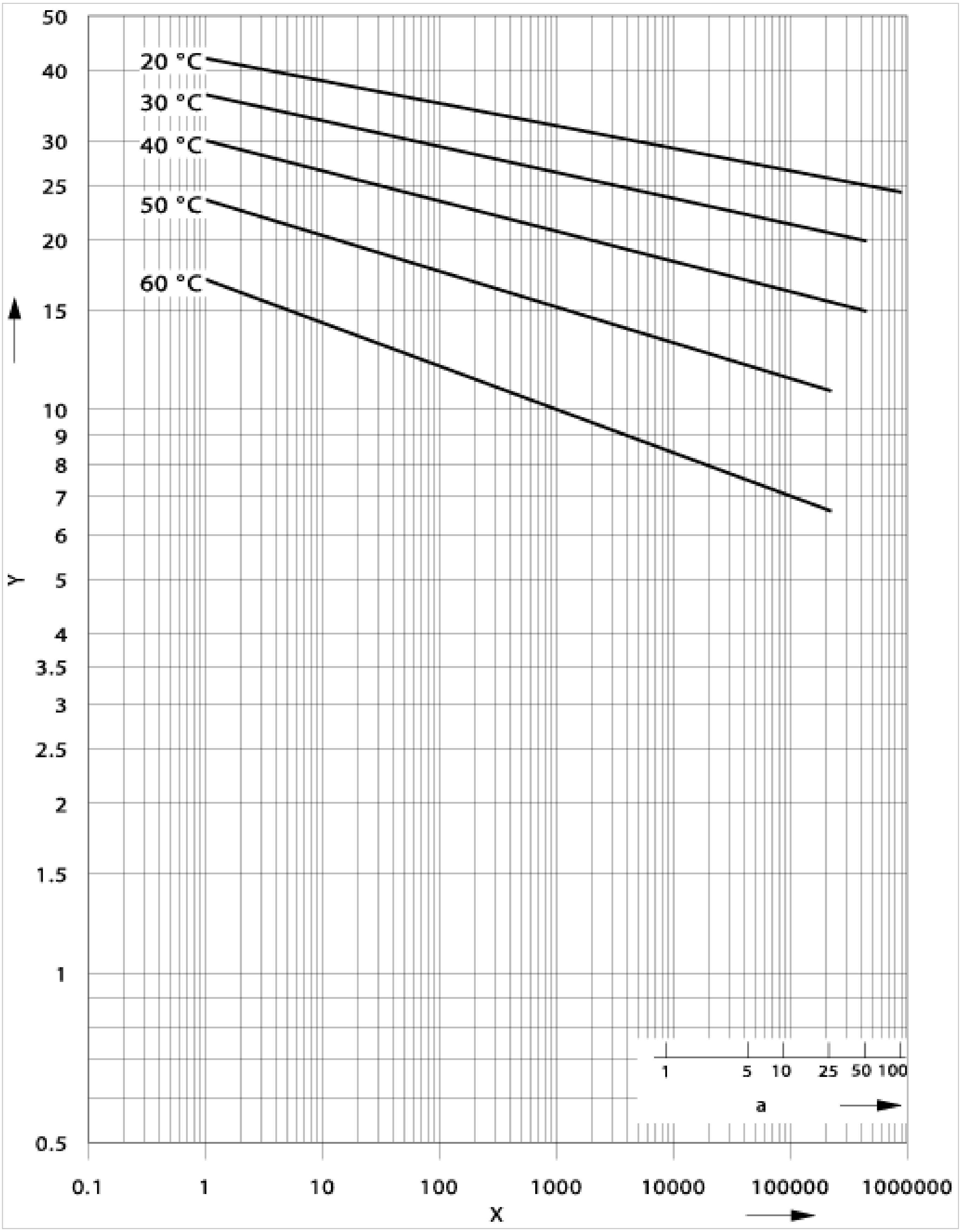
The long-term behavior was calculated by using the extrapolation method according to EN ISO 9080. With the following equation (4-parameter model), which was derived from the diagram, stress, temperature or time can be calculated for the temperature range of +20 °C to +60 °C.

$$\log t = -164.461 - 29349.493 \cdot \frac{\log \sigma}{T} + 60126.534 \cdot \frac{1}{T} + 75.079 \cdot \log \sigma$$

t Time to failure (h)
T Medium temperature (K)
σ Hoop stress (MPa) (1 MPa = 1 N/mm^2)

The pressure-temperature diagram that we provide for pipe and fittings made of PVC-U is derived from the long-term behavior, including the design factor, for a service life of 25 years.

Long-term behavior PVC-U



Y Hoop stress (MPa) (1 MPa = 1 N/mm²)
X Time to failure (h)
a Years

2.1.6 Long-term behavior of PVC-C

Calculation (based on EN ISO 15493:2015)

The following long-term diagram shows the long-term behavior of PVC-C. For the temperature range from +10 °C to +95 °C, lines of fracture are displayed. These are called LPL curves (Lower Predictable Limit); this means according to the definition that 97.5 % of all fracture points are on or above the corresponding curve.

Typically for amorphous thermoplastics like PVC-C, the long-term behavior does not show a knee.

The curves are plotted in a double logarithmic diagram (i.e. not linear). Please take this into account when reading values for stress or time.

The long-term behavior was calculated by using the extrapolation method according to EN ISO 9080. With the following equation (4-parameter model), which was derived from that diagram, stress, temperature or time can be calculated for the temperature range of +10 °C to +95 °C.

Pipe material in the temperature range of 10 °C to 95 °C

$$\log t = -109.95 - 21897 \cdot \frac{\log \sigma}{T} + 43702.87 \cdot \frac{1}{T} + 50.74202 \cdot \log \sigma$$

Fittings material in the temperature range of 10 °C to 90 °C

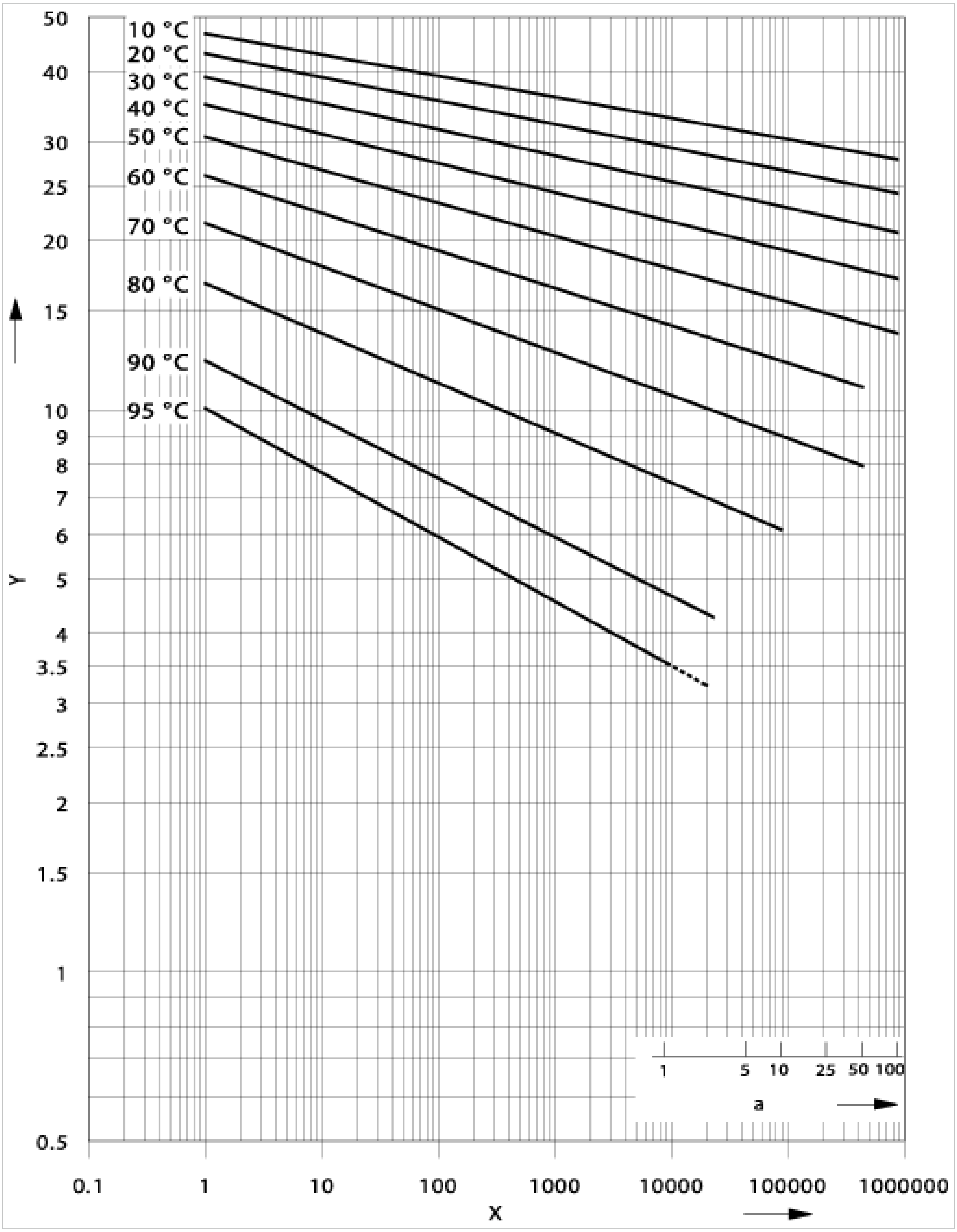
$$\log t = -121.699 - 25985 \cdot \frac{\log \sigma}{T} + 47143.18 \cdot \frac{1}{T} + 6303511 \cdot \log \sigma$$

t Time to failure (h)
T Medium temperature (K)
σ Hoop stress (MPa) (1 MPa = 1 N/mm^2)

The pressure-temperature diagram that we provide for pipe and fittings made of PVC-C is derived from the long-term behavior, including the design factor, for a service life of 25 years.

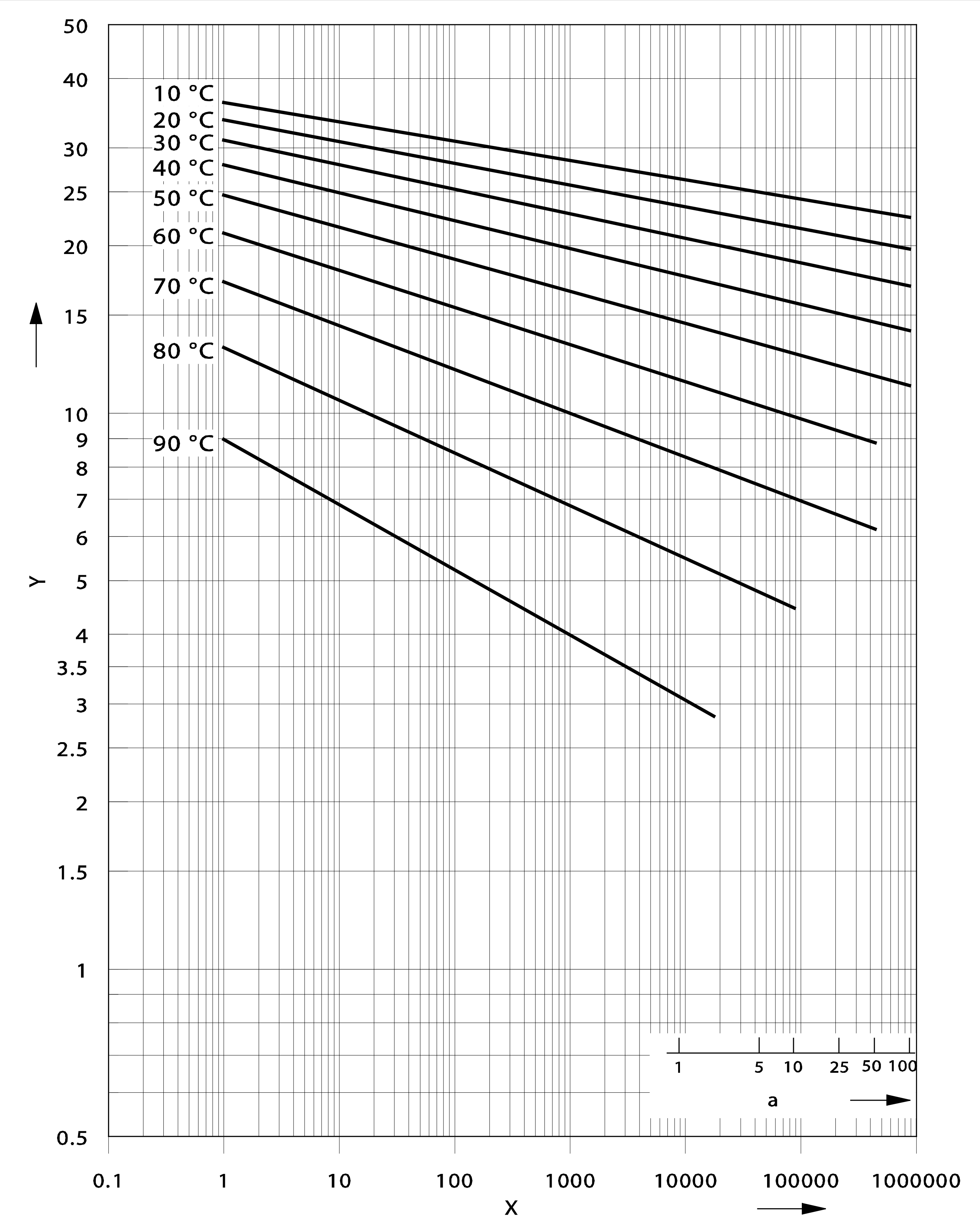
IV

Long-term behavior PVC-C pipe material



Y Hoop stress (MPa) (1 MPa = 1 N/mm²)
X Time to failure (h)
a Years

Long-term behavior PVC-C fittings material



Y Hoop stress (MPa) (1 MPa = 1 N/mm^2)
X Time to failure (h)
a Years

2.1.7 Long-term behavior of PVDF

Calculation (EN ISO 10931)

The following long-term behavior shows the long-term behavior of PVDF. For the temperature range from +10 °C to +140 °C, fracture lines are displayed. These are called LPL curves (Lower Predictable Limit); this means according to the definition that 97.5 % of all fracture points are on or above the corresponding curve.

The curves are plotted in a double logarithmic diagram (i.e. not linear). Please take this into account when reading values for stress or time.

The long-term behavior was calculated by using the extrapolation method according to EN ISO 9080. With the following equation (4-parameter model), which was derived from the diagram, stress, temperature or time can be calculated for the temperature range of
+10 °C to +140 °C.

First branch (left-hand portion of the curves as shown in the following long-term behavior)

$$\log t = -165.4958 - 36518.7 \cdot \frac{\log \sigma}{T} + 78465.65 \cdot \frac{1}{T} + 57.0467 \cdot \log \sigma$$

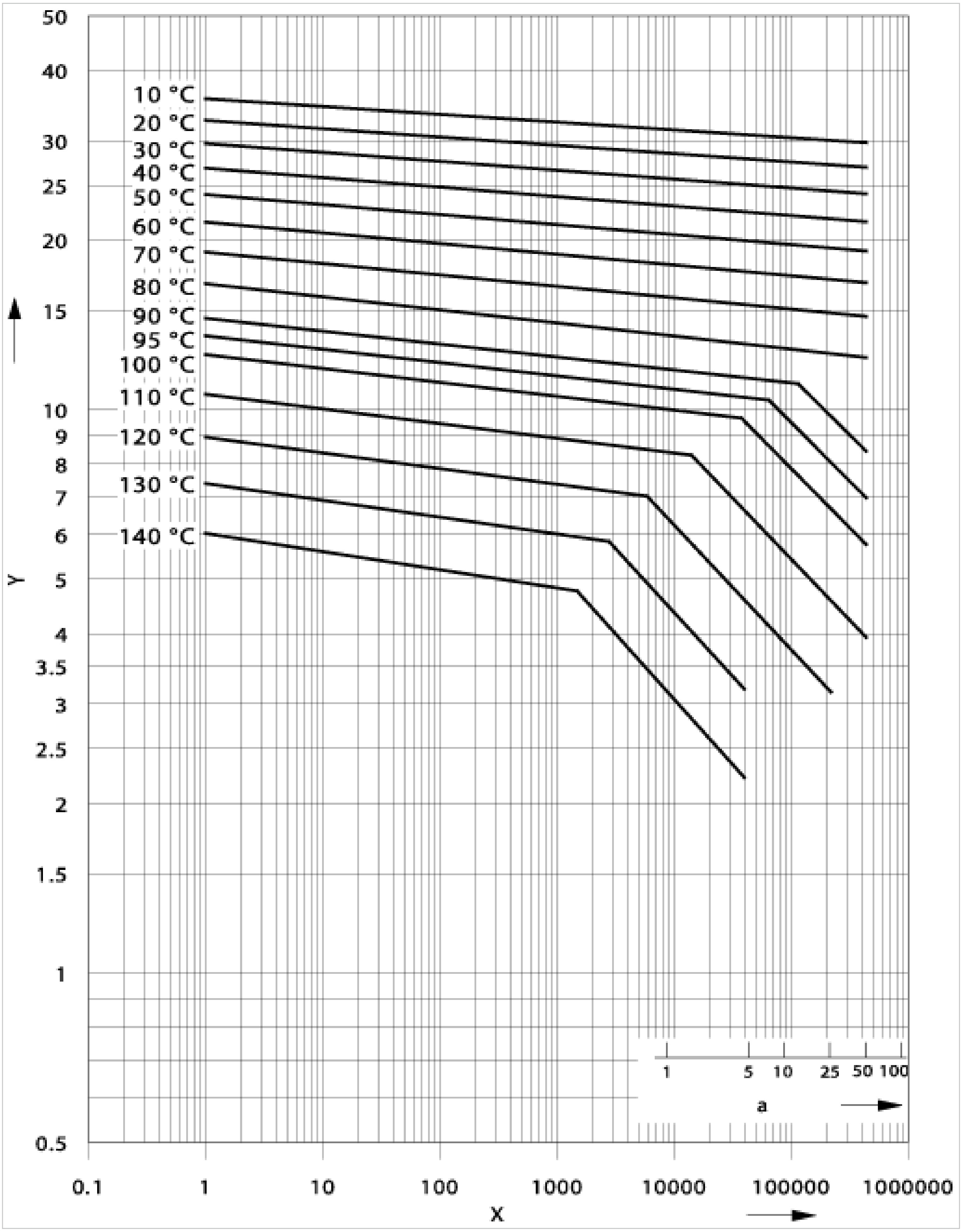
Second branch (right-hand portion of the curves as shown in the following long-term behavior)

$$\log t = -23.19426 - 1611.69 \cdot \frac{\log \sigma}{T} + 12100 \cdot \frac{1}{T} - 0.40473 \cdot \log \sigma$$

t Time to failure (h)
T Medium temperature (K)
σ Hoop stress (MPa) (1 MPa = 1 N/mm^2)

The pressure-temperature diagram that we provide for pipe and fittings made of PVDF is derived from the long-term behavior, including the design factor, for a service life of 25 years.

Long-term behavior PVDF



Y Hoop stress (MPa) (1 MPa = 1 N/mm^2)
X Time to failure (h)
a Years

2.1.8 Long-term behavior ECTFE

Calculation (EN ISO 9080)

The following long-term behavior shows the long-term behavior of ECTFE. For the temperature range from 0 °C to +80 °C, fracture lines are displayed. These are called LPL curves (Lower Predictable Limit); this means according to the definition that 97.5 % of all fracture points are on or above the corresponding curve.

The curves are plotted in a double logarithmic diagram (i.e. not linear). Please take this into account when reading values for stress or time.

The long-term behavior was calculated by using the extrapolation method according to EN ISO 9080. With the following equation (4-parameter model), which was derived from the diagram, stress, temperature or time can be calculated for the temperature range of 0 °C to +80 °C.

First branch (left-hand portion of the curves as shown in the following long-term behavior)

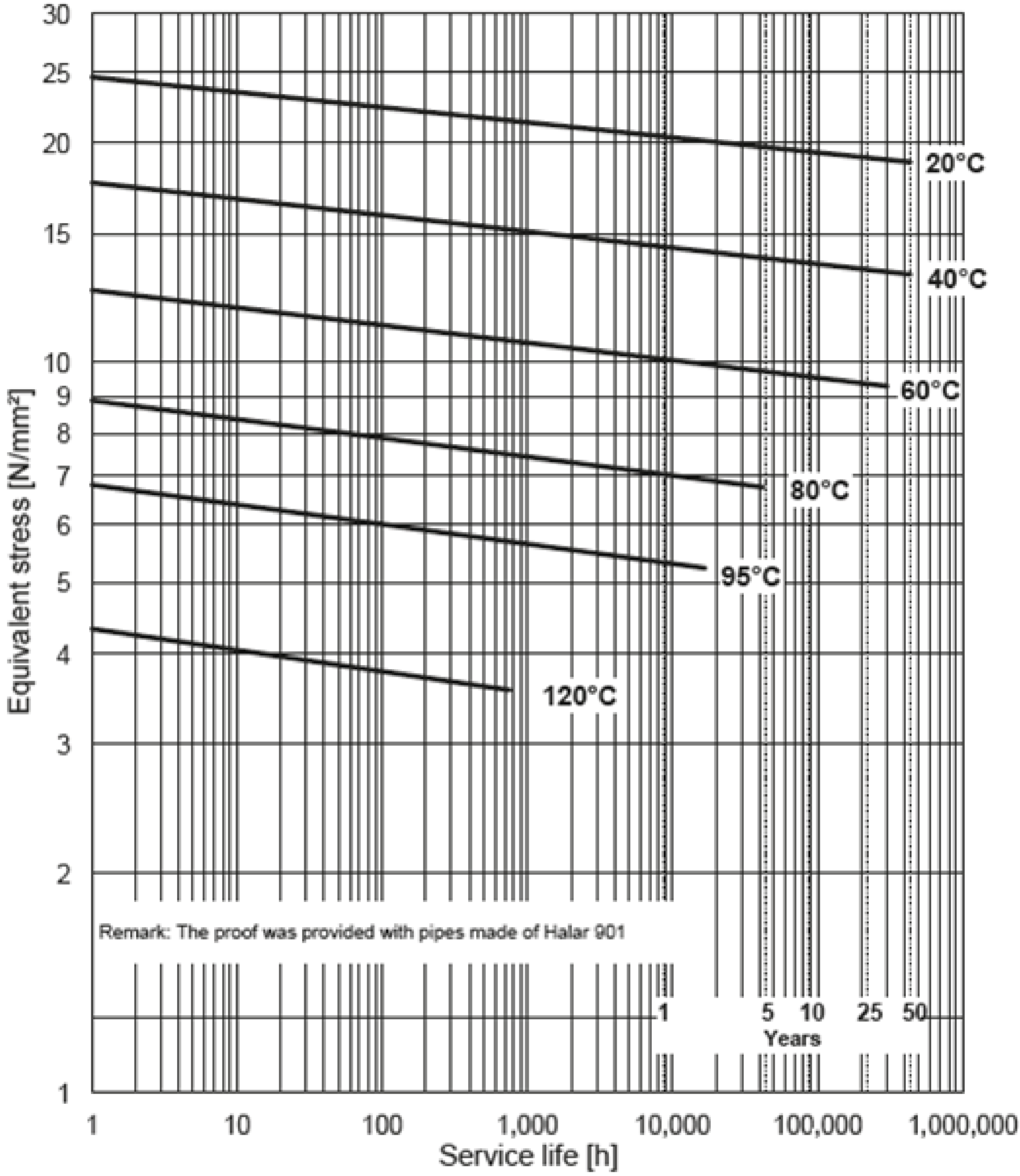
$$\log t = -149.9727 - 30448.284 \cdot \frac{\log \sigma}{T} + 63064.546 \cdot \frac{1}{T} + 56.9484 \cdot \log \sigma$$

t Time to failure (h)
T Medium temperature (K)
σ Hoop stress (MPa) (1 MPa = 1 N/mm^2)

The pressure-temperature diagram that we provide for pipe and fittings made of ECTFE is derived from the long-term behavior, including the design factor, for a service life of 25 years.

Long-term behavior ECTFE

5.1 Creep curves for pipes



Straight line equation:
$lg(t) = A + B/T \times lg(\sigma) + C/T + D \times lg(\sigma)$

Coefficients of the minimum curves:
A = –149.9727
B = –30,448.284
C = 63,064.546
D = 56.9484

Y Hoop stress (MPa) (1 MPa = 1 N/mm²)
X Time to failure (h)
a Years

2.2 Range of applications for pipe and fittings

2.2.1 In general

The choice of material and the pressure rating of the pipe components are important for both operating safety and for attaining the specified minimum service life of the system.

The decisive influencing factors are the following:

- Operating pressure
- Operating temperature
- Medium transported
- Duration of stress

Separate calculations are necessary if design factors are different or the service life is modified. The suitability of the material for the flow medium can be determined from the list of chemical resistance provided separately by GF Piping Systems.

2.2.2 Pressure-temperature diagram for ABS

The following two pressure-temperature diagrams for ABS pipe and fittings are valid for a service life of 25 years.

The design factor of 2.1 for British systems and 1.8 for metric systems recommended by GF Piping Systems has been incorporated.

The diagram can be used for water or media resembling water, in other words, media that have no reduction factor for their chemical resistance.

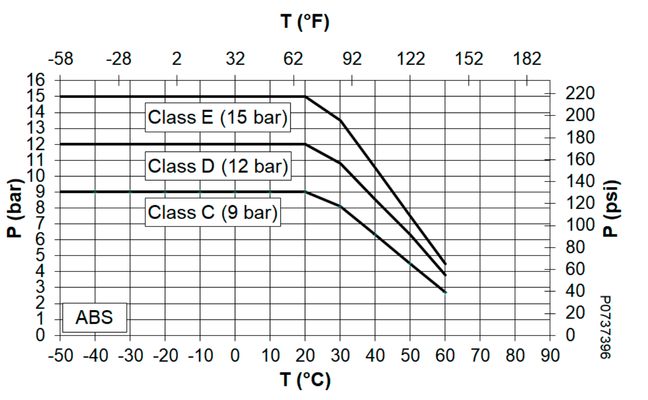
⚠ Please take into account the pressure-temperature diagrams for valves and special fittings. Because of the construction and/or sealing material used, differences are possible when compared to pipe and fittings. More information is available in the Planning Fundamentals of the relevant types of valves and special fittings.

⚠ The influence of the anti-freeze compound has to be taken into account when calculating the allowable operating pressure. Contact your authorized GF Piping Systems representative for additional information.

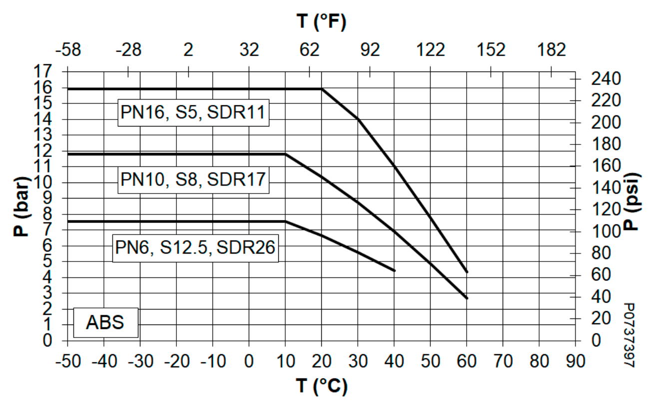
According to the 10 °C curve in the long-term behavior for ABS, the following information applies to the temperature range from -50 °C to +10 °C:

System	PN6	PN10	PN16
Permissible pressure	7.5 bar	11.8 bar	Max. 16 bar

British systems



Metric systems



P Permissible pressure (bar, psi)
T Temperature (°C, °F)

⚠ The permissible operating pressure can be used as a guide value for constant operating conditions (pressure, temperature). For changing operating conditions, it is recommended to perform a strength check in accordance with DVS 2210-1.

2.2.3 Pressure-temperature diagram for PE

PE100

The following pressure-temperature diagrams apply to PE100 pipes and fittings for a service life of 25 years. The pressure-temperature curves were calculated with design factors of C=1.25, C=1.6 and C=2.0.

- C=1.25 for water applications in the supply sector
- C=1.6 for industrial applications
- C=2.0 for chemical applications or piping systems requiring DIBt approval by the building authorities

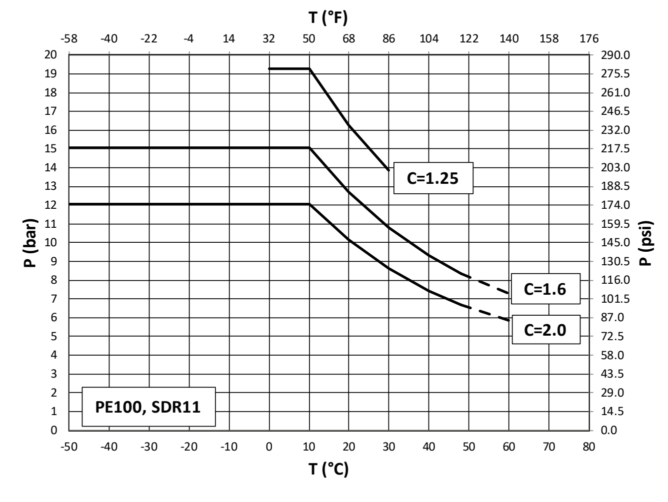
The long-term welding factor fs (or long-term joining factor) must be taken into account if relevant (e.g. stress check in longitudinal direction).

The diagrams can be used for water or media resembling water, in other words, media that have no reduction factor for chemical resistance.

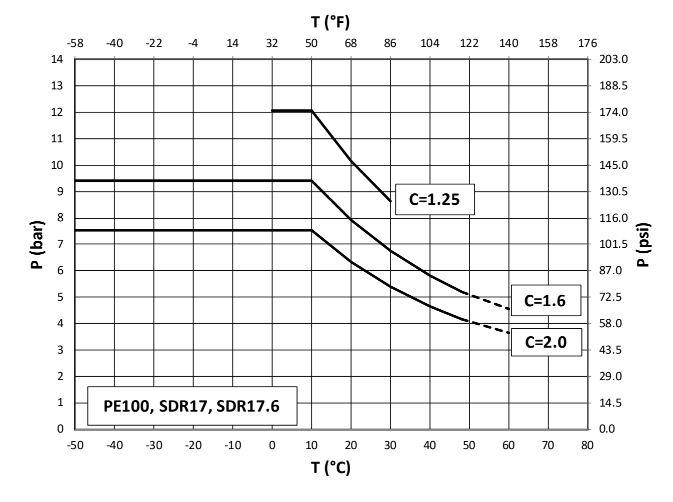
⚠ Please take into account the pressure-temperature diagrams for valves and special fittings. Because of the construction and/or sealing material used, differences are possible when compared to pipe and fittings. More information is available in the Planning Fundamentals of the relevant types of valves and special fittings.

In case of long-term operating pressure at temperatures above 47 °C, please contact your authorized GF Piping Systems representative.

PE100, SDR11



PE100, SDR17, SDR17.6



P Permissible pressure (bar, psi)
T Temperature (°C, °F)

⚠ The permissible operating pressure can be used as a guide value for constant operating conditions (pressure, temperature). For changing operating conditions, it is recommended to perform a strength check in accordance with DVS 2210-1.

PE80

The following pressure-temperature diagrams apply to PE80 pipes and fittings for a service life of 25 years. The pressure-temperature curves were calculated with design factors of C=1.25, C=1.6 and C=2.0.

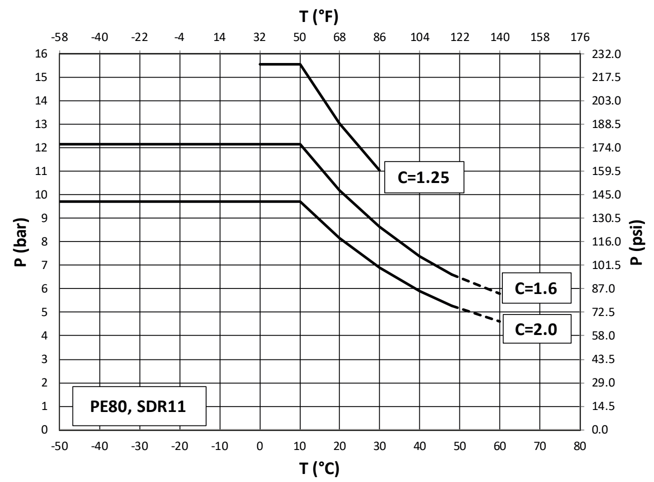
- C=1.25 for water applications in the supply sector
- C=1.6 for industrial applications
- C=2.0 for chemical applications or piping systems requiring DIBt approval by the building authorities

The long-term welding factor fs (or long-term joining factor) must be taken into account if relevant (e.g. stress check in longitudinal direction). The diagrams can be used for water or media resembling water, in other words, media that have no reduction factor for chemical resistance.

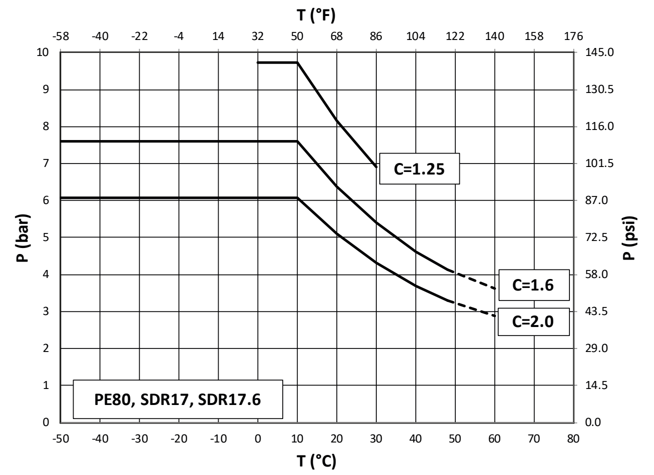
Please take into account the pressure-temperature diagrams for valves and special fittings. Because of the construction and/or sealing material used, differences are possible when compared to pipe and fittings. More information is available in the Planning Fundamentals of the relevant types of valves and special fittings.

In case of long-term operating pressure at temperatures above 48 °C, please contact your authorized GF Piping Systems representative.

PE80, SDR11



PE80, SDR17, SDR17.6



P Permissible pressure (bar, psi)
T Temperature (°C, °F)

The permissible operating pressure can be used as a guide value for constant operating conditions (pressure, temperature). For changing operating conditions, it is recommended to perform a strength check in accordance with DVS 2210-1.

Determining the nominal pressure (PN)

According to the standard, the nominal pressure is a numeric value for the size of a pipeline part that refers to the mechanical properties of that pipeline part. In addition to the geometric values, such as SDR, long-term creep strength / dimensioning tension and the minimum design factor are also taken into account.

For plastic piping systems intended to transport water, the nominal pressure indicates the maximum permitted operating pressure in bar at a temperature of 20 °C and for 50 years in water, relative to the minimum value of the total (calculation) coefficients. It is calculated by using the following equation:

$$PN = 10 \cdot \frac{\sigma_s}{S} = 20 \cdot \frac{\sigma_s}{(SDR - 1)}$$

σ_s Design stress (MPa)
PN Nominal pressure (bar)

Minimum required strength (MRS):

The value of σ_{LCL} at 20 °C and for 50 years in water, rounded down to the next value in the R10 standard series of numbers.

σ_{LCL} is the hoop stress determined from the long-term behavior for a given period and temperature. LCL stands for Lower Confidence Limit. The R10 standard series of numbers is a Renard standard series of numbers according to ISO 3 and ISO 497.

Design stress (σ_S):

The design stress is the permitted stress (unit in MPa) for a particular application or operating condition. It is derived by dividing the MRS by coefficient C and is calculated as shown in the equation below:

$$\sigma_s = \frac{MRS}{C}$$

σ_s Design stress (MPa)
C Minimum factor

The calculated value is rounded down to the next value in the R10 standard series of numbers.

Total operating (calculation) coefficient (C):

A total coefficient with a value greater than one that takes into account both the operating conditions and those characteristics of the pipeline component that have not yet been included in the lower confidence limit σ_{LCl}.

If we use the above definition to calculate the corresponding nominal pressure for both SDR classes, the result for a PE100 pipe is as follows:

	SDR 17	SDR 17.6
MRS	10 MPa	10 MPa
C (minimum factor)	1.25	1.25
σ_s	8.0 MPa	8.0 MPa
PN	10 bar	9.6 bar

The above definitions thus produce a calculated difference of 0.4 bar in nominal pressure. But in actual practice this difference does not matter, as shown below.

Industrial piping systems are normally designed for a service life of 25 years. If we determine a hoop stress of σ_{LCl} for the operating point of 25 years at 20 C from the long-term behaviors for ELTEX TUB121 or CRP100, we get a tension of 10.6 MPa (minimum value for both PE100 materials according to manufacturer's data). If we use this tension to calculate the design tension σ_s, and do not round it down, we get the value of 8.48 MPa.

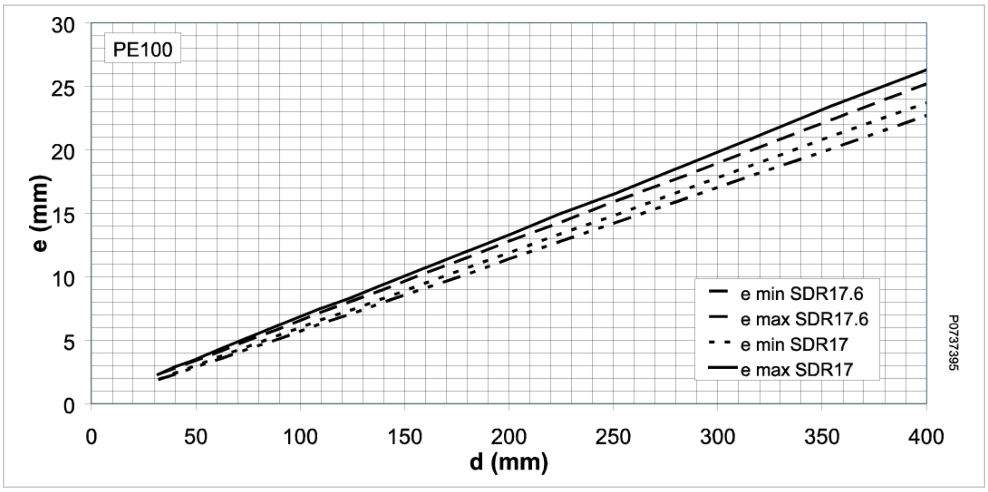
The actual nominal pressure in practice for SDR17 and SDR17.6 is:

- SDR17 PN = 10.6 bar und
- SDR17.6 PN = 10.2 bar.

Both SDR classes comply with requirements for industrial applications of a PN10 system.

Comparison of geometric dimensions

The two SDR classes differ only slightly in wall thickness of the pipe, as can be seen from the diagram below:



d Pipe outer diameter (mm)
e Wall thickness (mm)

For butt fusion, the wall offset may not exceed 10 %. In light of the differences in the wall thicknesses of SDR17 and SDR17.6, the resulting wall offset is significantly below this value; this provides for trouble-free butt fusion of both SDR classes.

2.2.4 Pressure-temperature diagram for PP

PROGEF Standard and PROGEF Plus piping system (PP-H)

The following pressure-temperature diagrams for PP pipe and fittings are valid for a service life of 25 years. The pressure-temperature curves are calculated with design factors of C=1.6 and C=2.0. For designs with the design factor C=1.6, a static verification is recommended. For chemical applications or piping systems that require approval by the building authorities, the dashed curve applies taking into account the toughness factors A1 according to DVS 2205-1.

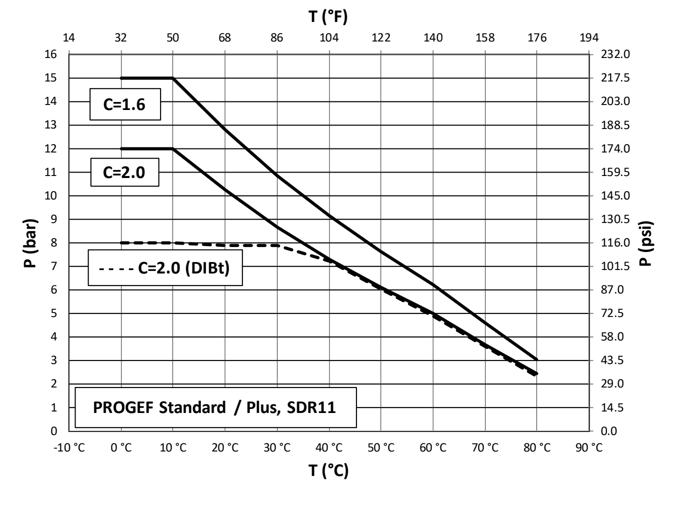
The long-term welding factor fs (or long-term joining factor) must be taken into account if relevant (e.g. stress check in longitudinal direction).

The diagrams can be used for water or media resembling water, in other words, media which have no reduction factor for chemical resistance.

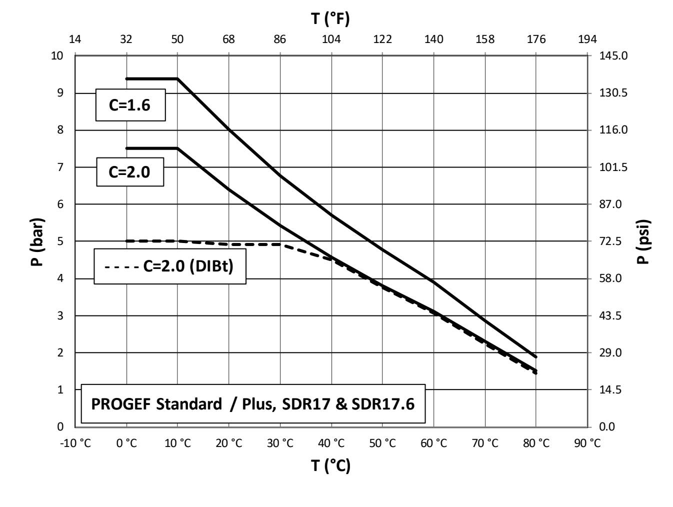
Please take into account the pressure-temperature diagrams for valves and special fittings. Because of the construction and/or sealing material used, differences are possible when compared to pipe and fittings. More information is available in the Planning Fundamentals of the relevant types of valves and special fittings.

Pressure-temperature diagrams for PP pipe and injection-molded fittings

PP, SDR11



PP, SDR17, SDR17.6



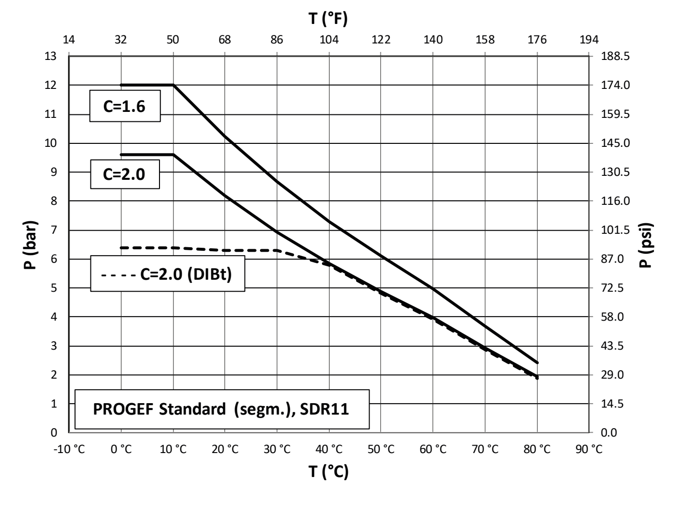
P Permissible pressure (bar, psi)
T Temperature (°C, °F)

The permissible operating pressure can be used as a guide value for constant operating conditions (pressure, temperature). For changing operating conditions, it is recommended to perform a strength check in accordance with DVS 2210-1.

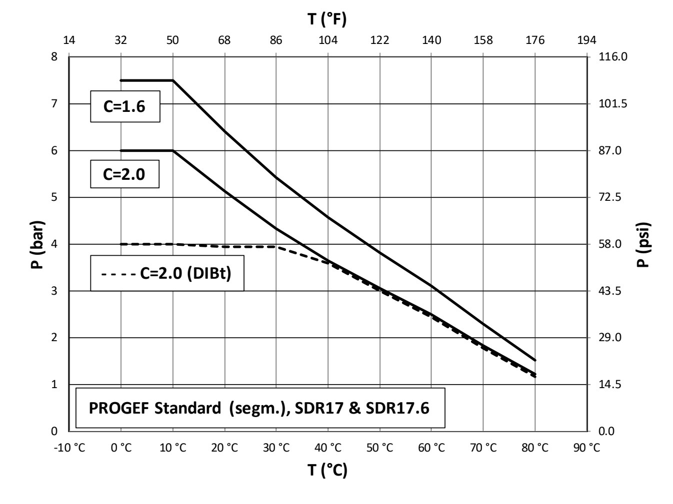
Pressure-temperature diagrams for PP segment-welded fittings

Segment-welded fittings have a reduction factor of 0.8 for the operating pressure/nominal pressure.

PP segment welded fittings, SDR11



PP segment welded fittings, SDR17, SDR17.6



P Permissible pressure (bar, psi)
T Temperature (°C, °F)

The permissible operating pressure can be used as a guide value for constant operating conditions (pressure, temperature). For changing operating conditions, it is recommended to perform a strength check in accordance with DVS 2210-1.

PROGEF Natural piping system (PP-n)

The following pressure-temperature diagram for PROGEF Natural pipe and fittings is valid for a service life of 25 years. The pressure-temperature curves have been calculated with design factors of C=1.6 and C=2.0. For designs with the design factor C=1.6, a static verification is recommended. For chemical applications and piping systems requiring approval by the building authorities, the dashed curve applies taking into account the toughness factors A1 according to DVS 2205-1.

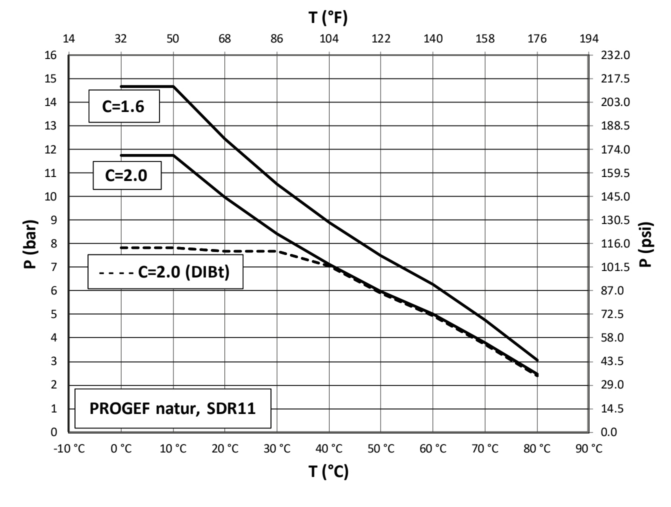
The long-term welding factor fs (or long-term joining factor) must be taken into account if relevant (e.g. stress check in longitudinal direction).

It can be used for water or media resembling water, in other words, media that have no reduction factor for chemical resistance.

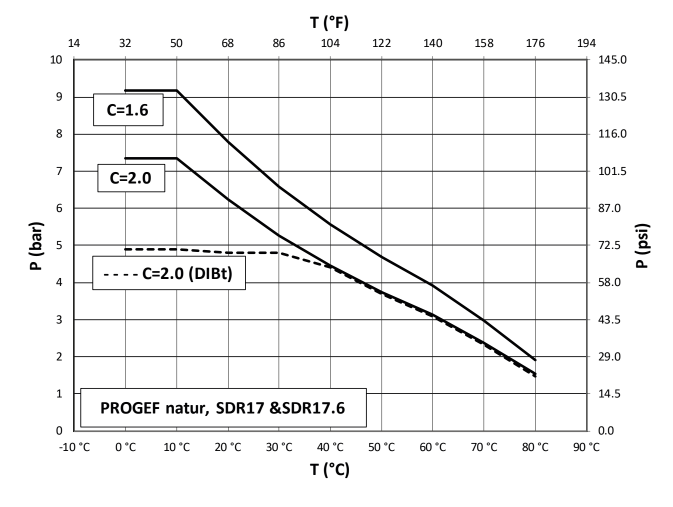
Please take into account the pressure-temperature diagrams for valves and special fittings. Because of the construction and/or sealing material used, differences are possible when compared to pipe and fittings. More information is available in the Planning Fundamentals of the relevant types of valves and special fittings.

Using PROGEF Natural at higher temperatures can cause a discoloration of the material.

PROGEF Natural, SDR11



PROGEF Natural, SDR17, SDR17.6



P Permissible pressure (bar, psi)
T Temperature (°C, °F)

The permissible operating pressure can be used as a guide value for constant operating conditions (pressure, temperature). For changing operating conditions, it is recommended to perform a strength check in accordance with DVS 2210-1.

2.2.5 Pressure-temperature diagram for PVC-U

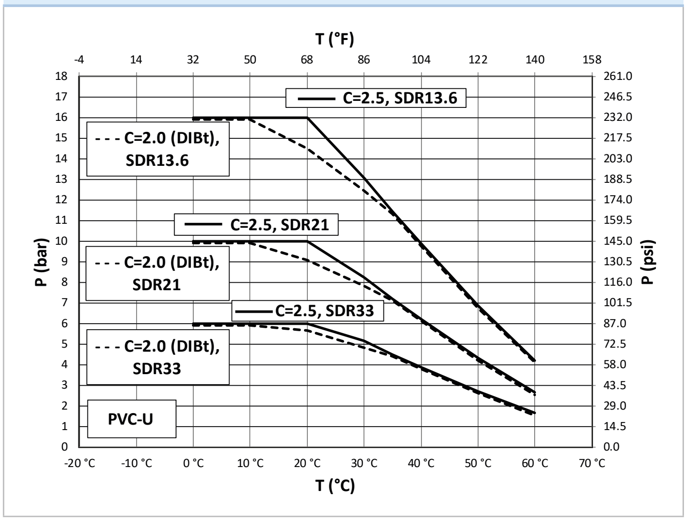
The following pressure-temperature diagrams for PVC-U pipe and fittings are valid for a service life of 25 years. The design factor of 2.5 recommended by GF Piping Systems has been incorporated. They can be used for water or media resembling water, in other words, media that have no reduction factor for chemical resistance.

For chemical applications or piping systems requiring approval by the building authorities, the dashed curves shown apply taking into account the toughness factors A1 according to DVS 2205-1.

The long-term welding factor fs (or long-term joining factor) must be taken into account if relevant (e.g. stress check in longitudinal direction).

Please take into account the pressure-temperature diagrams for valves and special fittings. Because of the construction and/or sealing material used, differences are possible when compared to pipe and fittings. More information is available in the Planning Fundamentals of the relevant types of valves and special fittings.

PVC-U, SDR13.6, SDR21, SDR33



P Permissible pressure (bar, psi)
T Temperature (°C, °F)

The permissible operating pressure can be used as a guide value for constant operating conditions (pressure, temperature). For changing operating conditions, it is recommended to perform a strength check in accordance with DVS 2210-1.

PVC-U fittings d200 to d280 by GF Piping Systems are designed and tested for a nominal pressure of PN10. Sizes d315 to d400 are designed and tested for a nominal pressure of PN6

Our experience and tests show that pipe equal to or greater than d315 can be slightly oval, which could produce an enlarged cementing gap.

GF Piping Systems therefore recommends that pipe equal or greater than d315 should be operated at a maximum operating pressure (+20 °C) of 6 bar. Please observe the special information for this dimension range in the cementing instructions for PVC-U.

2.2.6 Pressure-temperature diagram for PVC-C

The following pressure-temperature diagram for PVC-C pipe and fittings is valid for a service life of 25 years.

The design factors recommended by GF Piping Systems (C=2.5 for pipes and C=2.0 for fittings) are incorporated. The pressure-temperature curves are valid for water or media resembling water, in other words, media that have no reduction factor for chemical resistance.

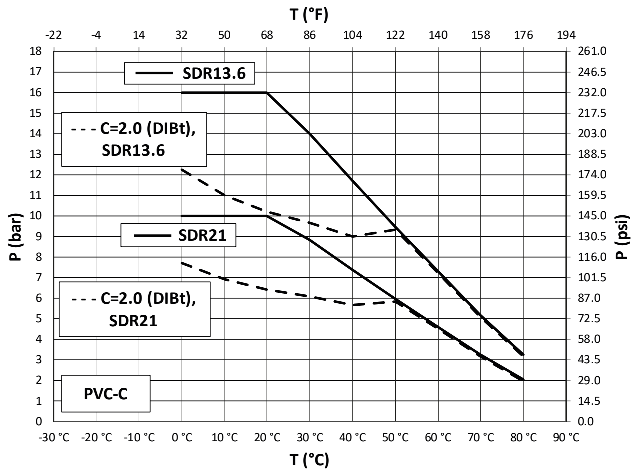
For chemical applications or piping systems that require approval by the building authorities according to DIBt, the dashed curves shown apply taking into account the toughness factors A1 according to DVS 2205-1.

The long-term welding factor fs (or long-term joining factor) must be taken into account if relevant (e.g. stress check in longitudinal direction).

Please take into account the pressure-temperature diagrams for valves and special fittings. Because of the construction and/or sealing material used, differences are possible when compared to pipe and fittings. More information is available in the Planning Fundamentals of the relevant types of valves and special fittings.

Under certain conditions, working temperatures up to 90 °C are possible for limited times. Please contact your GF Piping Systems representative for advice on applications beyond GF Piping Systems' specifications.

PVC-C, SDR13.6 und SDR21



P Permissible pressure (bar, psi)
T Temperature (°C, °F)

The permissible operating pressure can be used as a guide value for constant operating conditions (pressure, temperature). For changing operating conditions, it is recommended to perform a strength check in accordance with DVS 2210-1.

2.2.7 Pressure-temperature diagram for PVDF

The following pressure-temperature diagrams for PVDF pipe and fittings are valid for a service life of 25 years.

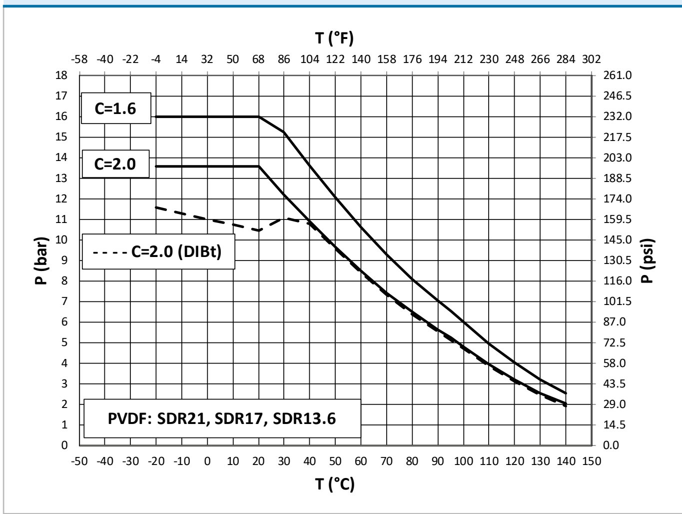
The design factor of 2.0 (or 1.6) recommended by GF Piping Systems has been incorporated. The pressure-temperature curves are valid for water or media resembling water, in other words, media that have no reduction factor for chemical resistance.

For chemical applications or piping systems that require approval by the building authorities, the dashed curves apply, taking into account the toughness factors A1 in accordance with DVS 2205-1.

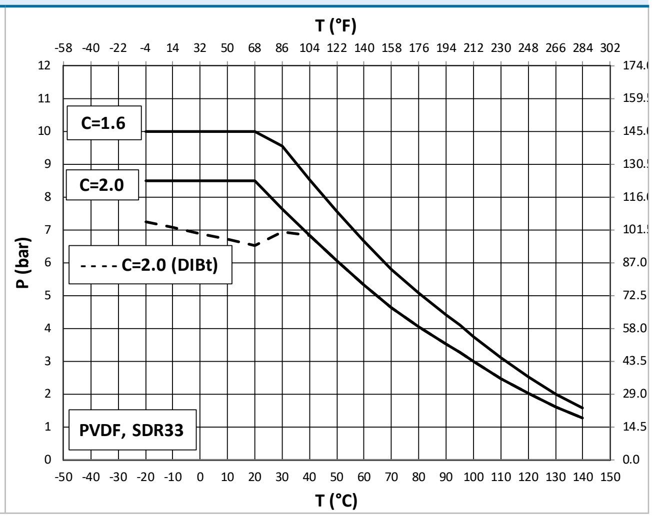
The long-term welding factor fs (or long-term joining factor) must be taken into account if relevant (e.g. stress check in longitudinal direction).

Please take into account the pressure-temperature diagrams for valves and special fittings. Because of the construction and/or sealing material used, differences are possible when compared to pipe and fittings. More information is available in the Planning Fundamentals of the relevant types of valves and special fittings.

PVDF, SDR21, SDR17, SDR13.6



PVDF, SDR33



P Permissible pressure (bar, psi)
T Temperature (°C, °F)

The permissible operating pressure can be used as a guide value for constant operating conditions (pressure, temperature). For changing operating conditions, it is recommended to perform a strength check in accordance with DVS 2210-1.

These diagrams can only be used for applications with liquids! In case of long-term operating pressure at temperatures above 80 °C, please contact your authorized GF Piping Systems representative.

Application example for PVDF material

The Miner's rule (calculation method for cumulative damage) may be used to approximate the expected damage for applications with varying conditions during their expected service life. The expected service life is calculated by adding the rates of damage due to each of the intermittent operating conditions.

For continuously changing conditions of temperature or pressure, the Miner's rule is applied. The following example, an application in the pharmaceutical industry, shows the calculation steps necessary:

Calculation basis		Main application	Steam sterilization
Pipe	SDR21	Purified water PW (water-like medium) at +25 °C and 5 bar operating pressure	Saturated steam at 135 °C and 2.2 bar, daily for 30 minutes
Design factor	2.0		
Service life	5 Jahre		

According to this rule:

$$T_X = \frac{100 \cdot T_1 \cdot T_2}{a_1 \cdot T_2 + a_2 \cdot T_1}$$

a_1 a_2 Shares of partial stress periods in overall stress period (%)
T_1 T_2 Service life at each of the operating conditions (pressure and temperature constant)
T_x Calculated service life at intermittent stress

For the above example the service life is calculated as:

$T_1 \geq 50$ years $T_2 = 4471$ h

The shares of partial stress periods in the overall stress time are:

$a_1 = 97.9$ % $a_2 = 2.1$ %

For the calculated service life T_x, this results in:
$T_X = 214\,608$ h = 24.5 Jahre

This calculated service life is higher than the specified operating life; i.e. the dimensions of this application are sufficient.

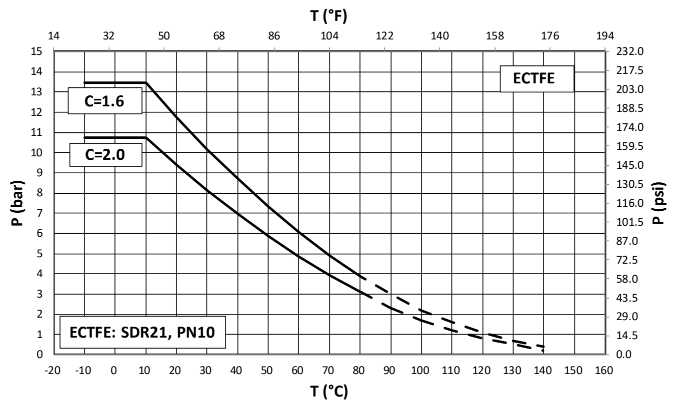
2.2.8 Pressure-temperature diagram for ECTFE

The pressure-temperature diagram that we provide for pipe and fittings made of ECTFE is derived from the long-term behavior, including the design factor, for a service life of 25 years.

The design factor of 2.0 (or 1.6) recommended by GF Piping Systems has been incorporated. It can be used for water or media resembling water, in other words, media that have no reduction factor for chemical resistance.

Please take into account the pressure-temperature diagrams for valves and special fittings. Because of the construction and/or sealing material used, differences are possible when compared to pipe and fittings. More information is available in the Planning Fundamentals of the relevant types of valves and special fittings.

ECTFE, SDR21



P Permissible pressure (bar, psi)
T Temperature (°C, °F)

For any additional project support like engineering, design and installation or chemical resistance please contact gss@georgfischer.com

2.3 Calculation of the allowable pressure/required wall thickness

2.3.1 Selecting plastic piping components

Dimensioning of thermoplastic pipe subjected to internal pressure strictly adheres to strength requirements and is calculated by using the vessel formula. All pipe dimensions listed in the standards are based on this formula. Deviations only occur in the lower range of diameters, since practical and manufacturing considerations make it necessary to maintain certain minimum pipe wall thicknesses.

$$e = \frac{p \cdot d}{20 \cdot \sigma_{zul.} + p}$$

e Pipe wall thickness (mm)
d Pipe outer diameter (mm)
p Permissible operating pressure (bar)
σ_{zul} Allowable hoop stress (N/mm^2)

Nominal pressure PN

The designation "nominal pressure" PN (also known as pressure level) by itself is no longer sufficient. The PN classification generally used all over the world as information for pipe dimensioning is rather confusing where butt fusion is concerned.

In the case of plastic pipe established practice is to use pressure-neutral descriptions for pipe of the same pressure capacity. This avoids incorrect use of pipe in different applications or under different conditions.

ISO 4065 classifies pipe by series according to pressure rating, so that pipe with the same series number have the same pressure rating, as is also the case in designations according to nominal pressure levels. The pipe series are denoted by the letter S. The series designation is based on the following formula:

S is a dimensionless value.

$$S = \frac{10 \cdot \sigma_{zul.}}{p \cdot C} = \frac{d - e}{2 \cdot e}$$

e Pipe wall thickness (mm)
d Pipe outer diameter (mm)
p Operating pressure (bar, psi)
C Design factor

Hence, a PP pipe with dimension d110 and wall thickness = 10 mm results in:

$$S = \frac{(110 - 10)}{(2 \cdot 10)} = 5$$

The designation SDR (Standard Dimension Ratio) is much more common on the market. SDR indicates the ratio of outside diameter to wall thickness.

$$SDR = \frac{d}{e}$$

The pipe series designation and the SDR designation are connected by this formula:

$$SDR = 2 \cdot S + 1$$

In the case of the example above, this results in:

$$SDR = 2 \cdot 5 + 1 = 11$$

The market primarily features the designations PN and SDR. GF Piping Systems recommends the use of dimension and wall thickness, as well as SDR at all times.

2.3.2 Calculating the effective design factor / permissible operating pressure

To calculate the design factor and allowable operating pressure, it is necessary to know the long-term behavior of the material. Such a diagram allows the long-term creep strength to be read depending on the desired service life and operating temperature. For fittings and valves, the wall thickness is usually greater than for pipe of the same pressure level. For this reason, the outside diameter and wall thickness of the pipe are used to calculate the design factor. The design factor is then calculated by using the following formula:

$$C = \frac{\sigma_s \cdot 20 \cdot e}{p \cdot (d - e)}$$

C Design factor
σ Hoop stress (N/mm^2)
e Pipe wall thickness (mm)
d Pipe outer diameter (mm)
p Operating pressure (bar)

Similarly, the maximum permissible operating pressure is calculated by rewriting the formula above as:

$$p = \frac{20 \cdot e \cdot \frac{\sigma_s}{C}}{d - e}$$

Example – Calculating the design factor and operating pressure

Intended service life	25 Jahre
Max. operating temperature	+40 °C
Max. operating pressure	3 bar
Material	PVC-U
Intended pressure level	PN16 bar
Outside diameter	110 mm
Wall thickness	8.1 mm
Hoop stress	15.5 N/mm^2

$$C = \frac{15.5 \cdot 20 \cdot 8.1}{3 \cdot (110 - 8.1)} = 8.2 > 2.5$$

For the sake of clarity, the calculations are carried out using the example above, but using the usual minimum design factor for PVC-U.

$$p = \frac{20 \cdot 8.1 \cdot \left(\frac{15.5}{2.5}\right)}{(110 - 8.1)} = 9.9 \text{ bar}$$

The calculation shown applies only to freely moving piping systems. Pipe that are fixed in the axial direction (fixed installation) must be checked for buckling. In most cases such a check leads to a reduction of maximum inner pressure, as well as shorter distances between the support brackets. Furthermore, the forces that act on the fixed points must be taken into account. Contact your authorized GF Piping Systems representative for additional information.

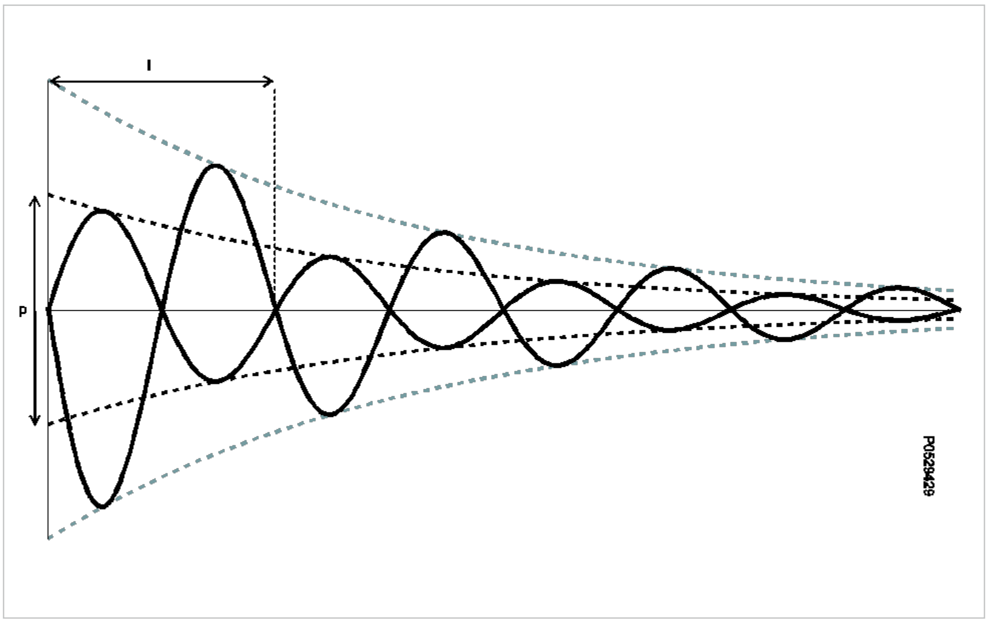
2.4 Water hammer

Water hammer is a term used to describe dynamic surges caused by pressure changes in a piping system. They occur whenever there is a deviation from the steady state, e.g. when the flow rate is changed, and may be transient or oscillating.

Water hammers may be generated by the following:

- Opening or closing a valve
- Pump startup or shutdown
- Change in pump or turbine speed
- Wave action in a feed tank
- Trapped air

The pressure wave created by water hammers causes the piping system to expand and contract. In the process the propagation speed of the pressure wave is limited by the speed of sound in the corresponding medium. The energy carried by the wave is dissipated in the piping system and the waves are progressively damped, see the following figure:



Damped pressure wave
l Wave length
p Pressure change

The maximum positive or negative addition of pressure is a function of flow rate, bulk modulus of elasticity of the fluid, pipe dimension and the modulus of elasticity of the pipe material. It can be calculated by using the following steps.

❶ Determine the velocity of the pressure wave

$$V_w = \sqrt{\frac{K}{\rho \cdot \left(1 + \frac{K \cdot d_i}{e \cdot E}\right)}}$$

V_w	Velocity of pressure wave (m/s)
K	Bulk modulus of elasticity of fluid (Pa)
ρ	Fluid density (kg/m^3)
E	Modulus of elasticity of pipe wall (Pa)
d_i	Inner diameter of pipe (mm)
e	Pipe wall thickness (mm)

The modulus of elasticity of pipe made of thermoplastic polymers varies with the operating duration and temperature. Hence, operating duration and temperature must be known for a precise calculation of water hammers.

❷ Calculate maximum pressure change due to water hammers

$$\Delta p = V_w \cdot \Delta v \cdot \rho / 10^5$$

Δp	Maximum pressure change (bar)
Vw	Pressure wave velocity (m/s) (see step 1)
Δv	Change in fluid velocity (m/s) = (v1-v2)
v1	Velocity of fluid before change (m/s)
v2	Velocity of fluid after change (m/s)
ρ	Fluid density (kg/m^3)

All pressure increases induced by a flow reduction will have a corresponding pressure drop on the other side (vacuum). If this exceeds the expected static minimum operating pressure, the calculated pressure must be compared to the pressure at which the pipe collapses in order to evaluate the safety factor in step 4.

❸ Calculate the maximum and minimum total pressures

$$p_{max} = p + \Delta p$$

$$p_{min} = p - \Delta p$$

p_{max}	Maximum total pressure (bar)
p_{min}	Minimum total pressure (bar)
p	Expected operating pressure (bar)
Δp	Change due to water hammer (calculated in step 2)

❹ Calculate the effective safety factor

$$C_{max} = \frac{20 \cdot \sigma \cdot e}{p_{max} \cdot (d - e)}$$

C_{max}	Safety factor (dimensionless)
σ	Circumferential stress (N/mm^2)
t	Pipe thickness (mm)
d	Outside diameter of pipe (mm)
p_{max}	Maximum total pressure (bar) (calculated in step 3)

The value for the circumferential stress can be found in the creep curves. As most water hammers last for a matter of seconds, the value for a load duration of 0.1 h can be used. The exception to this rule is when the water hammers are oscillating (e.g. from a positive displacement pump). In this case the system must be treated as if a load equal to the maximum total pressure (pmax) existed throughout the entire service life of the pipe.

5 Safety factors

For infrequent water hammers the common minimum values can be used as safety factors. For periodic water hammers the factor should be at least 3.

If the safety factor found in step 4 does not meet these criteria for safe operation, an increase in pipe diameter should be considered, or measures should be taken to reduce the occurrence of water hammers (e.g. powered valves, surge tanks, slow start-up pumps).

When using powered valves, valves are commonly designed with closure times greater than the critical period Tc to reduce water hammer. The critical period is the time a pressure wave needs to complete one cycle in the pipeline.

$$T_c = \frac{2 \cdot L}{V_w}$$

T_c	Critical period (s)
L	Pipe length (m)
V_w	Pressure wave velocity (m/s) (see step 1)

Example

A water pipeline from a storage tank is connected to a main valve that is hydraulically activated with an electrical remote control. The valve closing time is 1.5 s and the water flow rate is Q = 35 m^3/h.

Material	PP-H
Outside diameter	110 mm
Wall thickness	10 mm
Pipeline length	500 m
Operating temperature	+40 °C
Modulus of elasticity	E = 800 N/mm^2 = 800 x 10^6 Pa
Water density	$\rho = 10^3$ kg/m^3
Bulk modulus of elasticity of water	K = 2.05 GPa

1 Calculating the velocity of the pressure wave

$$V_w = \sqrt{\frac{2.05 \cdot 10^9}{10^3 \cdot \left(1 + \frac{90 \cdot 2.05 \cdot 10^9}{10 \cdot 800 \cdot 10^6}\right)}} = 292 \text{ m/s}$$

2 Calculating the fluid velocity before the change

$$v_1 = \frac{\text{Volume flow}}{\text{cross-sectional area}}$$

$$v_1 = \frac{35/3600 \text{ m}^3/\text{s}}{\pi \cdot (0.09/2)^2 \text{ m}^2} = 1.53 \text{ m/s}$$

Assume water velocity goes to zero after the valve is closed, i.e. Δv = 1.53 m/s.

Pressure change

$\Delta p = 292 \cdot (1.53) \cdot 1000/10000 = 4.47$ bar

IV

❸ Calculating the maximum pressure

$p_{max} = 10 + 4.47 = 14.47$ bar

Δp is less than p. Hence, the minimum pressure does not have to be taken into account.

❹ Calculating the circumferential stress

Find the circumferential stress in the PP-H long-term behavior. Take the value for a load duration of 0.1 h as, for non-oscillating water hammers, the pipe needs to withstand this extra pressure for only a matter of seconds.

$\sigma = 17.5\ \text{N/mm}^2$

$$C = \frac{20 \cdot \sigma \cdot e}{p_{max} \cdot (d - e)}$$

$$C = \frac{20 \cdot 17.5 \cdot 10}{14.47 \cdot (110 - 10)} = 2.42$$

❺ Calculating the maximum safety factor

The minimum safety factor for PP-H can be set to 2.0. Here, C = 2.42 > 2.0, so this piping is suitable for infrequent water hammers. However it would not be suitable if periodic water hammers occurred, because in that case we would need C > 3. Pipe dimensions or valve closing time would need to be adjusted in order to reduce water hammer.

Calculating the critical period

$$T_c = \frac{2 \cdot L}{V_w} = \frac{2 \cdot 500\ \text{m}}{292\ \text{m/s}} = 3.4\ \text{s}$$

In this example, the valve closing time is less than the value of the critical period. By increasing the closing time above this critical period, water hammer would be reduced. The piping would then be suitable for all situations involving periodic water surges.

2.5 Piping systems in highly combustible locations/ transport of explosive media

The non-conductivity of most plastics has led to their widespread use in the electrical engineering and electronics industry. But this property can be a disadvantage under certain circumstances in other applications. In the case of plastic piping system construction, the question of electrostatic charging of the pipeline becomes important when electrically non-conductive media are to be transported or when the pipe are to be installed in highly combustible locations. In both of these cases electrostatic charging of the material is not only a disadvantage but could even be dangerous.

ABS, PVC-U, PVC-C, PE, PP, PVDF and ECTFE belong to the class of electrically non-conductive materials. Electrically non-conductive materials are those whose specific resistance exceeds 10^6 Ωcm. The values for the materials listed above are on the order of 10^{15} Ωcm. Whenever specific resistance in solids exceeds 10^9 Ω the material is deemed to be subject to electrostatic charging.

For example, in the mining industry safety dictates that plastics be used only if their specific resistance does not exceed 10^8 Ωcm (measured at 20°C and 5 % relative humidity).

Similar restrictions apply to the installation of plastic pipe wherever flammable mixtures could occur. No danger arises from the use of plastic pipe to transport flammable gases or fluids as long as this is a closed system. Slower flow rates also reduce the accumulation of electrostatic charges. It is possible in principle to make non-conductive plastics conductive by means of special measures, e.g. adding carbon. But such additives could adversely affect other desirable properties. It is therefore imperative to evaluate each case individually to decide which material offers the best solution.

Whenever plastic piping is to be installed in rooms where explosive gas-air mixtures could arise, and whenever plastic pipe are used for the transport of electrically non-conductive media, the following must be considered during planning.

Installation of pipe in rooms where explosive gas-air mixtures can occur:

- Avoid the accumulation of explosive mixtures by providing for e.g. good ventilation or air extraction.
- Avoid the accumulation of electrical charge by ionizing the atmosphere.
- Discharge static electricity, e.g. by coating the pipe surface with an electrically conductive, solvent-free paint containing metallic powder or by wrapping the pipe in a conductive foil. It is essential that the pipe be grounded.
- Avoid the accumulation of electrical charges by increasing the relative humidity of the air. A conductive film of water on the surface of the pipe improves conductivity. There is hardly any accumulation of electrostatic charges when relative humidity exceeds 65 %.
- We advise strongly against relying solely on treating the pipeline with an antistatic and hygroscopic solution to improve its conductivity, because this measure is usually only effective for a limited period and accidental partial removal of the protective film cannot be ruled out.

Transport of electrically non-conductive media:

As a rule plastic pipe are not to be recommended for the transport of dry substances that are electrically non-conductive due to the effects of accumulating electrostatic charges and extensive wear on the material. Electrically non-conductive combustible gases or fluids can only be transported in closed pipeline systems.

2.6 Piping systems for transporting compressed air

Introduction

Plastic piping system have been used to transport compressed air for many years. Experience has shown that oil originating from compressors can be found to a greater or lesser extent in the compressed air. This can only be avoided by installing, and regularly servicing, a separation filter installed after the compressor. The composition of the oils used varies considerably, and the oils may also contain aromatic substances. In addition to the effect that the compressor oils may have on the material used for the piping, we must also take into account the fracture characteristics of the material.

Recommended material for compressed air piping systems

PE (polyethylene) or PB (polybutene)

Both materials are lightweight, easy to install and corrosion-free proof; they also have the advantage of high tensile strength. Therefore, GF Piping Systems recommends polyethylene up to a minimum temperature of -40 °C (e.g. outdoor applications), polybutylene up to a minimum temperature of 0 °C (e.g. indoor installation). Explosive fractures do not occur if the operating instructions are followed.

PE and PB are generally chemically resistant to compressor oils. Only a few oils that contain esters or aromatics, should not be used. Sealing materials, such as NBR or FKM, which are regularly used for compressed air networks, are in danger in such cases.

In order to simplify the selection of a compressor oil by the operator of a compressed air system, we have summarized many of the oils offered on the market and have divided them into sections according to their chemical structure. After consulting the oil supplier, it is also possible to choose an oil that is not on the list, since we do not claim that the list is complete. The type of oil used must be included in one of the categories deemed suitable by GF. GF Piping Systems recommends that you coordinate the selection of the oil with the manufacturer of the compressor.

Suitability of air compressor oils for compressed air lines made of polyethylene

Refined petroleum products (mineral oils)	Recommended
Paraffinic oils, aliphatic hydrocarbons	✓
Naphthenic oils, alicyclic hydrocarbons	✓
Aromatic oils	x

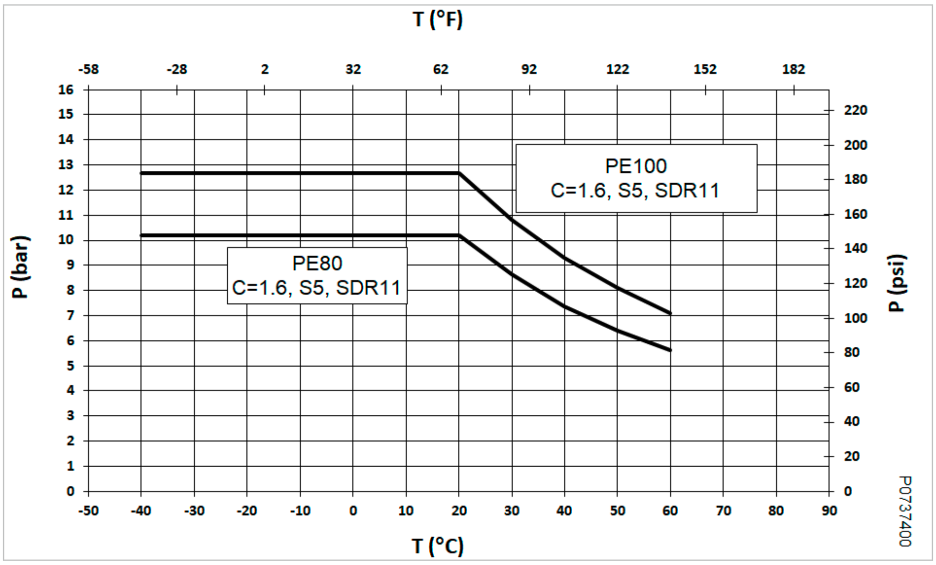
Synthetic oils (with O as an additional element of molecular structure)	Recommended
Polyalkylene glycols	✓
Poly-α-olefins	✓
Polyesters	x
Di-esters	x

Synthetic oils (with Si, P, N or F as an additional element of molecular structure)	Recommended
Silicone oils	✓
Phosphoric esters	x
Aromatic amines	x
Fluorine esters	x
Poly-α-olefins/polyol esters	x

Maximum allowable operating pressure for PE compressed air lines

The following pressure-temperature diagram (PE80 and PE100) for compressed air piping systems made of polyethylene should be taken into account. This diagram is based on a service life of 25 years and a design factor of 1.6. The ambient temperature has to be taken into account, for example for an installation under a sunny roof or in a room with compressors running. For safety reasons, GF Piping Systems recommends using SDR11 or SDR7.4 for compressed-air piping systems.

In case of long-term operating pressures at temperatures above +40 °C, please contact your authorized GF Piping Systems representative.

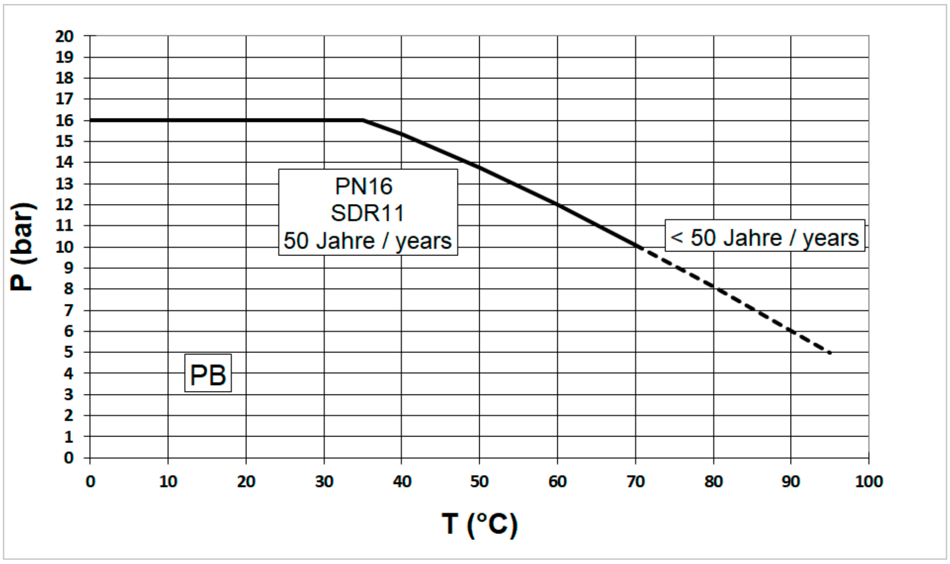


P Permissible pressure (bar, psi)
T Ambient temperature (°C, °F)

Maximum allowable operating pressure for PB compressed air lines

The following pressure-temperature diagram for compressed air piping systems made of polybutylene (PB) should be taken into account. This diagram is based on a service life of 25 years and a design factor of 1.6. The ambient temperature has to be taken into account, for example for an installation under a sunny roof or in a room with compressors running. For safety reasons, GF Piping Systems recommends using SDR11 for compressed-air piping systems from PB.

In case of long-term operating pressures at temperatures above +70 °C, please contact your authorized GF Piping Systems representative. Don't use PB lines for compressed air below 0°C!



P Permissible pressure (bar, psi)
T Ambient temperature (°C, °F)

2.7 Piping systems under vacuum

The mechanical load at absolute vacuum corresponds to a differential partial vacuum of 1 bar, i.e. the effective pressure on the pipe's inner wall is 1 bar less than the pressure on the outer wall at standard atmospheric pressure.

In case of a differential partial vacuum special attention must be paid to the dimensional stability of the pipe. It can be calculated with the classic buckling formula for cylindrical pipe:

$$P_k = \frac{E_c}{4 \cdot (1 - \mu^2)} \cdot \left(\frac{e}{r}\right)^3$$

Pk Critical buckling pressure (N/mm^2) (1 N/mm^2 = 10 bar)
Ec Long-term creep modulus (N/mm^2)
μ Poisson's ratio
e Pipe wall thickness (mm)
r Mean pipe radius (mm)

A pipe at absolute vacuum (differential partial vacuum 1 bar) is adequately dimensioned against buckling when the critical buckling pressure P_k = 2 bar, i.e. when a minimum design factor of 2 is used for calculation. Any influence caused by out-of-roundness and eccentricity must be taken into account separately. Under these assumptions, the following maximum application temperatures arise for the various pipe materials (taking into account the general application temperature limits for the specific material), see the table below. Thinner-walled pipe series are unsuitable for these conditions.

(25 year values: Poisson's ratio μ = 0.4; design factor = 2)

2.7.1 Pipe

Maximum application temperatures under vacuum (1 bar differential partial vacuum)

Material	PN (bar)	SDR	Temperature (°C)
ABS	10	17	60
	16	11	60
PVC-U	10	21	40
	16	13.6	60
PVC-C	10	21	70
	16	13.6	80
PE80	10	11	50
PE100	16	11	60
PP	10	11	80

Maximum application temperatures under vacuum (1 bar differential partial vacuum) or under 0.4 bar differential partial vacuum for PVDF PN10 system

Material	PN (bar)	SDR	Max. temperature (°C)
PVDF for Δp = 0.4 bar	10	33	20
PVDF for Δp = 1.0 bar	16	21	40
ECTFE for Δp = 1.0 bar	10	21	40

2.7.2 Fittings

Since GF Piping Systems fittings have a typicially greater wall thickness compared to pipe, they are not critical in vacuum applications and do not have to be taken into account when determining the application temperatures.

2.7.3 Mechanical connections

Similar to fittings, mechanical connections feature a typicially greater wall thickness compared to pipe. However, the vacuum resistance of the gaskets must be observed. The permissible vacuum for mechanical connections is listed in the following table:

Connection type	Permissible vacuum (differential partial vacuum) (bar)
Union	1
Threaded connection	1
Flange connection, flat gasket	Not possible
Flange connection, profile seal	1
Flange connection, O-ring seal	1

2.7.4 Valves

Ball valves are the preferred valves for vacuum applications. The permissible vacuum for valves is listed in the following table:

Valve type	DN (mm)	Permissible vacuum (differential partial vacuum) up to a maximum temperature of 50 °C (bar)
Ball valve type 546	10 - 100	1
Ball valve type 375	10 - 100	0.8
Diaphragm valve types 514-519, 314-319	15 - 50	0.5
Butterfly valve types 578, 567	65 - 200	1
	250, 300	0.65

2.8 Piping systems for surface finishing and varnishing technology

2.8.1 Silicone-free/cleaned

Growing environmental awareness, continuously increasing requirements and regulations in the field of toxic substances emission (TA air) have led to the development of water-soluble paints and varnishes. With new varnishing technologies, up to 90 % of the emission values can be reduced.

For the production, transport and processing of water-soluble paints and varnishes only pipeline components that do not contain substances which interfere with the varnishing process, such as silicones, certain greases, oils and waxes, may be used.

GF Piping Systems – An experienced partner

GF Piping Systems has worked closely from the beginning with manufacturers, plant constructors and operators in this special sector of surface finishing and varnishing technology. GF Piping Systems has successfully supplied plant constructors and users of varnishing processes for years, e.g. the automotive industry.

Production meets the most rigorous demands:

- Silicone-free separating agents in the paint shop
- Care in cleaning, installation and packing
- Quality assurance system certified according to ISO 9001

2.8.2 Fittings

The composition of the raw material (granulate) is silicone-free. All standard fittings are produced in a silicone-free environment. Following injection molding, the fittings are either directly packed, or if specified, cleaned in a special cleaning process to ensure the silicone-free and point-compatible characters.

2.8.3 Valves and unions

The individual components of the valves and unions are cleaned with distilled water in a special cleaning process. They are assembled in a special working silicone-free area.

Sliding components are lubricated slightly with special lubricants that can be varnished. Valves and unions are individually packed in a sealed bag. The packaging of the products ensures the silicone-free characteristics during transport and storage.

2.9 Gaskets

Gaskets undergo the same production, cleaning and packing processes as valves and unions.

> **Maintenance**
> For safety reasons we recommend replacing the entire body when disassembling the valve.

3 Hydraulic Calculation and Pressure Losses

3.1 Hydraulic calculation

3.1.1 Required pipe diameter

Formulas

The following formula can be used for a first approximation of the pipe diameter required for a given flow rate:

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

v	Flow velocity (m/s)
d_i	Pipe inner diameter (mm)
Q_1	Flow rate (m^3/h)
Q_2	Flow rate (l/s)
18.8	Conversion factor for units Q1 (m3/h)
35.7	Conversion factor for units Q2 (l/s)

The flow velocity must be approximated according to the intended use of the pipeline. Standard values for the flow velocity are:

Liquids

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

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

Gases

v = 10 – 30 m/s

The calculations of pipe diameter have not taken into account hydraulic losses. They have to be calculated separately as described in the following sections.

Conversion table with units for flow rate

(m^3/h)	(l/min)	(l/s)	(m^3/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

Example for calculating the inner diameter d_i

PP pipe	SDR11
Flow volume Q_2	8 l/s
Flow velocity v	1.5 m/s

$$d_i = 35.7 \cdot \sqrt{\frac{8}{1.5}} = 82.4 \text{ mm}$$

A pipe with DN80 (3" inch) is used. After defining the inner diameter, the real flow velocity can be calculated with the following formula:

$$v = 354 \cdot \frac{Q_1}{d_i^2} = 1.9 \frac{m}{s} \quad \text{or} \quad v = 1275 \cdot \frac{Q_2}{d_i^2} = 1.9 \frac{m}{s}$$

v Flow velocity (m/s)
d_i Pipe inner diameter (mm)
Q_1 Flow rate (m^3/h)
Q_2 Flow rate (l/s)
354 Conversion factor for units Q1 (m^3/h)
1275 Conversion factor for units Q_2 (l/s)

Correlation of outer diameter – Inner diameter

To find the outside diameter using the inside diameter and the applicable SDR, use the following formula:

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

3.1.2 Correlation of outside diameter to inside diameter for SDR13.6, SDR21 and SDR33

d_i (mm)	SDR33 PVDF d (mm)	d_i (mm)	SDR13.6 PVC-U, PVC-C d (mm)	d_i (mm)	SDR21 PVC-U, PVDF, ECTFE d (mm)
85	90	17	20	16	20
103	110	21	25	21	25
117	125	27	32	28	32
132	140	34	40	36	40
150	160	43	50	45	50
169	180	54	63	57	63
188	200	64	75	68	75
211	225	77	90	81	90
235	250	94	110	100	110
263	280	107	125	113	125
296	315	119	140	127	140
333	355	136	160	145	160
375	400			163	180
422	450			181	200
				204	225
				226	250
				253	280
				285	315
				362	400

Correlation of outside diameter to inside diameter for SDR11 and SDR17

d_i (mm)	SDR11 PE, PP d (mm)	d_i (mm)	SDR17, SDR17.6 ABS, PE, PP d (mm)
16	20	16	20
20	25	21	25
26	32	28	32
33	40	35	40
41	50	44	50
52	63	56	63
61	75	66	75
74	90	79	90
90	110	97	110
102	125	110	125
115	140	124	140
131	160	141	160
147	180	159	180
164	200	176	200
184	225	199	225
205	250	221	250
229	280	247	280
258	315	278	315
290	355	313	355
327	400	353	400
368	450	397	450
409	500	441	500
458	560	494	560
515	630	556	630
581	710	626	710
655	800	705	800

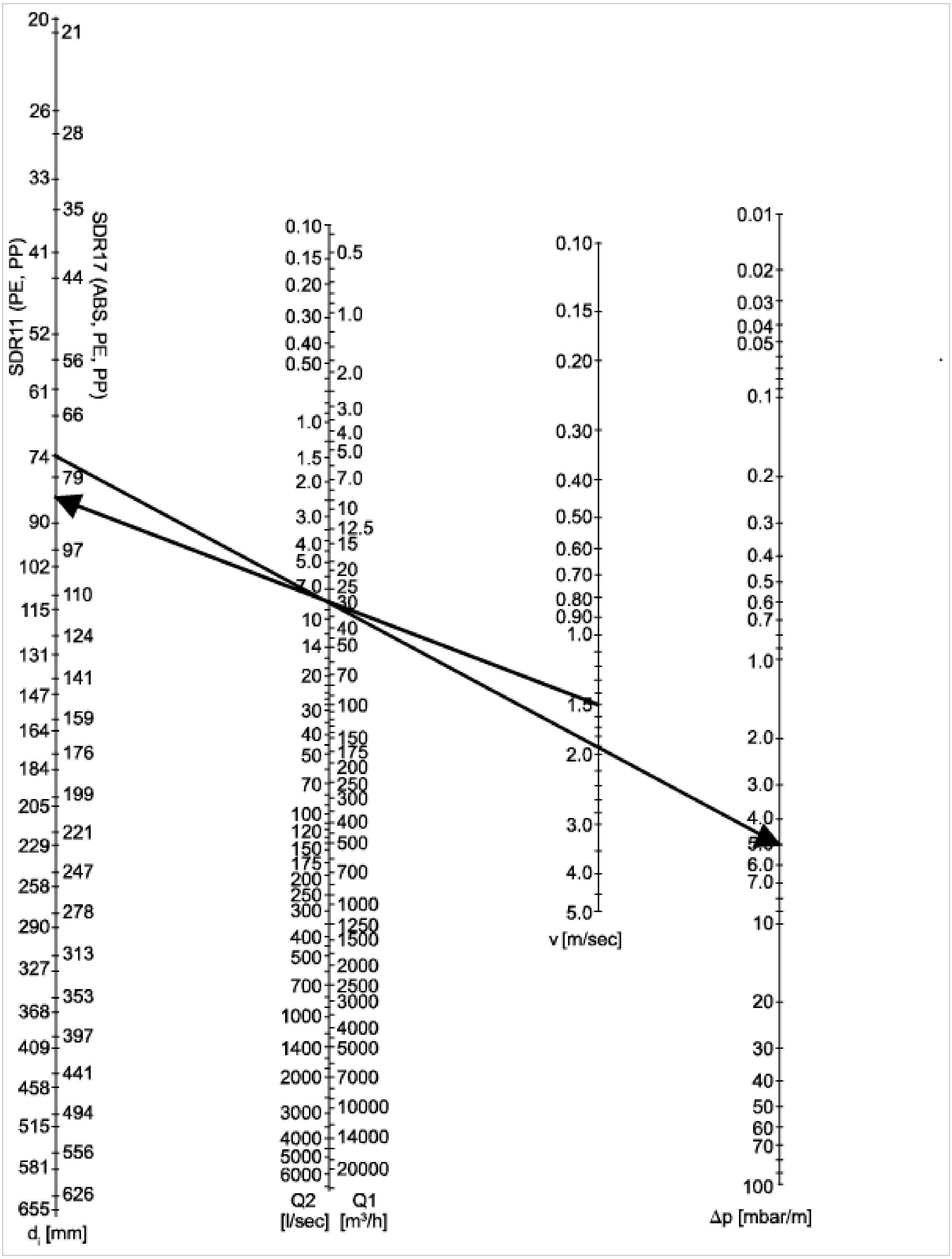
3.1.3 Nomogram for easy determination of diameter and pressure loss

The following nomogram simplifies the determination of the required diameter. In addition, the pressure loss of the pipe per meter pipe length can be read off.

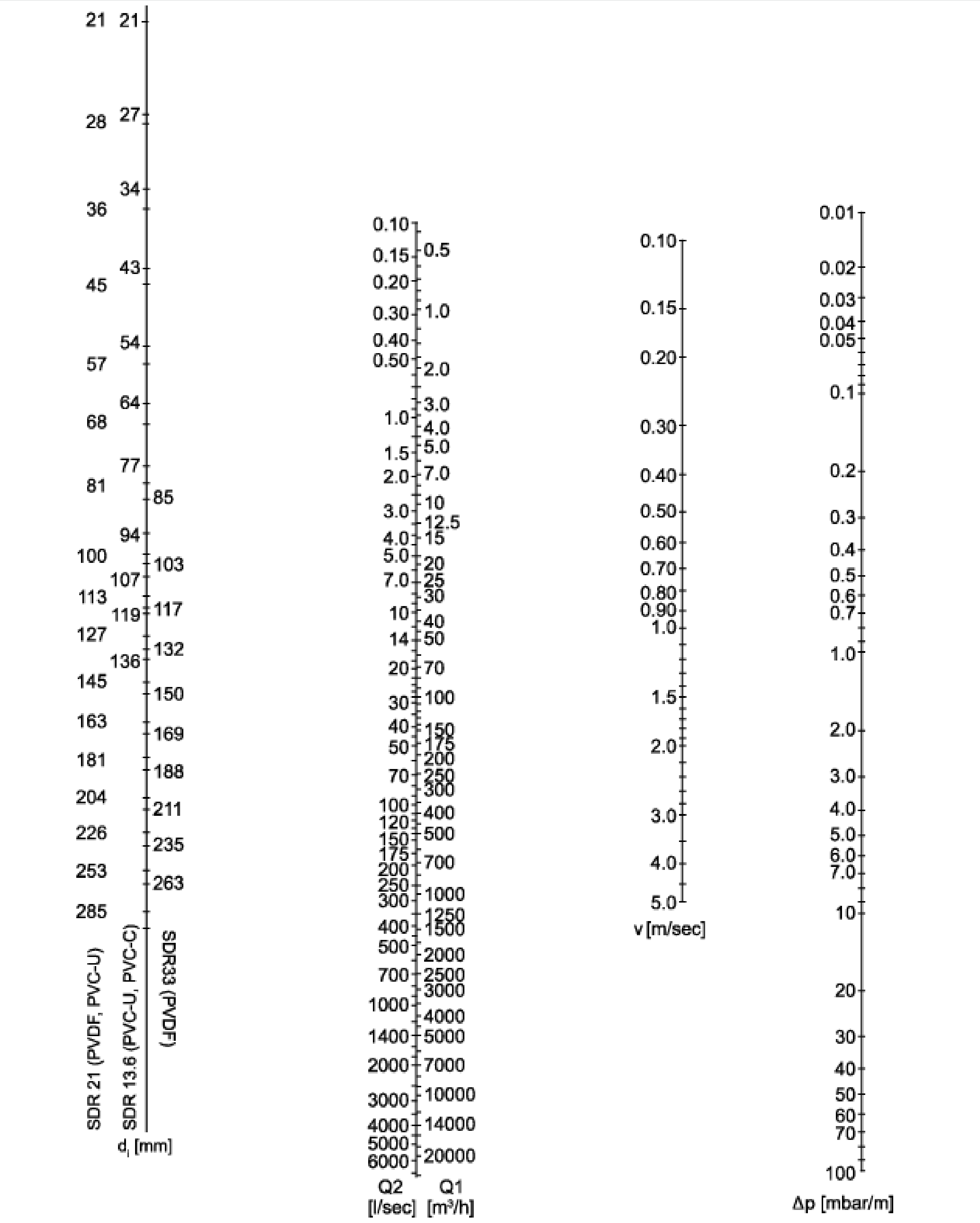
⚠ The determined pressure loss from the nomogram applies only to a density of the flow medium of 1,000 kg/m^3, e.g. for water. Further pressure losses of fittings, valves, etc. have to be considered as shown in the following.

3.1.4 Using the nomogram

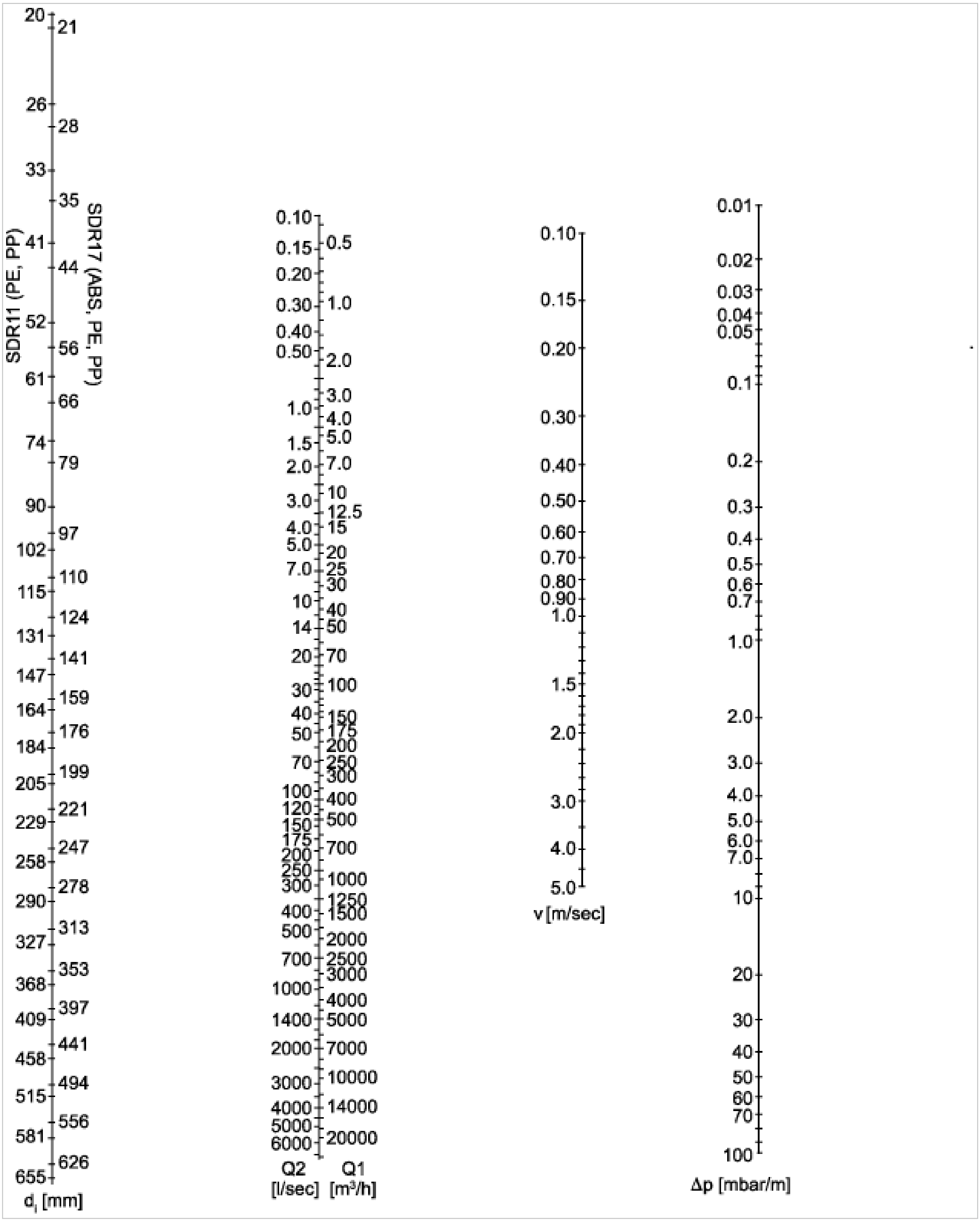
Based on a flow velocity of 1.5 m/s, a line is drawn through the desired flow rate (e.g. 30 m^3/h) to the axis with an inner diameter of di (≈ 84 mm). Then select a diameter nearby (74 mm for SDR11) and draw a 2nd line through the desired flow rate up to the pressure loss axis Δp (5 mbar per meter pipe).



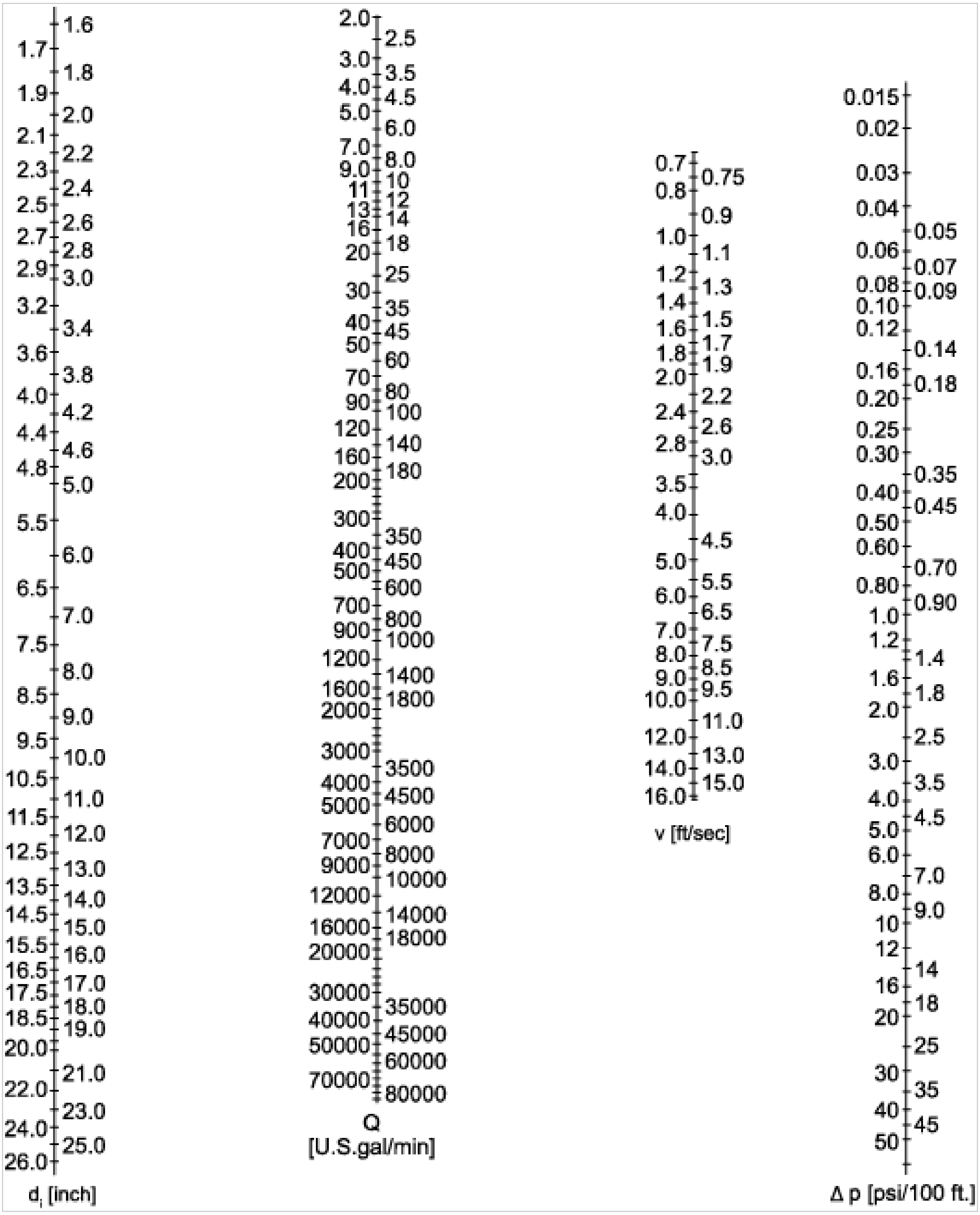
Nomogram for pipe SDR13.6, SDR21, SDR33 using the metric system



Nomogram for pipe SDR21, SDR17, SDR33 using the metric system



Nomogram for inch pipe



IV

3.2 Pressure loss

3.2.1 Pressure loss in straight pipe

When calculating the pressure loss in straight pipe lengths there is a distinction between laminar and turbulent flow. The important unit of measurement is the Reynold's number (Re). The changeover from laminar to turbulent flow occurs at the critical value, Reynold's number $Re_{crit} = 2320$.

Laminar flow occurs, in practice, particularly in the transport of viscous media such as lubricating oils. In the majority of applications, including media similar to water, a turbulent flow, having an essentially steadier velocity than laminar flow in a cross-section of pipe, occurs.

The pressure loss in a straight length of pipe is inversely proportional to the pipe diameter and is calculated by the following formula:

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

Δp_R	Pressure loss in a straight length of pipe (bar)
λ	Pipe friction factor
L	Length of the straight length of pipe (m)
d_i	Pipe inner diameter (mm)
ρ	Density of flow media (kg/m³) (1 g/cm³ = 1000 kg/m³)
v	Flow velocity (m/s)

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

3.2.2 Pressure loss 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-Wert) is used for calculations.

Fitting type	Coefficient of resistance ζ bending radius R	ζ-value
90° bend	1.0 • d	0.51
	1.5 • d	0.41
	2.0 • d	0.34
	4.0 • d	0.23
45° bend	1.0 • d	0.34
	1.5 • d	0.27
	2.0 • d	0.20
	4.0 • d	0.15
90° elbow		1.2
45° elbow		0.3
Tee [1]		1.3
Reduction (contraction)		0.5
Reduction (extension)		1.0
Connections (flanges, unions, fusioning between two pipe)	d >90 mm: 0.1 20 ≤ d ≤ 90 mm: 1.0 bis 0.1:	
	d20: 1.0	d50: 0.6
	d25: 0.9	d63: 0.4
	d32: 0.8	d75: 0.3
	d40: 0.7	d90: 0.1

1 For a more detailed view, differentiate between coalescence and separation. Values for z up to a maximum of 1.3 can be found in the respective literature. Usually the part of a tee in the overall pressure loss is very small, therefore in most cases ζ = 1.3 can be used.

Calculation of pressure loss

To calculate the total pressure loss in all fittings in a pipeline, 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 fittings (bar)
$\Sigma\zeta$	Sum of the individual losses
v	Flow velocity (m/s)
ρ	Density of the medium transported in kg/m^3 ($1\ g/cm^3 = 1{,}000\ kg/m^3$)

3.2.3 Pressure loss in valves

The k_v factor is a convenient means of calculating the hydraulic flow rates for valves. It allows for all internal resistances and for practical purposes is regarded as reliable. It is defined as the flow rate of water in liters per minute with a pressure drop of 1 bar across the valve. The technical data of the GF 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 of valve (bar)
Q	Flow rate (m^3/h)
ρ	Density of the medium transported (kg/m^3) ($1\ g/cm^3 = 1{,}000\ kg/m^3$)
k_v	Valve flow characteristic (m^3/h)

3.2.4 Pressure difference from static pressure

If the pipeline is laid vertically, a geodetic pressure difference must also be calculated. 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 pipeline (m)
ρ	Density of media (kg/m^3) ($1\ g/cm^3 = 1{,}000\ kg/m^3$)

3.2.5 Sum of pressure losses

The sum of all the pressure losses in the pipeline is given by:

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

Example of a pressure loss calculation

The following example shows the calculation to determine the pressure loss of a pipeline:

		Number of fittings
PVDF pipe	d40 mm	12 x elbow 90°
SDR 21 - flow rate	1.5 l/s	4 x elbow 45°
Medium	Zinn (II)-chlorid	3 x tees
Density of medium	1.9 g/cm³	3 x unions
Length of straight pipe sections	15 m	2 x flange connections
		1 x diaphragm valve, 30 % opened
Elevation difference	2.0 m	

The wall thickness of this pipeline can be calculated as follows with the SDR:

$$e = \frac{d}{SDR} = \frac{40\ \text{mm}}{21} = 1.9\ \text{mm}$$

The inner diameter of the pipeline is as follows:

$$d_i = d - 2 \cdot e = d - \frac{2 \cdot d}{SDR} = 36.2\ \text{mm}$$

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

$$v = 1275 \cdot \frac{Q_2}{d_i^2} = 1275 \cdot \frac{1.5}{36.2^2}\ \frac{m}{sec} = 1.46\ \frac{m}{sec}$$

Formulas for calculation of pressure losses

Pressure loss	Formula
Pressure loss of strait pipe	$\Delta p_r = 0.02 \cdot \frac{15}{36.2}\ \frac{1900}{2\ 10^2}\ 1.46^2 = 0.17$ bar
Pressure loss of fittings and connections	$\Sigma\zeta = (12 \cdot 1.2) + (4 \cdot 0.3) + (3 \cdot 1.3) + (5 \cdot 0.7) = 23$
	$\Delta p_{Fi} = 23 \cdot \frac{1.46^2}{2\ 10^5}\ 1900 = 0.47$ bar
Pressure loss of valve, 30 % opened. With the flow characteristics diagram for diaphragm valve, type 514, and 30% lift a percentile k_v value of 50 % can be read out, that means 50 % of k_v value 100: 0.5 * 45.5 m³/h (flow rate 1.5 l/sec = 5.4 m³/h):	$\Delta p_{Ar} = \left(\frac{5.4}{0.5 \cdot 45.5}\right)^2 \cdot \frac{1900}{1000} = 0.107$ bar
Pressure loss of height difference	$\Delta p_{geod} = 2.0 \cdot 1900\ 10^{-4} = 0.38$ bar
Total pressure loss of the pipeline	$\Sigma\Delta p = 0.17$ bar $+ 0.47$ bar $+ 0.107$ bar $+ 0.38$ bar $= 1.127$ bar

4 Installation

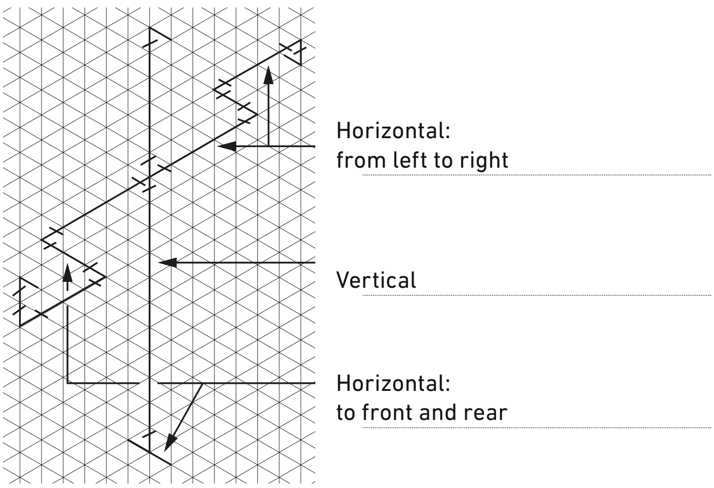
4.1 z-dimension method

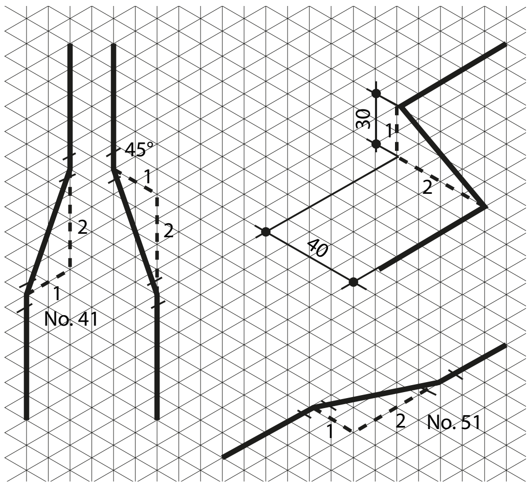
4.1.1 Overview

The pressure of competition and high costs on site makes it essential to install pipeline systems efficiently. The GF 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 GF Piping Systems.

Please adhere to the following guidelines for drawing:

Pipe running perpendicular to one another	Pipe running diagonally

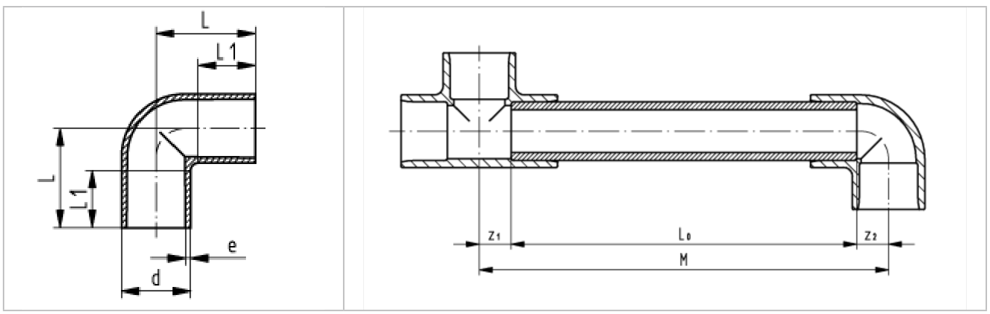




The z-dimensions of the fittings are needed for determining the actual cutting lengths of the pipe. The tables in our product ranges and in the online catalogues contain all the relevant data for the fittings. The length of pipe to be cut is given as in the following diagram by the distance between the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

4.1.2 Procedure

Socket fusion and socket adhesive fittings



IV

Formula for determining the required pipe length

$L_0 = M - z1 - z2$

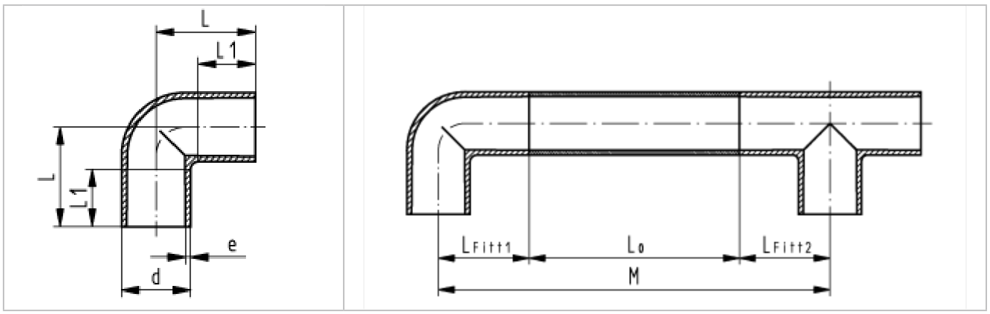
L_o	Length of pipe to be cut
M	Center-to-center distance of fitting
z	z-dimension of the fitting

Example

Material	PVC-U, d63, PN16
Center-to-center distance M	1000 mm
z1 (T 90°)	33 mm
z2 (angle 90°)z	33 mm

L_0 = 1000 mm – 33 mm – 33 mm = 934 mm

Butt fusion fittings



Formula for determining the required pipe length:

$L_0 = M - L_{Fitt1} - L_{Fitt2} + L_{MatVerl}$

L_o	Cut length of pipe
L_{fitt}	Length of fitting (z-dimension)
M	Distance center-to-center of fitting
$L_{MatLoss}$	Material loss through planning process and bead forming IR (infrared): 2 x 2 mm + 1mm = 5mm BCF (bead and crevice-free): 2 x 0.8

Example

Material	PP-H, d63, SDR11, IR-fused
Center-center distance M	1000 mm
L_{Fitt1} (T 90° equal)	66 mm
L_{Fitt2} (elbow 90°)	66 mm
$L_{MatLoss}$	2 x 2 mm

Pipe and fitting are faced for each fusion. Two fusions result in 2 x 5 mm = 10 mm.

L_0 = 1000 mm – 66 mm – 66 mm + 2 · 5 mm = 878 mm

4.1.3 Material losses for IR fusion procedure

Fusion machine IR-63 Plus

d (mm)	PP-natural (mm)	PE100 (SDR11) (mm)	PE100 (SDR17) (mm)	PP-H (SDR11) (mm)	PP-H (SDR17) (mm)	PVDF (mm)	ECTFE (mm)	PFA (mm)
20	5.0	5.5		5.0		4.5	4.5	4.5
25	5.0	5.5		5.0		4.5	4.5	4.5
32	5.0	5.5		5.0		4.5	4.5	4.5
40	5.0	6.0		5.0		4.5	4.5	4.5
50	5.0	6.0		5.0		4.5	4.5	4.5
63	5.5	6.0		5.0		4.5	4.5	4.5

Fusion machine IR-110 A and IR-110 Plus

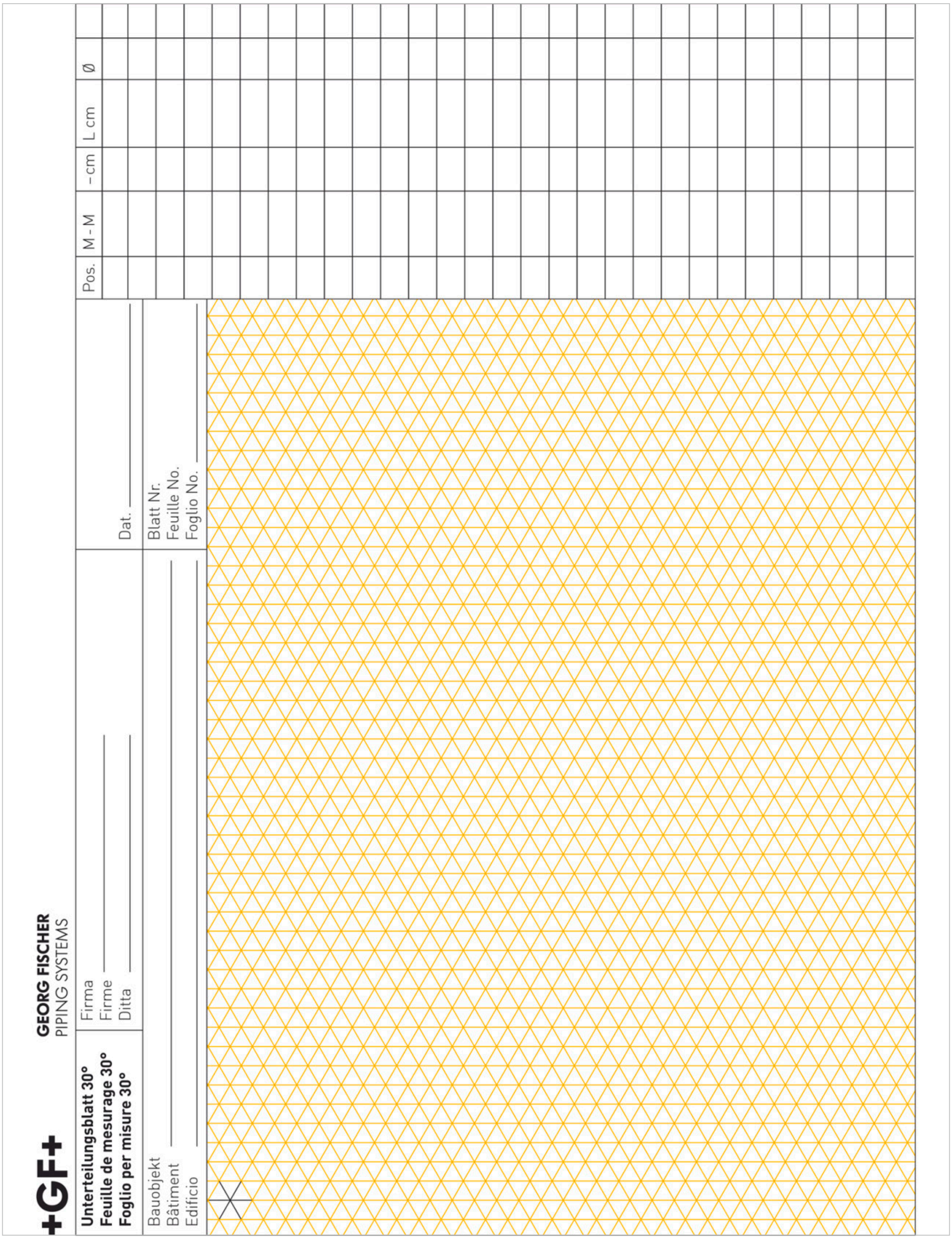
d (mm)	PP-natural (mm)	PE100 (SDR11) (mm)	PE100 (SDR17) (mm)	PP-H (SDR11) (mm)	PP-H (SDR17) (mm)	PVDF (mm)	ECTFE (mm)	PFA (mm)
20	5.0	5.5		5.0		4.5	5.0	4.5
25	5.0	5.5		5.0		4.5	5.0	4.5
32	5.0	5.5		5.0		4.5	5.0	4.5
40	5.0	5.5		5.0		4.5	5.0	4.5
50	5.0	5.5	5.5	5.0	5.0	5.0	5.0	4.5
63	5.0	5.5	5.5	5.0	5.0	5.0	5.0	4.5
75	5.0	5.5	5.5	5.0	5.0	5.0	5.0	
90	5.0	5.5	5.5	5.0	5.0	5.0	5.0	
110	5.0	5.5	5.5	5.0	5.0	5.0	5.0	

Fusion machine IR-315 A, IR-225 Plus and IR-315 Plus

d (mm)	PP-natural (mm)	PE100 (SDR11) (mm)	PE100 (SDR17) (mm)	PP-H (mm)	PVDF (mm)
63	5.0	6.5	6.5	6.0	4.5
75	5.0	6.5	6.5	6.0	4.5
90	5.0	6.5	6.5	6.0	5.0
110	5.5	6.5	6.5	6.0	5.0
125		6.5	6.5	6.0	5.0
140		6.5	6.5	6.0	5.0
160		7.0	6.5	6.0	5.0
180		7.0	6.5	6.0	
200		7.0	6.5	6.0	5.0
225		7.0	6.5	6.0	5.0
250				6.0	5.5
280				6.0	5.5
315				6.0	5.5

IV

Isometric paper



G4.1 Template for isometric paper

4.2 Handling plastic pipeline systems

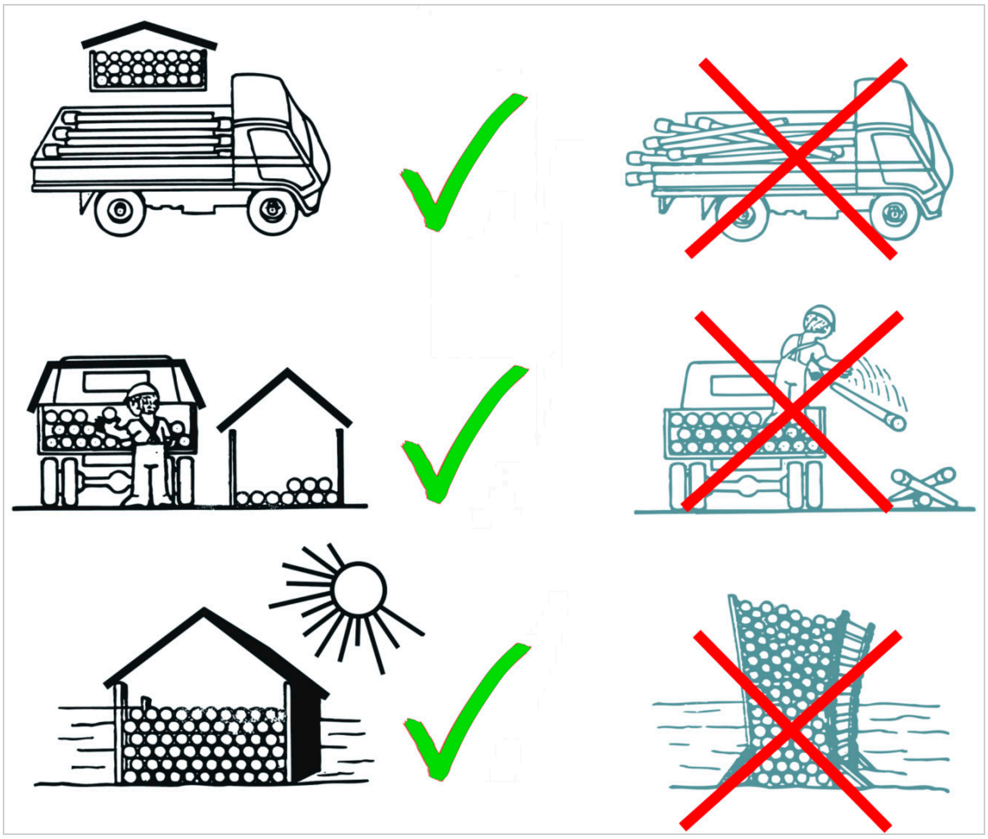
4.2.1 Transportation

Vehicles used to transport pipe must be capable of accommodating the full pipe length. The pipe must be supported to prevent them bending or deforming. The area where pipe rest (including side supports) should be lined with padded sheeting or corrugated cardboard to avoid damage by protruding rivets or nails. To protect against damage, pipe and fittings must not be slid over the transport vehicle's loading area, nor should they be dragged along the ground to their place of storage.

Due care must be taken with loading and unloading. If lifting gear is used, this must be fitted with special pipe grips. Throwing pipe and parts down from the cargo surface is unacceptable. Impacts must be avoided at all cost, especially at ambient temperatures below 0 °C where many plastics (e.g. PVC) have significantly lower impact resistance.

Pipe and fittings must be transported and stored so that they cannot be soiled by earth, mud, dirty water, etc. We recommend sealing pipe with protective endcaps to prevent the ingress of dirt.

We recommend that GF Piping Systems fittings and equipment are only unpacked immediately prior to use.



4.2.2 Storage

The pipe storage surface must be level and free of stones. Pipe must be layered and stacked in a way that avoids the risk of damage or permanent deformation. Larger-diameter, thin-walled pipe must be fitted with stiffening rings. Avoid single-point or narrow longitudinal supports.

The following table gives recommended maximum stacking heights for non-pallet pipe storage. Provided pipe are stacked on pallets and protected against sideways movement, the nominal stacking heights specified in the table may be increased by 50 %.

Pipe storage areas should be as well-protected as possible. Absorption of oil, solvents and other chemicals must be avoided at all costs during storage.

Stored pipe must not be exposed to the elements more than absolutely necessary, i.e. they should be kept in a covered warehouse. If stored outdoors (e.g. on a construction site), they should be covered with sheeting for protection against the weather (e.g. UV radiation).

One-sided warming from exposure to the sun could cause deformations.

Pipe and parts should be used in the order of manufacture/delivery, to ensure proper warehouse turnover of the plastic material.

Material	Permissible stacking height (m)
ABS	1.0
PE	1.0
PP	1.5
PVC-U	1.5
PVC-C	1.5
PVDF	1.5
ECTFE	1.0

4.3 CAD library

Product library of GF Piping Systems

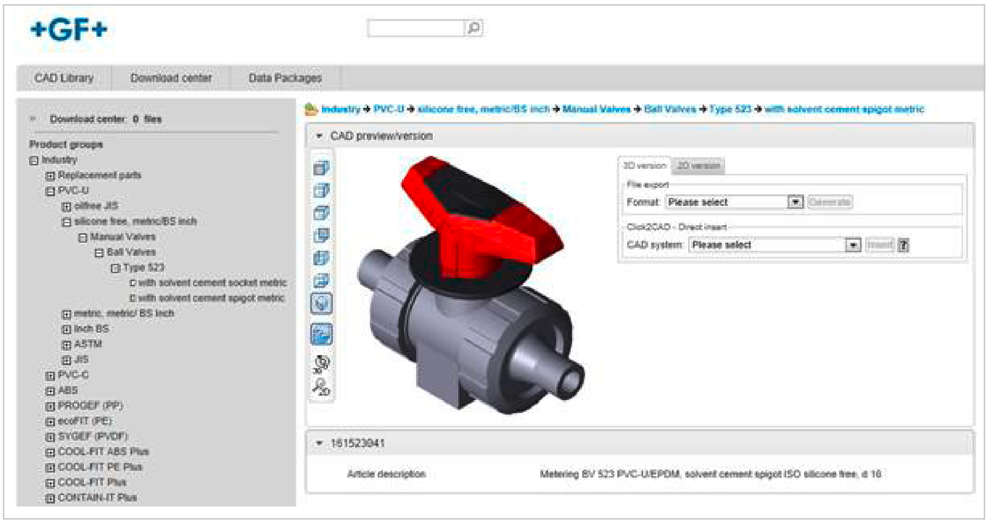
With this CAD library, GF Piping Systems aims to provide designers and engineers with even better and more efficient support for the design of piping systems.

Three-dimensional models (3-D models) of all piping components by GF Piping Systems in the area of industrial applications can be called up via the database. The user creates two dimensional drawings (2-D drawings) on his own in the desired views.

The library does work independently from the user's CAD system supporting many systems and interfaces. The database comprises over 30,000 drawings and technical data regarding pipe, fittings, measurement and control technology as well as manual and actuated valves.

The CAD library offers:

- Data packets with all the drawings of a system
- Over 30,000 drawings
- Pipe, fittings, valves, measurement & control
- Presentation in 2-D and in 3-D
- Optimized user interface
- Multifunctional drivers for the most common CAD systems
- Quick access



Sample presentation of a CAD library

Direct access to the online CAD library at http://cad.georgfischer.com

4.4 Length changes and flexible sections

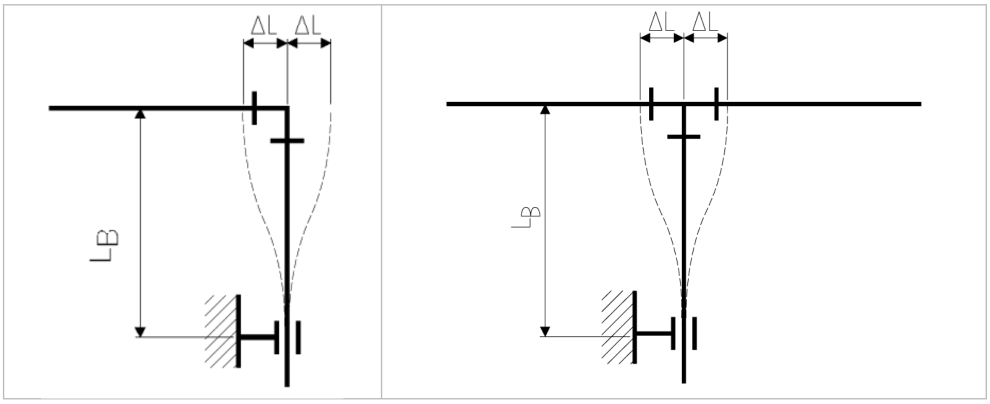
4.4.1 Overview

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 additional extra strain on the pipe. This applies especially to pipe exposed to operating temperature variations.

Length changes can be taken up by:

- Flexible sections
- Compensators

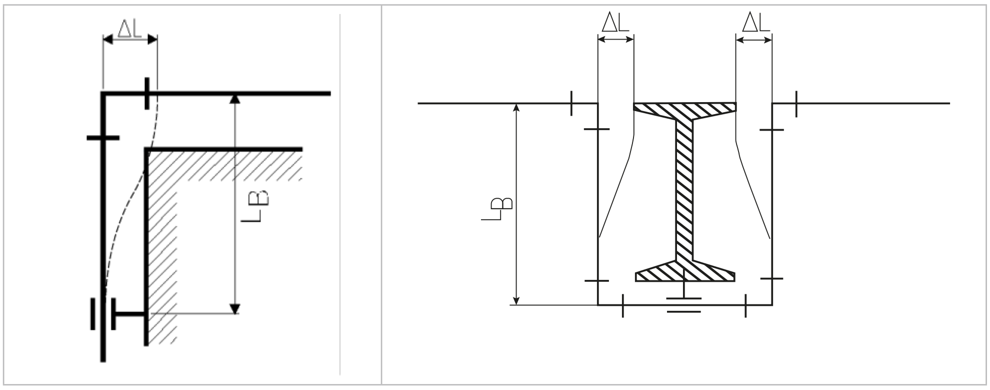
Flexible sections are the most common, the simplest and the most economical solution. The calculations for and the positioning of flexible sections are therefore described in detail.



ΔL Length change
L_B Flexible section

4.4.2 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 pipeline and the extent of the thermal expansion to be compensated.



ΔL Length change
L_B Flexible section

Flexible sections arise naturally at any branching or change in direction of the pipeline. 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.

4.4.3 Calculation of length changes

The change in length caused by temperature can be calculated using the following formula:

$\Delta L = L \cdot \Delta T \cdot \alpha$

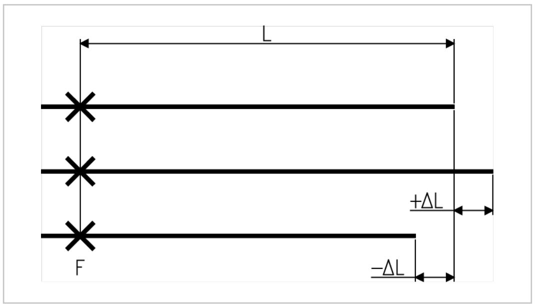
ΔL Temperature-related length change (mm)
L Length of the pipe section (m)
ΔT Difference of temperature (K)
α Coefficient of linear expansion (mm/m K)

Coefficients of linear expansion of polymers

Material	α = mm/m K
ABS	0.10
PA	0.10
PB	0.13
PE	0.15 – 0.20
PP	0.16 – 0.18
PPS	0.15
PVC-U	0.07 – 0.08
PVC-C	0.06 – 0.07
PVDF	0.12 – 0.18
ECTFE	0.08 – 0.135 (20°C – 100°C)

If the operating temperature is higher than the installation temperature, then the pipe expands. If, on the other hand, the operating temperature is lower than the installation temperature, then the pipe contracts in length.

- The installation temperature must therefore be incorporated into the calculations as well as the maximum and minimum operating temperatures.
- It is preferable to use "+" to indicate expansion of the pipe and "-" to indicate contraction.
- The larger change in length is the one to be used for determining the required length of the flexible section.



Boundary conditions for using the diagram

For easy determination of the required length of flexible section please use the following diagrams. The following boundary conditions should be taken into account:

- Assembly temperature $T_M = 20\ °C$
- Operating temperature T_B

$$\Delta T = T_B - T_M$$

- Allowable bending stress 15 % from σ_b
- PN6 to PN16
- Assumed coefficient of friction of the pipe in the loose brackets ≤ 0.5

Information

The following diagrams show the required flexible sections for straight pipe lengths of 10 m or 70 m. Exceeding the maximally permissible straight pipe distance would lead to buckling of the pipe due to too great friction in the pipe clamps. Therefore, the maximum possible pipe length must be considered depending on the pipe diameter visible above the shaded area.

Example: Determining the length of the required flexible section

Calculating the relevant change in length

The example of an ABS process pipe serves to illustrate the procedure. Length of piping from the fixed point to the branch point where the change in length is to be taken up:

Length L	8 m
Installation temperature T_M	20 °C
Max. operating temperature T_1	35 °C
Min. operating temperature T_2	- 20 °C

Expansion of the pipe section during heating

$+\Delta L_1 = L \cdot \Delta T_1 \cdot \alpha = 8 \cdot 15 \cdot 0.10 = 12$ mm

Contraction during cooling

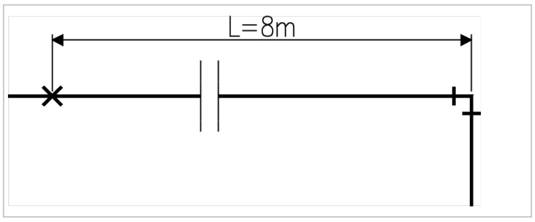
$-\Delta L_2 = L \cdot \Delta T_2 \cdot \alpha = 8 \cdot 40 \cdot 0.10 = 32$ mm

Temperature differences

$\Delta T_1 = T_1 \cdot T_M = 15\ K \Delta T_2 = T_2 - T_M = -40\ K$

Maximum change in temperature selected

$\Delta T = 40\ °C$



Determining the length of the flexible section for ABS

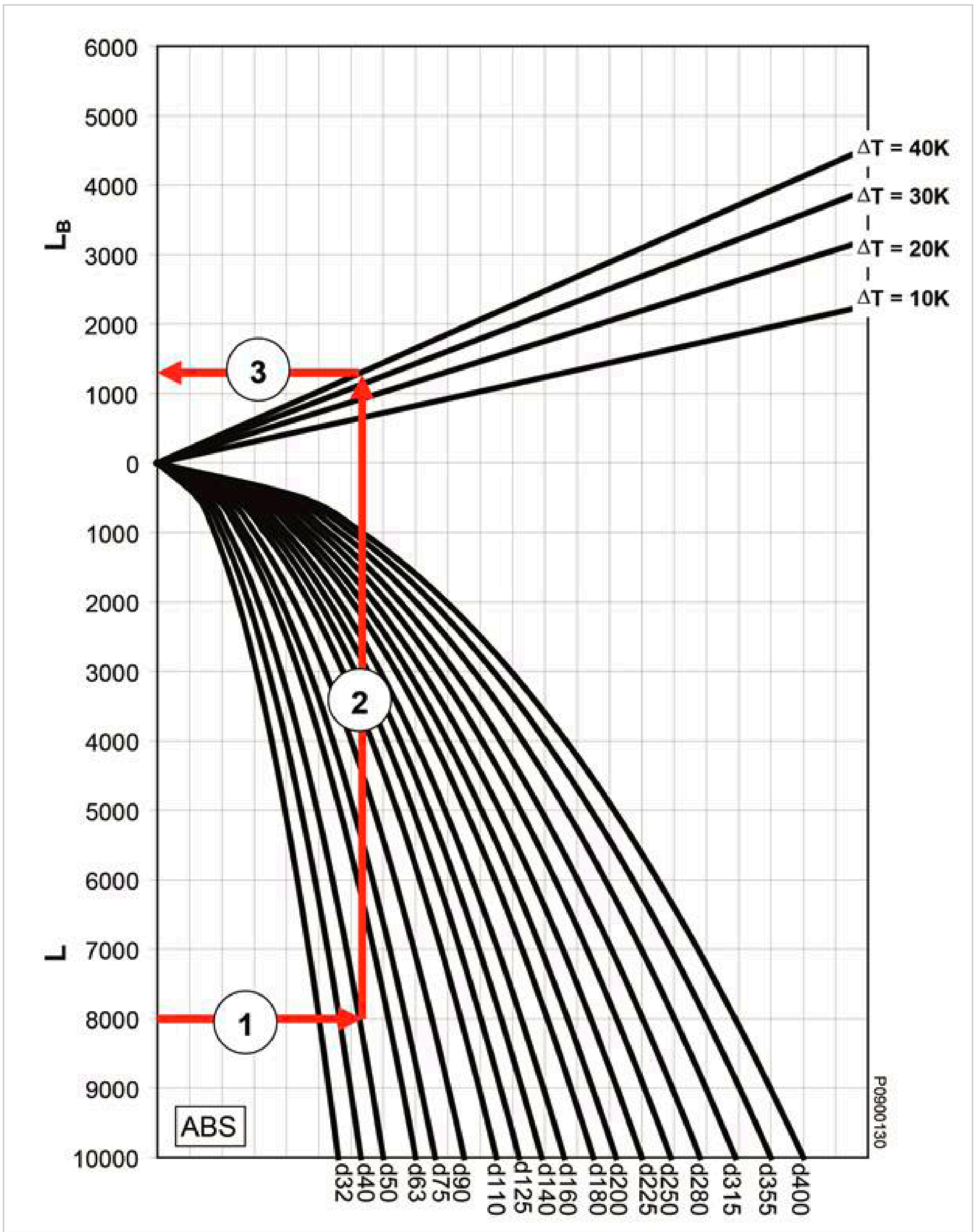
The values needed to determine the necessary length are:

- The maximum change in temperature from the 0-position (i.e. from the position in which the pipe was installed). But remember that the pipe could contract just as well as expand.
- Inner pipe diameter d
- Length of pipe section L

With these values, the required length of the flexible section can be read from the diagram for ABS.

The following information can be gained from the calculation example above:

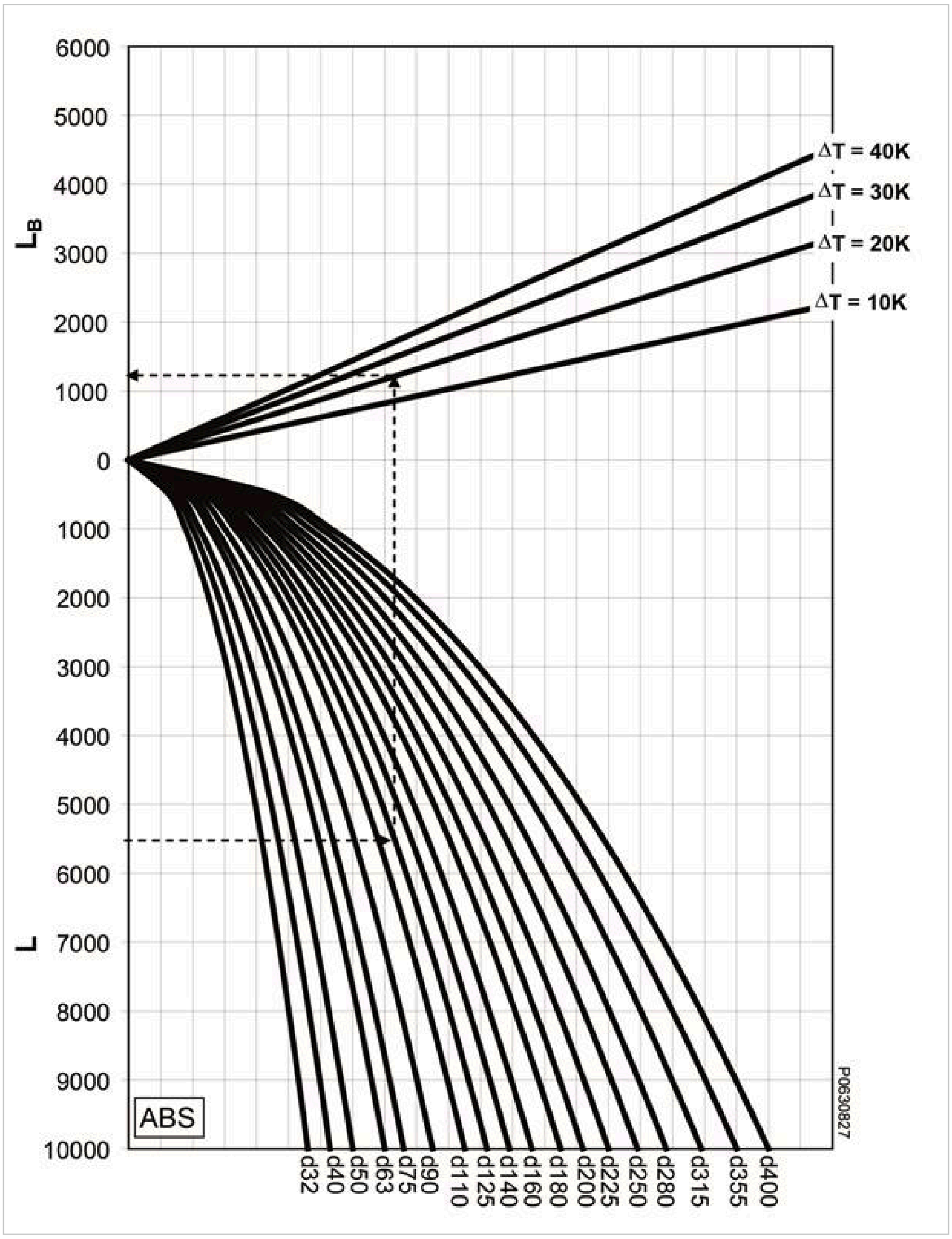
- Installing a pipe with d = 50 mm
- Maximum change in temperature ΔT = 40 K
- Material ABS
- Length of required flexible section L_F = 1300 mm (see diagram)



L Length of pipe section (mm)
L_B Required length of flexible section (mm)

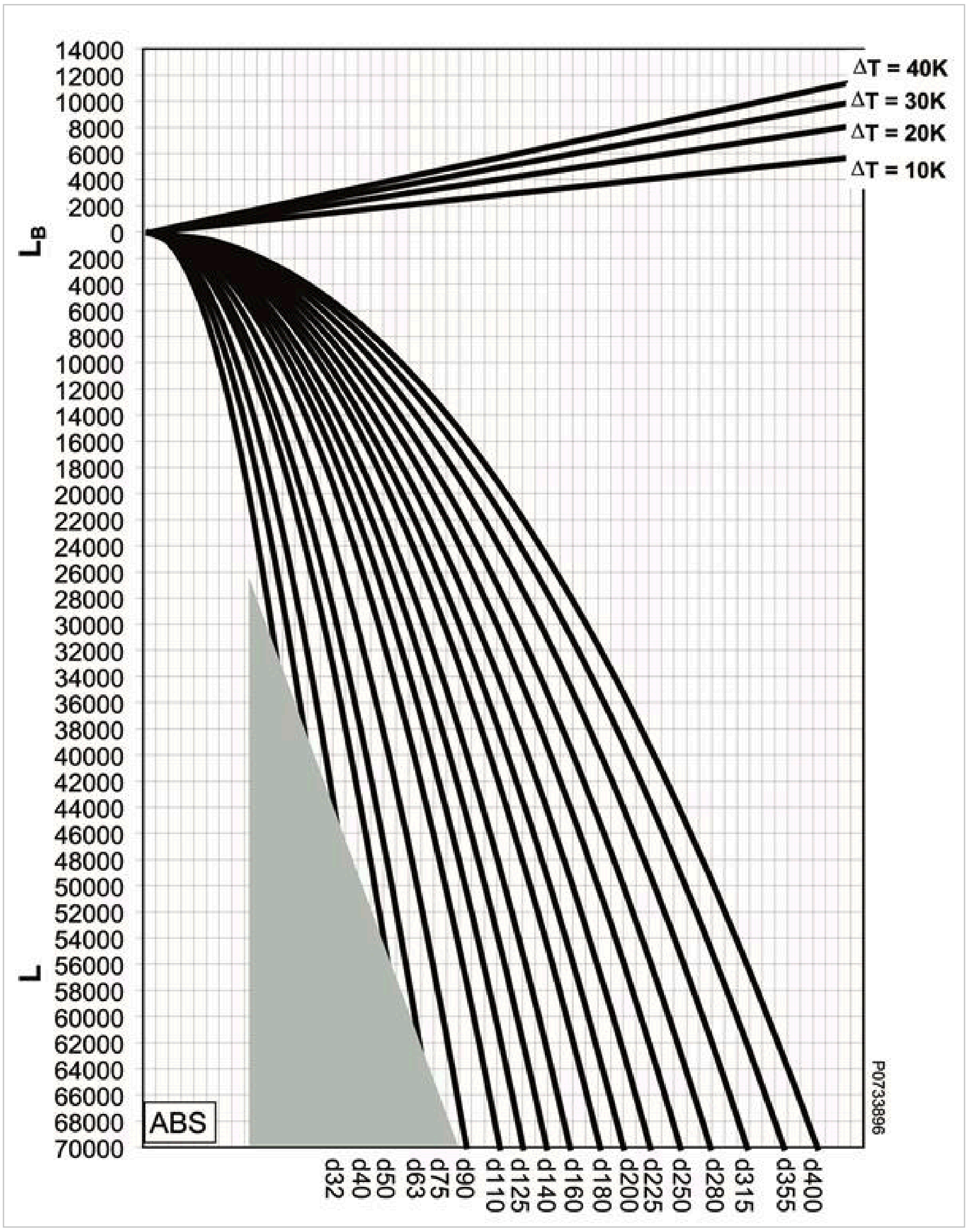
The diagram can be used also the other way around, if a maximum flexible section caused by the building construction is given. Then the maximum straight length of the pipe can be determined.

4.4.4 Flexible sections of ABS piping systems



L Length of pipe section (mm)

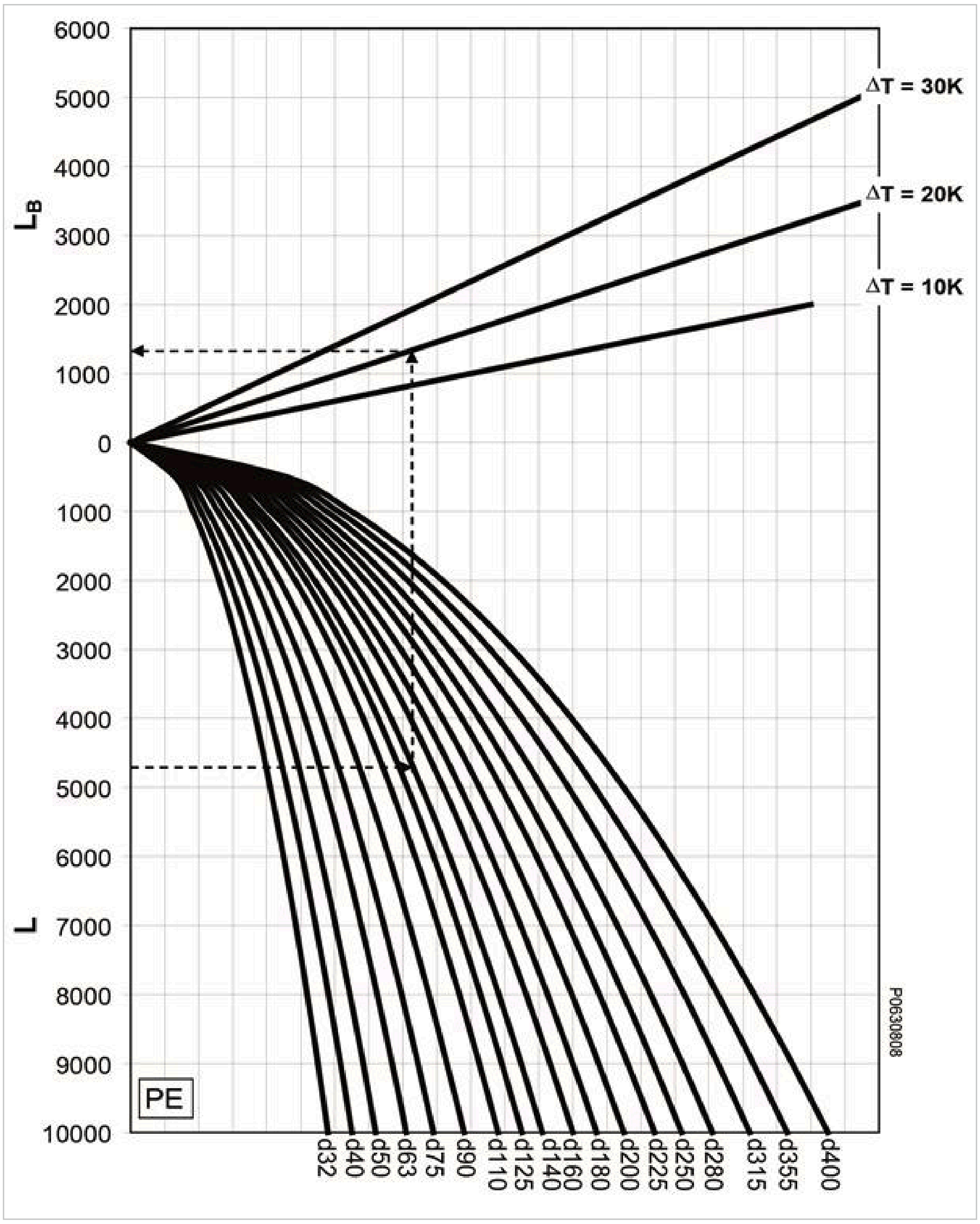
L_B Required length of flexible section (mm)



L Length of pipe section (mm)
L_B Required length of flexible section (mm)

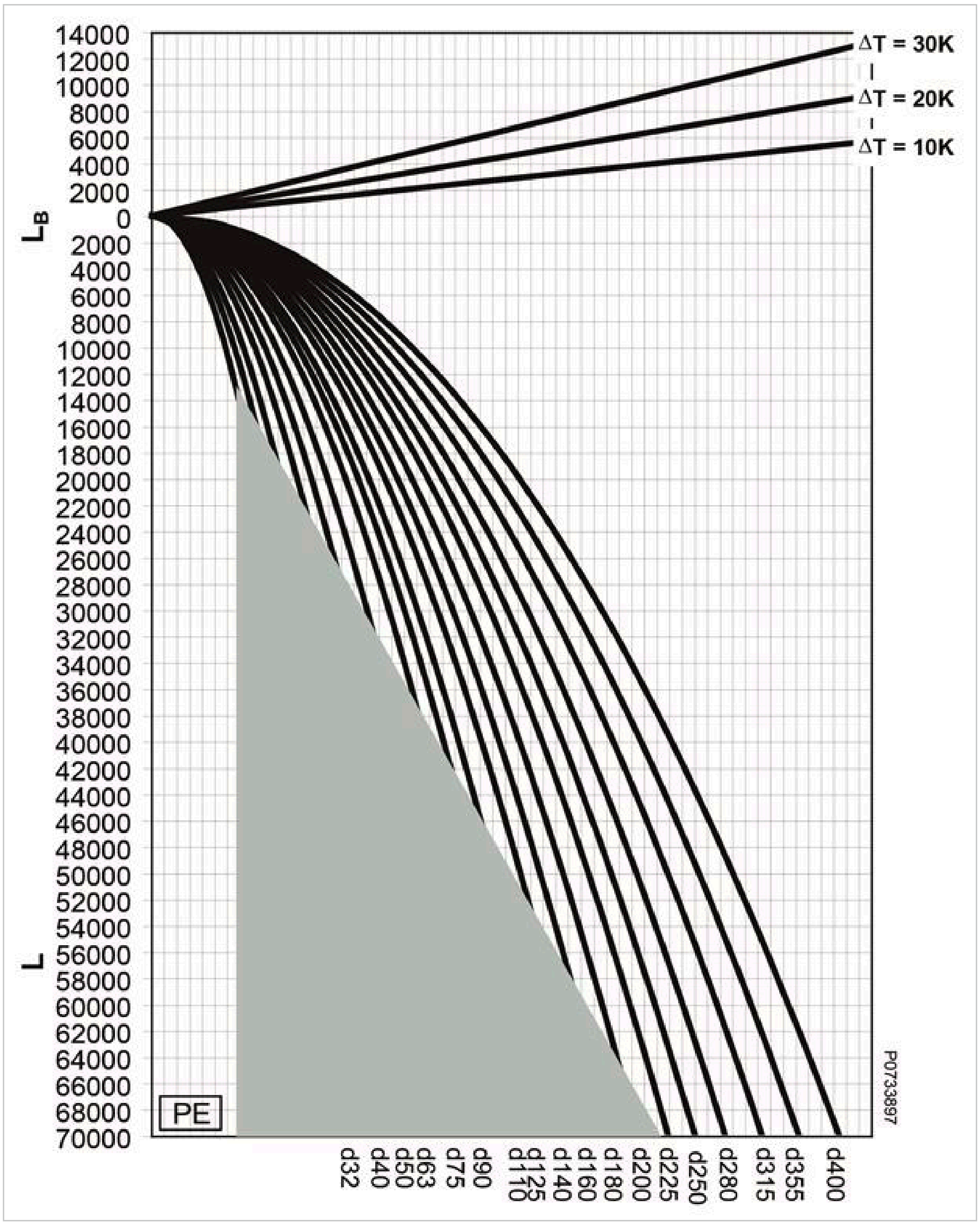
For explanations of the shaded area, see the introductory section "Boundary conditions for using the diagram".

4.4.5 Flexible sections of PE (PE80, PE100) piping systems



L Length of pipe section (mm)

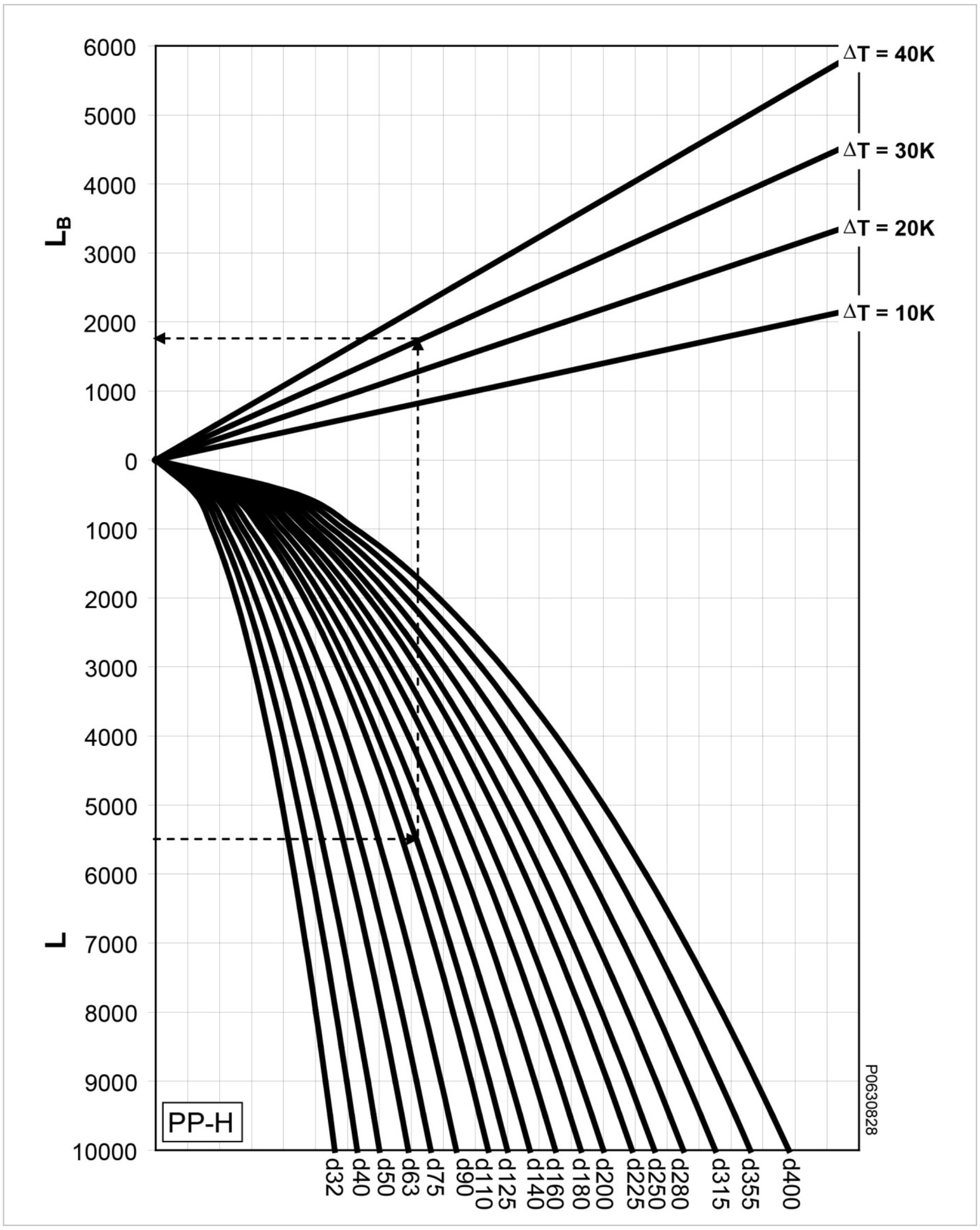
L_B Required length of flexible section (mm)



L Length of pipe section (mm)
L_B Required length of flexible section (mm)

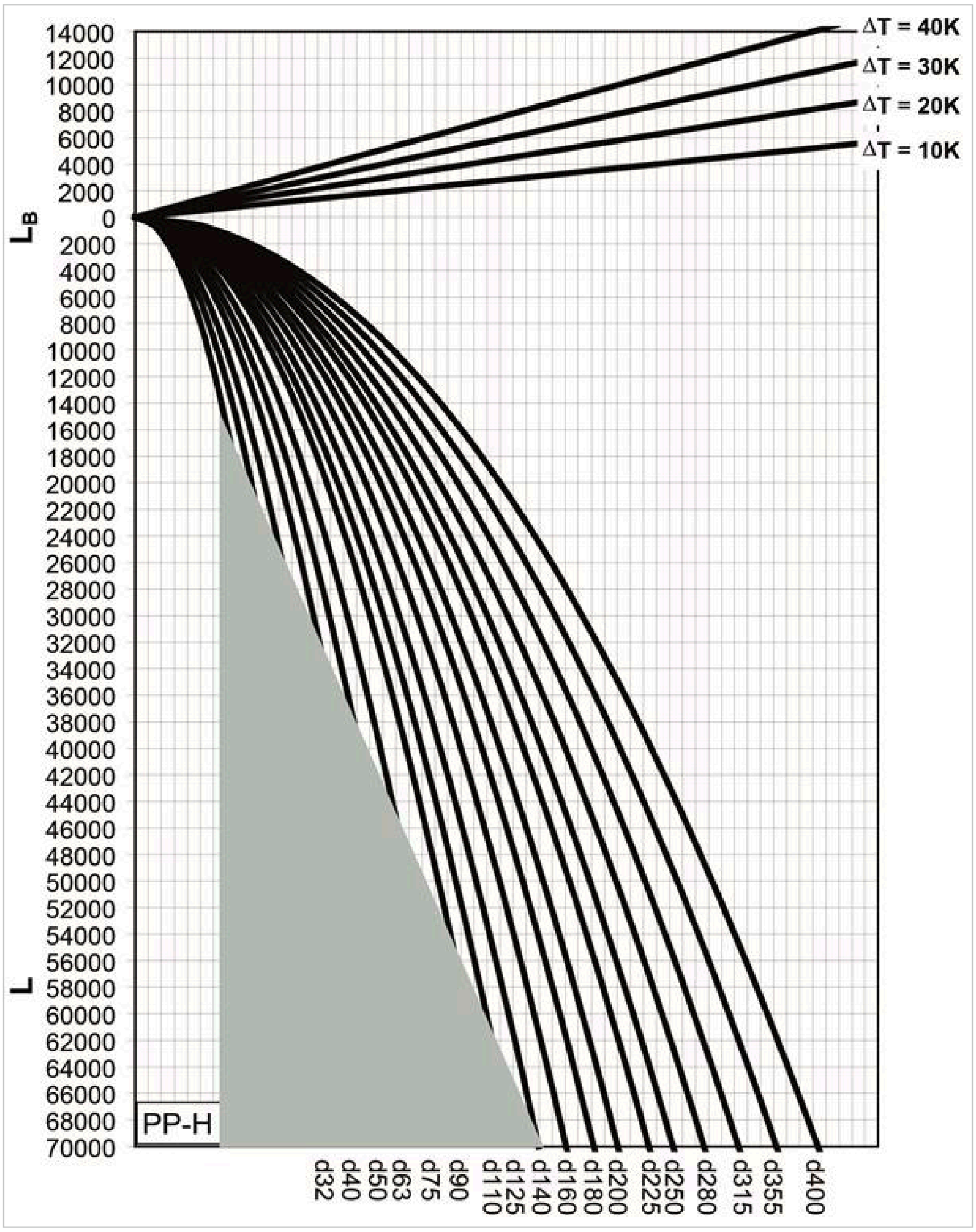
For explanations of the shaded area, see the introductory section "Boundary conditions for using the diagram".

4.4.6 Flexible sections of PP piping systems



L Length of pipe section (mm)

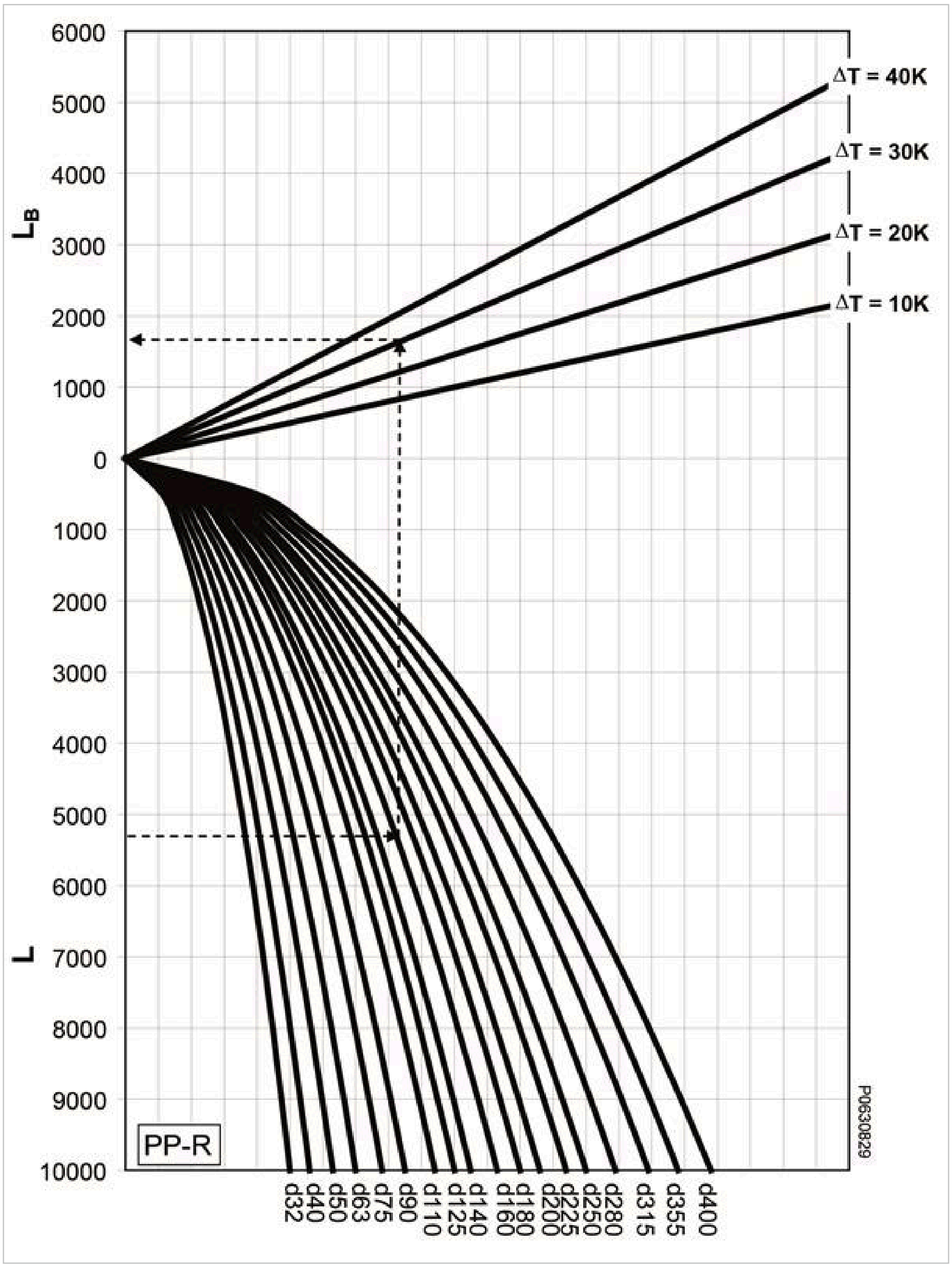
L_B Required length of flexible section (mm)



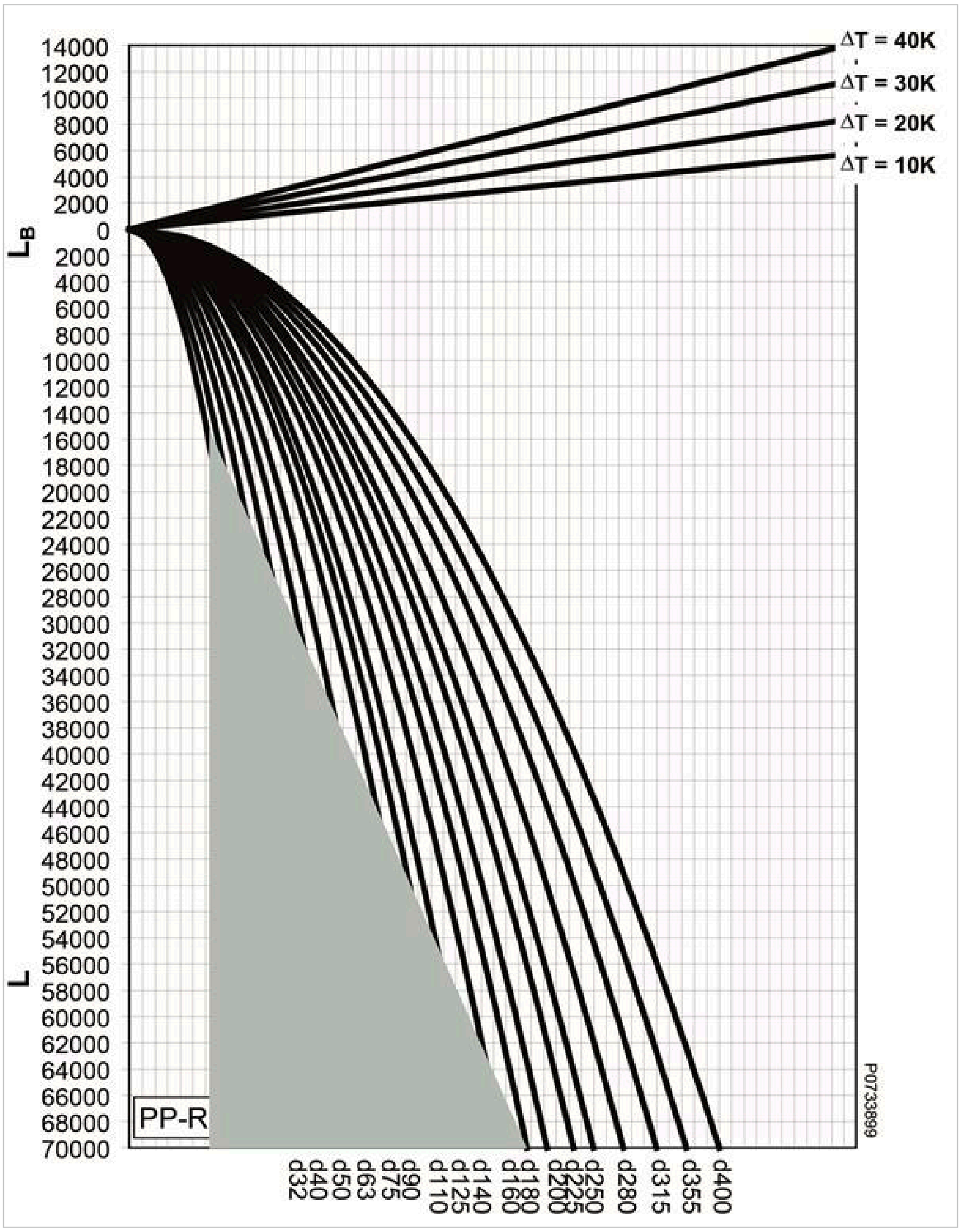
L Length of pipe section (mm)

L_B Required length of flexible section (mm)

For explanations of the shaded area, see the introductory section "Boundary conditions for using the diagram".



L Length of pipe section (mm)
L_B Required length of flexible section (mm)



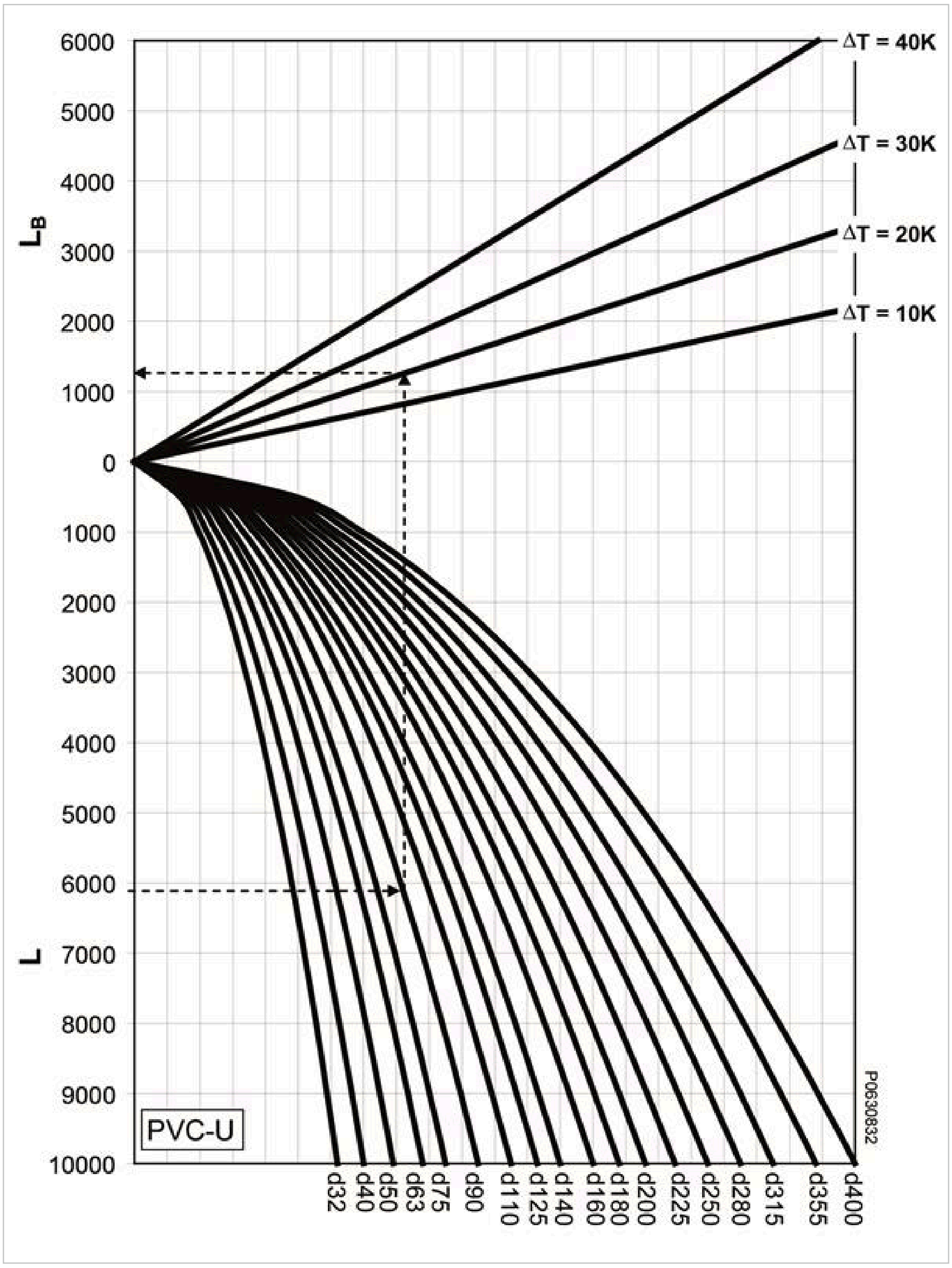
L Length of pipe section (mm)

L_B Required length of flexible section (mm)

For explanations of the shaded area, see the introductory section "Boundary conditions for using the diagram".

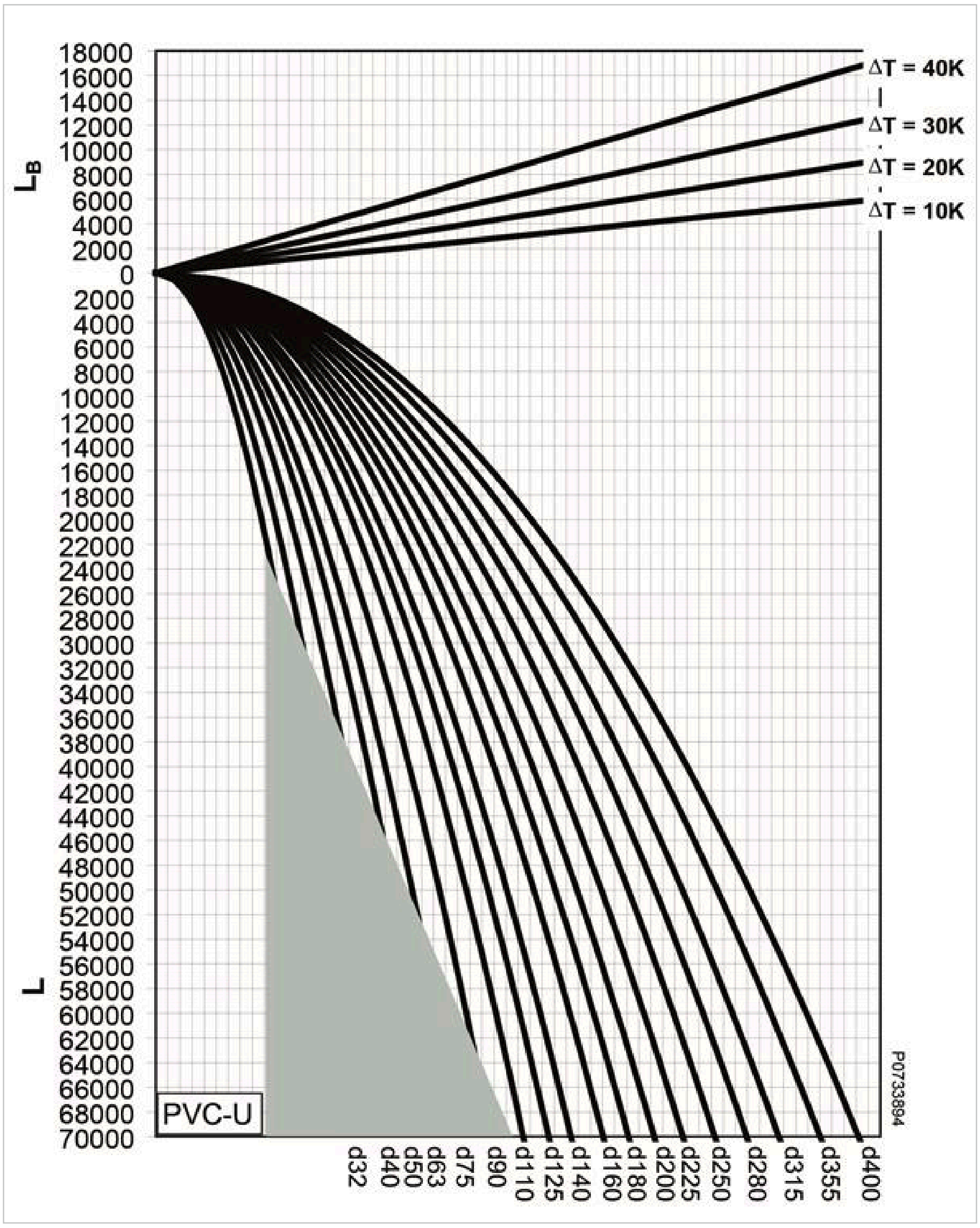
IV

4.4.7 Flexible sections of PVC-U/PVC-C piping systems



L Length of pipe section (mm)

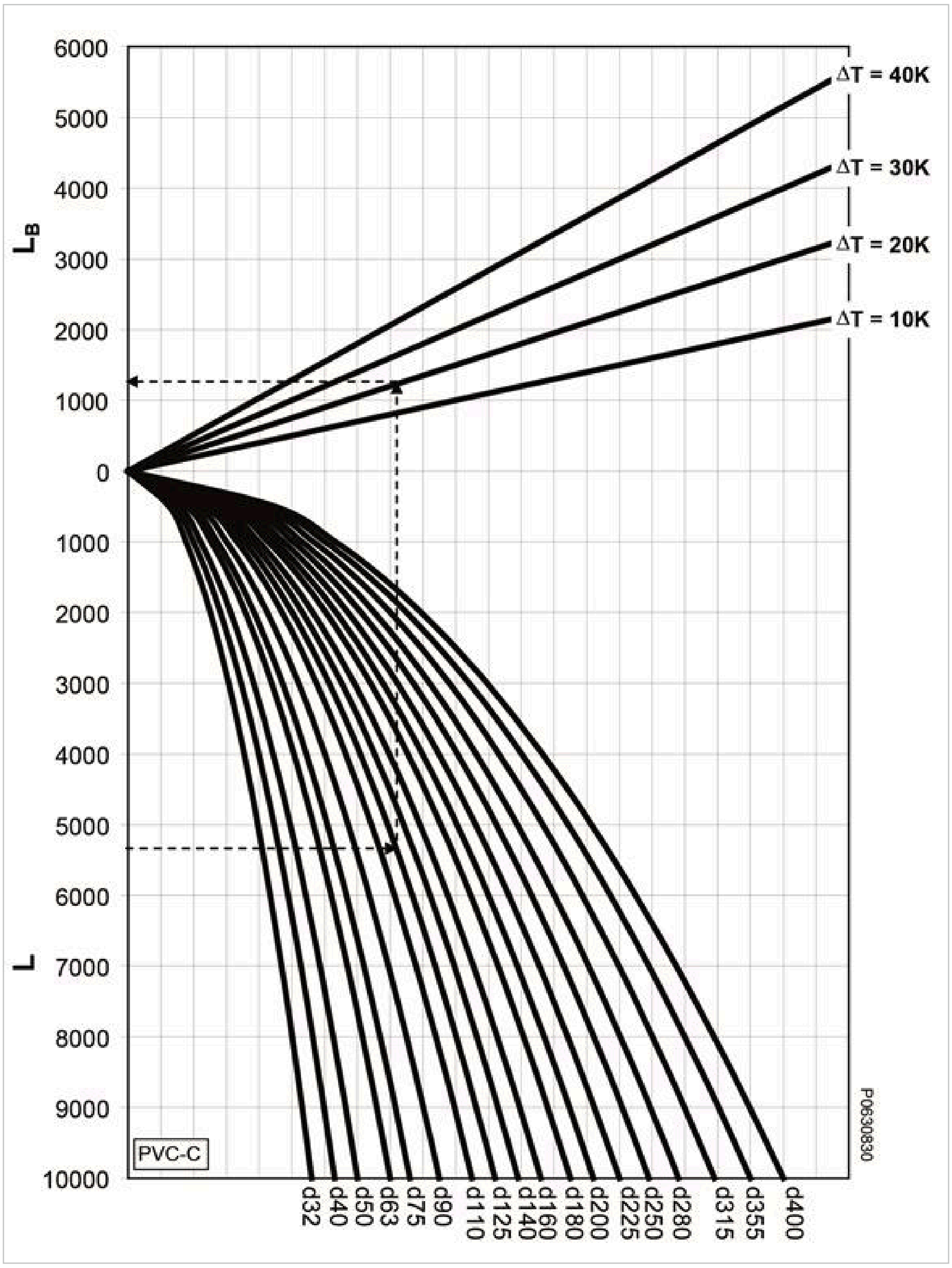
L_B Required length of flexible section (mm)



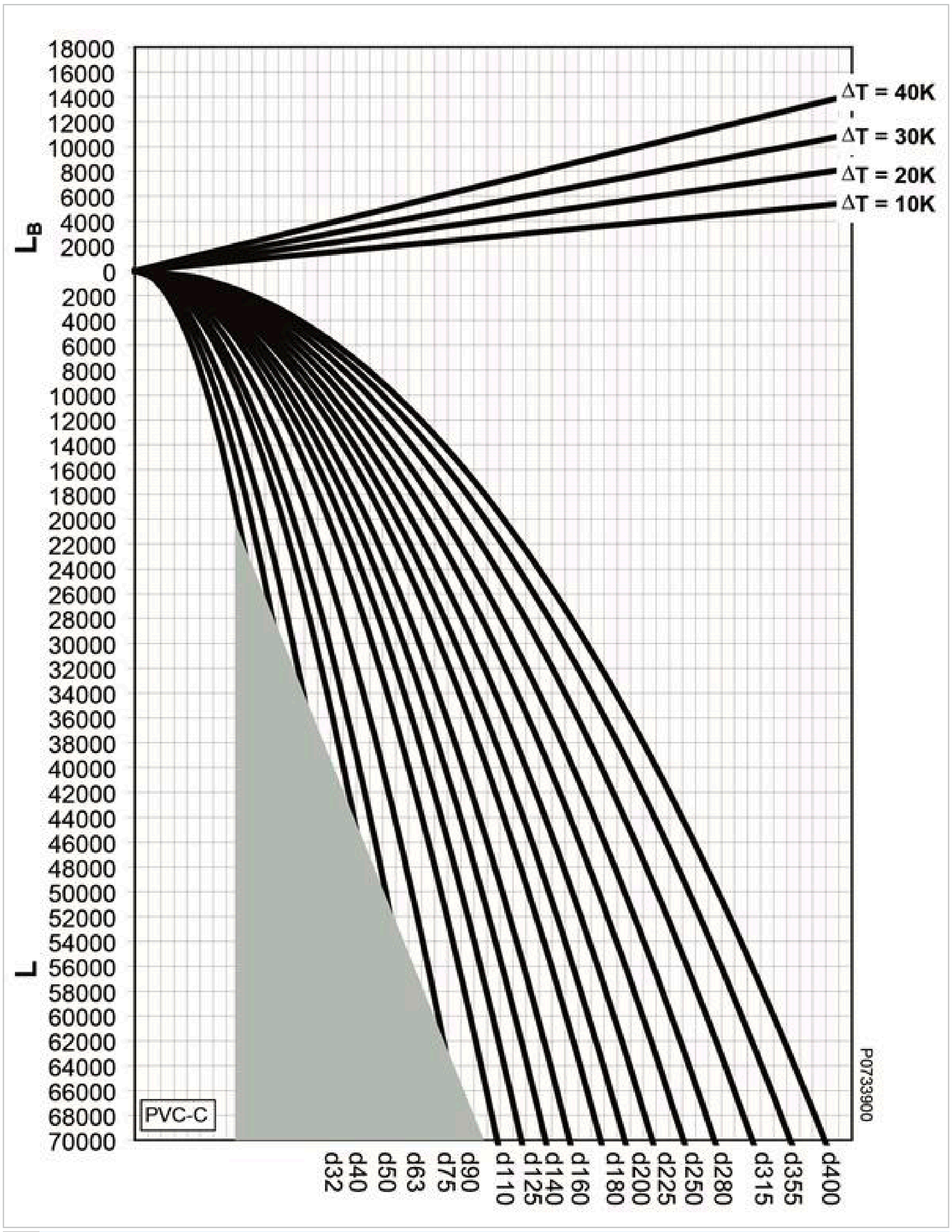
L Length of pipe section (mm)

L_B Required length of flexible section (mm)

For explanations of the shaded area, see the introductory section "Boundary conditions for using the diagram".



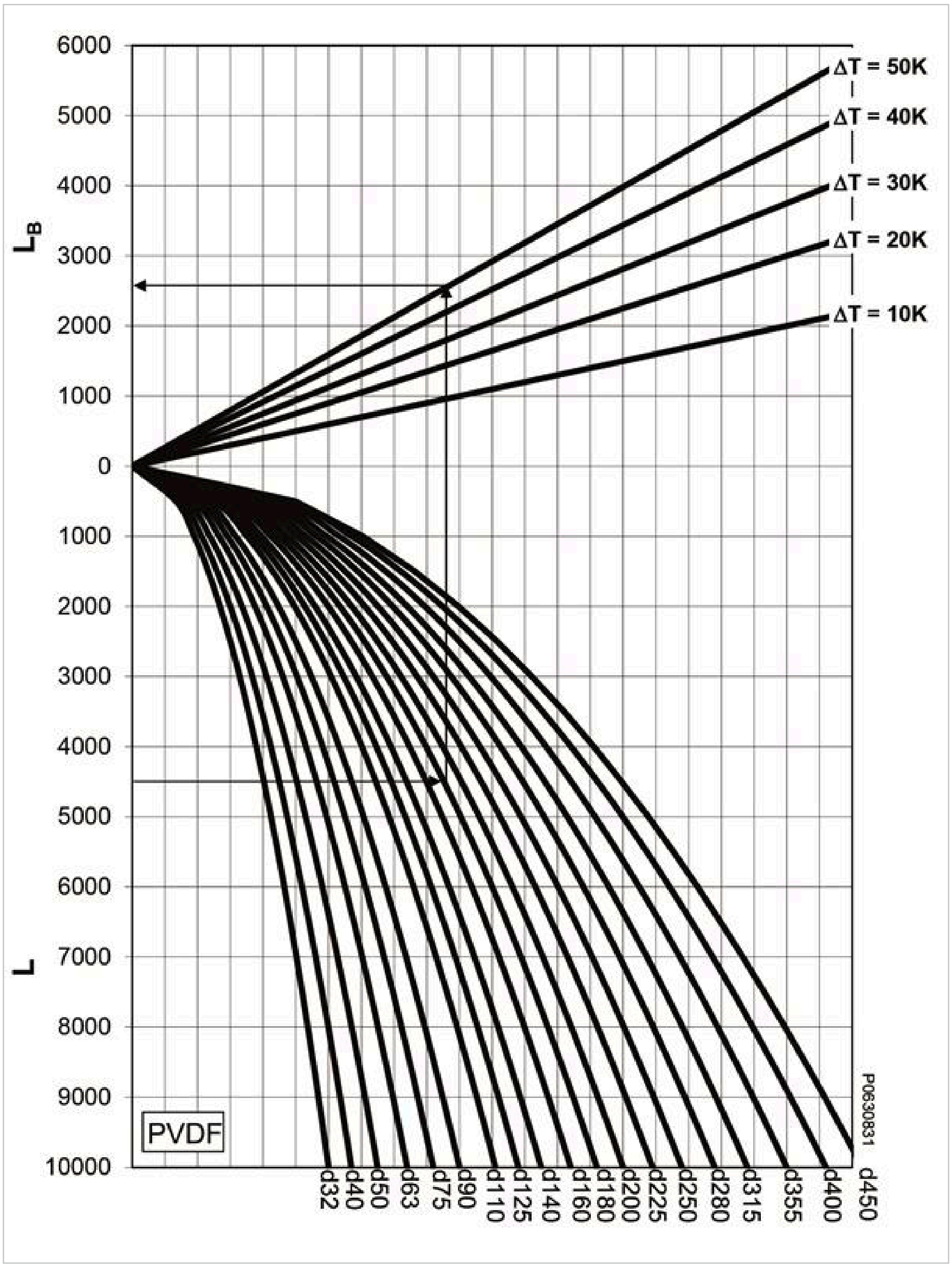
L Length of pipe section (mm)
L_B Required length of flexible section (mm)



L Length of pipe section (mm)
L_B Required length of flexible section (mm)

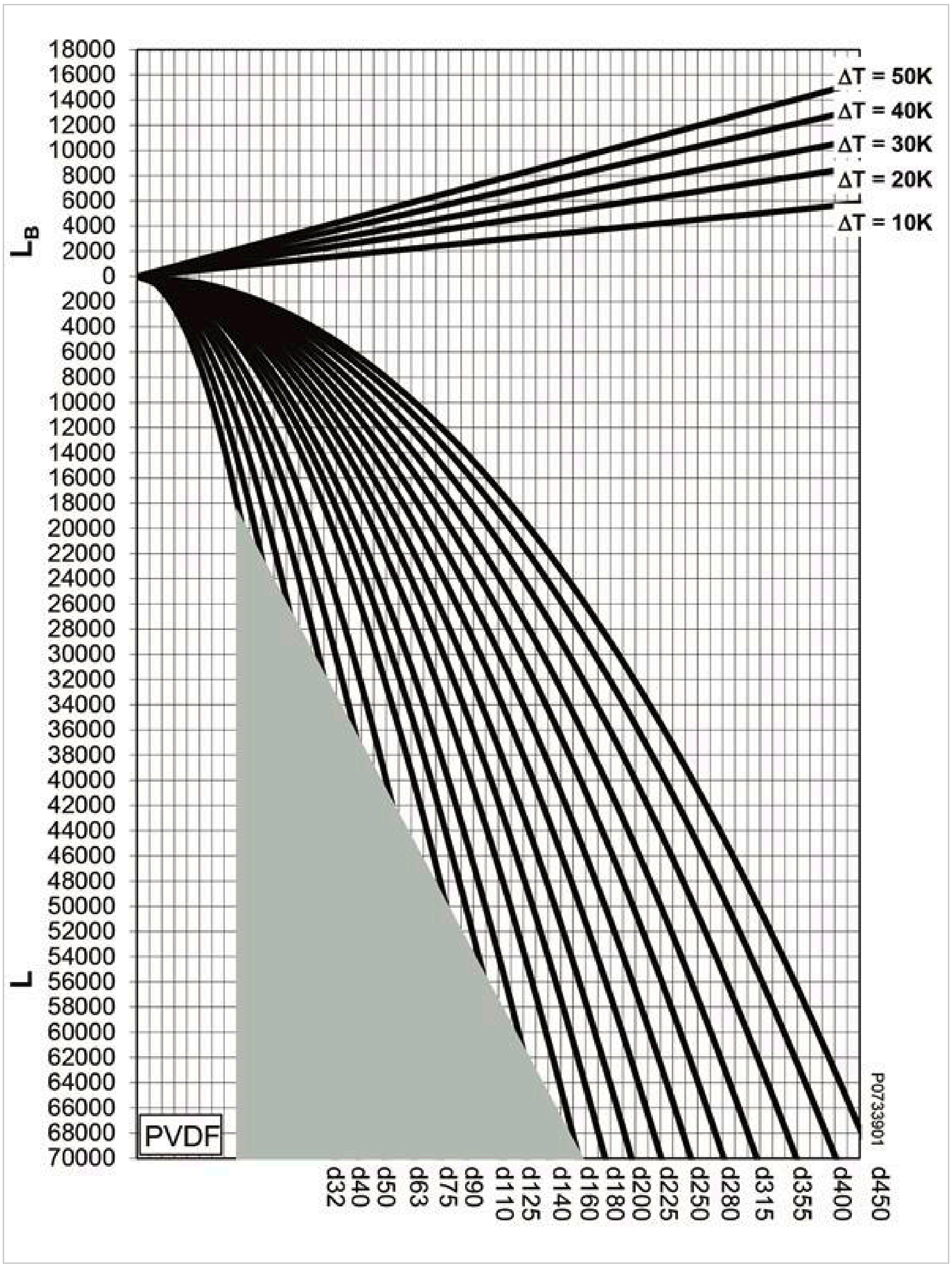
For explanations of the shaded area, see the introductory section "Boundary conditions for using the diagram".

4.4.8 Flexible sections of PVDF piping systems



L Length of pipe section (mm)

L_B Required length of flexible section (mm)



L Length of pipe section (mm)
L_B Required length of flexible section (mm)

For explanations of the shaded area, see the introductory section "Boundary conditions for using the diagram".

4.4.9 Flexible sections of ECTFE piping systems

Determining the length of the flexible section for ECTFE piping systems:

$\mathbf{L_{B\_ECTFE} = C * (d * \Delta l)^{\wedge 0.5}}$

d= pipe diameter [mm]

Δl= temperature-related length change [mm]

C= ECTFE material factor as a function of TB= Operating temperature:

TB ≤ 20°C → C = 22.6

TB > 20°C → C = 20.0

Note:

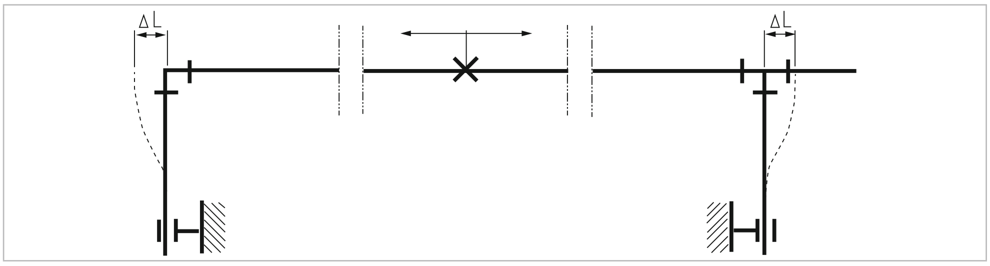
The simplified calculation of flexible section does not replace the stress analysis.

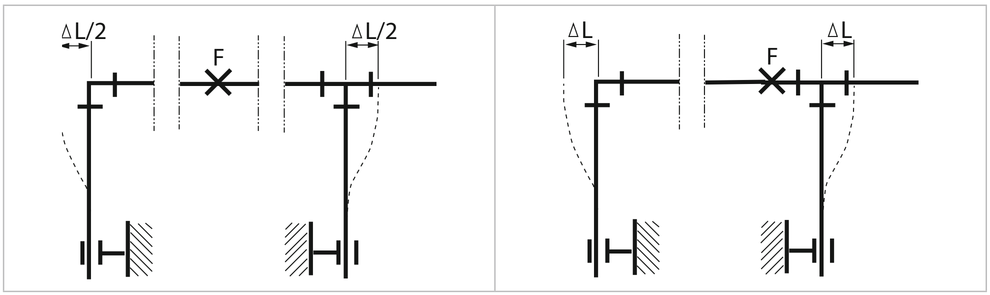
Shorter flexible sections are to be checked by means of a static evidence for the respective pipeline installation.

4.5 Installation

4.5.1 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:

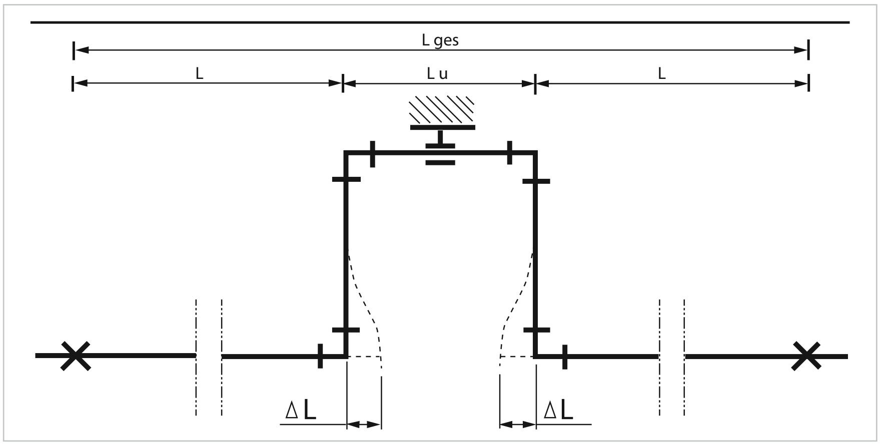




Recommended

Not recommended

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 pipeline 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.



Leaks caused by the bending load leakages can occur at mechanical joints.

Within the range of flexible sections and expansion loops no threaded connections or flange connections shall be used.

Pre-stress

In particularly difficult situations with large changes in one direction only (either expansion or contraction), it is possible to pre-stress the flexible section during installation and thereby shorten its length L_B, as illustrated in the next example:

Example

Installation data L	10 m
Outer diameter d	50 mm
Installation temperature	15 °C
Max. operating temperature	40 °C
Material	ABS

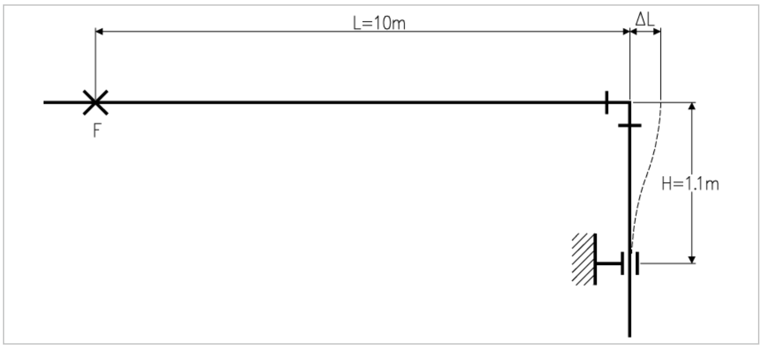
Length change:

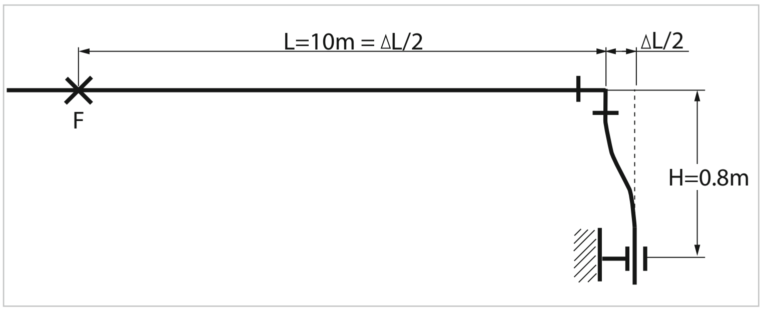
$+\Delta L = L \cdot \Delta T \cdot \alpha ABS = 10\text{ m} \cdot 25\text{ K} \cdot 0.10\text{ mm/mK} = 25\text{ mm}$

A flexible section to take up a change in length of **ΔL = 25 mm** needs to be **L_B = ca. 1150 mm** long according to the diagram.

If the flexible section is pre-stressed to ΔL/2 then the required length of the flexible section is reduced to about 800 mm. The variation length from the 0 position is then **± ΔL/2 = 25/2 = 12.5 mm**.

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



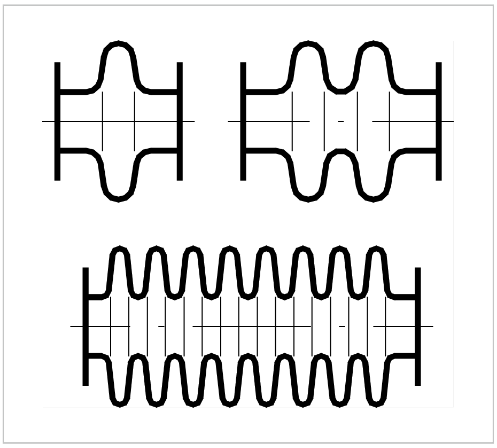


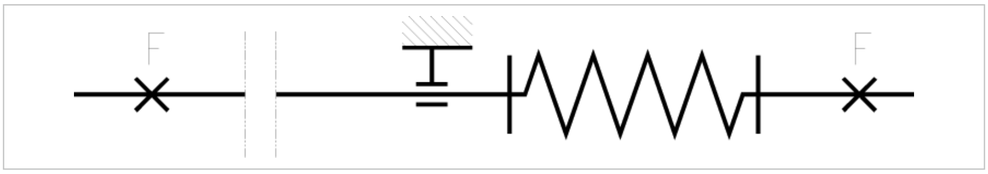
4.5.2 Installation of compensators

The low modulus of elasticity means that the reaction force of plastic pipe to thermal changes is low compared to metal pipe. This makes normal compensators designed for use with metal pipe unsuitable because of their high inherent resistance. Only freely moving compensators may be used in plastic pipe systems, i.e. those with a low resistance. The following compensators may be considered: rubber compensators, PTFE-corrugated compensators or suitably selected metal multi-disk compensators.

Carefully placed fixed points should be selected when fitting compensators for the regulation of the pipe in order to ensure their unhindered operation.

⚠ When using compensators, additional longitudinal forces are implemented into the pipeline. These forces have to be carried by guiding the pipeline. For example, threaded rods are not suitable. To estimate the lateral forces it can be assumed that they can reach about 15 % of the axial forces. Please contact the manufacturers of compensators for further support designing such piping systems.



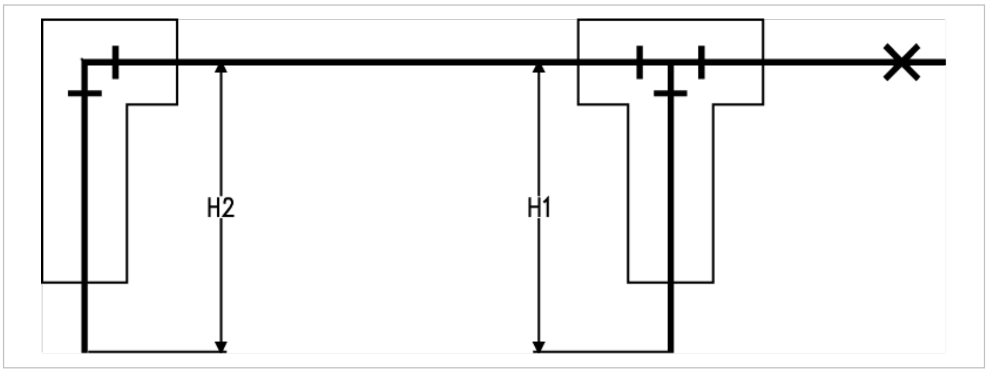


4.5.3 Installation of valves

Valves should be secured as directly as possible, e.g. to bracket or wall, so that the actuation forces are transmitted directly and not via the pipeline. Valve brackets or valves with integrated mounting device from GF Piping Systems are used for securely fastening plastic valves. The valve brackets are also used to accept loads from the valve and fill weight of the pipeline. Any changes in length which arise can be kept from the valve with the appropriate fixed points before or after the valve.

Installing pipework under plaster or embedding it in concrete padded piping systems

Where piping systems are installed under plaster or embedded into concrete, the flexible sections at bends and branches must be padded for the calculated distance H, as well as any branches and elbows included in the affected section.



The assigned tee or elbow pieces must be included in the cushioning. Only elastics materials, such as glass wool, rock wool, foamed plastic or similar may be used for cushioning.

Non-padded pipe

Plastic pipe can also be plastered or concreted in directly. Since the axial stress arising from internal pressure is half as great as the circumferential stress, piping systems can support limited additional axial stress without becoming overloaded. In these cases, the level of stress expected must be calculated. The same is true of any section of pipe between two fixed points where no allowance has been made for changes in length. The load at the fixed points must be calculated and considered when planning the fixed points. The distance between pipe brackets in such cases may have to be reduced from the normal values in order to prevent bowing in the pipeline.

Care must be taken to avoid creating cavities when plastering or concreting in the pipeline, because under unfavorable conditions these can become areas of stress concentration. A rich plaster mixture (1:3 to 1:4) should be used to allow the forces arising from temperature variations to be transmitted away without causing the plaster to crack.

4.6 Pipe bracket distances and installation of pipes

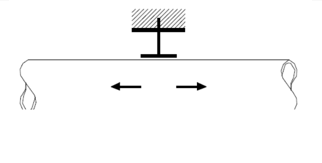
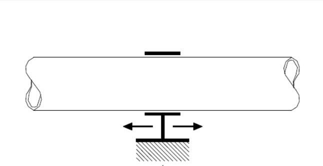
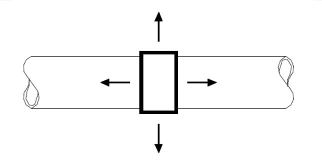
4.6.1 Overview

Installation of plastic pipe

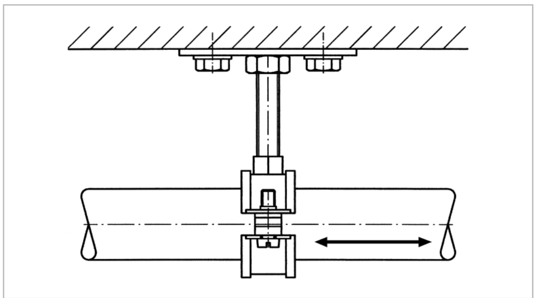
Plastic pipe should be installed using supports designed for use with plastics and should then be installed taking care not to damage or overstress the pipe.

Arranging loose brackets

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.

		
Movement of the pipe in the pipe bracket.	Pipe bracket firmly installed on the pipe, movement in the bracket suspension.	Movement of the pipe in 2 axes.

The inner diameter of the bracket should 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 clamping 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 pipeline changes direction and free movement of the pipe must be allowed.

Arranging fixed points

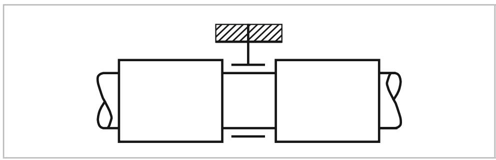
A fixed pipe bracket is a bracket which prevents the pipe from moving in any direction. The purpose of a fixed point is to control system stresses caused by temperature changes.

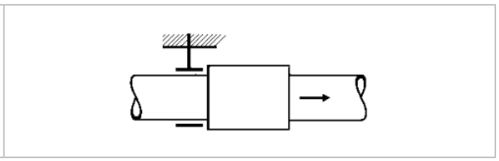
Fixed point design

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.

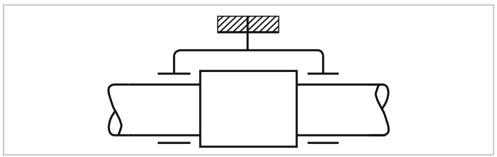
If it is necessary to restrict the length change of the pipe at both ends – as it is usually the case - then the pipe bracket should be arranged between two fittings or designed as a double bracket (two-sided fixed point).

Placing a pipe bracket immediately adjacent to a fitting restricts movement due to changes in length to one direction (one-sided fixed point).





One-sided fixed point



Two-sided fixed point

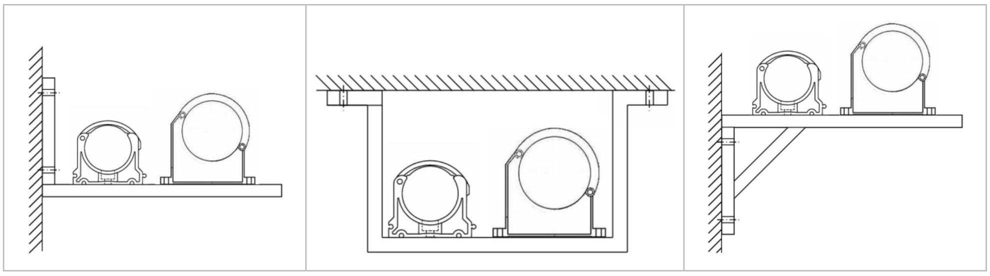
Pipe brackets must be robust and mounted firmly to be able to take up the forces arising from changes in length in the pipeline. Hanging brackets or KLIP-IT pipe brackets are unsuitable for use as fixed points.

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 GF Piping Systems are suitable for all pipe materials used.

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

Starting from the dimension d90, the KLIP-IT brackets must be installed standing, as shown in the following assembly examples. The support distances listed in sections starting with "Pipe bracket spacing for ABS pipes", specified for the KLIP-IT pipe clamps, apply only to this mounting method.



Pipe brackets for post-insulated piping systems

Special insulation clamps are offered for piping which is insulated after installation. These clamps shall be installed according to the clamp manufacturer's instructions.

Using the tables for pipe bracket spacing

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

Pipe which are fixed in the axial direction (fixed installation) must be checked for buckling. In most cases, this leads to a reduction of maximum inner pressure as well as shorter distances between the support brackets. Furthermore, the forces which act on the fixed points must be taken into consideration.

4.6.2 Pipe bracket spacing for ABS pipes

Liquids with a density of 1 g/cm³

d (mm)	DN (Inch)	Pipe bracket spacing L for pipe PN10 / SDR17 / S8 or Class C (mm)				
		≤ 20 °C	30 °C	40 °C	50 °C	60 °C
16	⅜	700	650	600	550	450
20	½	800	700	650	600	500
25	¾	850	800	750	650	600
32	1	1000	900	850	750	650
40	1¼	1100	1000	950	850	750
50	1½	1150	1100	1000	900	800
63	2	1300	1200	1100	1000	850
75	2½	1500	1350	1200	1100	950
90	3	1600	1450	1350	1200	1050
110	4	1800	1650	1550	1350	1200
140	5	2050	1800	1700	1400	1250
160	6	2200	1850	1750	1450	1300
200	7	2300	2050	1850	1550	1350
225	8	2400	2200	1900	1600	1450
250	9	2500	2300	2000	1650	1500
280	10	2650	2400	2100	1700	1600
315	12	2800	2500	2200	1800	1650

For other SDR / PN values or classes, multiply the values given in the table by the following factor:

- SDR11 und PN16: 1.08
- Klasse B: 0.90
- Klasse D: 1.05
- Klasse E: 1.09

The pipe bracket spacing given in the table may be increased by 30 % in the case of vertical pipe runs, i.e., multiply the values given by 1.3.

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Liquids with a density other than 1 g/cm^3

If the liquid to be transported has a density other than 1 g/cm^3, then the bracket spacings in the table above should be multiplied by the factor given in the following table to obtain different support spacings.

Density of medium (g/cm^3)	Type of medium	Factors for bracket spacing
1.00	Water	1.00
1.25	Other media	0.96
1.50		0.92
1.75		0.88
2.00		0.84
≤ 0.01	Gaseous media	1.30

4.6.3 Bracket spacing for PE pipe

Liquids with a density of 1 g/cm³

d (mm)	Bracket spacing L for SDR11 pipe (mm)				
	≤ 20 °C	30 °C	40 °C	50 °C	60 °C
16	500	450	450	400	350
20	575	550	500	450	400
25	650	600	550	550	500
32	750	750	650	650	550
40	900	850	750	750	650
50	1050	1000	900	850	750
63	1200	1150	1050	1000	900
75	1350	1300	1200	1100	1000
90	1500	1450	1350	1250	1150
110	1650	1600	1500	1450	1300
125	1750	1700	1600	1550	1400
140	1900	1850	1750	1650	1500
160	2050	1950	1850	1750	1600
180	2150	2050	1950	1850	1750
200	2300	2200	2100	2000	1900
225	2450	2350	2250	2150	2050
250	2600	2500	2400	2300	2100
280	2750	2650	2550	2400	2200
315	2900	2800	2700	2550	2350
355	3100	3000	2900	2750	2550
400	3300	3150	3050	2900	2700
450	3550	3400	3300	3100	2900
500	3900	3650	3500	3350	3100

For other SDR values, multiply the values by the following factors:

- SDR17 und SDR17.6: 0.91
- SDR7.4: 1.07

The pipe bracket spacing given in the table may be increased by 30 % in the case of vertical pipe runs, i.e., multiply the values given by 1.3.

Liquids with a density other than 1 g/cm³

If the liquid to be transported has a density other than 1 g/cm³, then the bracket spacings in the table above should be multiplied by the factor given in the following table to obtain different support spacings.

Density of medium (g/cm³)	Type of medium	Factors for bracket spacing
1.00	Water	1.00
1.25 1.50 1.75 2.00	Other media	0.96 0.92 0.88 0.84
≤ 0.01	Gaseous media	1.30 for SDR11 1.21 for SDR7.4

4.6.4 Bracket spacing for PP pipe

PP-H pipe for liquids with a density of 1 g/cm^3

d (mm)	Bracket spacing L for SDR11 pipe (mm)						
	≤ 20 °C	30 °C	40 °C	50 °C	60 °C	70 °C	80 °C
16	650	625	600	575	550	525	500
20	700	675	650	625	600	575	550
25	800	775	750	725	700	675	650
32	950	925	900	875	850	800	750
40	1100	1075	1050	1000	950	925	875
50	1250	1225	1200	1150	1100	1050	1000
63	1450	1425	1400	1350	1300	1250	1200
75	1550	1500	1450	1400	1350	1300	1250
90	1650	1600	1550	1500	1450	1400	1350
110	1850	1800	1750	1700	1600	1500	1400
125	2000	1950	1900	1800	1700	1600	1500
140	2100	2050	2000	1900	1800	1700	1600
160	2250	2200	2100	2000	1900	1800	1700
180	2350	2300	2200	2100	2000	1900	1800
200	2500	2400	2300	2200	2100	2000	1900
225	2650	2550	2450	2350	2250	2150	2000
250	2800	2700	2600	2500	2400	2300	2150
280	2950	2850	2750	2650	2550	2450	2300
315	3150	3050	2950	2850	2700	2600	2450
355	3350	3250	3150	3000	2850	2750	2600
400	3550	3450	3350	3200	3050	2900	2750
450	3800	3700	3600	3450	3300	3100	2950
500	4100	4000	3850	3700	3500	3350	3150

For other SDRs, multiply the values given in the table by the following factor:

- SDR17 and SDR17.6: 0.91

The pipe bracket spacing given in the table may be increased by 30 % in the case of vertical pipe runs, i.e. multiply the values given by 1.3.

PP-H pipe for liquids with a density other than 1 g/cm^3

If the liquid to be transported has a density not equal 1 g/cm^3, then the bracket spacing in the table above should be multiplied by the factor given in the following table to obtain different support spacings.

Density of medium (g/cm^3)	Type of medium	Type of medium
1.00	Water	1.00
1.25 1.50 1.75 2.00	Other media	0.96 0.92 0.88 0.84
≤ 0.01	Gaseous media	1.30 for SDR11 1.47 for SDR17.6 and SDR17

PP-R pipe for liquids with a density of 1 g/cm³

d (mm)	Bracket spacing L for SDR11 pipe (mm)						
	≤ 20 °C	30 °C	40 °C	50 °C	60 °C	70 °C	80 °C
16	500	475	450	425	425	400	375
20	525	500	500	475	450	425	425
25	600	575	575	550	525	500	500
32	725	700	675	650	650	600	575
40	825	800	800	750	725	700	650
50	950	925	900	875	825	775	750
63	1100	1075	1050	1025	975	925	900
75	1150	1150	1100	1050	1000	975	950
90	1250	1200	1150	1150	1100	1050	1000
110	1400	1350	1300	1300	1200	1125	1050
125	1500	1450	1450	1350	1300	1200	1150
140	1600	1550	1500	1450	1350	1275	1200
160	1700	1650	1600	1500	1450	1350	1300
180	1750	1750	1650	1600	1500	1425	1350
200	1900	1800	1750	1650	1600	1500	1450
225	2000	1900	1850	1750	1700	1600	1500
250	2100	2050	1950	1900	1800	1700	1600
280	2950	2850	2750	2650	2550	2450	2300
315	2350	2300	2200	2150	2050	1950	1850
355	2500	2425	2350	2250	2125	2050	1950
400	2650	2575	2500	2400	2275	2175	2050
450	2850	2775	2700	2575	2475	2325	2200
500	3075	3000	2875	2775	2625	2500	2350

For other SDRs, multiply the values given in the table by the following factor:

- SDR17 and SDR17.6: 0.91

The pipe bracket spacing given in the table may be increased by 30 % in the case of vertical pipe runs, i.e., multiply the values given by 1.3.

PP-R pipe for liquids with a density other than 1 g/cm³

If the liquid to be transported has a density not equal 1 g/cm³, then the bracket spacing in the table above should be multiplied by the factor given in the following table to obtain different support spacings.

Density of medium (g/cm³)	Type of medium	Factors for bracket spacing
1.00	Water	1.00
1.25 1.50 1.75 2.00	Other media	0.96 0.92 0.88 0.84
≤ 0.01	Gaseous media	1.30 for SDR11 1.47 for SDR17.6 and SDR17

4.6.5 Bracket spacing for PVC pipe

PVC-U pipe for liquids with a density of 1 g/cm³

d (mm)	DN (Inch)	Bracket spacings L for pipe SDR21 / S10 / PN10 (mm)				
		≤ 20 °C	30 °C	40 °C	50 °C	60 °C
16	⅜	950	900	850	750	600
20	½	1100	1050	1000	900	700
25	¾	1200	1150	1050	950	750
32	1	1350	1300	1250	1100	900
40	1¼	1450	1400	1350	1250	1000
50	1½	1600	1550	1500	1400	1150
63	2	1800	1750	1700	1550	1300
75	2½	2000	1900	1850	1700	1450
90	3	2200	2100	2000	1850	1550
110	4	2400	2300	2250	2050	1750
125		2550	2450	2400	2200	1850
140	5	2700	2600	2500	2300	1950
160	6	2900	2800	2700	2500	2100
180		3100	2950	2850	2650	2200
200		3250	3150	3000	2800	2350
225	8	3450	3300	3200	2950	2500
250		3650	3500	3350	3100	2600
280	10	3750	3700	3550	3300	2750
315	12	4100	3900	3750	3500	2950
355	14	4300	4200	4000	3700	3100
400	16	4600	4450	4250	3950	3300

For other SDR and PN levels, the values must be multiplied with the following factors:

- SDR51 / S25 / PN4: 0.83
- SDR34.3 / S16.7 / PN6: 0.90
- SDR13.6 / S 6.3 / PN16: 1.08
- SDR11 / S 5 / PN20: 1.15

The pipe bracket spacing given in the table may be increased by 30 % in the case of vertical pipe runs, i.e. multiply the values given by 1.3.

PVC-U pipe for liquids with a density other than 1 g/cm³

If the liquid to be transported has a density other than 1 g/cm³, then the bracket spacings in the table above should be multiplied by the factor given in the following table to obtain different support spacings.

Type of medium	Type of medium	Factors for bracket spacing
1.00	Water	1.00
1.25 1.50 1.75 2.00	Other media	0.96 0.92 0.88 0.84
≤ 0.01	Gaseous media	1.42 für SDR21, S8 und PN10 1.30 für SDR13.6, S6.3 und PN16 1.20 für SDR11, S5 und PN20

PVC-C pipe for liquids with a density of 1 g/cm³

d (mm)	Bracket spacing L for pipe SDR21 / S10 / PN10 (mm)						
	≤ 20 °C	30 °C	40 °C	50 °C	60 °C	70 °C	80 °C
16	1000	950	900	850	750	675	600
20	1150	1100	1025	950	875	775	700
25	1200	1150	1100	1000	900	800	700
32	1350	1250	1200	1100	1000	900	800
40	1500	1400	1300	1250	1150	1050	900
50	1650	1600	1500	1400	1300	1200	1100
63	1850	1750	1650	1600	1500	1350	1250
75	2050	1950	1850	1750	1650	1500	1350
90	2250	2100	2000	1900	1800	1650	1500
110	2500	2350	2200	2100	1950	1800	1650
125	2650	2500	2350	2250	2100	1950	1750
140	2800	2650	2500	2350	2200	2050	1850
160	3000	2850	2700	2550	2400	2200	2000
180	3150	3000	2850	2700	2500	2300	2100
200	3350	3150	3000	2850	2650	2450	2200
225	3550	3350	3200	3000	2800	2600	2350
250	3750	3550	3350	3150	3000	2750	2500
280	3950	3750	3550	3350	3150	2900	2650
315	4200	4000	3750	3550	3350	3050	2800
350	4450	4250	4000	3800	3550	3250	2950
400	4750	4500	4250	4000	3750	3450	3150

For other SDR levels, the values must be multiplied by the following factor:

- SDR13.6 / S6.3 / PN16: 1.08
- SDR11 / S5 / PN20: 1.12

The pipe bracket spacing given in the table may be increased by 30 % in the case of vertical pipe runs, i.e., multiply the values given by 1.3.

PVC-C pipe for liquids with a density other than 1 g/cm³

If the liquid to be transported has a density not equal 1 g/cm³, then the bracket spacing in the table above should be multiplied by the factor given in the following table to obtain different support spacings.

Density of medium (g/cm³)	Type of medium	Factors for bracket spacing
1.00	Water	1.00
1.25 1.50 1.75 2.00	Other media	0.96 0.92 0.88 0.84
≤ 0.01	Gaseous media	1.42 for SDR21, S8 and PN10 1.30 for SDR13.6, S6.3 and PN16 1.20 for SDR11, S5 and PN20

4.6.6 Bracket spacing for PVDF pipes

Liquids with a density of 1 g/cm³

d (mm)	Bracket spacings L for pipe PN16 / SDR21 (mm)									
	≤ 20 °C	30 °C	40 °C	50 °C	60 °C	70 °C	80 °C	100 °C	120 °C	140 °C
16	725	700	650	600	575	550	500	450	400	300
20	850	800	750	750	700	650	600	500	450	400
25	950	900	850	800	750	700	675	600	500	450
32	1100	1050	1000	950	900	850	800	700	600	500
40	1200	1150	1100	1050	1000	950	900	750	650	550
50	1400	1350	1300	1200	1150	1100	1000	900	750	600

d (mm)	Bracket spacings L for pipe PN10 / SDR33 (mm)									
	≤ 20 °C	30 °C	40 °C	50 °C	60 °C	70 °C	80 °C	100 °C	120 °C	140 °C
63	1400	1350	1300	1250	1200	1150	1100	950	800	650
75	1500	1450	1400	1350	1300	1250	1200	1050	850	700
90	1600	1550	1500	1450	1400	1350	1300	1100	950	850
110	1800	1750	1700	1650	1550	1500	1450	1250	1100	950
125	1900	1850	1800	1700	1650	1600	1500	1350	1200	1000
140	2000	1950	1900	1800	1750	1700	1600	1450	1250	1050
160	2150	2100	2050	1950	1850	1800	1700	1550	1350	1150
180	2300	2200	2150	2050	1950	1900	1800	1600	1400	1200
200	2400	2350	2250	2150	2100	2000	1900	1700	1500	1300
225	2550	2500	2400	2300	2200	2100	2000	1800	1600	1400
250	2650	2600	2500	2400	2300	2200	2100	1900	1700	1500
280	2850	2750	2650	2550	2450	2350	2250	2000	1800	1600
315	3000	2950	2850	2750	2600	2500	2400	2150	1900	1650
355	3200	3100	3000	2850	2750	2650	2500	2250	2000	1750
400	3400	3300	3200	3050	2950	2800	2650	2400	2100	1800
450	3650	3550	3450	3300	3200	3000	2850	2600	2250	1900

For other PN and SDR levels, the values in the table above (diameter ≥ d63) must be multiplied by the following factors:

- PN16 / SDR21: 1.08

Pipe bracket spacing for lines running vertically can be increased by 30 % with respect to the values in the table, i.e., table values multiplied by 1.3.

Liquids with a density other than 1 g/cm³

If the liquid to be transported has a density not equal 1 g/cm³, then the bracket spacing in the table above should be multiplied by the factor given in the following table to obtain different support spacings.

Density of medium (g/cm³)	Type of medium	Factors for bracket spacing
1.00	Water	1.00
1.25 1.50 1.75 2.00	Other media	0.96 0.92 0.88 0.84
≤ 0.01	Gaseous media	1.48 für SDR33 und PN10 1.36 für SDR21 und PN16

4.6.7 Bracket spacing for ECTFE pipes

Liquids with a density of 1 g/cm³

d (mm)	Bracket spacings L for pipe PN10 / SDR21 (mm)										
	≤ 20 °C	30 °C	40 °C	50 °C	60 °C	70 °C	80 °C	90 °C	100 °C	110 °C	120 °C
20	750	650	600	550	500	450	400	400	350	350	300
25	850	700	650	600	550	500	450	400	400	350	350
32	950	850	750	700	650	600	550	500	450	450	400
40	1050	950	850	750	700	650	600	550	500	500	450
50	1250	1100	1000	900	800	750	700	650	600	550	500
63	1400	1200	1100	1000	900	850	750	700	650	600	550
75	1550	1350	1200	1100	1000	950	850	800	750	700	650
90	1700	1500	1350	1250	1150	1050	950	900	850	800	700
110	1850	1650	1550	1450	1300	1200	1100	1000	950	900	800

Pipe bracket spacing for lines running vertically can be increased by 30 % with respect to the values in the table, i.e. table values multiplied by 1.3.

Liquids with a density other than 1 g/cm³

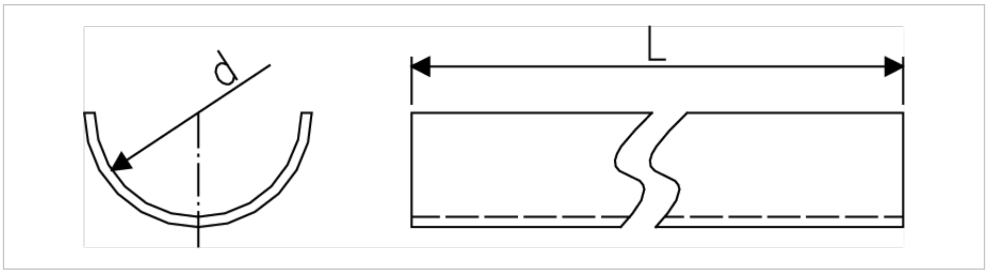
If the liquid to be transported has a density not equal 1 g/cm³, then the bracket spacing in the table above should be multiplied by the factor given in the following table to obtain different support spacings.

Density of medium (g/cm³)	Type of medium	Factors for bracket spacing
1.00	Water	1.00
1.25	Other media	0.96
1.50		0.92
1.75		0.88
2.00		0.84
≤ 0.01	Gaseous media	1.36 for SDR21 and PN10

4.6.8 Bracket spacing for plastic pipe in carriers

Continuous support may be more economical and practicable than pipe brackets for horizontal or vertical piping systems, especially for small diameter pipe and in areas with high temperatures.

In order to avoid inadmissible loadings on the piping systems, ensure during installation that the carriers in the pipe brackets overlap.



Carriers, diameter (d) matched to pipe diameter, length (L) of carrier

The following table indicates the support spacings when using carriers. These values apply regardless of the type of pipe material or the temperature.

d (mm)	Support spacing when using carriers (mm)
16	1600
20	1750
25	1900
32	2000
40	2150
50	2300
63	2500
75	2600
90	2750
110	2900

4.7 Internal pressure and leak test

4.7.1 Introduction to pressure testing

Overview of the different testing methods

Testing method	Internal pressure test			Leak test	
Medium	Water	Gas[1]	Compressed air[1]	Gas/air (oil-free)	Gas/air (oil-free)
Type	Incompressible	Compressible	Compressible	Compressible	Compressible
Test pressure (overpressure)	$P_{p\,(perm)}$ or $0.85 \cdot P_{p\,(perm)}$	Operating pressure + 2 bar	Operating pressure + 2 bar	0.5 bar	1.5 bar
Hazard potential during pressure test	Low	High	High	Low	Medium
Material	All plastics	ABS, PE	PB, PE	All plastics	ABS
Informative value	High: Proof of resistance to pressure including tightness against test medium	High: Proof of resistance to pressure including tightness against test medium	High: Proof of resistance to pressure including tightness against test medium	Low	Medium

[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 pipeline, 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.

The following comparison attempts to point out the difference between water and air as a test medium:

> Water is an incompressible medium, i.e. setting a 1 m PVDF pipe with a diameter of d160 under a pressure of 3 bar results in an energy of approx. 1 joule. In contrast, air is a compressible medium. The same pipe with test pressure of 3 bar already stores an energy of 5,000 joule. If there were a failure during the internal pressure test, the water-filled pipe would jump up 0.02 m, the air-filled pipe 110 m.

Fracture behavior of plastics

In case of a failure, thermoplastic materials show different behaviors. Hence, PE and PB exhibit a ductile behavior (and ABS slightly lower), so that brittle fracture cannot occur.

Nevertheless, the following safety precautions must be taken into consideration during the internal pressure test. As mentioned before, the pressure test is the first loading placed on the pipeline and is intended to uncover any existing processing faults (e.g. insufficient fusioning).

Gas leak-tightness cannot be demonstrated by a water pressure test, not even with increased test pressure!

4.7.2 Internal pressure test with water or a similar incompressible test medium

Overview

The internal pressure test is done when installation work has been completed and presupposes an operational pipeline 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 recommended methods for performing the internal pressure test.

Object	Pre-test	Main test
Test pressure $_{pp}$ (depends on the pipe wall temperature and the permissible test pressure of the built-in components, see the section "Determining the test pressure")	$\leq P_{p\,(perm)}$	$\leq 0.85\ P_{p\,(perm)}$
Test duration (depends on the length of the pipeline 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 progression must be recorded)	At least 3 checks, distributed over the test duration with restoring the test pressure	At least 2 checks, distributed over the test duration 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)
PVC-U	0.5
PVC-C	0.5
ABS	0.6
PP	0.8
PE	1.2
PB	1.4
PVDF	0.8
ECTFE	0.9

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 pipeline to be tested contains compensators, it has an influence on the expected axial forces on the fixed points of the pipeline. 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 pipeline (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 exit of the medium or any pollution of the inside of the valve.

4.7.3 Filling the pipeline

Before starting with the internal pressure test, the following points must be checked:
- Was installation done according to the available plans?
- All pressure relief devices and flap traps mounted in the flow direction?
- All end valves shut?
- Valves in front of other devices are shut to protect against pressure?
- Visual inspection of all joints, pumps, measurement devices and tanks?
- Has the waiting period after the last fusion/cementing been observed?

Now the pipeline 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 pipeline and these should be open when filling the system. Flushing velocity should be at least 1 m/s.

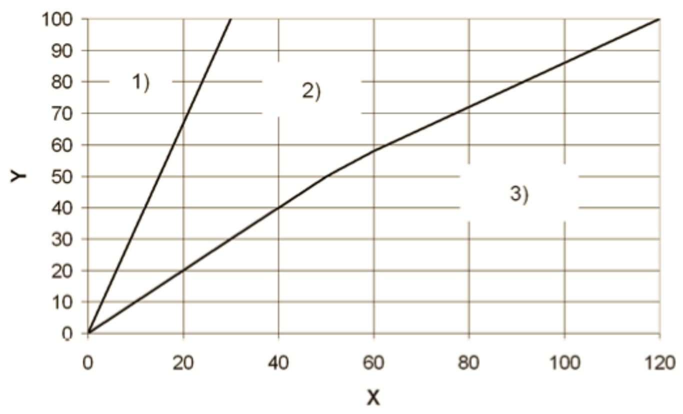
Reference values for the filling volume are given in the table below.

DN (mm)	V (l/s)	DN (mm)	V (l/s)
≤ 80	0.15	250	2.0
100	0.3	300	3.0
150	0.7	400	6.0
200	1.5	500	> 9.0

Adequate time should be allowed between filling and testing the pipeline, so that the air contained in the piping system can escape via the vents: approx. 6 - 12 h, depending on the nominal diameter.

Applying the test pressure

The test pressure is applied according to the diagram. Here it is important that the pressure increase rate does not cause any water hammering!



Y Test pressure (%)
X Time for pressure increase (min)
1) Pressure increase rate up to DN100 mm
2) Range of pressure increase rates between DN100 and DN400 mm
3) Values for pressure increase rate DN500 and greater is: 500/DN (bar/10 min)

Determining the test pressure

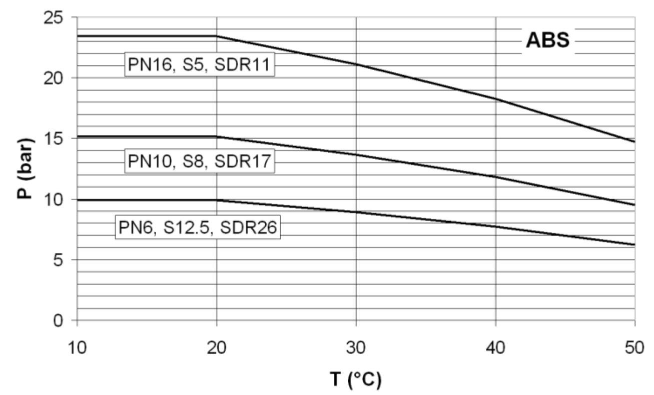
The permissible test pressure is calculated according to the following formula:

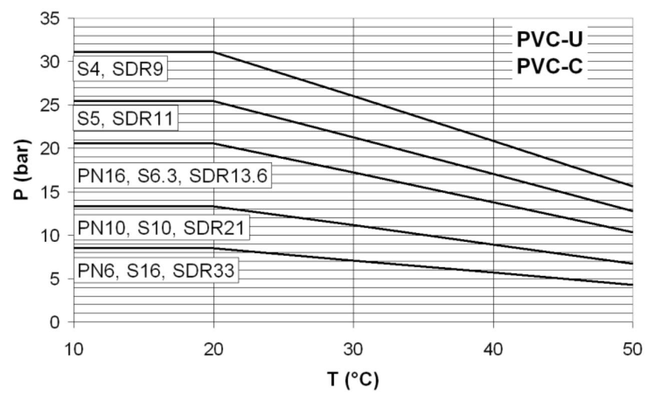
$$P_{p(zul)} = \frac{1}{SDR} \cdot \frac{20 \cdot \sigma_{v(T,\,100\,h)}}{S_p \cdot A_G}$$

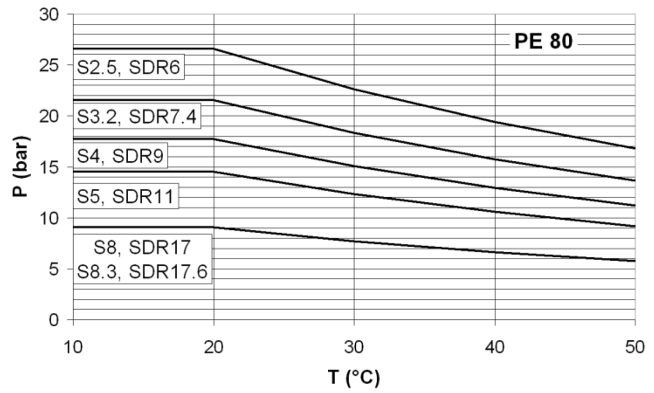
$\sigma_{v(T,\,100\,h)}$ Long-term creep strength for pipe wall temperature T_R (at t = 100 h)
S_p Minimum safety factor for long-term creep strength
A_G Processing or geometry-specific factor that reduces the allowable test pressure
T_R Pipe wall temperature: average value of test medium temperature and pipe surface temperature

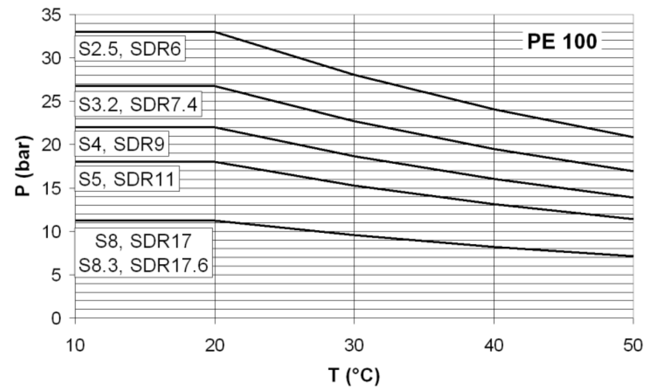
Material	S_p Minimum safety factor DVS 2210-1 Suppl.2
ABS	1.6
PE80, PE100	1.25
PP-H	1.8
PP-R	1.4
PVC-U, PVC-C	2.5
PVDF	1.4
ECTFE	1.6

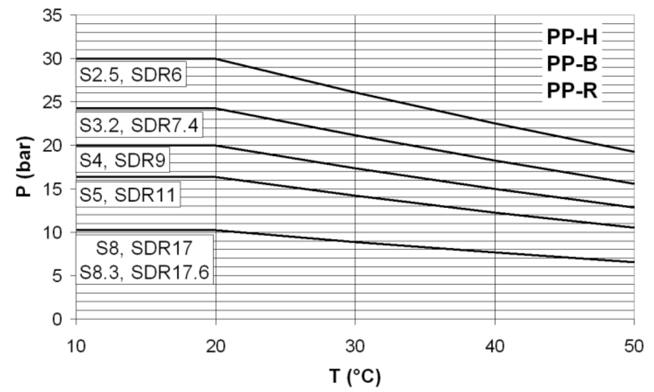
To make things easier, the permissible test pressures can be taken directly from the following diagrams.

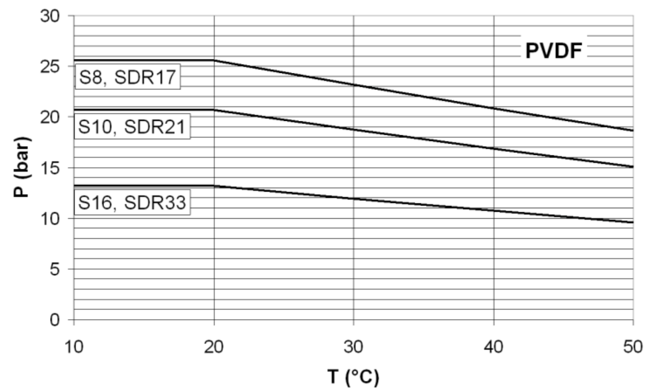


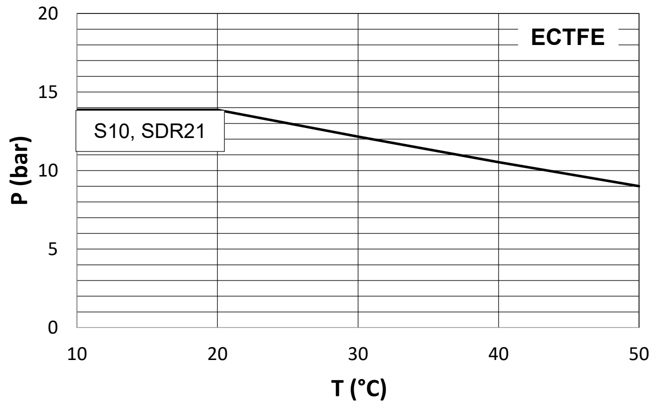












P Permissible test pressure (bar)
T Pipe wall temperature (°C)

Checks during testing

The following measurement values must be recorded consistently during testing:

- Internal pressure at the absolute lowest point of the pipeline
- Medium and ambient temperature
- Water volume input
- Water volume output
- Pressure drop rates

4.7.4 Internal pressure test and leak-tightness test of ABS piping systems with gas/air as test medium (compressible medium)

Overview

Usually the 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.

Compensators

If the pipeline to be tested contains compensators, it has an influence on the expected axial forces on the fixed points of the pipeline. 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.

Valves

When using a valve at the end of a pipeline (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 exit of the medium or any pollution of the inside of the valve.

Minimum waiting times for the internal pressure test

Before carrying out the pressure test, observe the minimum waiting times according to the following table:

Ambient temperature	Waiting time
10 - 30 °C	Min. 48 hours

Performing the internal pressure test

The test pressure shall be least 2 bar higher than the operating pressure, but shall not exceed the nominal pressure PN of the installed piping system. Any components with a lower PN than the rest of the piping systems have to be taken into account. The test temperature shall be between 10 and 30 °C.

The piping systems must be free from any grease or paint.

Only oil-free air or inert gases such as nitrogen should be used as the test medium. No refrigerant gases, such as R22, may be used.

Once the pressure in the system has stabilized, hold the pipeline under the test pressure for at least 15 minutes. If a drop in pressure is observed, inspect all the joints, flanges, etc. for leaks using a foam-building agent. A soap solution which can be removed simply with water after the test is recommended.

⚠ Commercial leak detection sprays can cause stress cracks in plastics. If these sprays are used, remove any residues after testing.

⚠ The leak-tightness of valves against gases is not representative of the leak-tightness of valves against a liquid. Therefore, if a GF Piping Systems valve shows a leak during internal pressure testing with a gas, it is recommended to reduce the pressure to 1.5 bar and re-inspect the valves.

Leak-tightness test with gas/air

To check the leak-tightness shortly after installation, a test pressure of up to 1.5 bar with a minimum waiting time of 3 hours after the last cementing applies.

4.7.5 Internal pressure test of compressed-air piping systems

Overview

For practical reasons, this testing is done with compressed air. The pressure test follows DVGW G 469. The pressure test for pipeline lengths less than 500 m using air A3 based on visual inspection is described below. More details are available in the DVGW guideline.

Compressible media like compressed air under internal pressure.

In case of failure: life-threatening danger during internal pressure testing due to explosive escape of the medium.

- → The area around the pipeline under test pressure is to be clearly restricted for access only by persons assigned with the testing.
- → Required control equipment is to be placed at a safe distance.
- → The testing should be timed so that there are as few persons as possible in the immediate blocked-off area.
- → Additional signs (e.g. Do Not Enter or Warning! Gas pressure tests!) should be placed particularly at the entrances to the hazard area. If necessary, persons in neighboring buildings should be informed.

Testing procedure

The test pressure shall be least 2 bar higher than the permissible operating pressure. If this is not possible because of insufficient compressor output, then the maximum compressor pressure shall be used.

The piping systems must be free from any grease or paint.

The test pressure is applied to the installed pipeline with a maximum increase in pressure of 3 bar/min (risk of water hammer!). Hold the pipeline under the test pressure until all connection parts of the pipeline like flanges, unions, valves, etc. are inspected for tightness using a foam-building agent. A soap solution, which can be removed simply with water after the test, is best. It is recommended to subsequently reduce the test pressure to 2 bar and repeat the test using a foam-building agent.

Leak test with gas as test medium (compressible medium) and maximum test pressure of 0.5 bar

If it is not possible to do an internal pressure test with water (e.g., pipeline must be kept dry), a leak test can be carried out with slight overpressure. For safety reasons, the test pressure must then be limited to maximum 0.5 bar overpressure. During the leak test, all joints must be sprayed with a foam-building agent and checked. A soap solution, which can be removed simply with water after the test, is best. Since the efficiency of the leak test is significantly limited due to the low load, it is recommended to use it preferably for systems with operating pressures below 0.5 bar.

4.8 Modifications, repairs, commissioning

4.8.1 Modifications and repairs

The following safety measures are to be observed when modifying or repairing piping systems:

- Wear protective clothing
- Drain the respective pipeline section completely
- Rinse the pipe section
- Protect against dripping
- Clean and dry the joints
- Perform the tasks by trained personnel

Modifications and repairs to the piping system must not cause mechanical weakening of the piping system.

To ensure the operational safety of the piping system following a modification or a repair, an internal pressure test should be done.

4.8.2 Commissioning

When putting a pipeline into operation for the first time, it is not only placed under internal pressure load, but also under temperature effect. The thermal stress or expansions were not simulated during testing.

We recommend an initial inspection at the earliest 3 days, at the latest 7 days, after commissioning and recording the results.

The checks during the inspection shall cover the following items:

- Visual inspection
- Flange joints, unions, valves (leak-proof)
- Condition and function of safety and leak detection equipment

The remaining inspections of the piping system, together with the general checks, shall be performed by the operating personnel according to the operating instructions.

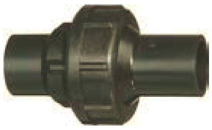
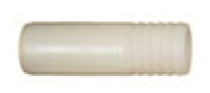
5 Jointing technology – Mechanical, cementing and welding

5.1 Mechanical joints

5.1.1 Overview

Of the many diverse solutions offered by GF Piping Systems for mechanical joints, the following table offers information on the conventional methods used in industrial piping system construction:

Overview of mechanical connections

Figure	Connection type	Gasket	Connection of plastic with
	Flange connection	O-ring Profile seal High Purity gasket	Plastic or metal
	Union	O-ring	Plastic (same or different materials)
	Adaptor union	O-ring	Metal
	Adaptor pipe fitting	PTFE tape Thread sealing cord	Plastic or metal
	Threaded fitting	PTFE tape Thread sealing cord	Plastic (same or different materials)
	Hose connection		Hose
	Victaulic® adaptor	Lip seal	Steel
	SYGEF Plus sanitary adaptor	Special seal	Stainless steel
	Universal coupling	Special seal	Plastic or metal

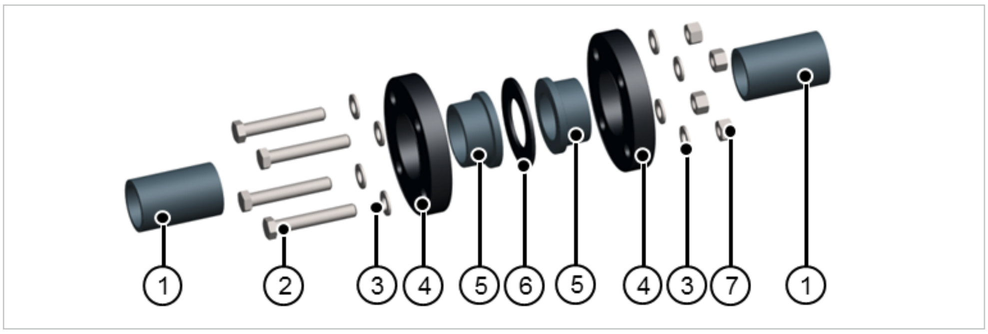
Thread types

The following thread types are used:

Designation of the thread	Standard	Description	Application
Rp	ISO 7-1, EN 10226-1	Parallel internal thread, where pressure-tight joints are made on the threads	Transitional and threaded fittings, Malleable cast iron fittings
Rc	ISO 7-1, EN 10226-2	Tapered internal thread, where pressure-tight joints are made on the threads	JIS connections
R	ISO 7-1, EN 10226-1	Tapered male thread, where pressure-tight joints are made on the threads	Transitional and threaded fittings, Steel pipe
G	ISO 228-1	Parallel internal or male threads, where pressure-tight joints are not made on the threads, dimension up to and including 4"	Unions (with coupling nut)
NPT = National (American Standard) Pipe Taper	ASTM F 1498	Tapered internal or male threads, where pressure-tight joints are made on the threads	Transitional and threaded fittings
Acme thread	Special thread	Fastening thread for unions made of ABS, PVC-U and PVC-C d75, d90 and d110	Unions
Buttress thread	Special thread	Fastening thread for unions made of PE, PP and PVDF d75, d90 and d110	Unions

5.1.2 Flange connections

Flanges with sufficient thermal and mechanical stability must be used. The different flange types by GF 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 Flange
⑤ Valve end/flange adapter
⑥ Flange seal
⑦ Nut

Comparison of flange connections

Flange connection	Properties
PP-V flange	• Corrosion-free all-plastic flange made of polypropylene PP-GF30 (fiber-glass reinforced) • High chemical resistance (hydrolysis-resistant) • Maximum possible break resistance due to elasticity (deforms if it is tightened too much) • Use for ambient temperatures up to 80 °C • The temperature of the medium is restricted by the material of the plastic piping system (ABS, PVC-U, PVC-C, PP or PE) • For PVDF up to 140 °C media temperature, the ambient temperature is limited to at most 40 °C • UV-stabilized • With integrated bolt-fixing • Self-centering aid for the flanges on the flange adapter • Symmetric design allows assembly on either side: A "reverse" installation is never possible. All important information is readable • V-groove (patented) • Even distribution of forces across the flange (preserves life expectancy of components) • Supports a longer-lasting torque for a safe joint
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) • Maximum ambient temperature 80 °C • UV-stabilized
PVC flange	• PVC-U flanges may be used as long as the flow medium or the ambient temperature does not exceed a temperature of 45 °C. • At higher temperatures, the flanges could distort over time. • At temperatures above 45 °C, flanges with sufficient thermal and mechanical stability must be used. These requirements are met by the PP-V and PP steel flanges by GF Piping Systems.
Blind flange	• Combination of a backing flange and an end blank. The end blanks are available in PP-H and PE materials. • Combines end blanks in the dimensions d63 to d315 with the PP-V backing flange. • The dimensions d355 to d630 are combined with a backing flange made of PP with steel inlay. • With the blanking flange set, the piping system can be closed off using the same material. • If the piping system is extended, the backing flange can be used again, cutting down on additional costs. • Suitable for pressure piping • Easy assembly of the blank flange set: The end blank is centered on the inner diameter of the backing flange.

Creating flange connections

When making a flange connection, the following points have to be taken into account:

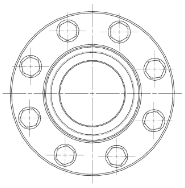
Usage information

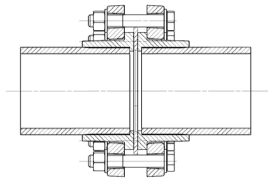
Backing flanges are identified with the following pictograms of the usable flanges:

	
Socket fusion	Butt fusion

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 adapter, valve end or fixed flange, gasket, as well as backing flange, must be aligned centered on the pipe axis.
- Before pre-tightening the bolts, the jointing faces must be flush with each other and must fit tightly against the gasket. Pulling badly aligned flanges together within the flange connection must to be strictly avoided because of the resulting tensile stress.

Selecting and handling bolts

- The length of the bolts should be selected in such a way that the bolt thread does not protrude more than 2 to 3 turns of the thread at the nut. Washers must be used at the bolt head as well as the nut.
  - 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 “Bolt tightening torque guidelines for ISO flange connections”. 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 necesary, retightened.

i For more information on flange connections, see DVS 2210-1 Supplement 3.

Tightening the bolts using a torque wrench

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.

i In the area of flexible sections and expansion loops, no bolt connections or flange connections should be used since the bending stress may cause leaks.

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

The indicated torques are recommended by GF 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 GF Piping Systems are dimensioned for these upper limits.

Pipe outer diameter d (mm)	Nominal diameter DN (mm)	No. of bolts	For PROGEF PP, SYGEF PVDF, SYGEF ECTFE, ecoFIT PE, ABS, PVC-U/C metric systems, with PP-Steel, PP-V and PVC-U flanges (Nm)						
			Flat gasket, lubed	Flat gasket, unlubed	Profile gasket, lubed	Profile gasket, unlubed	O-ring, lubed	O-ring, unlubed	SYGEF HP gasket unlubed
d16	DN10	4	10	13	10	13	10	13	
d20	DN15	4	10	13	10	13	10	13	
d25	DN20	4	10	13	10	13	10	13	14
d32	DN 25	4	15	20	10	13	10	13	16
d40	DN 32	4	20	26	15	20	15	20	20
d50	DN 40	4	25	33	15	20	15	20	26
d63	DN 50	4	35	46	20	26	20	26	34
d75	DN 65	4	50	65	25	33	25	33	38
d90	DN 80	8	30	39	15	20	15	20	45
d110, 125	DN 100	8	35	46	20	26	20	26	30
d140	DN 125	8	45	59	25	33	25	33	
d160, 180	DN 150	8	60	78	35	46	30	39	49
d200, 225	DN 200	8	70	91	45	59	35	46	65
d250, 280	DN 250	12	65	85	35	46	30	39	65
d315	DN 300	12	90	117	50	65	40	52	76
d355	DN 350	16	90	117	50	65			223
d400	DN 400	16	100	130	60	78			176
d450, 500	DN 500	20	190	247	70	91			264
d560, 630	DN 600	20	220	286	90	117			

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Bolt tightening torque guidelines for ASME flange connections with PP-V, PP-steel and PVC flanges

Flange size (inch)	Nominal diameter DN (mm)	No. of bolts	For PROGEF PP, SYGEF PVDF, SYGEF ECTFE and ecoFIT PE systems, with PP-Steel and PP-V flanges (ft-lb)				
			Flat gasket, lubed	Flat gasket, unlubed	SYGEF HP gasket, unlubed	Profile gasket, lubed	Profile gasket, unlubed
½"	DN15	4	7	9		5	7
¾"	DN20	4	9	12	10	7	9
1"	DN25	4	11	14	12	9	12
1¼"	DN32	4	14	18	15	10	13
1½"	DN40	4	16	21	19	13	17
2"	DN50	4	28	36	25	19	25
2½"	DN65	4	43	56	28	21	27
3"	DN80	4	47	61	33	25	33
4"	DN100	8	30	39	22	16	21
6"	DN150	8	45	59	36	25	33
8"	DN200	8	52	68	48	33	43
10"	DN250	12	56	73	48	31	40
12"	DN300	12	64	83	56	37	48
14"	DN350	16	66	75	165	49	64
16"	DN400	16	75	80	130	45	59
18"	(DN450)	16	120	132	195	56	73
20"	DN500	20	140	154		60	78

Please observe the special bolt tightening torques listed for butterfly valves. See also the section "Planning fundamentals for butterfly valves, hand-operated".

Installation recommendation:

Either the bolt or the nut, and preferably both, should be zinc-plated to ensure minimal friction.

- zinc-on-zinc, with or without lube
- zinc-on-stainless-steel, with or without lube
- stainless-on-stainless, with lube only

Cadmium-plated fasteners are also acceptable with or without lubrication. Galvanized and carbon-steel fasteners are not recommended. Use a copper-graphite anti-seize lubricant to ensure smooth engagement and the ability to disassemble and reassemble the system easily.

Length of bolts

In practice, it is often difficult to specify the correct bolt length for flange connections. 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 adapter) (2x)
- Valve installation length, if applicable (1x)

The following tables are useful in determining the necessary bolt length. Due to the various combinations of the individual components, only thicknesses of the individual parts of flange connections can be provided. However, you simply add them together to determine the necessary bolt length.

According to DVS 2210-1, you should dimension the necessary bolt length for flange connections so that 2-3 turns of the thread protrude beyond the nut.

Online tool "Bolt lengths and tightening torques" located at www.gfps.com/tools

Washer (mm)	Thickness (mm)
DN10–DN25	3
DN32–DN600	4

Nuts (mm)			Pitch (mm)	Height of nut (thickness) (mm)
DN10–DN25	M12	WAF 19 (18)	1.7	10.4
DN32–DN125	M16	WAF 24	2.0	14.1
DN150–DN350	M20	WAF 30	2.5	20.2
DN400–DN500	M24	WAF 36	3.0	20.2
DN600	M27	WAF 41	3.0	23.8

Flat gasket (mm)	Thickness (mm)
DN10–DN80	Approx. 2
DN100–DN600	Approx. 3

Profile seal (mm)	Thickness (mm)
DN10–DN40	Approx. 3
DN50–DN80	Approx. 4
DN100–DN125	Approx. 5
DN150–DN300	Approx. 6
DN350–DN600	Approx. 7

Flange (hole circle PN10) (mm)	Thickness (mm)			
	PP-V	PP steel	PVC-U, PVC-C	Blind flange (PVC-U)
DN10			10	
DN15	16	12	11	12
DN20	17	12	12	13
DN25	18	16	14	15
DN32	20	20	15	16
DN40	22	20	16	17
DN50	24	20	18	20
DN65	26	20	19	21
DN80	27	20	20	22
DN100	28	20	22	24
DN125	30	24	26	28
DN150	32	24	28	30
DN200	34	27	32	36
DN250	38	30	36	36
DN300	42	34	36	36
DN350	46	40	38	38
DN400	50	40	42	42
DN500		54		
DN600		64		

Metric valve end for socket joints, flat or profile gasket (mm)	Thickness (mm)		
	ABS, PVC-C, PVC-U	PP, PE	PVDF
d16/DN10	6		
d20/DN15	6	7	6
d25/DN20	7	9	7
d32/DN25	7	10	7
d40/DN32	8	11	8
d50/DN40	8	12	8
d63/DN50	9	14	9
d75/DN65	10	16	
d90/DN80	11	17	
d110/DN100	12	18	
d125/DN100	13		
d140/DN125	14		
d160/DN150	16		
d200/DN200	24		
d225/DN200	25		
d250/DN250	23		
d280/DN250	23		
d315/DN300	27		
d355/DN350	32		
d400/DN400	34		

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Metric valve end for socket joints, O-ring (mm)	Thickness (including gasket) (mm)		
	PVC-C, PVC-U	PP, PE	PVDF
d16/DN10	9		
d20/DN15	9	9	9
d25/DN20	10	10	10
d32/DN25	10	10	10
d40/DN32	13	13	13
d50/DN40	13	13	13
d63/DN50	14	14	14
d75/DN65	15	15	
d90/DN80	16	16	
d110/DN100	18	18	
d125/DN100	19		
d140/DN125	20		
d160/DN150	22		
d200/DN200	30		
d225/DN200	31		
d250/DN250	23		
d280/DN250	30		
d315/DN300	35		
d355/DN350			
d400/DN400			

Metric flange adapters for butt fusion joints, flat or profile gasket (mm)	Thickness (mm)		
	PP, PE, SDR11	PP, PE, SDR17	PVDF, SDR33, SDR21, ECTFE SDR21
d16/DN10			
d20/DN15	7		6
d25/DN20	9		7
d32/DN25	10		7
d40/DN32	11		8
d50/DN40	12	12	8
d63/DN50	14	14	9
d75/DN65	16	16	10
d90/DN80	17	17	12
d110/DN100	18	18	13
d125/DN100	25	25	14
d140/DN125	25	25	16
d160/DN150	25	25	17
d180/DN150	30	30	
d200/DN200	32	32	22
d225/DN200	32	32	22
d250/DN250	35	25	22
d280/DN250	35	25	22
d315/DN300	35	35	24
d355/DN350	40	30	30
d400/DN400	46	33	32
d450/DN500	60	60	
d500/DN500	60	60	
d560/DN600	60	60	
d630/DN600	60	60	

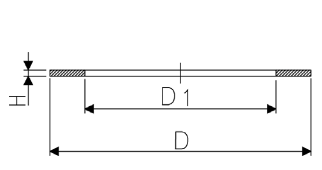
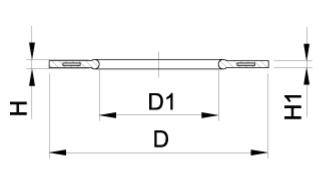
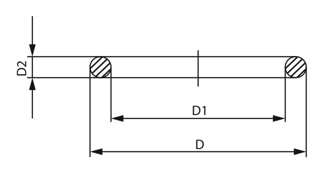
Valves installed in flange connection (mm)	Installation length (mm)		
	Butterfly valve Type 567/578	Butterfly valve Type 037/038	Wafer check type 369
DN32			15
DN40			16
DN50	45	43	18
DN65	46	46	20
DN80	49	46	20
DN100	56	52	23
DN125	64	56	23
DN150	72	56	26
DN200	73	60	35
DN250	113	68	40
DN300	113	78	45
DN350	129		
DN400	169		
DN450	179		
DN500	190		
DN600	209		

Selection of gaskets for flange connections

When selecting suitable flange seals for thermoplastic piping systems, the following factors must be taken into account:

- Operating conditions
- Sealing forces
- Gasket form
- Dimension
- Material

Type of gasket

Flat gasket	Profile gasket	O-ring
		

In applications with low operating pressures, the customary flat gasket, which is made of 2 to 5 mm thick sheet material (depending on the nominal width), is sufficient. Flange connections with flat gaskets require flanges with sufficient stiffness. All flanges by GF Piping Systems meet these requirements.

For higher operating and testing pressures, profile flange gaskets and O-rings have proven useful. Compared to flat gaskets, profile flange gaskets consist of two parts. One is the crowned flat gasket part, which is reinforced with steel, and the other is the profile gasket part (O-ring, lip seal) on the inner side of the gasket.

Stabilized profile flange gaskets, as well as O-ring gaskets, have the following advantages:

- Reliable seal with low bolt tightening torque
- Usable at higher internal pressures and internal vacuum
- Minor influence of flange or collar surface
- Safe operation when connecting pipe made of different materials

A suitable gasket form can be found by using the table below.

Gasket form	Recommended application limits	Flange or collar design
Flat gasket	p ≤ 10 bar, above DN200 only ≤ 6 bar T to 40 °C	With sealing grooves
Profile flange gasket	Vacuum p = 1 bar to 16 bar T = entire application range	With or without sealing grooves
O-ring	Vacuum p = 1 bar to 16 bar T = entire application range	One side with groove

Gasket material

The choice of a gasket material is based on the flow media. Details about the suitability of the gasket material, or specifically its chemical resistance, can be found in the GF Piping Systems resistance tables.

The use of gasket materials with a high degree of hardness, as in steel pipe, is not recommended for thermoplastic piping systems because the flange or the adaptor could become deformed due to the required high sealing forces. Elastomer materials, such as EPDM or FKM, with a Shore-A hardness of up to 75° are preferable.

Gasket dimension

The dimensions of the gaskets are set in the general standards for pipe jointing components. Excessive dimensional deviations in the inside or outside diameter of the gasket compared to the flange adapter or valve end cause increased mechanical stress of the flange connection, accelerated wear of the inner side of the gasket, as well as deposits inside the pipe.

5.1.3 Unions joining plastic piping components

Wherever available, unions are the preferred choice over flange adapters for the mechanical connection of plastic pipe. With no metal parts, there is no corrosion and the weight of the connection is also reduced. In addition, the smaller outside diameter compared to a flange connection means that the distance from pipe axis to pipe axis is shorter. Furthermore, assembly is easier and faster. Unions are available in a wide variety of materials and material combinations.

General notes on assembly

Plastic unions are always sealed with an O-ring. The coupling nut may only be tightened manually. Pipe wrenches customarily used in steel pipe construction are not permissible. For bigger sizes, a pipe wrench with belt can be used. When using unions, care should be taken to obtain a low-stress assembly.

⚠ In the area of flexible sections and expansion loops, unions cannot be used because the bending load can lead to leakages.

ℹ To make assembly of large unions easier, "lubricate" the thread with some water.

Assembly of unions made of PP, PE, PVDF with d75, d90 and d110

The newest generation of plastic unions in the above mentioned materials and dimensions has been equipped with a modern, plastics-oriented buttress thread, resulting in a product with considerably increased nominal pressure and safety reserves. Several notable/ important points in this respect are listed below.

Threads on coupling nut and union bush for PP, PVDF and PE

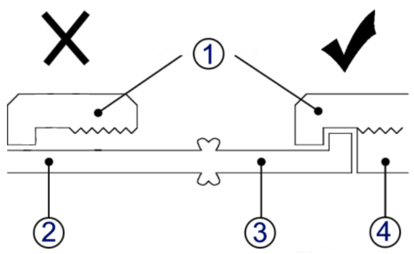
When using individual parts, check prior to the assembly whether the threads of the union bush and coupling nut are identical and can be bolted together:

- Coupling nut with trapezoidal thread on union bush with trapezoidal thread
- Coupling nut with buttress thread on union bush with buttress thread

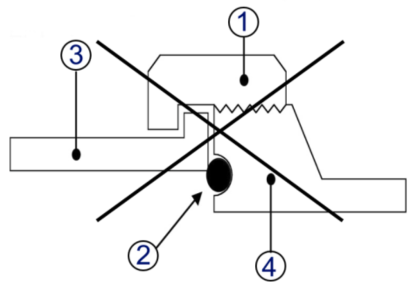
Fusion bead at unions for butt fusion

For the dimensions d90 and d110, we advise fusing the complete union to the pipe, if possible (or slide the coupling nut to the collar of the union end) because it may not be possible to slide the coupling nut over the fusion bead after the fusion.

Only use union bushes and union ends with the same nominal diameter. A butt fusion union bush d75 may not be combined with a butt fusion union end d90 to form a reducer, because this can cause leakage, as illustrated below.



① Coupling nut
② Pipe
③ Union end
④ Union bush



① Coupling nut d75
② Insufficient seal
③ Butt fusion union end d90
④ Butt fusion union bush d75

Unions as adaptor connections for different plastics

The component parts of the unions d20 to d63 of different plastics can be combined. Each of the two components with thread, union bush and coupling nut must be made of the same material. The union end can be selected from another material. For larger dimensions (d75 to d110), the material transition is not generally possible, and should be looked at on a case by case basis.

5.1.4 Adaptor unions for connections between plastic and metal pipe

The GF Piping Systems line of fittings contains various adaptor and threaded fittings. For the connection of plastic piping components to metal pipe, fittings or valves made of metal (or vice versa) with threaded connections, adaptor unions with metal inlays are preferred.

The seal in the metal thread can either be made with hemp or a PTFE tape as long as the counterpart is not made of plastic.

To prevent electrochemical corrosion, malleable iron connecting elements should preferably be used for steel transitions and brass connecting elements for transitions to non-ferrous metals.

IV

5.1.5 Transitional and threaded fittings

Combination 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 reliably established.

NPT (US-American standard)

A combination of R or G threads with NPT threads is not possible because of the different pitch.

Transitional and threaded fitting	Figure	Property
Adaptor fittings with parallel internal pipe thread Rp and rustproof reinforcement ring A2 (sockets)		Make it possible to connect both plastic and metal pipe, as well as plastic pipe with one another. ⚠ Metal pipe may only be bolted into adaptor pipe fittings with a reinforcement ring!
Adaptor pipe fitting with tapered male thread R (nipple)		Nipples with tapered male pipe thread R with the exception of a double nipple can be bolted into plastic as well as metal sockets.
Threaded sockets with tapered internal pipe thread Rp without reinforcement ring		Threaded fittings (without reinforcement ring) with tapered internal pipe thread Rp allow the establishment of connections between plastic pipe.

Installation tips for transition and threaded fittings

It is especially important that the pipe installation is low stress. Adaptor pipe or threaded fittings should be avoided at points in the piping system that are subjected to bending stress. If piping systems are subject to significant temperature changes, adaptor unions should be used because of the O-ring seal.

⚠ To avoid damage to plastics fittings, remove any flash (if present) in the area of the metal thread before bolting in the fittings.

Plastic transition and threaded fittings are initially bolted in by hand and without any force. Using a suitable tool, the fittings are subsequently bolted in until only approx. 1 to 2 turns of the thread are visible.

For plastic transition and threaded fittings, GF Piping Systems recommends using PTFE tape for sealing. As an alternative, thread sealing cord Henkel Tangit Uni-Lock or Loctite 55 and/or thread sealing paste Loctite 5331 can also be used. Please consider the appropriate installation guidelines from the manufacturer. If other sealing materials are used, compatibility with the plastics to be used must be established first.

⚠ Do not use hemp! When using hemp, the plastic fittings may be overloaded when the hemp swells and may damage the thread. In addition, hemp is not resistant to chemicals depending on the medium used.

5.1.6 Adaptor pipe fittings for connecting plastic piping systems and metal threads

PVC-U/ stainless steel R	ABS/brass R	ABS/brass Rp	PVC-U/ stainless steel R
			

The adaptor pipe fittings for connecting plastic piping systems and metal threading offer the greatest possible flexibility for assembly given the combined socket/spigot on the plastic end. The metal thread can be sealed with either hemp or PTFE-tape.

The adaptor pipe fitting is factory-sealed with an EPDM O-ring. The O-ring also serves as protection against damage to the plastic during assembly. Compared to the usual adaptor unions, the special connecting technology with circlip increases reliability, even at temperature changes and during vibration.

In addition to the classic transition to metal pipe, the fittings can also be used for connecting manometers.

⚠ To avoid electrochemical corrosion in transitions to non-ferrous metals, brass connections must be used.

5.1.7 Hose connections to plastic piping systems

GF Piping Systems has a wide range of products for hose connections to plastic piping systems.

⚠ The hose must be fixed on the spigot by using a suitable hose clip.

		
Laboratory hose connector with solvent cement spigot and tapered hose spigot (PVC-U)	Pressure hose nozzle with solvent cement or fusion spigot and tapered hose spigot (all materials)	Flare adaptor pipe fitting with BCF/IR/butt fusion spigot to connect flared PFA (inch) hoses (PVDF and ECTFE only)

5.1.8 SYGEF Plus and PROGEF Natural sanitary adaptor for standard TriClamp connections

Clamp connections form part of the group of longitudinal interference-fit, detachable adapter connections and are primarily used for pure water and production piping systems in the pharmaceutical, biotechnology, food and cosmetic industries. A special characteristic of the TriClamp connection is simple, rapid and low-cost assembly.

	
SYGEF Plus sanitary adaptor	SYGEF Plus Sanitary Adaptor with clamp: plastic-stainless steel connection

Use of the SYGEF Plus or PROGEF Natural sanitary adaptor provides an aseptic plastic-stainless steel connection. The majority of connection standards are taken into account (inner diameter of stainless steel component). The adaptors can be combined with commercially available gaskets and clamps.

5.1.9 Universal coupling

The coupling made of stainless steel offers various advantages compared to similar connecting elements.

A patented gasket prevents leakage and the specially formed anchor ring ensures a reliable and permanent connection. It features a special helical tooth profile with ball tempering that ensures very good support on the piping, particularly for hard surfaces, such as thin-walled stainless steel and cast iron.

The simple design allows the coupling to be installed in no time. Thanks to the large variety of types, it can be used as connector between pipe made of different materials and with different outside diameters. Given the larger clamping range, one coupling can be used to connect up to three different pipe dimensions. The housing consists of corrosion-free stainless steel, the gasket of high-quality elastomers (EPDM or NBR).

The connection is made by slipping the coupling over the elements to be connected and tightening the bolts with the specified tightening torque.

5.2 Solvent cement jointing using Tangit

5.2.1 Overview

Material/cement

PVC-U	PVC-C	ABS
		

5.2.2 Requirements and information

Safety information

Solvent cement jointing calls for adequate technical know-how, which can be acquired in the appropriate training courses. Your authorized GF Piping Systems representative will be happy to provide information about training options.

For the correct selection of the cement, observe the information on chemical resistance for the use of Tangit cement. For more information, see www.gfps.com/tools.

- **The current safety data sheet from Henkel is available at www.mysds.henkel.com**

Adequate ventilation of the workplace

Tangit cement and Tangit cleaner contain highly volatile solvents. This makes good ventilation or adequate fume extraction essential in closed spaces. Since the solvent fumes are heavier than air, extraction must occur at floor level, or at least below the working level. Place paper that has been used for cleaning or for the removal of surplus cement into closed containers to avoid of solvent fumes in the air.

No open flames when cementing. No smoking.

Cement and cleaner are flammable. Extinguish open flames before starting work. Switch off electric devices without explosion protection, electric heaters, etc. Avoid electrostatic charges. Discontinue any fusing operations. Furthermore, observe all instructions issued by the solvent cement manufacturer (e.g. label on the can and supplementary documentation).

Protection against spilled liquids

Pipe and fittings must be kept away from spilled cement, cleaner and used paper. Cement and cleaner that are no longer needed must be disposed of in an environmentally sound manner.

Use of gloves and protective glasses

The use of protective gloves is recommended to avoid cement or cleaner contact with the skin. If the cement or the cleaner come in contact with your eyes, rinse immediately with water. Consult a doctor! Immediately change clothes that have cement on them.

Always observe the safety regulations issued by the responsible authorities, as well as information in the safety data sheet. The safety data sheet is available at www.mysds.henkel.com

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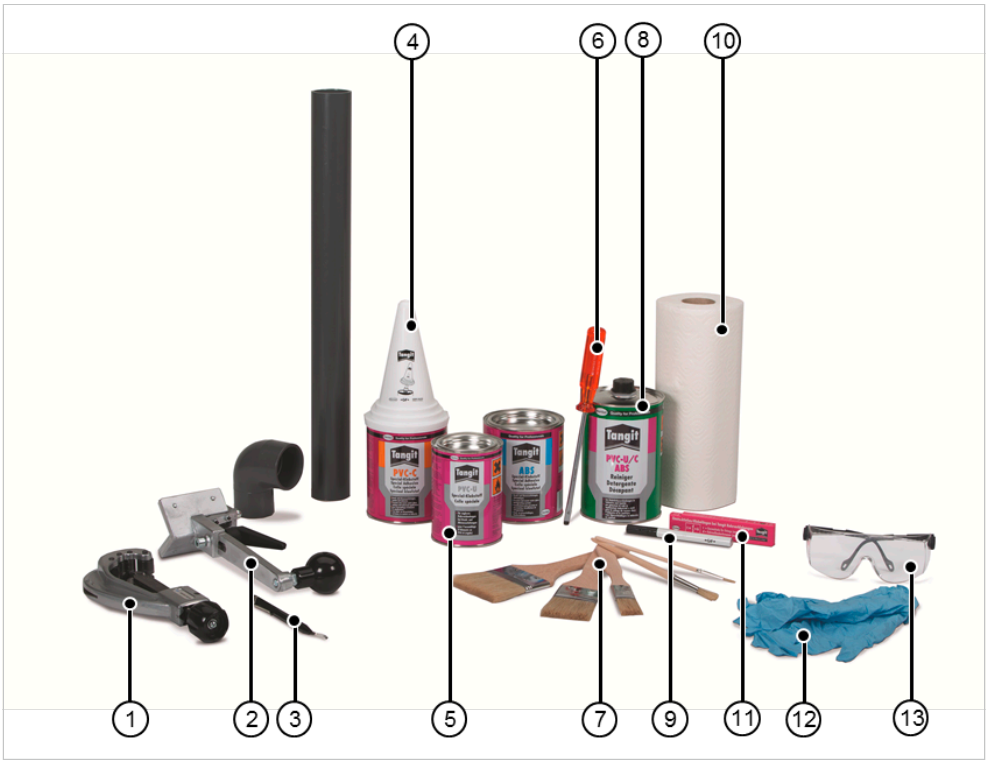
5.2.3 Required tools and equipment



Nr.	Description		Dimensions
①	Pipe cutter		d10–d63 mm d50–d110 mm d110–d160 mm
②	Chamfer device		d16–d200 mm d63–d400 mm
③	Deburring device		Commercially available
④	Can lid		
⑤	Tangit cement	PVC-C	0.7 kg can
		PVC-U	0.125 kg tube 0.25 kg can 0.50 kg can 1.0 kg can
		ABS	0.65 kg can
⑥	Screwdriver or wooden spatula		Commercially available
⑦	Round brush ø 4 mm Round brush ø 8 mm Flat brush 1“, 25 x 3 mm Flat brush 2“, 50 x 5 mm Flat brush 3“, 75 x 6 mm		Fitting 6–10 mm Fitting 12–32 mm Fitting 40–63 mm Fitting 75–225 mm Fitting 250–400 mm
⑧	Tangit PVC-U, PVC-C, ABS cleaner		1 liter can
⑨	Marking pen		
⑩	White, absorbent, lint-free paper		Commercially available
⑪	Folding ruler		Commercially available
⑫	Solvent-resistant safety gloves		Commercially available
⑬	Protective glasses		Commercially available

5.2.4 Dimensions and tolerances

The dimensions of pipe, fittings and valves made of PVC-U, PVC-C and ABS by GF Piping Systems generally conform to the standards EN ISO 15493 and EN ISO 1452-3. They can be connected with any fittings and valves made of the same material that have also been produced based on these standards.

5.2.5 Required amounts of Tangit cement

Diameter (d)	Tangit (kg/100 connections)	Amount (g/joint)
20	0.25	2.5
32	0.40	4.0
40	0.55	5.5
50	0.70	7.0
63	1.10	11.0
75	1.50	15.0
90	2.50	25.0
110	4.10	41.0
140	6.00	60.0
160	8.00	80.0
200	13.00	130.0
225	20.00	200.0
315	40.00	400.0

i The amount of cement used depends on a variety of factors. The table provides average values. It is generally not necessary to exceed these values.

5.2.6 Cementing

Cementing should be performed at an ambient temperature of 5 °C to 35 °C.

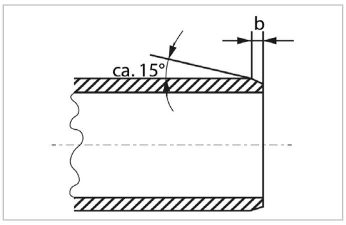
1 Cutting the pipe to length

Cut off the pipe at a right angle by using a pipe cutter.

2 Chamfering the pipe

Chamfer the end of the pipe with the chamfer device according to the following figure and table to enable a perfect cementing joint.

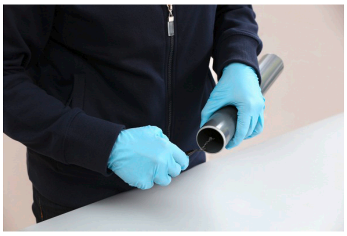
d (mm)	b (mm)
6 – 16	1 – 2
10 – 55	2 – 3
63 – 225	3 – 6
250 – 400	6 – 8



i Well-chamfered pipe ends prevent the layer of cement from being removed as the pipe is inserted into the fitting.

3 Deburring the pipe

Deburr the inside of the pipe with a deburring device.



4 Cleaning pipe and fitting

First, remove any coarse dirt from the cementing surfaces (outside of pipe, inside of fittings). Clean the cementing surfaces thoroughly with Tangit PVC-U/PVC-C/ABS cleaner and paper. Always use a fresh piece of paper for each component. Remove any condensation that may have formed on the parts.

Pipe may have a waxy surface. To ensure proper jointing in such a case, the cleaning process must be repeated until the pipe surface becomes visibly matte.

Mechanical machining of the pipe surface may be necessary in individual cases. An indication of expected inadequate jointing quality is an absent or insufficient adhesion of the jointing parts following fine cleaning ("finger-nail check"). The jointing surfaces should then be roughened evenly with emery cloth of grain 80 or finer, observing the maximum permitted gaps.

> ⚠ The cementing surfaces must be dry and free from grease and dirt, and must not be touched after cleaning.

5 Marking the insertion depth

Mark the cementing length of the fitting on the pipe end using the folding ruler and marking pen; this allows for checking the required application of adhesive and whether the pipe has been completely inserted.

Calculating the insertion depth:

$$t = \frac{d}{2} + 6$$

t Insertion depth (mm)
d Pipe diameter (mm)

> ℹ If the outside diameter of the pipe and the inside diameter of the socket are at opposite extremes of their tolerances, then the pipe cannot be inserted dry into the fitting socket. Insertion will only become possible once the cement has been applied.

6 Checking the cement

Tangit cement is supplied ready for use. Stir thoroughly with a screwdriver or wooden spatula prior to use! Cement of the correct consistency will run evenly from a wooden spatula held at a slant. Cement that no longer runs smoothly is unusable. The cement must not be thinned since thinning would falsify the mixing ratio.

7 Applying the cement

Using firm brush pressure, apply an even, closed cement layer brushing in axial direction, first in the fitting, then on the pipe. Use a thin layer of cement in the fitting to avoid excessive bead formation inside the pipe, apply a generous amount on the pipe end.

> ⚠ Starting at d75 (ABS/PVC-C) or d90 (PVC-U), two people are needed to apply the cement to the pipe end and fitting socket simultaneously in order to avoid exceeding the maximum opening time of the cement.

> ⚠ Starting at d250, the cement is poured directly from the can into the middle of the cementing surface and distributed first radially and then axially over the entire area with a flat brush until an even, closed layer is present. The minimum layer thickness in the fitting area is 1 mm, while a heavier coat is applied at the pipe end. Cementing in these dimension ranges must be performed by at least 2 people.

8 Connecting pipe and fitting

Immediately push pipe and fitting together to the stop or the full length of the socket (check insertion depth on the pipe) without twisting or misalignment and hold in position for a few seconds until the cement has set.

⚠ Starting at d250, push pipe and fitting together and align them by using 3 to 4 people. Hold the joint in this position for 1 minute.

9 Checking and removing surplus cement

After jointing, a complete bead must be visible on the inside (smaller) and outside (larger).

Immediately wipe off any surplus cement using clean, absorbent paper.

⚠ Jointing faces must be kept clean.

⚠ Important note

Cement and cleaner should be stored in a cool, dry place (5 to 35 °C)! Under these conditions, the cement and cleaner can be used for 24 months starting from the date of filling (imprinted on the can).

Cans not in use should be closed immediately to prevent solvent losses and thickening. The brush lid can be used, which allows for leaving the brush in the can of cement.

Since both cement and cleaner dissolve the material, pipe and fittings must not be laid on or allowed to come into contact with spilled cement or paper containing cement residues.

Scrape off thickened cement sticking to the brush using dry paper and then rinse the brush with cleaner. Cleaned brushes must be dry before reuse.

Flushing before putting into operation

After the drying process (see table in the section "Waiting time and pressure test") the piping systems can be filled. To remove remaining solvent vapor, the pipeline must be thoroughly flushed before putting it into operation. For pipe that are not put into operation immediately, we recommend filling them with water and flushing them regularly after careful cleaning. Do not use compressed air for flushing.

Documenting Tangit batch for ABS cementing

To ensure the traceability of the Tangit batch(es) used, if needed, document the batch identification attached to every shipped unit to the test/acceptance report. If several batches are used in one project, add one identification from each batch to the test report.

5.2.7 Waiting time and pressure test

The length of the drying period before the joint may be subjected to testing or operating pressure depends on the drying temperature, the dimension and the fit requirements, as well as ambient influences.

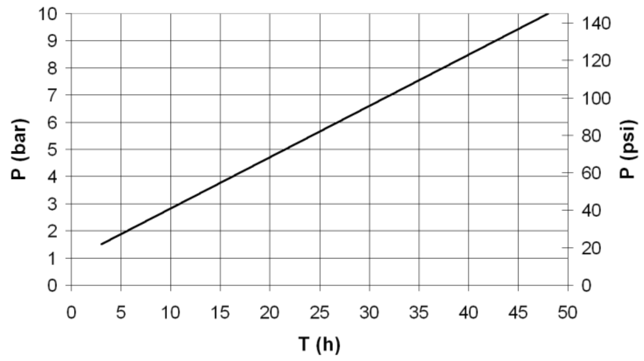
The following table shows the corresponding waiting times:

Materials and dimension	Temperature: 10 °C - 30 °C			Temperature: <10 °C / >30 °C		
	Between cementing	Operating pressure repair	Pressure test water max. 1.5 x PN	Between cementing	Operating pressure repair	Pressure test water max. 1.5 x PN
PVC-U						
< d250	5 Min	1h / bar	24h	15 min	2h / bar	48h
d250-400	15 Min	1h / bar	48h	30 min	2h / bar	72h
PVC-C						
All dim.	5 Min	1h / bar	24h	15 min	2h / bar	48h
ABS						
< d160	10 Min	1h / bar	24h	15 min	2h / bar	48h
d160-225	30 Min	2h / bar	24h	60 min	4h / bar	48h
d250-315	60 Min	4h / bar	48h	120 min	8h / bar	72h

Actual values at the construction site may deviate. These are empirical values.

5.2.8 Internal pressure test or leak tightness test of ABS with gas/air

Due to the risk of a pressure test with a compressible test medium, this pressure test should be carried out only in exceptional cases. The following diagram shows the required waiting times depending on the test pressure for ambient temperatures between 10 and 30 °C:



P Test pressure (bar, psi)
T Waiting time after last cementing (h)
Ambient temperature from 10 to 30°C

> In principle, PVC-U and PVC-C may not be pressure tested by using a compressible medium!

5.2.9 Disposal

Dried product residues can be added to household or industrial waste. Large quantities must be disposed of separately. The disposal key (EAC code) is available upon request. Empty packaging can be added to recycling.

5.3 2-component cement jointing using Tangit RAPID

5.3.1 Overview

Tangit RAPID is suitable for restraint-proof connections of pressure pipe in system installations with fittings and valves made of PVC-U or PVC-C

- Meets DIN EN 14814
- For piping systems in accordance with EN ISO 15493 (PVC-U and PVC-C)
- Also suitable for repairs
- Construction cementing with plate material (e.g. catch trays and housing boxes)

Technical data	
Raw material basis	Methacrylate
Density	0.99 and 1.01 g/cm³
Processing temperature	+5 °C to +35 °C
Viscosity	70,000 mPas components A/B, DIN EN 12092, 20 °C
Open time	Approx. 8 min.
Fitness for use: (20 °C)	For new installation 12 h, for repairs 4 bar/h (min. 1 h)
Final strength	Corresponds to the strength of the cemented material
Temperature resistance	PVC-U: 60 °C, PVC-C: 80 °C
Storage	Not below 5 °C
Minimum shelf life	At +20 °C, 12 months in unopened original package. Minimum shelf life date and batch number are located on the cartridge.

5.3.2 Requirements and information

Safety information

Cement jointing calls for adequate technical know-how, which can be acquired in the appropriate training courses. Your authorized GF Piping Systems representative will be happy to provide information about training options.

For the correct selection of the cement, observe the information on chemical resistance for the use of Tangit cement. For more information, see www.gfps.com/tools.

For acids and heavily oxidative substances as flow media, Tangit solvent cements can be used. The current safety data sheet from Henkel is available at www.mysds.henkel.com

Protective measures before cementing

Adequate ventilation of the workplace

Tangit RAPID and Tangit PE/PP/PVDF/PB cleaning cloths and special cleaner are highly flammable. The solvent vapors are heavier than air, can collect at the floor and form explosive vapors. For this reason, ensure that sufficient ventilation and exhaustion is present during processing and drying, including after cementing. Prolonged inhalation of vapors poses health hazards.

Keep used cleaning paper in a closed container (e.g. bucket with a lid) to keep the exposure to solvent vapors low.

No open flames when cementing. No smoking.

In the work room and in adjacent rooms: No smoking! No fusion! Do not use open flame or fire, avoid creating sparks under any circumstances. Prior to fusion tasks, remove any collected solvent vapors and explosive mixtures. Thoroughly flush piping systems with water and blow them out. Do not close piping systems during the drying phase.

Avoid product accumulations! Fire hazard! Two-component products can generate high heat during hardening if they are applied in a block. Always spread product residues out over the surface.

Protection against spilled liquids

Pipe and fittings must be protected against spilled cement, cleaning agent and used paper. Do not pour cement or cleaner that is no longer needed into sewer lines.

Use of gloves and protective glasses

The use of protective gloves is recommended to avoid contact of cement or cleaner with the skin. If the cement or the cleaner comes in contact with your eyes, rinse immediately with water. Consult a doctor! Immediately change clothes that have cement on them.

Always obey the safety regulations issued by the responsible authorities, as well as the information in the safety data sheet. The safety data sheet is available at www.mysds.henkel.com.

5.3.3 Required tools and equipment

Nr.	Description	Dimensions
①	Pipe cutter	d10–63 mm d50–110 mm d110–160 mm
②	Chamfer device	d16–200 mm d32 –200 mm
③	Deburring device	Commercially available
④	Tangit RAPID cement	Kit with 50 ml cartridges Kit with 400 ml cartridges
⑤	Folding ruler	Commercially available
⑥	Marking pen	
⑦	Tangit cleaner PP/PE/PVDF/PB	1 liter can
⑧	White, absorbent, lint-free paper	Commercially available
⑨	Tangit cleaning cloths PP/PE/PVDF/PB	
⑩	Plastic brush	1" 2"
⑪	Safety gloves	Commercially available
⑫	Protective glasses	Commercially available
⑬	Cartridge gun	50 ml 400 ml

5.3.4 Dimensions and tolerances

The dimensions of pipe, fittings and valves by GF Piping Systems made of PVC-U and PVC-C conform to the standards EN ISO 15493 and EN ISO 1452-3. They can be connected with any pipe, fittings and valves made of the same material that have also been produced based on these standards.

5.3.5 Cementing

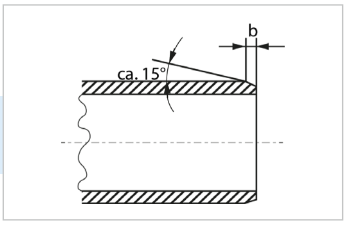
1 Cutting the pipe to length

Cut off the pipe at a right angle by using a pipe cutter.

2 Chamfering the pipe

Chamfer the pipe with a chamfer device according to the following figure and table to enable a perfect cementing joint.

Pipe outer diameter (mm)	b (mm)
6 – 16	1 – 2
10 – 55	2 – 3
63 – 225	3 – 6
250 – 400	6 – 8



Well-chamfered pipe ends prevent the layer of cement from being removed as the pipe is inserted into the fitting.

3 Deburring the pipe

Deburr the inside of the pipe with a deburring device.

4 Cleaning pipe and fitting

Clean the pipe and fitting with Tangit PE/PP/PVDF/PB cleaning cloths or cleaner with paper. Replace the paper after every cleaning. The cleaned surfaces must be dry before applying the cement.

Pipe end and fitting socket must be dry and free from grease and dirt, and must not be touched after cleaning.

❺ Marking the insertion depth

Mark the cementing length of the fitting on the pipe end using the folding ruler and marking pen; this allows for checking the required application of adhesive and whether the pipe has been completely inserted.

Calculating the insertion depth:

$$t = \frac{d}{2} + 6$$

t Insertion depth (mm)
d Pipe diameter (mm)

If the outside diameter of the pipe and the inside diameter of the socket are at opposite extremes of their tolerances, then the pipe cannot be inserted dry into the fitting socket. Insertion will only become possible once the cement has been applied.

❻ Checking the cement

Tangit RAPID cement is supplied ready for use. Before its use, check whether both components can be evenly pushed out of the cartridge.

Tangit RAPID should not be stored below +5 °C since this would cause an increase in viscosity and solidification of the structure, which would affect its processing ability. After bringing the cement to room temperature, the temperature-based increase in viscosity and structure is reduced again.

❼ Applying the cement

- Apply Tangit RAPID to the cementing surfaces from the cartridge by using a cartridge gun and static mixer. Apply the cement in the form of rings to ensure a sufficient amount of cement.
- First, evenly distribute the cement in axial direction in the socket and then on the pipe using a plastic brush.
- Apply a thin layer of Tangit RAPID in the socket. To avoid subsequent bead formation inside the pipe, apply a generous amount on the pipe end. Tangit RAPID can be used according to DIN EN 14814 to cover diameter tolerances up to +0.6 mm.

Depending on the processing temperature, the following approximate times are available:

Temperature (°C)	Estimated processing time (min)
10	10
20	8
30	6

If there is series production, the static mixer can be used multiple times. However, after the processing time has been exceeded, a new static mixer is required. Immediately tightly close any cartridges that are not in use. (For short-term interruptions, the static mixer used can remain on the cartridge.)

8 Connecting pipe and fitting

- Immediately push pipe and fitting together to the stop or the full length of the socket (check insertion depth on the pipe) without twisting or misalignment and hold in position for a few seconds until the cement has set.
- The jointing parts must be pushed together during the open time of the cement (approx. 8 minutes from the start of the application of adhesive).
- Excess cement does not have to be removed. However, any flash that is created may have sharp edges and should be removed.
- Wipe off cement residues from the plastic brush. The dried cement film can be pulled off the plastic brush by using a slight rotation.

⚠ For dimensions starting at d160, one person should apply the cement to the pipe and socket while the second person distributes the cement.

9 Wiping off the cement bead

A cement bead must be visible on the inside and outside. Excess cement can remain at the cementing joint (quality assurance) or be wiped off (aesthetics).

5.3.6 Waiting time and pressure test

During the first 5 minutes after cementing, the pipe must not be moved. At temperatures below +10 °C, this time is extended to at least 15 minutes. Larger piping systems should be supported during the first 30 minutes due to their intrinsic weight.

Filling the pipeline as well as the pressure test up to the test pressure cannot be performed until 12 hours after the last cementing. If the line is to be stressed at the operating pressure, a minimum waiting time of 4 bar/h must be followed (min.1 hour). At 10 °C, the waiting times are doubled. For pipe that are not put into immediate operation, we recommended flushing them thoroughly.

5.3.7 Internal pressure test with water

⚠ In principle, PVC-U and PVC-C may not be pressure tested by using a compressible medium!

To remove remaining product vapors, thoroughly flush the pipeline before putting it into operation.

5.3.8 Disposal

Dried product residues can be added to household or industrial waste. Large quantities must be disposed of separately. The disposal key (EAC code) is available upon request. Empty packaging can be added to recycling.

5.4 Special cements

5.4.1 Tangit DTX

Tangit DTX in conjunction with the PVC-U/PVC-C/ABS cleaner is a special cementing system for PVC-U/PVC-C piping systems that are exposed to the effects of highly aggressive chemicals, such as concentrated, inorganic acids.

Applications

- Cementing thermoplastic PVC-U/PVC-C piping systems in accordance with EN ISO 15493
- Suitable for critical media (see the list of chemical resistance at www.gfps.com/tools)

Properties

- Solvent cement based on tetrahydrofurane (THF-stabilized)
- Open time: 1 minute
- Gap-filling and thixotropic
- Diameter, pipe: max. 140 mm, gap: max. + 0.4 mm
- Maximum operating temperature limited to 60 °C
- Meets DIN EN 14814: Adhesives for thermoplastic piping systems for fluids under pressure
- CE marking and DoP (01011))

Resistance

The cementing joints are watertight. Their chemical resistance, especially to inorganic acids and strongly oxidizing materials, depends on the following factors:

- Diameter tolerances
- Curing times
- Pressure ratings
- Temperatures
- Acid type
- Acid concentration

For pressure piping systems made of PVC-C, special PVC-C cement is recommended for high temperatures (technical data sheet upon request).

Cemented PVC-U or PVC-C pipe connections, if they are installed following the Tangit cementing instructions, are just as stable as the installed pipe material. Exceptions are the media listed in the following table. When these media are used, the use of Tangit DTX special cement for laying piping made of PVC-U or PVC-C is recommended. Since these media can attack the pipe material, GF Piping Systems recommends the use of PN16 pipe. For all media not featured in the list of chemical resistance, or those with a lower concentration, Tangit PVC-U or Tangit PVC-C cement can be used, if the pipe and fitting material are suitable. When using Tangit DTX special cement for PVC-C piping and a critical medium featured in the list, the temperature and pressure recommendations for PVC-U material must definitely be followed.

Medium	Concentration	De-rating factor	Temperature
Sulfuric acid	> 70 - 93 % H_2SO_4	AF: 1.6 (> 70 - 78 %) AF = 2 (> 78 %)	max. 60 °C max. 40 °C
Hydrochloric acid	> 25 - 37 % HCl	AF: 1.6	max. 60 °C
Nitric acid	> 20 – 55 % HNO_3	AF: 1.6	max. 60 °C (> 20 – 30 %) max. 40 °C (>30 %)
Sodium- / Potassium hypochlorite	> 6 – 15 % NaOCl / KOCl	AF: 1.6	max. 40 °C
Hydrogen peroxide	> 5 – 70 % H_2O_2	AF: 1.6	max. 40 °C
Hydrofluoric acid	</= 40% HF	AF: 1.6	max. 40 °C

⚠ Tangit DTX solvent cement jointing calls for adequate technical know-how, which can be acquired in the appropriate training courses. Your authorized GF Piping Systems representative will be happy to provide you with information about training options.

For the correct selection of the cement, observe the information on chemical resistance for the use of Tangit DTX cement. For more information, see www.gfps.com/tools

5.4.2 GF Dytex

GF Dytex, in conjunction with the GF Dytex solvent, is a special adhesive for piping systems made of PVC-U/ PVC-C for aggressive media at higher concentrations (mainly sulfuric acid 93% - 98%). See chapter „4.1.1 General information regarding chemical resistance“ auf Seite 105 for more details.

For general information see chapter "Jointing Technology" at "Solvent cementing joint Tangit". In this chapter, only the GF Dytex specific topics are addressed.

Specifications for GF Dytex cement	
Resource base	Post-chlorinated PVC dissolved in methylene chloride
Density	1,35 g/cm^3
Temperature resistance	+40 °C
Processing temperature	+10 °C – +25 °C
Viscosity cement	200 – 300 mPas, DIN EN 12092, 20 °C
Operational strength	48 Hours
Full Strength	Corresponds to the strength of the bonded material
Dilution	GF Dytex must not be diluted.

Specifications for GF Dytex solvent	
Resource base	Methylene chloride
Density	1,32 g/cm^3
Viscosity	Runny

Area of application

Jointing of thermoplastic PVC-U/PVC-C piping systems acc. EN ISO 15493 for aggressive media at higher concentrations (mainly sulfuric acid 93% - 98%). See chapter „4.1.1 General information regarding chemical resistance“ auf Seite 105 for more details. Due to the influence of the aggressive media to the pipe material, it is recommended to use pipe with nominal pressure PN16. Regarding the expected service life and pressure rating, please contact our experts on chem@georgfischer.com.

GF Dytex is not suitable for use in drinking water applications. For the solvent cementing of PVC-U or PVC-C in use with other media, using Tangit PVC-U/PVC-C or Tangit DTX is recommended (for material and adhesive selection see list of chemical resistance www.gfps.com/tools).

Important features

- Cement is not gap filling, multiple cement application possibly necessary
- Maximum outer diameter (pipe) d140 mm, gap: max. +0.4 mm
- limited maximum operating temperature 40 °C

Resistance

The cemented joints are waterproof. Their chemical resistance depends on the following factors:

- Diameter tolerances
- Curing time
- Pressure charges
- Temperatures
- Concentration of sulfuric acid
- Quality of the jointing

Processing

First, clean the cementing surfaces (outside of the pipe end, fitting inside) of coarse dirt. Potentially adhering ice must be removed by heating (lukewarm).

The pipe ends must be cut square, chamfered and deburred. If there is no or insufficient pipe chamfer, no permanent tight connection is achieved.

Due to the missing gap filling properties of GF Dytex, check the pipe / fitting fit when dry.

> ⚠ If the pipe end can slide in to the pipe stop without resistance, multiple application of cement is required. Gaps with a difference in diameter of >0.4 mm are not permitted! Pipe / fittings from dimension d110 mm have to be measured for admissible gap size.

Cleaning is done with GF Dytex solvent. For this, coat the surfaces with GF Dytex solvent with a brush until they are significantly dissolved (slimy test/ fingernail test).

Then mark the cementing length of the fitting on the pipe end, so that the necessary cement application and the complete insertion of the pipe can be checked.

Apply to still solvated surface, the GF Dytex with a brush in axial direction, and allow to dry at least 30 seconds. Repeat cement application several times, depending on the gap.

After the final adhesive application, apply GF Dytex solvent again to both surfaces until they are sufficiently wetted, then immediately push the parts to the full fitting depth without twisting / tilting and hold for a few seconds. Due to the rapid setting of the cement, the joining of the parts must be done within one minute after the last application of the GF Dytex solvent. At temperatures above 25 °C, the open time is reduced to less than one minute. When inserting, a definite resistance should be felt. The forming bead must be complete and even.

The excess adhesive should be wiped off immediately.

> ⚠ The production of GF Dytex cemented joints requires adequate expertise, which can be acquired in the appropriate training courses. The local branch of GF Piping Systems provides information on training opportunities and adhesive instructions.

> ⚠ For the correct choice of adhesive, observe the instructions for use of the chemical resistance of GF Dytex. More information on www.gfps.com/tools

5.4.3 Tangit EXPRESS

Tangit EXPRESS is suitable for pressure resistance connections of pressure pipe (e.g. in potable water pipe) with fittings made of PVC-U.

Applications

- For cementing thermoplastic pressure piping systems made of PVC-U (potable water) in accordance with EN 1452 and EN 1329
- For construction cementing with PVC-U/PVC-C plate material (e.g. catch trays and housing boxes)
- Specifically suited for PVC-U/PVC-C pipe and hoses in swimming pool and whirlpool areas

Properties

- Fast load capacity as early as 15 minutes (= 1 bar)
- Cementing joint as permanent as the pipe material (exception: critical media, see Tangit DTX)
- Meets DIN EN 14814
- Certified by the testing institute "Technologiezentrum Wasser" (TZW) in Karlsruhe, Germany
- For quick repairs (e.g. drain pipe, pressure pipe and gutters)
- Ideal for pipe up to d110

5.5 Retrofit of branch fittings into an existing ABS, PVC-U or PVC-C piping system

Existing situation

Occasionally it may be necessary to install measuring sensors, venting fittings or similar devices in an existing piping system without using additional installation fittings.

Solution

A hole is drilled for the solvent cement spigot in the section of the piping system with the greatest wall thickness (in the center of the pipe-socket joint). A suitable branch fitting is then cemented into the hole.

Detailed installation steps

1. The hole is drilled into a drained pipe section.
2. The hole is drilled at a right angle to the pipe axis.
3. The hole diameters and tolerances provided in the table below correspond to socket dimensions according to ISO 727-1 and are to be observed.
4. The dimension X in the table below indicates the distance from the entrance of the socket to the center of the hole to be drilled in order to place the hole in the center of the joint.
5. The edges of the hole are deburred using a deburring tool.
6. Shavings must be removed from the pipe.
7. Permissible combinations of pipe and branch fitting dimensions are indicated in the table below by the symbol ✓ Selection criteria were: the spigot of the branch fitting does not extend into the pipe by more than 1 mm and the socket joint with the hole is completely covered.
8. The branch fitting's spigot is cemented into the drilled hole according to the instructions for spigot jointing provided in the Planning Fundamentals of GF Piping Systems
9. The waiting times before reapplying pressure must be observed

i If properly installed, such a connection can be pressurized up to PN10 at 20 °C and water as the medium.

Permissible combinations of pipe and outlet

ABS PN10		Wall thickness e (mm)		Outlet dimension d (mm)	
Pipe dimension (mm)	S8, SDR17	20	25	32	40
75	4.5	✓	✓	x	x
90	5.4	✓	✓	x	x
110	6.6	✓	✓	x	x
125	7.4	✓	✓	x	x
140	8.3.	✓	✓	x	x
160	9.5	✓	✓	x	x
180	10.7	✓	✓	✓	x
200	11.9	✓	✓	✓	x
225	13.4	✓	✓	✓	✓

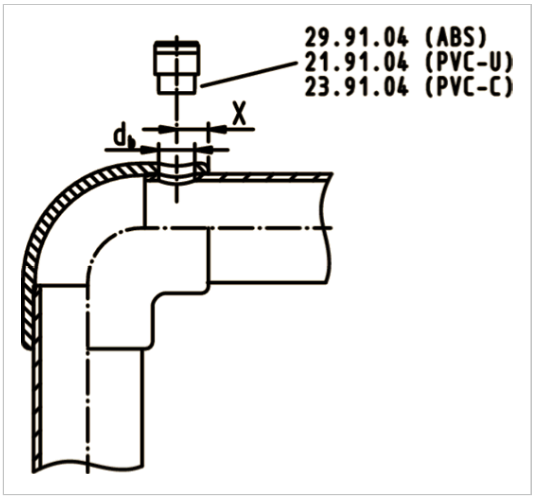
ABS PN6		Wall thickness e (mm)		Outlet dimension d (mm)	
Pipe dimension (mm)	S12.5, SDR26	20	25	32	40
250	4.5	x	✓	✓	x
280	5.4	x	✓	✓	✓
315	6.6	x	x	✓	✓

PVC-U PN10		Wall thickness e (mm)		Outlet dimension d (mm)	
Pipe dimension (mm)	S10, SDR21	20	25	32	40
125	6.0	x	x	x	x
140	6.7	✓	x	x	x
160	7.7	✓	✓	x	x
180	8.6	✓	✓	x	x
200	9.6	✓	✓	✓	x
225	10.8	✓	✓	✓	✓
250	11.9	x	✓	✓	✓
280	13.4	x	✓	✓	✓
315	15.0	x	x	✓	✓
400	19.1	x	x	✓	✓

PVC-U PN16		Wall thickness e (mm)		Outlet dimension d (mm)	
Pipe dimension (mm)	S6.3, SDR13.6	20	25	32	40
125	9.2	✓	x	x	x
140	10.3	✓	✓	x	x
160	11.8	✓	✓	✓	x

IV

Drilling specifications



Outlet dimension d (mm)	Hole diameter, d_b (mm)
20	20.2
25	25.2
32	32.2
40	40.2
Tolerance	**± 0.1 mm**

Pipe dimension d (mm)	Drilling position X (mm)
75	22
90	26
110	31
125	34
140	38
160	43
180	48
200	53
225	59
250	66
280	73
315	82
400	103
Toleranz	**± 1 mm**

5.6 Cementing different pipe materials

It is possible to cement the pipe materials ABS, PVC-U and PVC-C with one another; certain conditions must, however, be observed.

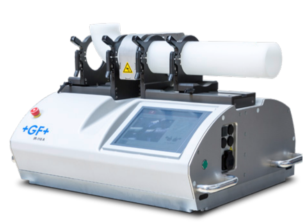
> i If different pipe materials are to be cemented, please contact your authorized GF Piping Systems representative.

5.7 Infrared fusion jointing

5.7.1 Overview

Material

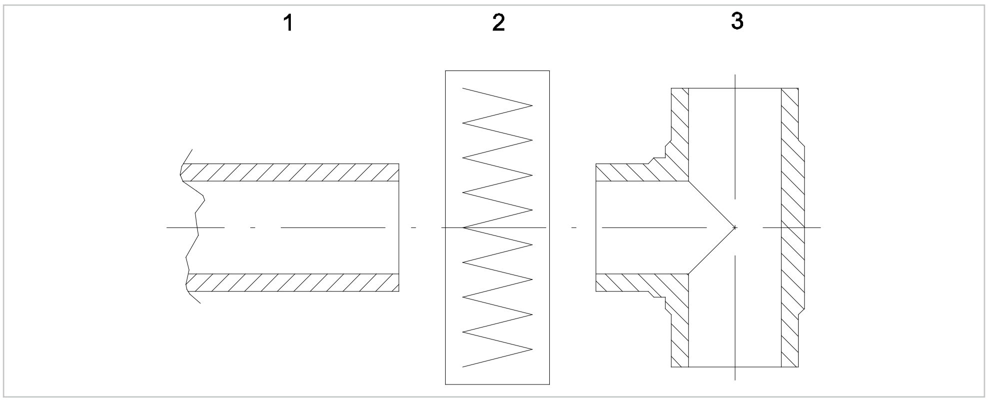
- PVDF
- ECTFE
- PP
- PP-n
- PE100

Fusion device	Jointing cross section (PP-H)	Macro view
		

5.7.2 Fusion procedure

In infrared (IR) fusion the fusion areas of the components (pipe, fittings or valves) are heated to fusion temperature without contact to the heating element and fused by means of mechanical pressure or jointing pressure path without using additional materials.

Principle of the fusion procedure



1 Pipe
2 Heating element
3 Fitting

The resulting fusion joints are homogeneous and display the following characteristics:

- Non-contact heating of the jointing components eliminates the risk of contamination and inhomogeneities
- Small fusion beads due to adjustment of jointing pressure path prior to the fusion process itself, i.e. elimination of the equalization process
- Low-stress fusion joints due to very uniform heating by using an IR radiator

5.7.3 Properties and advantages compared to conventional butt fusion

Non-contact heating

The components being jointed are heated to the ideal fusion temperature uniformly and without contact by using infrared radiation.

A defined gap between the infrared heater and the end faces minimizes the risk of contamination of the jointing surface. Contamination of the infrared heater by plastic particles is thus also eliminated.

Reduced bead formation

The fusion bead produced during fusion is considerably reduced without any loss of quality. Bead-forming equalization is eliminated by non-contact melting of the end faces. The minimal, defined bead is only formed during the jointing process. The fusion zone thus has improved flow dynamics, is nearly zero-static, and features a greater throughput area.

Reproducible jointing processes

The jointing path controls the jointing pressure and thus the fusion process. The high reproducibility of the joints is assured by the clearly defined and controlled process sequence.

Clear, simple operator guidance

Clear, straightforward operator guidance in different languages guides the user interactively through the fusion process in logical operating steps.

Fusion reports and traceability

Fusion reports with all relevant fusion parameters for the corresponding fusion operation can be printed out on a commercial printer via USB interfaces on the fusion device. For identification purposes, labels can be printed on a label printer that assigns the fusion to the corresponding protocol. In addition, the data can be exported (for example USB stick). Together with the signatures of fusion operator and inspector, this allows for meeting the most stringent quality assurance requirements.

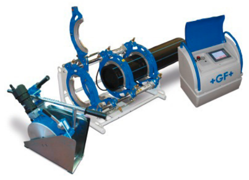
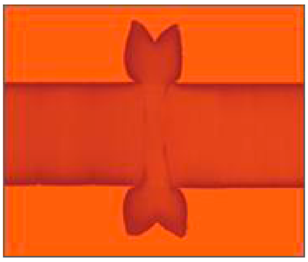
i For additional information about using the fusion procedure for corresponding materials, see www.gfps.com

5.8 Butt fusion jointing (heating element butt fusion conventional butt fusion)

5.8.1 Overview

Material

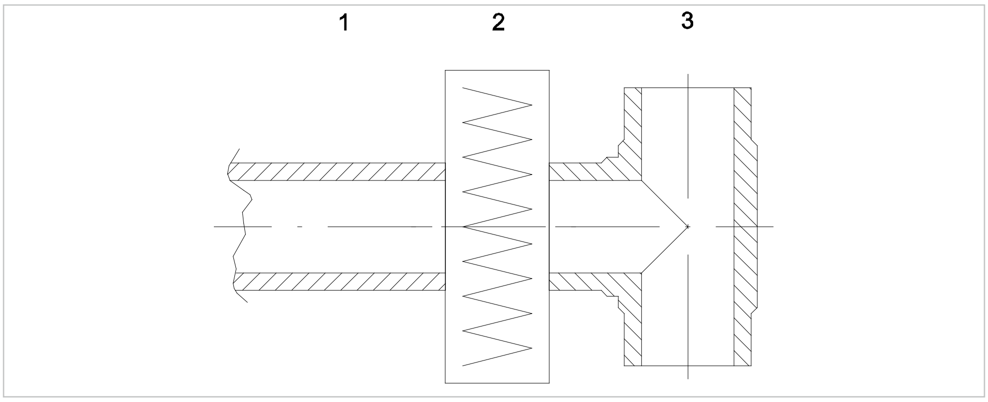
- PE
- PP
- PVDF

Fusion device	Jointing cross section	Macro view
		

5.8.2 Fusion procedure

For heating element butt fusion (HB), the fusion areas of the parts to be joined (pipe, fittings or valves) are heated to fusion temperature and joined by means of mechanical pressure, without using additional materials. A homogeneous joint is the result. Butt fusion joints for pressure piping systems must only be created with a fusion device that allows the jointing pressure to be regulated. When building pressure piping systems, the components to be jointed must have the same wall thicknesses.

Principle of the fusion procedure



1 Pipe
2 Heating element
3 Fitting

5.8.3 Advantages and properties

Heating element butt fusion joints are inexpensive connections that can be made on corresponding systems up to large diameters (2,000 mm and more). Professionally prepared butt fusions meet the same requirements as the components. On specially equipped butt fusion devices, it is also possible to fuse parts at an angle so that segment-fused elbows or T-pieces can be made from pipe segments. A wide range of devices is available for conventional butt fusion; these are designed for workshops, pipe trenches or fitting fusion and can be operated manually, electrically or hydraulically.

For additional information about using the fusion procedure for corresponding materials, see www.gfps.com

5.9 Socket fusion jointing (heating element socket fusion)

5.9.1 Overview

Material

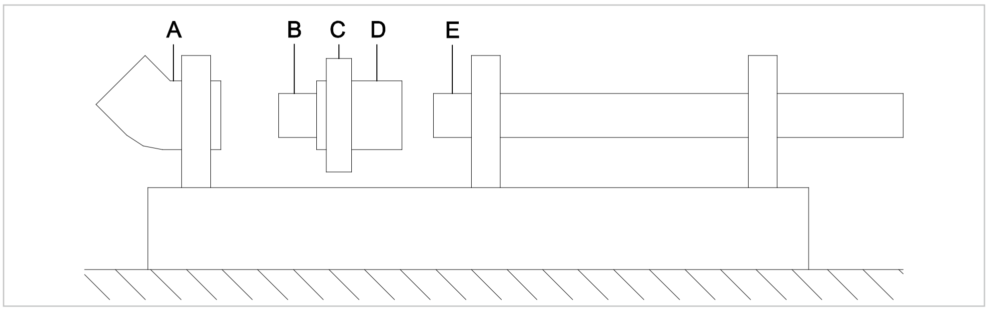
- PE
- PP
- PVDF

Fusion device	Jointing cross section	Macro view
		

5.9.2 Fusion procedure

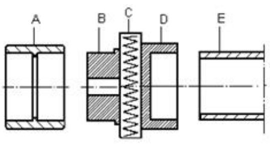
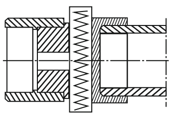
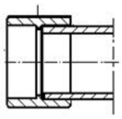
In heating element socket fusion, the pipe end and fusion socket overlap and are fused without using any additional material. The pipe end and fitting socket are heated to fusion temperature using a socket- or spigot-shaped heating element, and are then pushed into each other. The dimensions of the pipe end, fitting socket and heating element correlate in such a way that a fusion pressure is obtained during jointing, resulting in a homogeneous joint.

Fusion device



A Fitting
B Heating spigot
C Heating element
D Heating bush
E Pipe

Principle of the fusion procedure

	Heating	Finished joint
		

A Fitting
B Heating spigot
C Heating element
D Heating bush
E Pipe

5.9.3 Advantages and properties

Heating element socket fusion joints up to a pipe diameter of approx. 50 mm can be created manually. That is, only a heating element with matching attachments is required, a fusion device with clamping elements is not needed. For larger diameters, a fusion device with movable clamping elements is required due to the higher jointing forces.

The rather larger fusion surface compared to butt fusion provides the socket fusion method with an unusually high fault tolerance.

For additional information about using the fusion procedure for corresponding materials, see www.gfps.com

5.10 Electrofusion (heating element fusion joints)

5.10.1 Overview

Material

- PE100

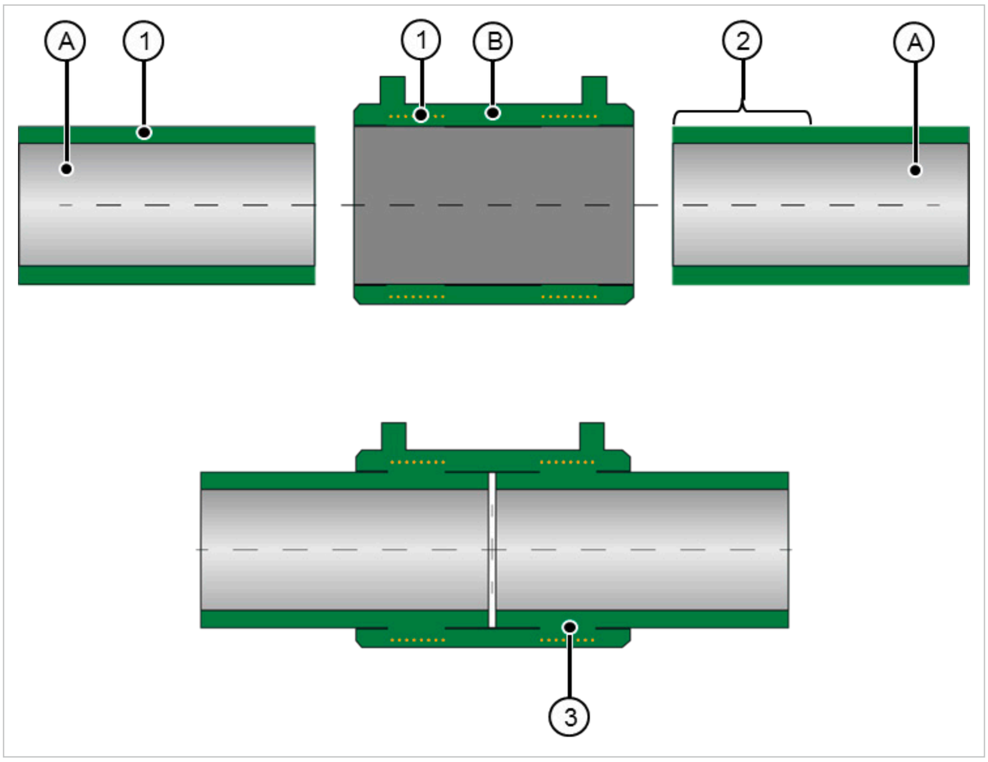
Fusion device	Jointing cross section	Macro view
		

5.10.2 Fusion procedure

By electro fusion, plastic pipe and electrofusion fitting are permanently connected with each other by a restraint and homogenuous joint s.

The electrofusion fittings are equipped with internal resistance wires to which electric current is applied during the fusion process. This heats the inside of the fittings and the outside of the pipe to the fusion temperature and melts them. The dimensions of the pipe end and fitting socket correlate in such a way that a fusion pressure is obtained during jointing, resulting in a homogeneous joint. The jointing force in the polymer melt required for the fusion is the result of the volume increase of the melt. After it cools off, the result is a permanent, homogenous joint.

Principle of the fusion procedure



A Pipe
B Fitting
① Connecting area
② Insertion depth
③ Jointing level

5.10.3 Advantages and properties

The use of electrofusion to connect pipe and fittings allows safe, rational, economic and efficient installation of underground and aboveground PE piping systems.

Advantages

- No fusion bead on inside of the pipe
- Fast pipe-laying speed (compared to conventional butt fusion) because fusion device is barely fixed
- Connection of pipe made of PE80, PE100 as well as a combination of PE80 and PE100
- Low investment need because all dimensions are fused with one fusion device
- Small space requirement for execution because of lightweight and compact fusion devices
- Fully automatic fusion process (high process reliability)

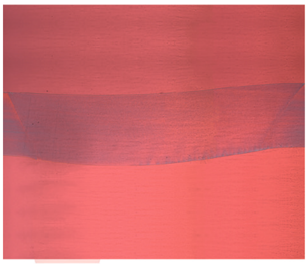
For additional information about using the fusion procedure for corresponding materials, see www.gfps.com

5.11 BCF Plus fusion jointing (bead and crevice-free)

5.11.1 Overview

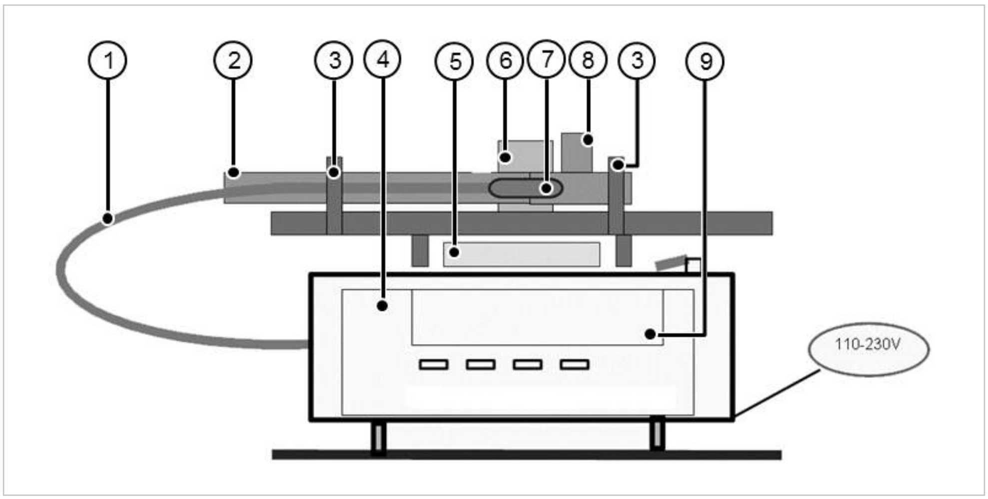
Material

- PVDF
- PP-n (PP Natural)

Fusion device	Jointing cross section	Macro view
		

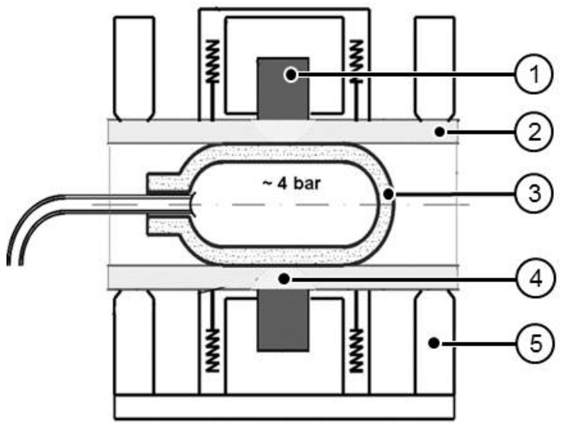
5.11.2 Fusion procedure

The fusion process consists of transmitting precisely defined thermal energy radially to the pipe and fitting ends being jointed by means of half-shell heating elements. At the same time an elastic, pressurized bladder supports the inside surface of the fusion zone in order to prevent the formation of a fusion bead. Keeping the melted thermoplastic at controlled pressure ensures ideal, homogeneous fusion of the plastic components. Fully automatic process control of the fusion process with a fusion device developed by GF Piping Systems permits extremely simple handling and reproducible fusion quality.



1. Compressed-air supply
2. Pipe
3. Clamping position
4. Compressor for bladder
5. Cooling air blower
6. Heating element with clamping device
7. Bladder (elastic pressure vessel)
8. Fitting
9. Control unit with control panel

IV



① Heating element
② Pipe/fitting
③ Bladder (elastic pressure vessel)
④ Fusion zone
⑤ Clamping position

5.11.3 Advantages and properties

Bead and crevice-free fusion result

The result of the jointing process is a surface similar to the actual piping system components without any beads or crevice. Hence, no dead spots are created. The surface roughness is within the range of the piping system components.

Reproducible jointing processes

The high reproducibility of the fusions is assured by the clearly defined and controlled process sequence.

Clear, simple operator guidance

Clear, straightforward operator guidance in different languages leads the user interactively through the fusion process in logical operating steps.

Fusion reports and traceability

Fusion reports with all relevant fusion parameters for the corresponding fusion operation can be printed out on a commercial printer via USB interfaces on the fusion device. For identification purposes, labels can be printed on a label printer that assign the fusion to the corresponding protocol. In addition, the data can be exported to a USB stick and edited with special software. Together with the signatures of fusion operator and inspector, this allows for meeting the most stringent quality assurance requirements.

For additional information about using the fusion procedure for corresponding materials, see www.gfps.com

Design and Installation

of Special Solutions

Content

1 CONTAIN-IT Plus

1.1 Introduction

Application areas

- For gaseous or liquid media, where any leakage of the piping system would endanger the personnel, the environment or the operations
- For strong diffusing media (HF, HCL, HNO_3)
- For piping systems which must be maintained in operation under all circumstances, in order to guarantee process reliability, even in the case of a leak
- For application conveying critical liquids

Market segments

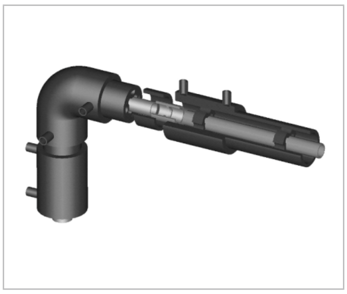
- Water treatment (wastewater treatment)
- Chemical process industry (distribution pipe systems, galvanization plant for metal treatment)
- Microelectronics industry (chemical waste, photovoltaics)
- Cooling (breweries and food industry)
- Food & Beverage industry (Cleaning in place (CIP), end-product safety)
- Data center (protection of IT infrastructure)

Characteristics

Connection benefit

The patented double containment jointing technique enables the jointing of the double containment pipe similar to the jointing of a single pipe according to the same directives and guidelines from the DVS (German association for jointing) as for standard thermoplastic piping connections.

The type of connection allows a pressure testing of the inner pipe before the outside pipe is welded.



Design benefit

To ensure operational safety and a long life, the choice of the material and welding technology is of key importance. GF Piping Systems helps you to find the ideal material for your application from a large product range of seven different thermoplastics materials.

Engineering benefit

A large number of well-known international companies choose a complete system from a single-source supplier because reliable calculation can be made only with a dedicated system. For a double containment piping system, the tensions created by the longitudinal expansion stresses and temperature differences between the inner and outer pipe are being calculated. This will confirm the mechanical stability of the whole piping system.

Environmental benefit

Environmental risks are systematically analyzed in the scope of ISO 14001, and appropriate measures are then taken to minimize these risks. Double containment piping systems help to minimize the risks of incidents, giving you the opportunity to reduce insurance premiums and maintain your company image.

Environmental awareness and increased safety standards are becoming more and more important in today's society. Personal injury, property damage and environmental pollution, caused by leakages, are key concerns that have led us, as a piping system supplier, to design a suitable system to reduce potential hazards. To ensure plant safety during transport of substances which could endanger humans and the environment and process it, requires a piping system which offers optimal chemical resistance and which recognizes and collects any leakage that may occur. Customer-friendly installation and proven and approved connection technologies are important requirements for manufacture.

Legal provisions

Switzerland

The regulation concerning the protection of disturbances (§ 3, General Safety Measures) states that companies have to take all suitable measures in order to minimize risks. This includes measures to reduce the hazard potential, prevent disturbances and limit their environmental impacts.

The federal law about the prevention of water pollution (§ 22, General Requirements) states that owners of installations conveying liquids hazardous to waters have to make sure that all measures are taken to protect waters. These measures define that installations must be designed, installed, maintained and operated to guarantee that no natural water supplies can be polluted. Furthermore, any kind of loss of liquids must be avoided and any leakage of liquids must be prevented for storage facilities and refilling points.

Germany

The German Water Management Act (§ 62 g WHG) applies the "duty of care" principle for the storage, filling, manufacturing and treatment of substances which are hazardous to water and to internal piping systems in the industry. This stipulates that installations which handle liquids that endanger the water quality must be designed, installed, maintained and operated to guarantee that no natural water supplies can be polluted.

In accordance with a ruling of the German Federal Administrative Court, the "duty of care" principle requires the elimination of even the likelihood that any water pollution may occur.

Requirement of German regulations on installations handling substances which are hazardous to water (§17 AwSV)

- (1) Facilities must be planned and built, designed and operated in such a manner that 1. substances that are hazardous to water cannot escape, 2. leaks in all parts of the facility which are in contact with substances that are hazardous to water can be detected quickly and reliably, 3. escaping substances that are hazardous to water are detected quickly and reliably, retained and disposed of properly; this also applies to losses arising from spraying and dripping which occur due to operating conditions, and 4. mixtures that may contain escaping substances that are hazardous to water which accumulate during a disruption to the facility's proper operation (operational malfunction) are retained and disposed of properly as waste or eliminated as wastewater.
- (2) Facilities must be leakproof, stable and sufficiently resistant to the anticipated mechanical, thermal and chemical influences.
- (3) Single-walled underground containers for liquid substances that are hazardous to water are not permitted. Single-walled underground containers for gaseous substances that are hazardous to water are not permitted if the gaseous substances that are hazardous to water escape in liquid form, are heavier than air or dissolve in available moisture once they have leaked into the surrounding soil.
- (4) In the event that a facility is decommissioned, the operator shall remove all substances that are hazardous to water contained in the facility, or parts thereof, where this is technically feasible. The operator must secure the facility against improper use.

The before mentioned requirements for piping systems can be fulfilled through the existing retention space between the inner and outside pipe in GF's double containment piping system.

1.2 Double containment piping systems

1.2.1 Pressure-tight outer pipe

The CONTAIN-IT Plus double containment piping system comprises an outer protective pipe made from PE100, which is welded pressure-tight using ELGEF Plus electrofusion couplers.

The protective pipe serves as a leak monitoring space, where spills that could leak from the inner pipe under certain circumstances, are contained until the leak has been discovered and repaired. In addition, it is used to convey liquids for the purpose of stabilizing the temperature of the medium in the inner pipe.

Both the inner and the outer protective pipe are reliable, quality-controlled pressure piping systems, which are implemented without changes. The jointing techniques correspond without exception to the relevant guidelines for pressure piping system construction. There are no limits to the choice of inner pipe materials, ensuring that the material can be ideally matched to the chemical resistance required by the particular application.

1.2.2 Outer pipe splash guard

The CONTAIN-IT Plus splash protection system differs from the pressure-tight system in usage of an EPDM rubber collar with a stainless steel coupler for connection of the outer pipe. The EPDM rubber collar is pressure-tight up to 1 bar. The rubber collar allows different outer pipe materials (PE100 and transparent PVC-U) to be quickly connected together, without the use of tools or any machining of the pipe. The connection of the fittings is the same as on the pressure-tight system. The preferred material for the outer pipe is transparent PVC-U.

1.2.3 Criteria for safe operation

The following criteria are important for safe operation:

- For safety reasons, the components of the media-conveying inner pipe should not be altered from their standard version. This ensures the consistent, tested quality of our DIBt-approved (German Institute for Building Technology) individual components of the fittings for the following materials: PVC-U Z-40.23-2; PE80 and PE100 Z-40.23-282; PP-H Z-40.23-264 and PVDF Z-40.23-262. The pipe have to be DIBt-approved.
- The DVS (German Association for Fusion Technology) fusion guidelines and KRV (Plastic Pipe Association) solvent cementing instructions are applicable without exception, especially to double containment piping systems. Particularly important quality factors are monitoring and the visual inspection during the build-up of the fusion bead on the internal pipe during the fusion process.
- The pressure test on the inner pipe must be carried out before the outer pipe is sealed. Particularly in the case of double containment piping systems, where the emphasis is on safety, no "dry joints" can be tolerated.
- Fix-point installation with structural certificate: the minimum dimensional difference between the inner and outer pipe prevents any possible longitudinal expansion. The entire system must be installed as a fix-point installation. A structural certificate is recommended for the pipe system. See chapter „1.10 Static evidence“ auf Seite 308. The product range includes radial dismountable mechanical couplings for maintenance or repair of the piping system, or to carry out subsequent extensions. Connections for commercial leak detection devices must be provided.

1.2.4 Authorization of installation personnel

Easy-to-learn technology, strict adherence to standards and regulations as well as many decades of experience in plastic piping system construction are the marks of distinction of the double containment piping system from GF Piping Systems. Added to these essential requirements, in the interest of safety, is the careful training of the installers. Double containment systems may be installed only by persons who have been specifically trained and authorized by GF Piping Systems.

1.2.5 CONTAIN-IT Plus product range

PE100 outer pipe

Dimension (mm)	Inner pipe											
	Solvent cementing				Socket fusion			Butt fusion				IR fusion
	PVC-U Tangit	PVC-U Dytex	PVC-C Tangit	PVC-C Dytex	PP-H	PE80	PVDF	PP-H SDR11	PE-100 SDR11	PVDF SDR21	PVDF SDR33	ECTFE
d20/D50	✓	✓	✓	✓	✓	✓	✓	•	•	•		✓
d25/D50	✓	✓	✓	✓	✓	✓	✓	•	•	•		✓
d32/D63	✓	✓	✓	✓	✓	✓	✓	•	•	•		✓
d40/D75	✓	✓	✓	✓	✓	✓	✓	•	•	•		✓
d50/D90	✓	✓	✓	✓	✓	✓	✓	•	•	•		✓
d63/D110	✓	✓	✓	✓	✓	✓	✓	•	•	•		✓
d75/D125	✓	✓	✓	✓	✓	✓		•	•	•		✓
d90/D140	✓	✓	✓	✓	✓	✓		•	•	•		✓
d110/D160	✓	✓	✓	✓	✓	✓		•	•	•		✓
d125/D180	✓							✓	✓		✓	
d140/D200	✓							✓	✓		✓	
d160/D225	✓							✓	✓		✓	
d200/D280	✓							✓	✓		✓	
d225/D315	✓							✓	✓		✓	

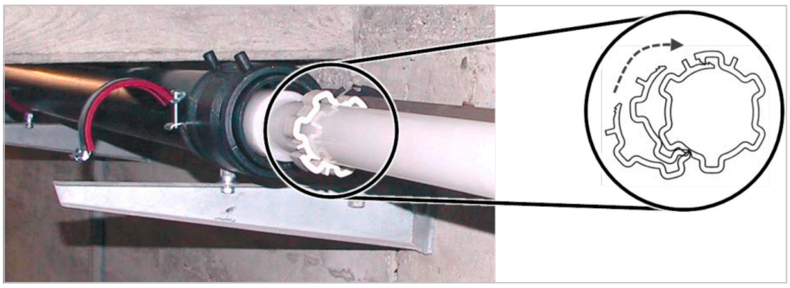
- Compatible with butt- and infrared (IR) welding technology

Other combinations,
e.g. PVDF with BCF (bead and crevice-free) on request.

1.2.6 Inner pipe

The choice of different types of plastic for the inner pipe allows the pipe material to be optimally matched to physical and chemical requirements: PVC-U, PVC-C, PP-H, PE, PVDF, ECTFE and PFA.

"Click system" spacers are clamped to the inner pipe, which is then pushed into the outer pipe – pipe are not supplied ex-works as double pipe. The pipe can also be used as single pipe.



Spacer on inner pipe

Outer pipe PE100

The outer protective pipe, which surrounds the medium-conveying inner pipe, is made of PE100 polyethylene. The key features of this material are its good chemical resistance to acids, alkalis and salts as well as a number of organic and inorganic solvents. The high resistance of this black (stabilized with carbon black) polyethylene to UV effects, its insusceptibility to notching, flexibility and impact resistance, even at low temperatures down to -50 °C, make this protective pipe material ideal for pipe laid indoors, outdoors and in the ground.

Transparent PVC-U splash outer pipe

The pressure level of the outer pipe is restricted to 1 bar by the use of an EPDM rubber collar. The code numbers and wall thicknesses of the protective pipe (PE100 or PVC-U) are listed in the double containment product catalog.

Gaskets

When laying the inner pipe, sealing material should be selected that is suitable for the prevailing operation conditions. Available choices are EPDM, FKM and, for ball valves, also FFKM (on request). The sealing material used for the protective pipe is EPDM.

Fittings for inner and outer pipe

The individual fittings for the inner and outer pipe are injection molded using the latest quality assured procedures. The inner fittings are available in all GF Piping Systems plastic materials. Fittings are factory-made and supplied ready to install. In the CONTAIN-IT Plus double containment system, the outer fitting – always made from PE100 polyethylene – is already attached to the inner fitting. The inner and outer fittings are connected together using sturdy support rings, which act as fixed points for the inner pipe. This prevents an expansion of the inner pipe inside the outer pipe. The entire system must be finished as a fix-point installation with a structural certificate.

On solvent cementable plastics (PVC-U, PVC-C), a cemented socket joint is used to connect the inner pipe. A number of different fusion processes are available for connecting fusionable plastics (PE, PP-H, and PVDF). Socket fusion can be used for PP-H / PE (d20/50 to d110/160) and PVDF (d20/50 to d63/110). For the range d20/50 to d225/315, butt fusion techniques can be used, although infrared fusion techniques can also be used in certain cases. See chapter „1.2.5 CONTAIN-IT Plus product range“ auf Seite 268.

Wherever possible, factory-finished joints are made by infrared fusion.

The PE outer fittings have integrated pipe spigots – which also act as the support rings for the inner pipe – for connection by means of push-on ELGEF Plus electrofusion sockets or EPDM rubber collars. The push-on ELGEF Plus electrofusion socket or rubber collar can be pushed over the end of the pipe being connected, or the long end of the fitting, before the inner pipe is connected. The electrofusion socket will fit along only half the length of the short end of the fitting.




Termination fitting

Specially designed and patented termination fittings, with an Rp½ connection to the monitoring space, are installed at the start and end of the double containment system. These fittings are also suitable for subdividing the outer pipe, i.e. to divide the pipe system into leak detection zones, thereby enabling easier location of leaks.

Branch saddles

Branch saddles, for fitting to the protective pipe after connection, are used for the installation of a leakage locating system, for flushing the space between the pipe, for venting at the highest point of the piping system, or as unions for carrying out a pressure test in the space between the pipes.

Valves

Specially designed manual and actuated double containment valves can be easily integrated in the system analogous to the fittings. Double containment valves are factory-made and supplied as a system unit. They can be externally operated and opened for maintenance purposes and to carry out a pressure test on the inner pipe.

1.3 Planning criteria

1.3.1 Material selection for the medium-conveying inner pipe

The choice of material and the pressure rating of the pipe components are important for both operating safety and for attaining the specified minimum operational life of the system. The decisive factors are the following:

- Operating pressure
- Operating temperature
- Medium transported
- Time of operation

The chemical resistance list and the material-related pressure and temperature charts can be used to preselect the material.

These aids can be found in the technical manual and on our website www.gfps.com.

1.3.2 Material selection for the outer pipe

The pressure rating of the outer pipe must correspond to the service pressure of the inner pipe until the damage is repaired. In case of leakage, the pressure-resistant and chemical-resistant PE100 outer pipe must be able to contain the spill. In the event of a leak, exposure to the medium normally does not require an immediate shutdown of the operation. It may be possible to complete ongoing production runs before shutting down.

When using the splash guard outer pipe system with a transparent PVC-U outer pipe, the restricted pressure loading of 1 bar must be taken into account. There must be no possibility of higher pressure developing in the protective pipe in the event of a leak.

1.3.3 Questionnaire for static evidence

The questionnaire for static evidence (Section: Static evidence) is used by GF to determine if the selected piping system is resistant under the given operating conditions. See chapter „1.10.2 Questionnaire for static evidence“ auf Seite 310.

For fix-point installation (restricted longitudinal expansion), it is necessary to calculate the stresses and forces on the outer pipe fittings, which the fix-point pipe brackets are required to absorb.

The fix-point for the inner pipe is already built into each fitting by means of a support ring. If the calculated stress on the pipe is too high, the operating conditions or the material must be changed.

The calculation also indicates the distances between spacers for the inner pipe and the distances between pipe brackets for the outer pipe, as well as the forces on fixed points.

Expansion in the piping system need not be taken into consideration; no additional expansion loops or compensators are required.

1.3.4 Determining the layout

The pipe layout should be planned so that the pipe are protected from mechanical and thermal effects. The necessary minimum distance from walls and ceilings must be considered.

For large fix-point forces, the anchoring method on the building material should be checked. If building material cannot absorb any fix-point forces (e.g. trapezoidal corrugated roofs), the forces must be absorbed via sturdy traveling rails.

1.3.5 Determining the leak detection

Leak detection is an important element of the double containment piping system and must be taken into consideration.

Leak detection and locating systems must be observed. See chapter „1.7 Leak detection and leak locating systems“ auf Seite 298.

1.3.6 Isometric drawing

The 30° isometric drawing (see example of cutting length calculation) provides an accurate view of the piping layout. When the axis dimensions are entered, the cutting lengths can be calculated and the installation direction of the fittings determined.

This can be used to represent the ventilation, rinsing and shut-off requirement, as well as the installation position of the end and sectional fittings.

1.3.7 Sizing

The pipe diameter is determined by calculating the pressure loss within the pipe. This depends not only on the diameter, length or pipe material but, also on the flow medium and the flow rate.

A calculation can be done based on DVS 2210.

For project planning, construction and installation of double containment systems, please refer to the DVS guideline DVS 2210-2.

1.4 Installation instructions

1.4.1 Jointing double containment pipe

Patented double containment jointing technology

The principle of the GF Piping Systems double containment jointing technology is based on the fact that the inner pipe is joined first using the techniques described below. This means that a double containment piping system is jointed in the same manner as a single piping system. The so-called “last joints”, which occur with every change of direction in other systems and which are then usually done “blind”, are therefore not applicable. When the clamps are removed, there is a gap of 30 mm between the ends of the outer pipe. This serves to check the joint of the inner pipe according to the DVS guidelines. When the pressure test on the inner pipe has been completed, this gap is closed with a snap ring.

Inner pipe

The inner pipe are connected using standard, tried and tested jointing methods. Depending on the material and sizes, the available options are: solvent cementing, socket fusion, butt fusion and infrared fusion. The choice of method is also determined by suitability for the operating conditions. PVDF BCF (bead and crevice-free) on request.

Solvent cementing (PVC-U and PVC-C)

A quick jointing method that is carried out without extensive use of tools or machinery.

Socket fusion heater element (PP, PE and PVDF)

Socket fusion is particularly suited for dimensions from d20/50 up to d110/160. Up to and including dimension d50/90, these joints can be easily made in the piping system route, using hand fusion equipment.

Butt fusion heater element (PP, PE and PVDF)

In pressurized pipe systems, all butt fusion joints must be produced in a butt fusion machine and not by hand!

IR infrared fusion (PP, PE100, PVDF and ECTFE)

In IR fusion, the parts to be connected (pipe and fitting) are heated to fusion temperature in the fusion area and fused in a contact-free process. This low-stress fusion method allows smaller fusion beads to be created.

1.4.2 Jointing the outer pipe

After the inner pipe has been pressure-tested, the outer pipe is sealed. A pressure-resistant version with an electrofusion socket and the splash guard version (PN1) with an EPDM rubber collar are available for this purpose. The activities described below to prepare for making the joint, must be carried out at the same time as the installation of the inner pipe.

Jointing the outer pipe with ELGEF Plus electrofusion coupler

- Cut the pipe size at a right angle in accordance with the calculation sheet (it is advisable to number the cut lengths of pipe)
- Clean any coarse dirt from the pipe
- Prepare the pipe ends with a rotary scraper
- Depending on the recess type of the electrofusion socket, the length of the pipe to be scraped is either ½ or full length of the socket
- New double containment fittings, removed from the packaging shortly before processing, do not need to be scraped
- Please refer to the separate installation instructions for electrofusion fittings and the dimensional tolerances when scraping the PE pipe
- Clean/degrease pipe end with Tangit KS cleaner and clean absorbent paper.

Permissible minimum outside pipe diameter*

d (mm)	Min. chip thickness (mm)	Permissible minimum outer pipe diameter (mm)
50	0.20	49.5
63	0.20	62.5
75	0.20	74.4
90	0.20	89.4
110	0.20	109.4
125	0.20	124.4
140	0.20	139.4
160	0.20	159.4
180	0.20	179.4
200	0.20	199.4
225	0.20	224.4
280	0.20	279.3
315	0.20	314.3

* Measured at 23 °C ambient temperature

Pushing on the electrofusion coupler

Calculating the insertion depth:

Insertion depth = ½ socket length – snap ring(mm)

$$\text{Snap ring width} = \frac{30\ \text{mm}}{2} = 15\ \text{mm}$$

Insertion depth = ½ socket length – 15 mm

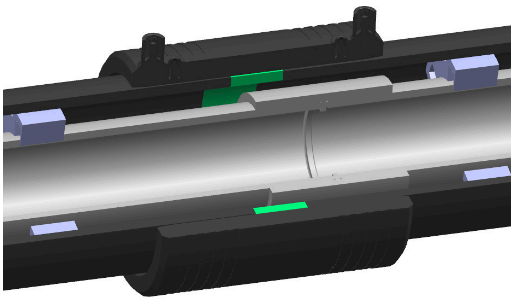
- Immediately prior to use, remove ELGEF Plus electrofusion coupler from the bag, whilst keeping it clean, remove the middle stop and push completely over the stripped end of the pipe. Seal/secure with the PE stretch film to protect from contamination and moisture. Check for proper functioning.

> ⚠ The ELGEF Plus coupler must be on the pipe before the inner pipe are jointed.

- Remove the stretch film immediately before fusing the outer pipe.
- Apply the snap ring

If the electrofusion socket is pushed on without a snap ring, the outer pipe can shift, so that a reliable fusioning can no longer be guaranteed. The snap ring must sit centrally on the ELGEF Plus electrofusion coupler (cold zone). The ends of the outer pipe must butt up to the snap ring with no gap.

- Clean the fusion zone.
- Refer to instructions, wherever possible, use clamps for electrofusion of couplers and branch saddles.
- Fuse.

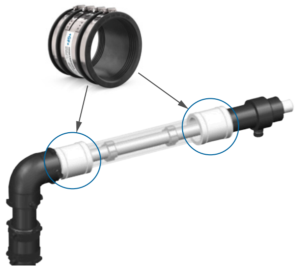
Snap ring 30 mm	**MSA 4.0 fusion machine for ELGEF Plus couplers with GPS function**
	

d (mm)	SDR	L (mm)	½L – 15 (mm)
50	11	88	29.0
63	11	96	33.0
75	11	110	40.0
90	11	125	47.5
110	11	145	57.5
125	11	156	63.0
140	11	166	68.0
160	17	180	75.0
180	17	192	81.0
200	17	208	89.0
225	17	225	97.5
280	17	252	111.0
315	17	267	118.5

L Length of ELGEF Plus couplers

1.4.3 Jointing the outer pipe using the EPDM rubber collar with stainless steel

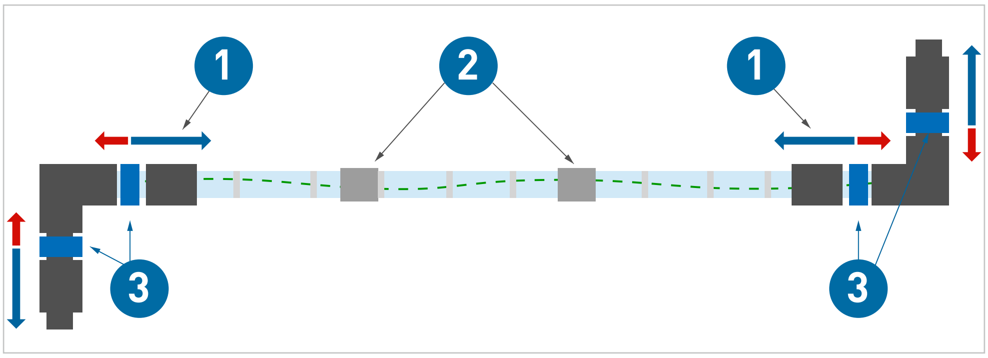
The CONTAIN-IT Plus PVC-U (transparent) outer pipe system is a splash protection double containment solution with up to 1 bar in the monitoring room.



Steel construction: Fix-Point Installation

When carrying out installation using the EPDM-Coupler, it is essential to ensure that the outer pipe is securely clamped to prevent axial movement and that no pipe expansion occurs. The EPDM-Coupler has no tensile strength!

Note: Check results of static evidence and stress calculation to get all required installation information for your specific application conditions (support clamps distances, spacer distances, expected forces radial/axial, etc.).



1. Connection EPDM-Coupler
2. Connection Sockets
3. Fix point to steel construction

Mechanical connections: fitting to pipe or fitting to fitting

EPDM-Couplers are used for the transition between PVC-U pipe (transparent) and the CONTAIN-IT Plus fittings, valves and mechanical connections (PE).

Preparation and positioning: EPDM-Coupler

Clean the square-cut (90°) pipe with a clean cloth and push the EPDM-Coupler onto the outer pipe. The snap ring must sit centrally on the rubber collar. The ends of the outer pipe must butt up to the snap ring without gap.

Note: EPDM-Coupler must be placed on the outer pipe before the inner pipes are jointed.

Calculation of the insertion depth for pipe and fitting

1. Check your EPDM-Coupler length.
2. Insertion depth = ½ coupler length – ½ snap ring width.
3. ½ Snap ring width = 15 mm.
4. Insertion depth = ½ coupler length – 15 mm.
5. Marking of the insertion depth on fitting & pipe.

Note:
- The snap ring has to be centered in the middle of the EPDM-Coupler, see picture.
- Precise measurement required, so that there is no gap between snap ring and pipe/ fitting.

① Snap ring: 30 mm
② Inner pipe connection
③ PVC-U (transparent) pipe
④ CONTAIN-IT Plus components (PE outer pipe)

Cementing: pipe to pipe

Since the EPDM coupling itself does not provide tensile strength, GF recommends cemented joints (PVC-U sockets) for the straight pipe runs.

For pipe to pipe connections the snap ring is not necessary, PVC-U sockets. Information on the cementing process can be found in the chapter PVC-U (transparent) in the GF planning fundamentals.

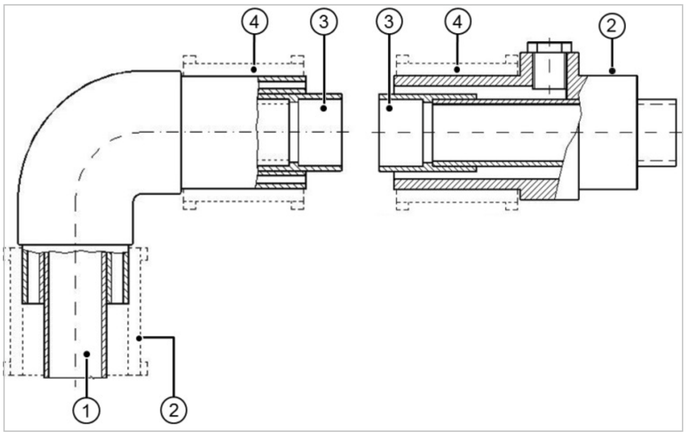
1.5 Fittings for solvent cementing / socket fusion and installation

1.5.1 Overview

Since the axis sizes (z-dimension) of 90° and 45° elbows and the T-pieces are the same, only the 90° elbow is shown. The socket is always on the long side of the fitting.

Possible connections:

- Direct fitting to fitting
- Fitting to intermediate pipe section
- Fitting to termination fitting



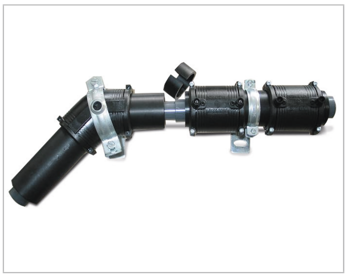
① Spigot for solvent cementing / socket fusion
② Space for ½ ELGEF Plus coupler
③ Socket on double containment fitting for solvent cementing / socket fusion
④ Space for complete ELGEF Plus socket or EPDM collar

From the central axis to the front edge, all types of fittings have the same Z dimension (i.e. same axis size). This applies only to fittings made from the same material and for use with the same jointing method!

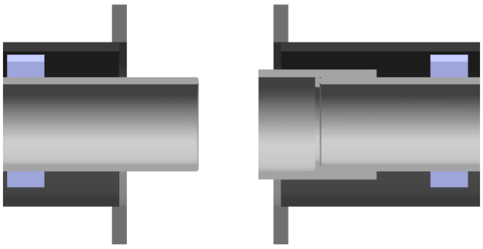
The lengths of the outer pipe (black, scraped and cleaned fusion surfaces) and inner pipe (gray with clipped-on spacers) are different.

The inner pipe is pushed into the outer pipe and the fusion sockets are positioned on the outer pipe.

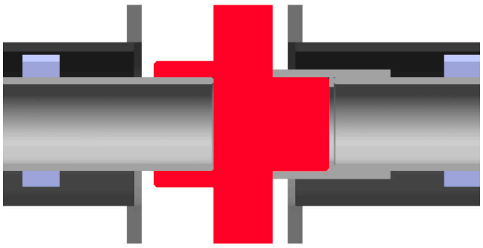
The fitting is first of all jointed (fused or cemented) to the inner pipe with the prepared double containment pipe piece. The inner pipe is now pressure-tested. Following the successful pressure test, a pressure-tight joint of the outer pipe with inserted snap ring is produced, using an electrofusion socket.



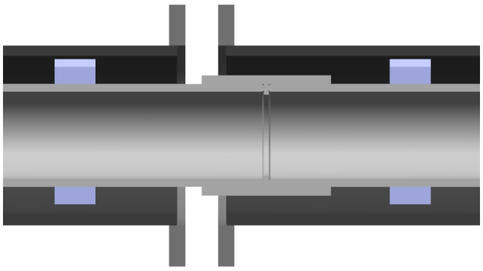
1.5.2 Fusion procedures



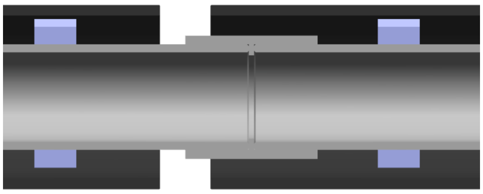
1. Special clamps hold the inner pipe and the inner fitting



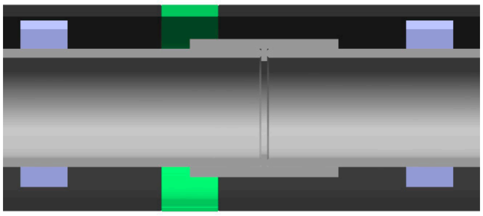
2. Standard heating element for socket fusion: pipe and fitting are heated simultaneously



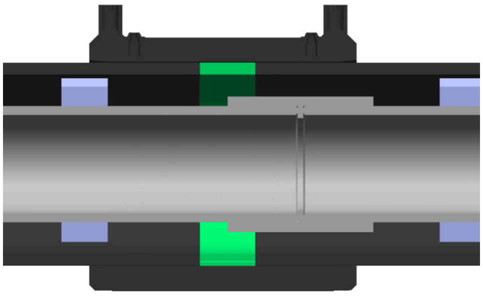
3. Heating element for socket fusion



4. Visual inspection:
   check the joint, then pressure test of the inner pipe



5. Place the snap ring between the ends of the outer pipe



6. A pressure-tight seal of the outer pipe is produced by the ELGEF Plus electrofusion coupler, or the EPDM collar is used as splash guard

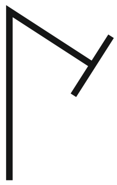
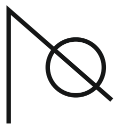
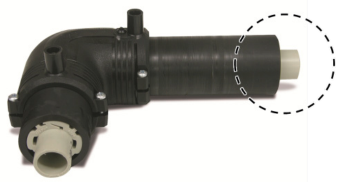
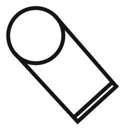
1.5.3 Various connection examples

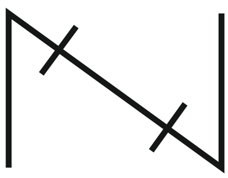
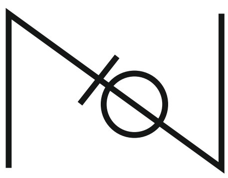
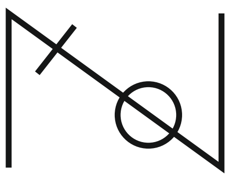
CONTAIN-IT Plus: socket cementing / fusion

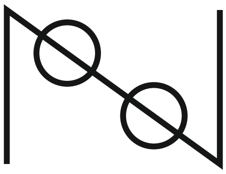
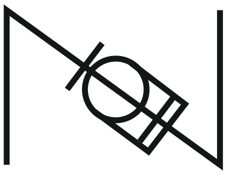
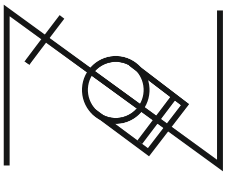
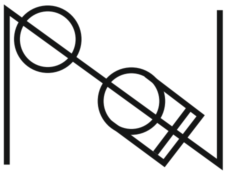
- Short end of fitting with internal spigot (S) (90° elbow, 45° elbow, 90° T-piece, equal)
- Long end of fitting with internal socket (L) (90° elbow, 45° elbow, 90° T-piece, equal)
- Termination fitting (T) - long end of fitting with internal socket
- Pipe (P)

Legend

The following symbols are used to demonstrate the various connection examples of socket fusion/cementing and butt fusion:

Abbreviation	Name	Symbol	Example 90° elbow
S	Short end of fitting with internal spigot		
L	Long side of fitting with internal socket		
T	Termination fitting with long side of fitting with internal socket		

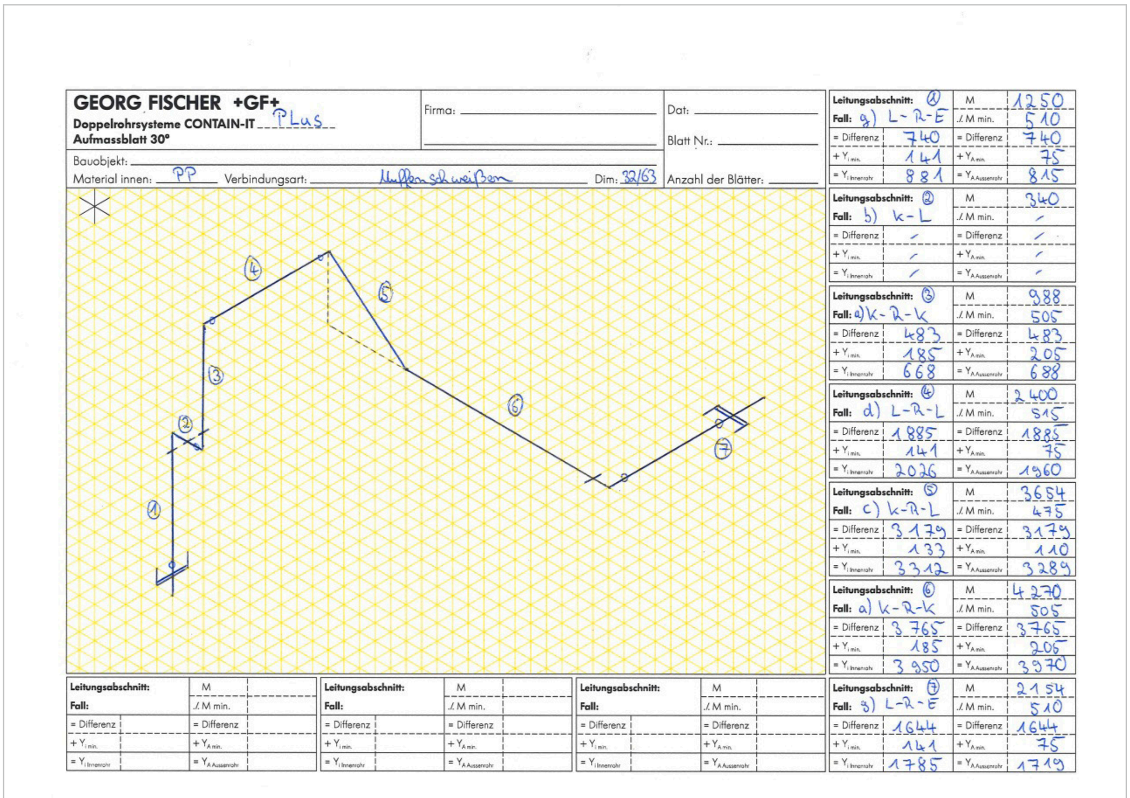
Example	Symbol	Combination
a) S – P – S		Fitting end with spigot – Pipe with 2 equal sockets – Fitting end with spigot
b) S – L		Fitting end with spigot – Direct – Fitting end with socket
c) S – P – L		Fitting end with spigot – Pipe with 1 socket – Fitting end with socket

Example	Symbol	Combination
d) L – P – L		Fitting end with socket – Pipe – Fitting end with socket
e) S – T		Fitting end with spigot – Termination fitting with socket
f) S – P – T		Fitting end with spigot – Pipe with 1 socket – Termination fitting with socket
g) L – P – T		Fitting end with socket – Pipe – Termination fitting with socket

Sample calculation to find cutting lengths for inner and outer pipe

In the double containment system, the inner and outer pipe are always cut to different lengths. The deduction sizes "./. M_{min}" and allowance sizes "+ $Y_{i\,min}$" for the inner pipe and "+ $Y_{o\,min}$" for the outer pipe are dependent on a combination of the installation length of the fittings, and can be found in the following tables.

- **Since the axis sizes for the 90° elbow, 45° elbow and T-piece are the same, only the 90° elbows are shown and discussed here.**



Piping system section 1		M	1250
Case g) L – P – T		./. M min.	510
= Difference	740	= Difference	740
+$Y_{i\ min.}$	141	+ $Y_{o\ min.}$	75
= $Y_{i\ inner\ pipe}$	881	= $Y\ o_{outer\ pipe}$	815

Piping system section 2		M	340
Case b) S – L direct		./. M min.	
= Difference		= Difference	
+$Y_{i\ min.}$		+ $Y_{o\ min.}$	
= $Y_{i\ inner\ pipe}$		= $Y\ o_{outer\ pipe}$	

Piping system section 3		M	988
Case a) S – P – S		./. M min.	505
= Difference	483	= Difference	483
+$Y_{i\ min.}$	185	+ $Y_{o\ min.}$	205
= $Y_{i\ inner\ pipe}$	668	= $Y\ o_{outer\ pipe}$	688

Piping system section 4		M	2400
Case d) L – P – L		./. M min.	515
= Difference	1885	= Difference	1885
+$Y_{i\ min.}$	141	+ $Y_{o\ min.}$	75
= $Y_{i\ inner\ pipe}$	2026	= $Y\ o_{outer\ pipe}$	1960

Piping system section 5		M	3654
Case c) S – P – L		./. M min.	475
= Difference	3179	= Difference	3179
+$Y_{i\ min.}$	133	+ $Y_{o\ min.}$	110
= $Y_{i\ inner\ pipe}$	3312	= $Y\ o_{outer\ pipe}$	3289

Piping system section 6		M	4270
Case a) S – P – S		./. M min.	505
= Difference	3765	= Difference	3765
+$Y_{i\ min.}$	185	+ $Y_{o\ min.}$	205
= $Y_{i\ inner\ pipe}$	3950	= $Y\ o_{outer\ pipe}$	3970

Piping system section 7		M	2154
Case g) L – P – T		./. M min.	510
= Difference	1644	= Difference	1644
+$Y_{i\ min.}$	141	+ $Y_{o\ min.}$	75
= $Y_{i\ inner\ pipe}$	1785	= $Y\ o_{outer\ pipe}$	1719

Calculation of examples on previous pages

The shortest connection between two double containment fittings is the direct connection. The M dimension between axes is preset.

Piping system section 2		M	340*
Case b) S – L direct		**./. M min.**	
= Difference		= Difference	
$+Y_{i\ min.}$		$+ Y_{o\ min.}$	
$= Y_{i\ inner\ pipe}$	No pipe required	$= Y_{o\ outer\ pipe}$	No pipe required

* Give axes distance

If a pipe is required between the fittings, the minimum dimension ./.M min between axes must be observed.

Piping system section 3		M	988
Case a) S – P – S		**./. M min.**	**505***
= Difference	483	= Difference	483
$+Y_{i\ min.}$	185	$+ Y_{o\ min.}$	205
$= Y_{i\ inner\ pipe}$	668	$= Y_{o\ outer\ pipe}$	688

* Minimum distance between axes

All longer dimensions are calculated as follows:

Piping system section 6		M	4270*
Case a) S – P – S		**./. M min.**	**505**
= Difference	3765	= Difference	3765
$+Y_{i\ min.}$	185	$+ Y_{o\ min.}$	205
$= Y_{i\ inner\ pipe}$	3950	$= Y_{o\ outer\ pipe}$	3970

* Dimension between axes

Material checklist

Required quantity per	Socket equal	Snap ring	ELGEF Plus electrofusion socket	EPDM rubber collar
90° elbow	1	2	2	2
45° elbow	1	2	2	2
T-90° equal	2	3	3	3
Termination fitting	0 (1*)	1 (2*)	1(2*)	1 (2*)
Butt fusion				
90° elbow	0	2	2	2
45° elbow	0	2	2	2
T-90° equal	0	3	3	3
Termination fitting	0	1	1	1
Inner piping system	[4]	0	0	0
Outer piping system	0	[4]	[4]	[4]

* 1 x per pipe length to be processed

* For segmentation of the piping system into leak detection sections

GEORG FISCHER +GF+

Secondary Containment System CONTAIN-IT ____

Pipe layout chart 30°

Client: ____

Date: ____

Sheet No.: ____

Contract: ____

Material of inner pipe: ____ Assembling method: ____ Dim: ____

Number of sheets: ____

Pipeline Section No.:		M	
Case:		./. M min.	
= Difference		= Difference	
+ $Y_{i\,min.}$		+ $Y_{O\,min.}$	
= $Y_{i\,Inner\,Pipe}$		= $Y_{O\,Outer\,Pipe}$	

Pipeline Section No.:		M	
Case:		./. M min.	
= Difference		= Difference	
+ $Y_{i\,min.}$		+ $Y_{O\,min.}$	
= $Y_{i\,Inner\,Pipe}$		= $Y_{O\,Outer\,Pipe}$	

Pipeline Section No.:		M	
Case:		./. M min.	
= Difference		= Difference	
+ $Y_{i\,min.}$		+ $Y_{O\,min.}$	
= $Y_{i\,Inner\,Pipe}$		= $Y_{O\,Outer\,Pipe}$	

Pipeline Section No.:		M	
Case:		./. M min.	
= Difference		= Difference	
+ $Y_{i\,min.}$		+ $Y_{O\,min.}$	
= $Y_{i\,Inner\,Pipe}$		= $Y_{O\,Outer\,Pipe}$	

Pipeline Section No.:		M	
Case:		./. M min.	
= Difference		= Difference	
+ $Y_{i\,min.}$		+ $Y_{O\,min.}$	
= $Y_{i\,Inner\,Pipe}$		= $Y_{O\,Outer\,Pipe}$	

Pipeline Section No.:		M	
Case:		./. M min.	
= Difference		= Difference	
+ $Y_{i\,min.}$		+ $Y_{O\,min.}$	
= $Y_{i\,Inner\,Pipe}$		= $Y_{O\,Outer\,Pipe}$	

Pipeline Section No.:		M	
Case:		./. M min.	
= Difference		= Difference	
+ $Y_{i\,min.}$		+ $Y_{O\,min.}$	
= $Y_{i\,Inner\,Pipe}$		= $Y_{O\,Outer\,Pipe}$	

Pipeline Section No.:		M	
Case:		./. M min.	
= Difference		= Difference	
+ $Y_{i\,min.}$		+ $Y_{O\,min.}$	
= $Y_{i\,Inner\,Pipe}$		= $Y_{O\,Outer\,Pipe}$	

Pipeline Section No.:		M	
Case:		./. M min.	
= Difference		= Difference	
+ $Y_{i\,min.}$		+ $Y_{O\,min.}$	
= $Y_{i\,Inner\,Pipe}$		= $Y_{O\,Outer\,Pipe}$	

Pipeline Section No.:		M	
Case:		./. M min.	
= Difference		= Difference	
+ $Y_{i\,min.}$		+ $Y_{O\,min.}$	
= $Y_{i\,Inner\,Pipe}$		= $Y_{O\,Outer\,Pipe}$	

V

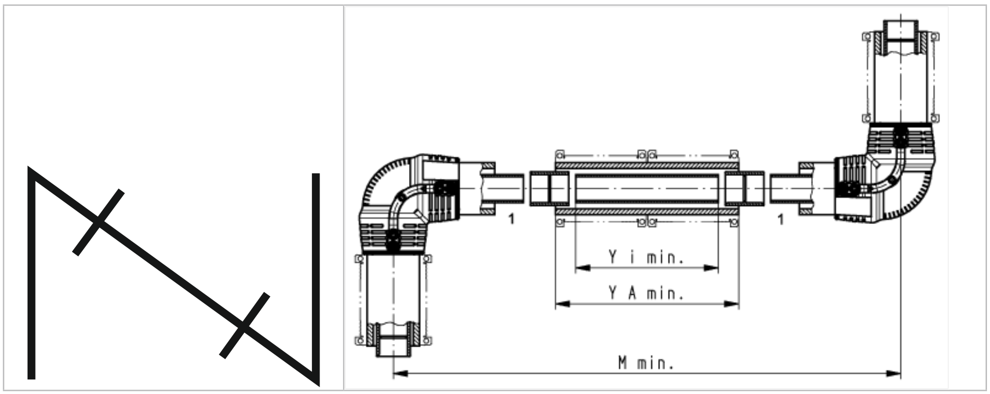
1.5.4 Dimensions for calculating the cutting lengths

CONTAIN-IT Plus: socket cementing / fusion

Caution: The “last joint“ should always be made on the double containment fitting. Loose sockets should first be connected with the intermediate pipe.

Case a) S – P – S

Piping system section 3 and 6

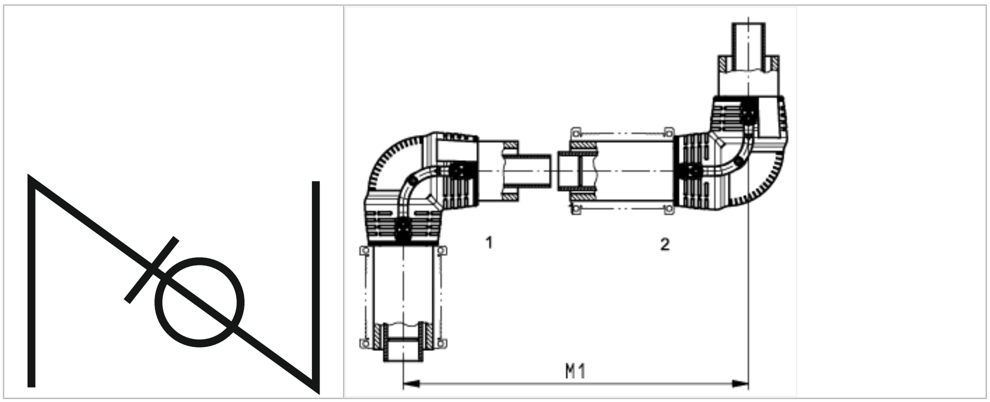


1 Short end of fitting (S)

d/D (mm)	Direct M (mm)	M_{min} (mm)	Inner pipe: $Y_{i\,min}$ / material (mm)				Outer pipe: $Y_{A\,min}$ (mm)
		S – P – S	PVC-U	PVC-C	PP-H, PE80	PVDF	
20/50		460	182	182	178	178	190
25/50		460	176	176	174	174	190
32/63		505	185	185	185	185	205
40/75		580	202	202	204	204	230
50/90		660	222	222	228	228	260
63/110		780	248	248	260	260	300
75/125		840	264	264	282		330
90/140		910	268	268	288		350
110/160		1020	276	273	360		380
125/180		1055	283				405
140/200		1100	304				440
160/225		1230	312				470
200/280		1405	325				525
225/315		1355	327				555

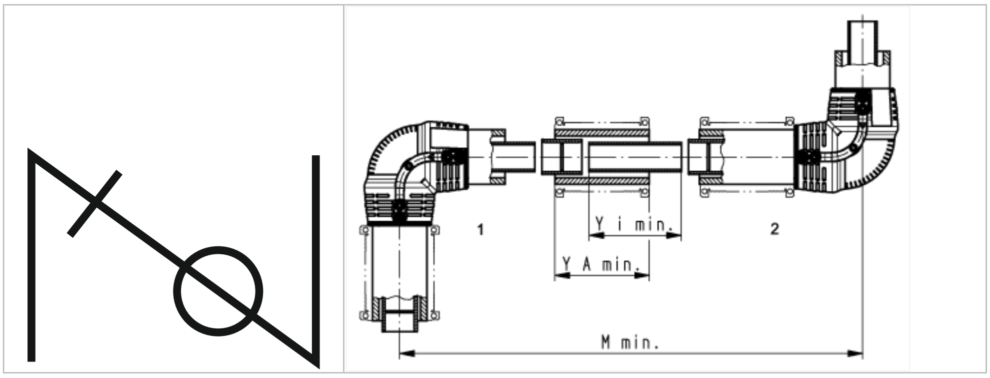
Case b) S – L

Piping system section 2



1 Short end of fitting (S)
2 Long end of fitting (L)

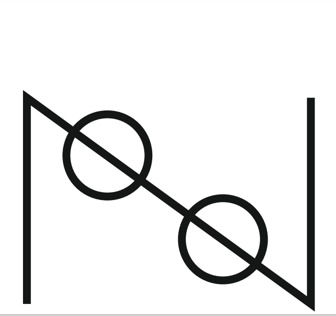
Case c) S – P – L

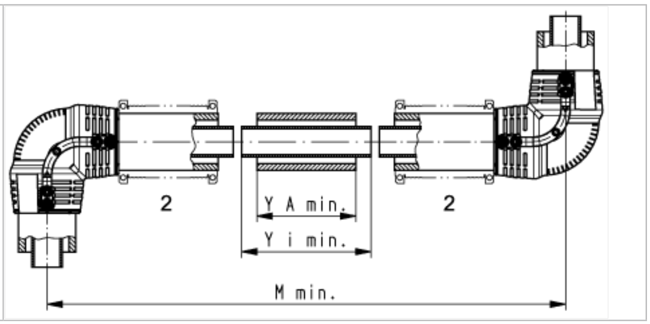


1 Short end of fitting (S)
2 Long end of fitting (L)

d/D (mm)	Direct M (mm)	M_{min} (mm)	Inner pipe: $Y_{i\,min}$ / material (mm)				Outer pipe: $Y_{A\,min}$ (mm)
	S – L	S – P – L	PVC-U	PVC-C	PP-H, PE80	PVDF	
20/50	310	440	124	124	123	123	100
25/50	310	440	124	124	123	123	100
32/63	340	480	134	134	133	133	110
40/75	400	550	144	144	142	142	120
50/90	460	625	159	159	157	157	135
63/110	550	735	179	179	177	177	155
75/125	585	790	197	197	197		175
90/140	640	855	205	205	204		185
110/160	730	960	218	220	281		200
125/180	740	985	231				215
140/200	750	1010	246				230
160/225	855	1130	259				245
200/280	990	1295	287				275
225/315	970	1290	300				290

Case d) L – P – L

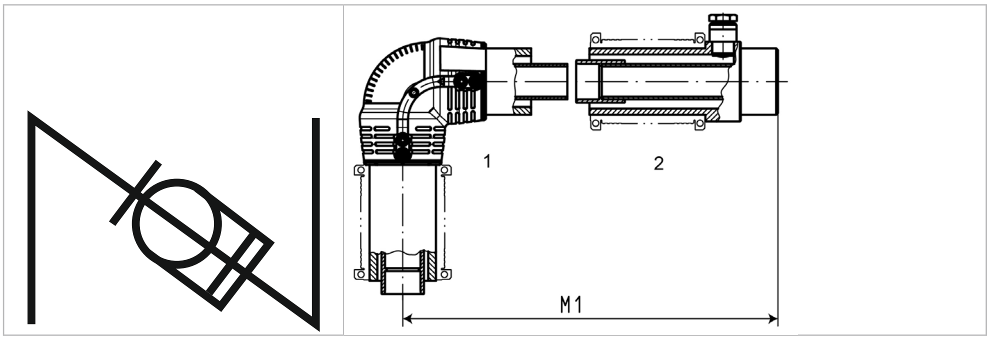




2 Long end of fitting (L)

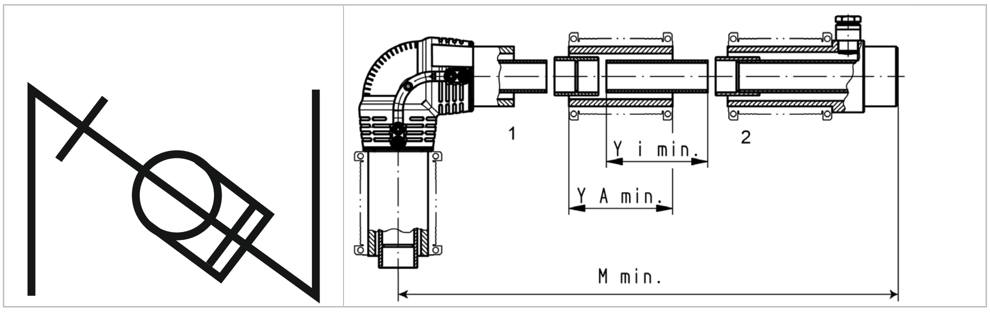
d/D (mm)	Direct M (mm)	M $_{min}$ (mm)	Inner pipe: Y $_{i\,min}$ / material (mm)				Outer pipe: Y $_{A\,min}$ (mm)
		L – P – L	PVC-U	PVC-C	PP-H, PE80	PVDF	
20/50		475	127	127	123	123	65
25/50		475	133	133	127	127	65
32/63		515	149	149	141	141	75
40/75		595	167	167	155	155	85
50/90		680	192	192	176	176	100
63/110		800	226	226	204	204	120
75/125		855	253	253	227		135
90/140		925	277	277	245		145
110/160		1035	307	312	337		155
125/180		1060	338				170
140/200		1085	367				185
160/225		1210	402				200
200/280		1390	472				230
225/315		1445	513				245

Case e) S – T



1 Short end of fitting (S)
2 Termination fitting (T)

Case f) S – P – T

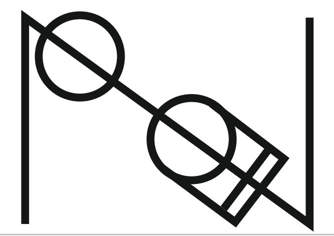


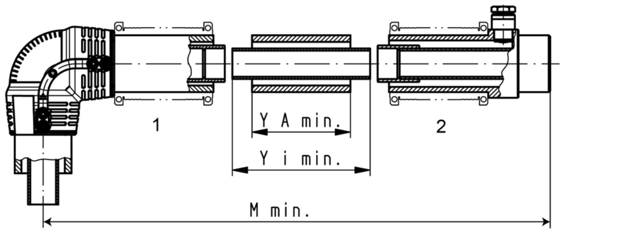
1 Short end of fitting (S)
2 Termination fitting (T)

d/D (mm)	Direct M (mm)	M_{min} (mm)	Inner pipe: $Y_{i\,min}$ / material (mm)				Outer pipe: $Y_{A\,min}$ (mm)
	S – T	S – P – T	PVC-U	PVC-C	PP-H, PE80	PVDF	
20/50	310	440	124	124	123	123	100
25/50	310	440	124	124	123	123	100
32/63	335	475	134	134	133	133	110
40/75	380	530	144	144	142	142	120
50/90	450	615	159	159	157	157	135
63/110	510	695	179	179	177	177	155
75/125	545	750	197	197	197		175
90/140	590	805	205	205	204		185
110/160	650	880	218	220	246		200
125/180	670	915	231				215
140/200	690	950	246				230
160/225	770	1045	259				245
200/280	815	1120	287				275
225/315	830	1150	300				290

V

Case f) L – P – T





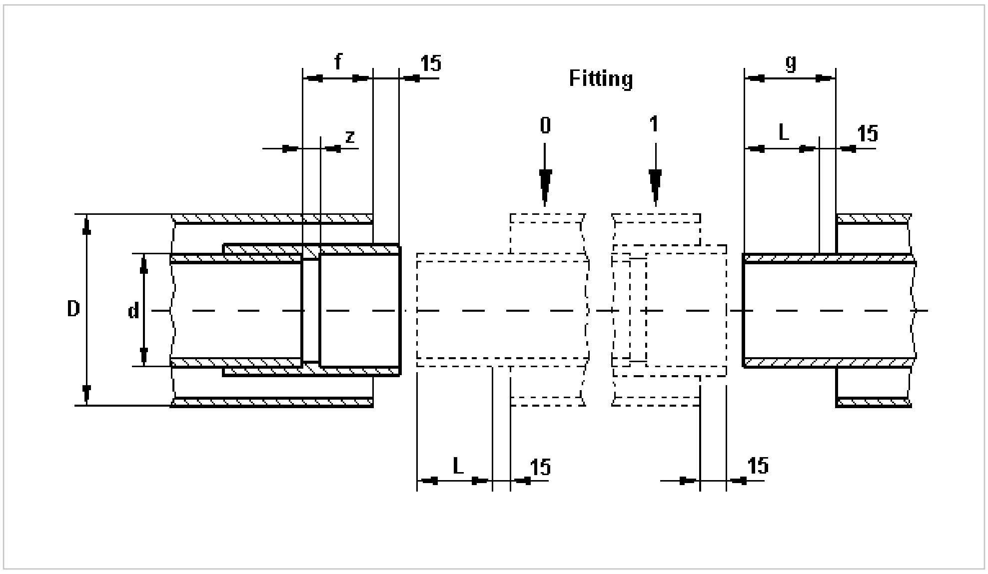
1 Long end of fitting (L)
2 Termination fitting (T)

d/D (mm)	Direct M (mm)	M_{min} (mm)	Inner pipe: $Y_{i\,min}$ / material (mm)				Outer pipe: $Y_{A\,min}$ (mm)
		L – P – T	PVC-U	PVC-C	PP-H, PE80	PVDF	
20/50		475	127	127	123	123	65
25/50		475	133	133	127	127	65
32/63		510	149	149	141	141	75
40/75		575	167	167	155	155	85
50/90		670	192	192	176	176	100
63/110		760	226	226	204	204	120
75/125		815	253	253	227		135
90/140		875	277	277	245		145
110/160		955	307	310	302		155
125/180		990	338				170
140/200		1025	367				185
160/225		1125	402				200
200/280		1215	472				230
225/315		1305	513				245

1.5.5 Connection sizes for double containment

If the cutting sizes on long pipe are not calculated from tables, the inner and outer pipe can be finished to dimension "f" for connection to fitting end S, and to dimension "g" for connection to fitting end L.

Last connection always on the double containment fitting! First, fit equal socket to the pipe section to be connected.



f Insertion depth of socket: "L" + z-dimension of equal socket "z" – 15 mm
g Insertion depth of socket: "L" + 15 mm
15 Width of snap ring
L Insertion depth of pipe in socket
z z-dimension of equal socket
0 Typ 0
1 Typ 1

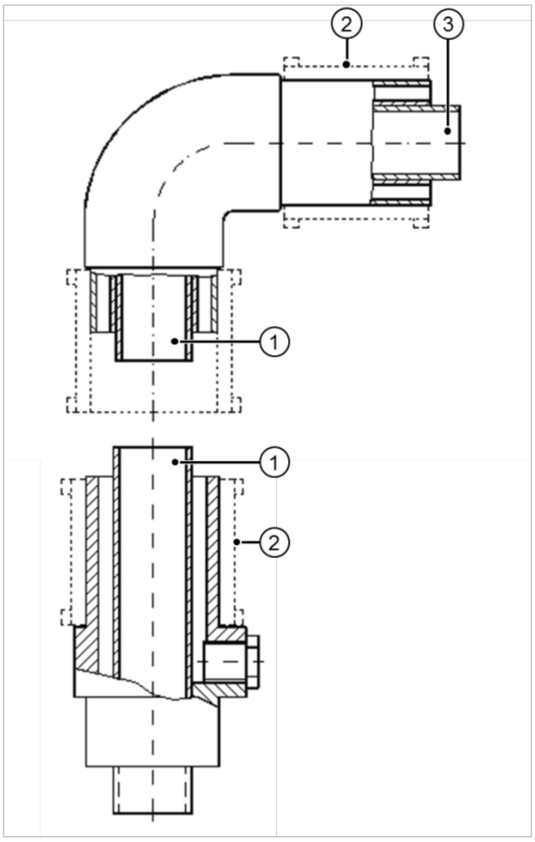
d (mm)	Connection to DC fitting, spigot end. Shorter length compared with outer pipe: "f"		Connection to DC fitting, socket end. Longer length compared with outer pipe: "g"	
Inner pipe	PVC-U, PVC-C	PP, PE, PVDF	PVC-U, PVC-C	PP, PE, PVDF
20	4.0	6.0	31.0	29.0
25	7.0	8.0	34.0	31.0
32	10.1	10.0	37.0	33.0
40	14.0	13.0	41.0	35.0
50	19.0	16.0	46.0	38.0
63	26.0	20.0	53.0	42.0
75	33.0	24.0	59.0	46.0
90	41.0	30.5	66.0	50.0
110	52.0	40.0	76.0	56.0
125	61.0		84.0	
140	68.0		91.0	
160	79.0		101.0	
200	100.0		121.0	
225	114.0		134.0	

1.6 Fittings for butt and IR fusion and installation

1.6.1 Overview

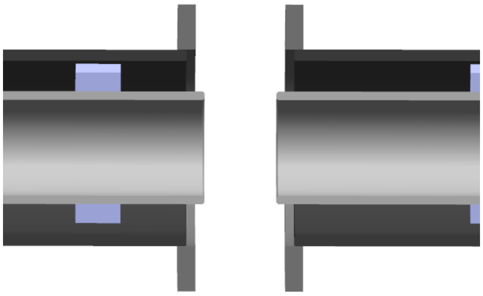
Possible connections:

- Direct fitting to fitting
- Fitting to intermediate pipe section
- Fitting to termination fitting

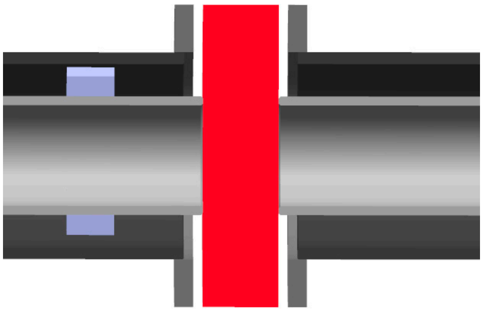


① Spigot for butt fusion
② Space for full ELGEF Plus electrofusion coupler or EPDM rubber collar
③ Space for ½ ELGEF Plus electrofusion coupler or EPDM rubber collar

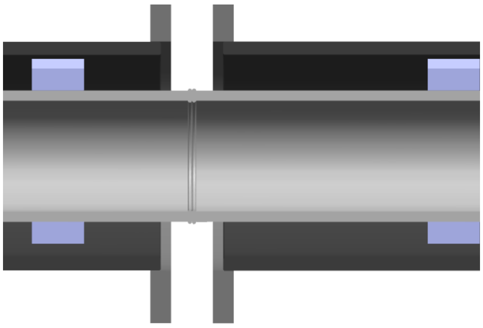
1.6.2 Fusion procedures



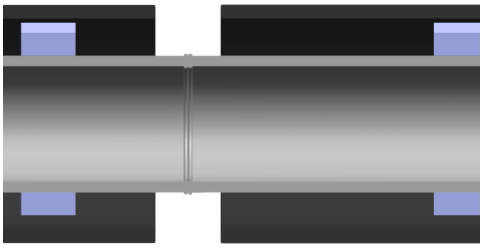
1. Clamps hold the inner pipe and/or fitting



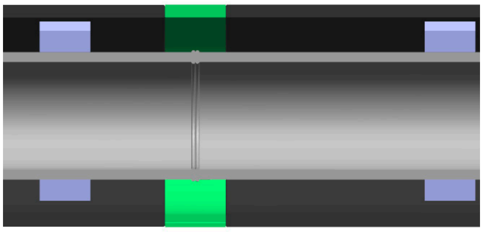
2. Standard heating element for butt fusion. The pipe and fitting are heated simultaneously.



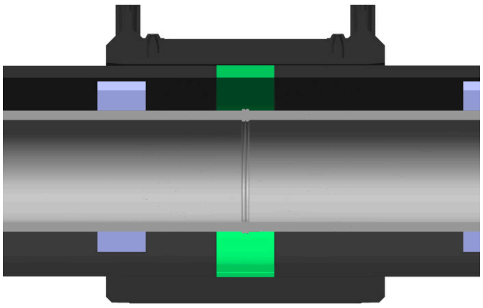
3. Heating element for butt fusion



4. Visual inspection of joint, then pressure test the inner pipe



5. A snap ring is fitted between the ends of the outer pipes to close the inspection gap



6. An ELGEF Plus coupler or EPDM rubber collar is used to seal the outer pipe

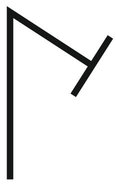
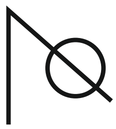
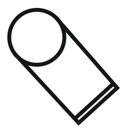
1.6.3 Various connection examples

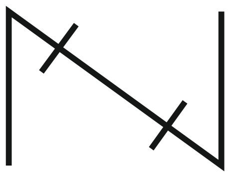
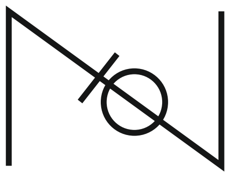
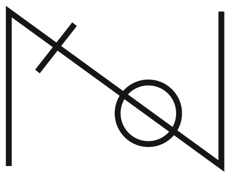
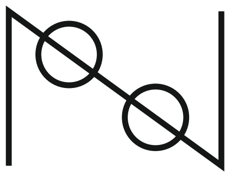
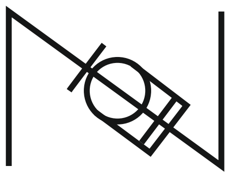
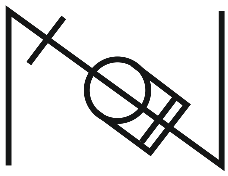
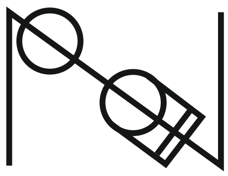
CONTAIN-IT Plus: butt fusion

- Short end of fitting (S) with space for ½ ELGEF Plus coupler minus 15 mm
- Long end of fitting (L) for full ELGEF Plus coupler
- Termination fitting (T)
- Pipe (P)

Legend

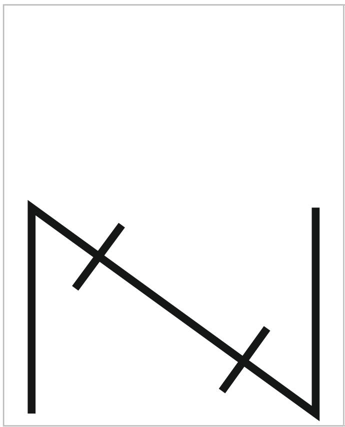
The following symbols are used to demonstrate the various connection examples of socket fusion/cementing and butt fusion:

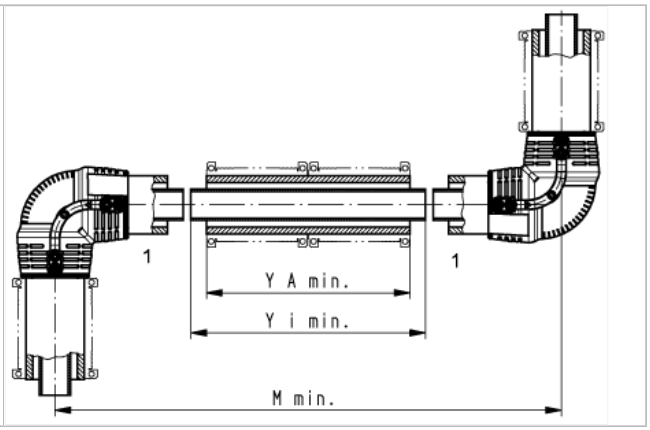
Abbreviation	Name	Symbol	Example 90° elbow
S	Short end of fitting with internal spigot		
L	Long end of fitting with internal spigot.		
T	Termination fitting		

Case	Symbol	Combination
m) S – P – S		Short end of fitting – Pipe – Short end of fitting
n) S – L		Short end of fitting – Long end of fitting
o) S – P – L		Short end of fitting – Pipe – Long end of fitting
p) L – P – L		Long end of fitting – Pipe – Long end of fitting
q) S – T		Short end of fitting – Termination fitting (long)
r) S – P – T		Short end of fitting – Pipe – Termination fitting (long)
s) L – P – T		Long end of fitting – Pipe – Termination fitting (long)

1.6.4 Dimensions for calculating the cutting lengths

Case m) S – P – S

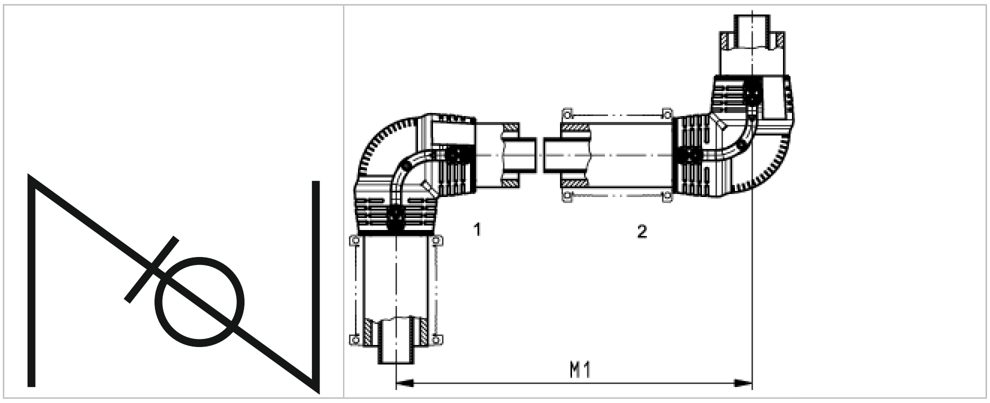




1 Short end of fitting (S)

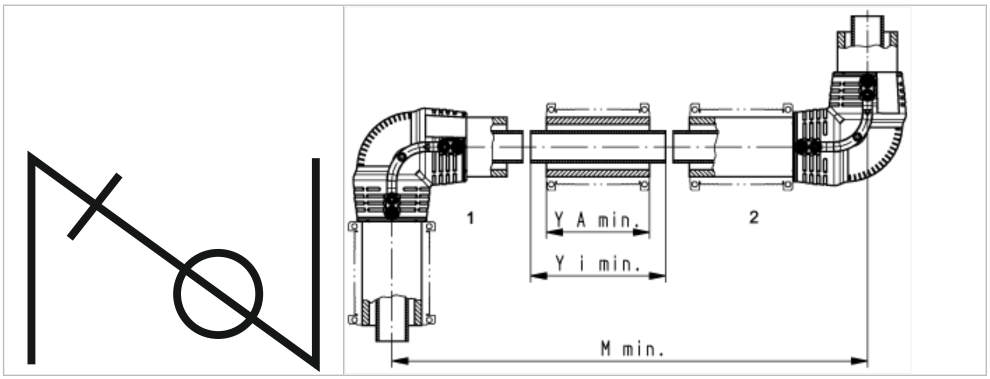
d/D (mm)	Direct M (mm)	M $_{min}$ (mm)	Inner pipe: Y $_{i\,min}$ / material (mm)				Outer pipe: Y $_{A\,min}$ (mm)
		S – P – S	PP	PE	PVDF	ECTFE	
20/50		460	220	220	220	220	190
25/50		460	220	220	220	220	190
32/63		505	235	235	235	235	205
40/75		580	260	260	260	260	230
50/90		660	290	290	290	290	260
63/110		780	330	330	330	330	300
75/125		840	360	360	360	360	330
90/140		910	380	380	380	380	350
110/160		960	410	410	410	410	380
125/180		1055	435	435	435	435	405
140/200		1100	470	470	470	470	440
160/225		1230	500	500	500	500	470
200/280		1415	555	555	555	555	525
225/315		1415	585	585	585	585	555

Case n) S – L



1 Short end of fitting (S)
2 Long end of fitting (L)

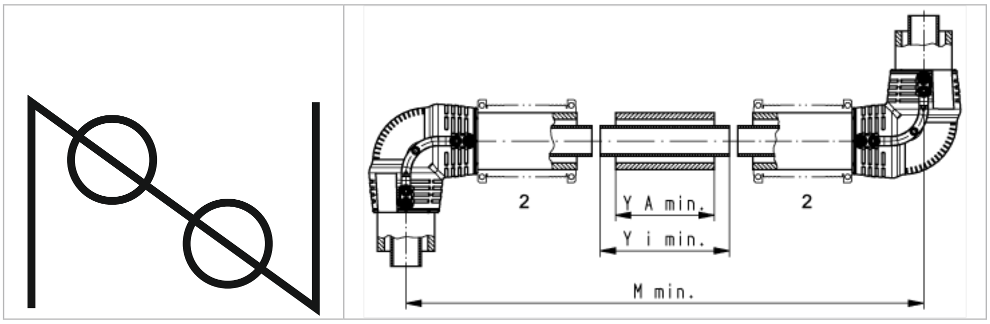
Case o) S – P – L



1 Short end of fitting (S)
2 Long end of fitting (L)

d/D (mm)	Direct M (mm)	M_{min} (mm)	Inner pipe: $Y_{i\,min}$ / material (mm)				Outer pipe: $Y_{A\,min}$ (mm)
	S – L	S – P – L	PP	PE	PVDF	ECTFE	
20/50	310	440	130	130	130	130	100
25/50	310	440	130	130	130	130	100
32/63	340	480	140	140	140	140	110
40/75	400	550	150	150	150	150	120
50/90	460	625	165	165	165	165	135
63/110	550	735	185	185	185	185	155
75/125	585	790	205	205	205	205	175
90/140	640	855	215	215	215	215	185
110/160	665	895	230	230	230	230	200
125/180	740	985	245	245	245	245	215
140/200	750	1010	260	260	260	260	230
160/225	855	1130	275	275	275	275	245
200/280	1000	1305	305	305	305	305	275
225/315	980	1300	320	320	320	320	290

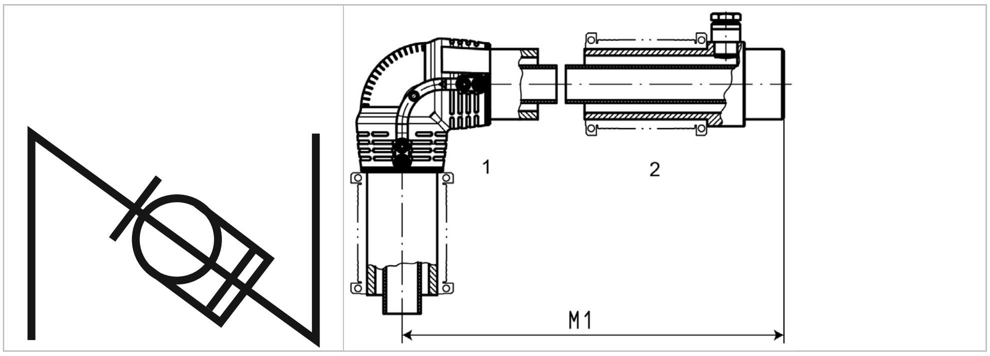
Case p) L – P – L



2 Long end of fitting (L)

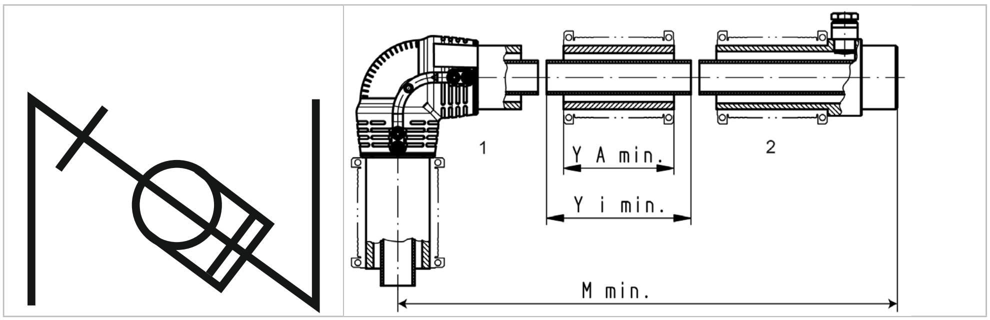
d/D (mm)	Direct M (mm)	M $_{min}$ (mm)	Inner pipe: Y $_{i\ min}$ / material (mm)				Outer pipe: Y $_{A\ min}$ (mm)
		L – P – L	PP	PE	PVDF	ECTFE	
20/50		475	95	95	95	95	65
25/50		475	95	95	95	95	65
32/63		515	105	105	105	105	75
40/75		595	115	115	115	115	85
50/90		680	130	130	130	130	100
63/110		800	150	150	150	150	120
75/125		855	165	165	165	165	135
90/140		925	175	175	175	175	145
110/160		965	185	185	185	185	155
125/180		1060	200	200	200	200	170
140/200		1085	215	215	215	215	185
160/225		1210	230	230	230	230	200
200/280		1400	260	260	260	260	230
225/315		1405	275	275	275	275	245

Case q) S – T



1 Short end of fitting (S)
2 Termination fitting (T)

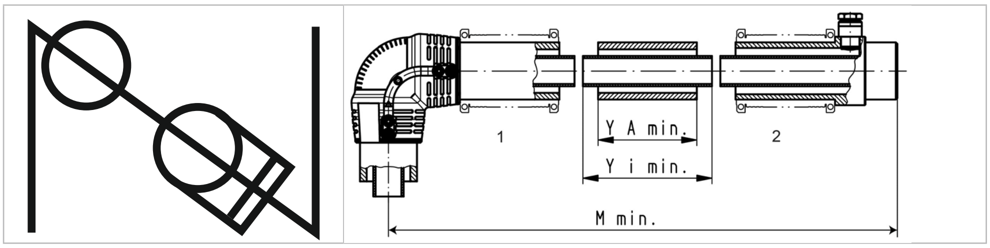
Case r) S – P – T



1 Short end of fitting (S)
2 Termination fitting (T)

d/D (mm)	Direct M (mm)	M_{min} (mm)	Inner pipe: $Y_{i\,min}$ / material (mm)				Outer pipe: $Y_{A\,min}$ (mm)
	S – T	S – P – T	PP	PE	PVDF	ECTFE	
20/50	280	440	130	130	130	130	100
25/50	280	440	130	130	130	130	100
32/63	305	475	140	140	140	140	110
40/75	350	530	150	150	150	150	120
50/90	420	615	165	165	165	165	135
63/110	480	695	185	185	185	185	155
75/125	515	750	205	205	205	205	175
90/140	560	805	215	215	215	215	185
110/160	590	850	230	230	230	230	200
125/180	640	915	245	245	245	245	215
140/200	660	950	260	260	260	260	230
160/225	740	1045	275	275	275	275	245
200/280	790	1125	305	305	305	305	275
225/315	830	1180	320	320	320	320	290

Case s) L – P – T



1 Long end of fitting (L)
2 Termination fitting (T)

d/D (mm)	Direct M (mm)	M $_{min}$ (mm)	Inner pipe: Y $_{i\ min}$ / material (mm)				Outer pipe: Y $_{A\ min}$ (mm)
		L – P – T	PP	PE	PVDF	ECTFE	
20/50		475	95	95	95	95	65
25/50		475	95	95	95	95	65
32/63		515	105	105	105	105	75
40/75		595	115	115	115	115	85
50/90		680	130	130	130	130	100
63/110		800	150	150	150	150	120
75/125		855	165	165	165	165	135
90/140		925	175	175	175	175	145
110/160		965	185	185	185	185	155
125/180		1060	200	200	200	200	170
140/200		1085	215	215	215	215	185
160/225		1210	230	230	230	230	200
200/280		1400	260	260	260	260	230
225/315		1405	275	275	275	275	245

1.7 Leak detection and leak locating systems

To make certain that a leak in the inner pipe of a double containment system does not go unnoticed (rendering the system no better than a regular single pipe), it is essential that leaks are being detected. There are several different systems available on the market for the purpose of monitoring pipes.

1.7.1 Visual monitoring

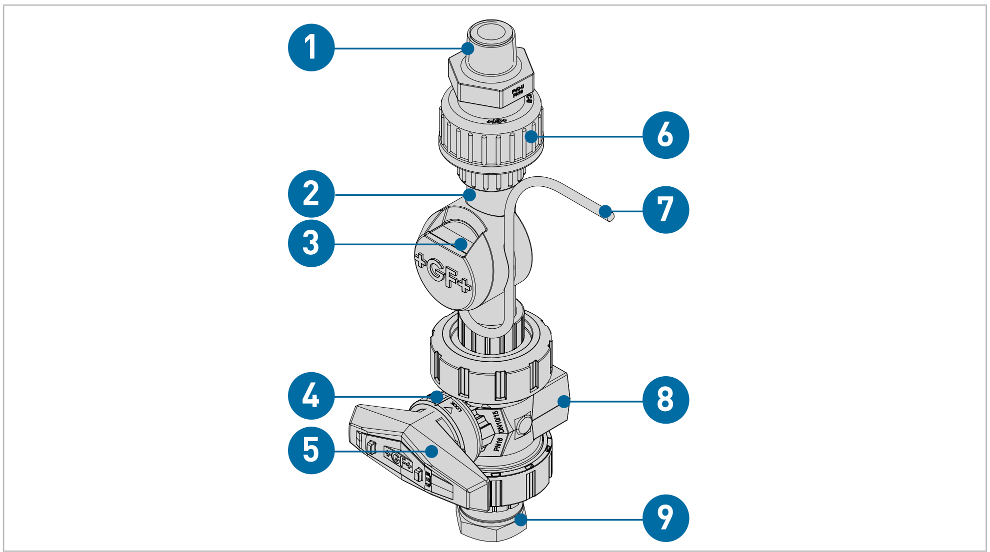
For optical leak detection, a d20 ball valve with a transparent PVC-U monitoring pipe is mounted on the Rp½" branch of the termination fitting or on the branch saddle.

Advantages	Disadvantages
• Cost-efficient variant • Retrofit on the branch saddle is possible	• No automatic alarm • Outer pipe is not monitored • Can be installed only at the lowest point

Branch saddle with leak monitoring

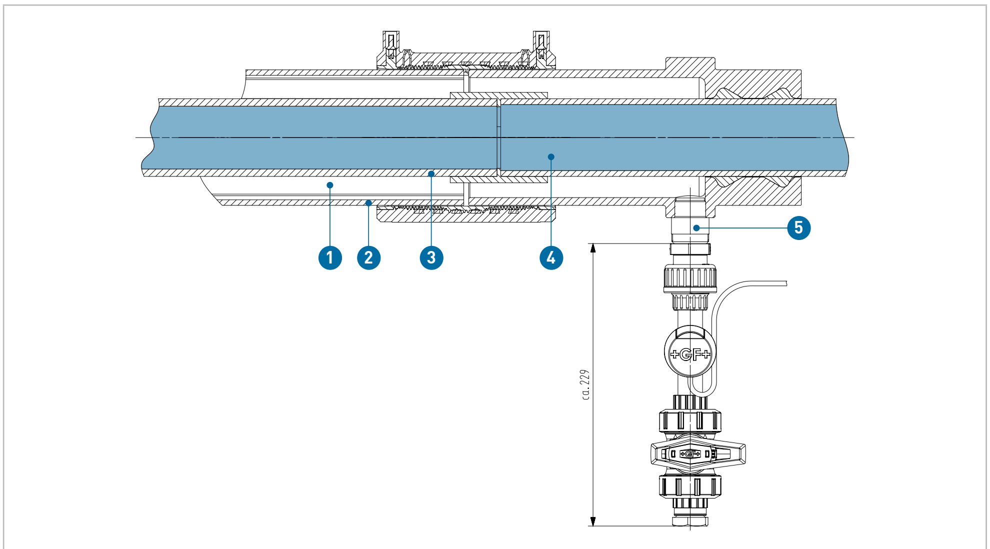
1.7.2 Leak Detection Sensor

The Double Containment - Leakage Detection Sensor detects leaking liquids in the monitoring room of GF double containment systems, and outputs a signal.



① Monitoring room connection R½"
② Transparent monitoring tube
③ Type 2286 sensor with LED indicator (green/yellow)
④ Locking mechanism
⑤ Ball valve handle (closed)
⑥ Union nut
⑦ Connection cable 5 m (3x 0.14 mm²)
⑧ Ball valve type 546 Pro
⑨ Flushing connection (Rp ½") with plug (R½")

To ensure that even a small amount of the leaking medium covers the measuring point in the event of a leakage and thus leads to a change in the dielectric permettivity, the Double Containment - Leak Detection Sensor must be mounted at the lowest point of the monitoring room. Access to monitoring room can be realized via Rp½'' of the termination fittings or GF branch saddles.



① Monitoring room
② Containment pipe
③ Inner pipe
④ Medium in inner piping
⑤ Connection to Double Containment piping system R½''

For detailed information please check instruction manual.

1.7.3 Sensor cable and Differential pressure monitoring

Sensor cable

In the space between the inner and outer pipe, a cable is laid which reacts either to conductive fluids or chemicals and emits an alarm.

Advantages	Disadvantages
• Leak point is indicated precisely to within 1 m • Automatic alarm	• Outer pipe is not monitored • Relatively expensive • Retrofit is not possible • Depending on the system, larger outer diameter of outer pipe will be required • Susceptible to condensates

Due to the minimal difference in dimensions between the inner and outer pipe in the CONTAIN-IT Plus double containment system, sensor cables are not feasible. If this option is required, please contact the local sales representative of GF Piping Systems.

Differential pressure monitoring

A distinction is made between overpressure and underpressure monitoring.

	Overpressure monitoring	Vacuum monitoring (underpressure monitoring)
General	In differential pressure monitoring with overpressure, nitrogen is pumped at a specific pressure into the space between the inner and outer pipes. If there is a pressure loss in this space, an alarm will indicate the leak.	In differential pressure monitoring in a vacuum, a pump is used to create a vacuum in the range of 600 – 700 mbar in the space between the inner and outer pipe. If there is a pressure loss in this space, a vacuum switch (VS) switches on a vacuum pump. At the same time, a warning light and buzzer provide visual and acoustic warnings.
Advantages	• Inner and outer pipe are monitored for leak-tightness • Retrofit installation is possible • TÜV test certificate • Automatic alarm	• No pressure loading on the inner pipe • Inner and outer pipe are monitored for leak-tightness • Retrofit installation is possible • TÜV test certificate • Automatic alarm
Disadvantages	The nitrogen which is pumped in must be at a higher pressure than the medium-conveying inner pipe. It is, therefore, essential to check that the inner pipe will not collapse, taking account of the operating conditions (please refer to the questionnaire for the "static evidence").	• Pumping head of the vacuum pump must be at least 750 mbar with clear intake • Where there is a large volume of space between the inner and outer pipe, the vacuum pump will need to be powerful enough, or the piping system will need to be divided into leakage sections, each with its own vacuum pump (divisions with termination fittings, refer to chapter „1.7.4 Termination fittings - Tools for leakage localization" auf Seite 301.
Leak locating	• Outer pipe direct • Inner pipe through exploratory borehole in the outer pipe	• Outer pipe direct • Inner pipe through exploratory borehole in the outer pipe

Suppliers of differential pressure monitoring systems

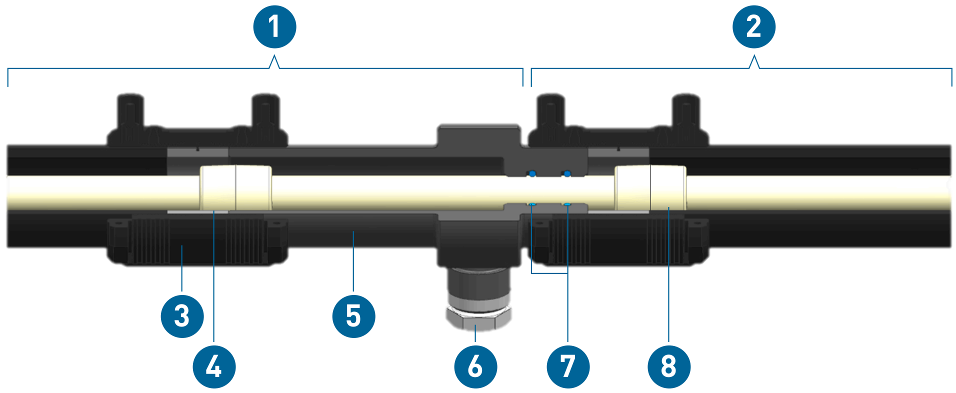
SGB Sicherungsgerätebau GmbH
Hofstrasse 10
57076 Siegen, Germany
Ph.: +49 271 48 964-0
Fax: +49 271 48 964-6
www.sgb.de

1.7.4 Termination fittings - Tools for leakage localization

By separating the outer pipe into leak detection sections with termination fittings, the leaking medium can only spread in the piping section between the installed end fittings.

Advantages

- Fast and safe leak detection
- Only the respective piping section of the outer pipe needs to be rinsed and cleaned
- Length of leakage sections freely selectable



① Section 1
② Section 2
③ ELGEF Plus Coupler
④ Snap ring
⑤ PE outer pipe of the termination fitting
⑥ Connection leak detection
⑦ Body sealing (EPDM)
⑧ Inner pipe (e.g. socket fusion)

1.8 Operating and maintenance instructions

General information

In case of a maintenance (sealants of ball valve, diaphragm valve, mechanical connection, mechanical separation, etc.) or a leakage please contact your local safety supervisor before opening the outer and inner pipe. Safety procedures should be defined by the plant operator to ensure a safe maintenance and repair (Control systems for Pumps/Valves/etc., Pressure, Medium, Temperature, Safety Equipment, etc.).

Operation

- If the system consists of several double containment lines or several leak monitoring sections, all these monitoring rooms must be equipped with leak detection devices (manual/automatic). Leakages must be detected within 72 hours to ensure the safe system condition.
- Operators must comply with appropriate rountine controls or use automatic leak detection sensors (regular funtion checks are mandatory). Attention: In case of a detected leakage, the double containment system becomes a single line. Following safety measures have to be taken into account, see section repair.
- Double containment systems must be protected from uncontrolled thermal and mechanical influences.

Maintenance

- For a safe maintenance it is mandatory to contact the safety supervisor!
- Before maintenance is carried out, comply with precautionary measures such as checking the leakage warning system, complete draining of the inner & outer piping, etc.

Repair – Case of a Leakage:

- For a safe repair it is mandatory to contact the safety supervisor!
- If a leak occurs, the procedure defined in advance by the operator of the double containment system must be followed.
- Prior to beginning with a repair, it is essential to take appropriate precautions, including completely emptying and flushing the inner and outer pipe, preventing any dripping, etc. If a leak cannot be precisely located, it is useful to proceed section by section.
- Only use water to search for the leak.
- Our mechanically fastened tapping saddle, with a ½" tapping point, allows test drillings to be carefully made on the underside of the protective pipe to section off the leak. The saddle is later resealed with a PVC plug.
- GF Piping Systems recommends the use of termination fittings when the pipe system is being installed, to divide it up into leakage detection zones.
- The pipe must be replaced in accordance with the pipe installation instructions from GF Piping Systems.

Extension of the existing piping system and subsequent installation of a T-piece

Before starting work, it is essential to take appropriate precautions, including completely emptying and flushing the inner and outer pipe, preventing any dripping, etc.

Pressure test - recommissioning

A pressure test of the inner & outer pipe is mandatory as soon as a new connection has been made. See chapter „1.9 Pressure testing the inner and outer pipe“ auf Seite 303.

Safety and fire prevention measures

GF Piping Systems refers to the relevant safety datasheets of the plastic materials used.

Firestop collars

Approved firestop collars for double containment pipe are available on the market.

Laying pipe in the ground

When laying pipe in the ground, care must be taken to ensure compliance with the relevant regulations and directives of professional organizations and public authorities and agencies, relating to trenching, embedding, the double containment system and backfilling.

1.9 Pressure testing the inner and outer pipe

1.9.1 Inner pipe

General

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 reasons for these adjustments are listed below:

- 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.
- 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 recommended methods for performing the internal pressure test.

Object	Pre-test	Main test
Test pressure P_p (depends on the pipe wall temperature and the permissible test pressure of the built-in components, see the section "Determining the test pressure")	≤ P_p (perm)	≤ 0.85 P_p (perm)
Test duration (depends on the length of the piping system or the piping system 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 progression must be recorded)	At least 3 checks, distributed over the test duration with restoring the test pressure	At least 2 checks, distributed over the test duration 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 screws.

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

Material	Pressure drop (bar/h)
PVC-U	0.5
PVC-C	0.5
PP	0.8
PE	1.2
PVDF	0.8
ECTFE	0.9

V

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.

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 exit of the medium or any pollution of the inside of the valve.

Filling the piping system

Before starting with the internal pressure test, the following points must be checked:

- Was installation done according to the available plans?
- All pressure relief devices and flap traps mounted in the flow direction?
- All end valves shut?
- Valves of devices are shut to protect against pressure?
- Visual inspections of all joints, pumps, measurement devices and tanks?
- Has the waiting period after the last fusioning/cementing 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.

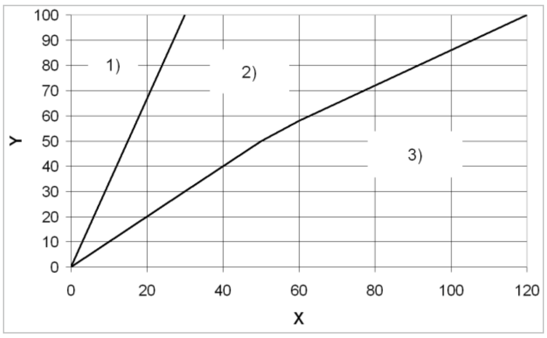
Reference values for the filling volume are given in the following table:

DN (mm)	V (l/s)	DN (mm)	V (l/s)
≤ 80	0.15	250	2.0
100	0.3	300	3.0
150	0.7	400	6.0
200	1.5	500	>9.0

Adequate time should be allowed between filling and testing the piping system, so that the air contained in the piping system can escape via the vents: approx. 6 - 12 h, depending on the pipe diameter.

1.9.2 Applying the test pressure

The test pressure is applied according to the diagram. Here it is important that the pressure increase rate does not cause any water hammering!



Y Test pressure (%)
X Time for pressure increase (min)
1) Pressure increase rate up to DN100
2) Range of pressure increase rates between DN100 and DN400
3) Values for pressure increase rate DN500 and higher is: 500/DN (bar/10 min)

Determining the test pressure

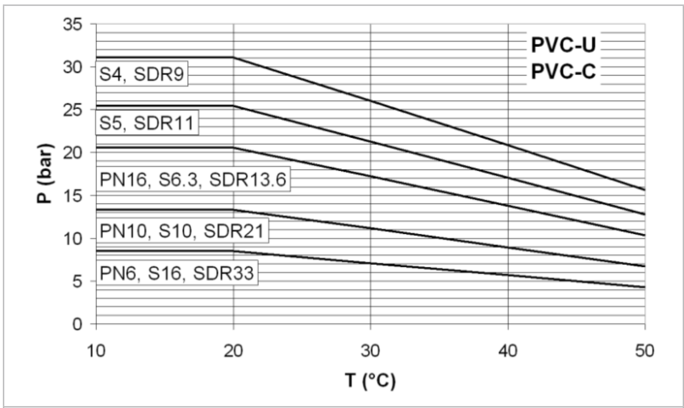
The permissible test pressure is calculated according to the following formula:

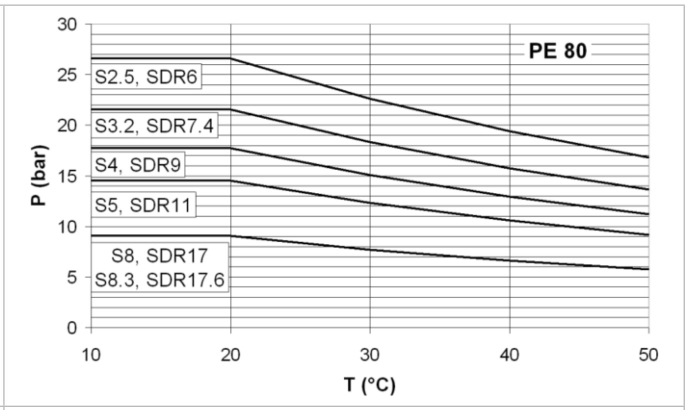
$$P_{p(zul)} = \frac{1}{SDR} \cdot \frac{20 \cdot \sigma_{v(T,\,100\,h)}}{S_p \cdot A_G}$$

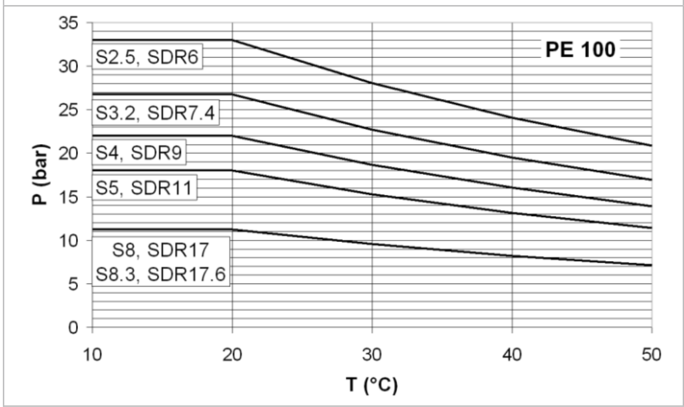
$\sigma_{v\,(T,100\,h)}$ Long-term creep strength for pipe wall temperature TP (at t = 100 h)
S_p Minimum safety factor for long-term creep strength
A_G Processing or geometry-specific factor that reduces the allowable test pressure (if the AG factor is less than zero, you need to use the reciprocal (1/AG)
T_R Pipe wall temperature: average value of test medium temperature and pipe surface temperature

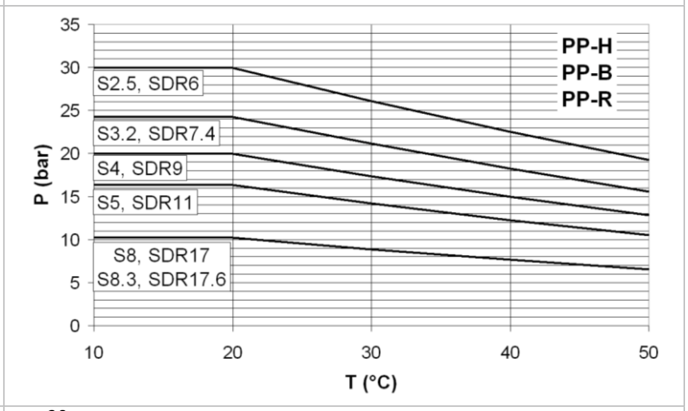
If the piping system contains diaphragm valves, the maximum allowable test pressure is limited to the nominal pressure of the diaphragm valves.

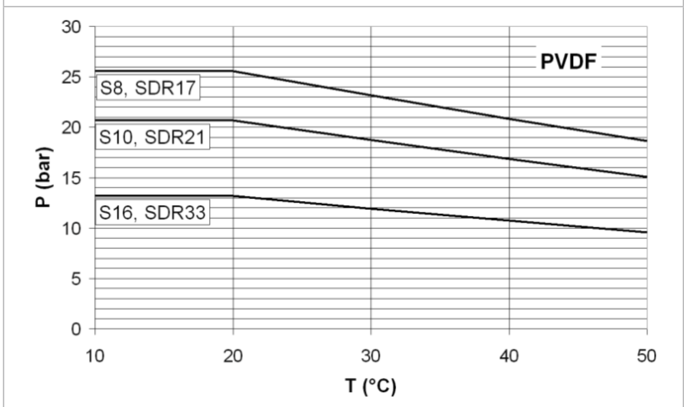
To make things easier, the permissible test pressures can be taken directly from the following diagrams.

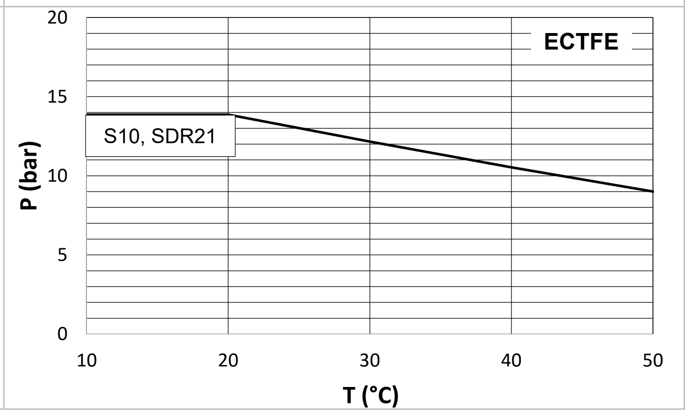












P Permissible test pressure (bar)
T Pipe wall temperature (°C)

Checks during testing

The following measurement values must be recorded consistently during testing:

- Internal pressure at the absolute lowest point of the piping system
- Medium and ambient temperature
- Water volume input
- Water volume output
- Pressure drop rates

Leak test

If it is not possible to do an internal pressure test with water (e.g. piping system must be kept dry), a leak test can be carried out with slight overpressure. For safety reasons, the test pressure must then be limited to maximum 0.5 bar overpressure.

During the leak test, all joints must be sprayed with a foam-building agent and checked. Since the efficiency of the leak test is significantly limited due to the low load, it is recommended to use it preferably for systems with operating pressures below 0.5 bar.

1.9.3 Outer pipe

General

Once the test of the inner pipe is complete, the outer pipe is tested with a fully filled inner pipe under internal pressure (the internal pressure of the inner pipe must be at least equal to or higher than the internal pressure of the outer pipe) to avoid loading the inner pipe as a result of external pressure. To carry out the pressure test, suitable filling and ventilation facilities must be provided on the outer pipe.

After the installation of the double containment system has been completed, the pressure connection (pressure joint) for the leakage indicator, or a test union to monitor the proper operation of the leakage indicator, is installed as near as possible to (no further than 1 m from) or directly inside the termination fitting and at the end of each length of piping. The leak-tightness test of the space between the pipe is carried out at room temperature (20 °C).

⚠ Thin-walled inner pipe in particular can collapse under excess pressure in the space between the pipe. The maximum permissible test and/or overpressure in the space between the pipe depend on the load capacity of the medium-conveying inner pipe. Care should be taken here to ensure that the internal pressure load on the pipe (PN stage) is not the same as the external pressure load.

Water is the preferred test medium. However, complete drainage must be ensured. In many cases, air or inert gas are also suitable test media.

The following points should be noted:

- Compressor oils can contain damaging elements for the pipe.
- Depending on the temperature, some materials tend to chip and break under mechanical influence and inner pressure of compressed media.
- The appropriate safety precautions should be taken to prevent a crack in the outer pipe, especially transparent PVC-U.
- The maximum gas pressure depends on the material and should not exceed the values in the following table.

CONTAIN-IT Plus test parameters

Test medium for piping systems	PE100 outer pipe, pressure-resistant welded with ELGEF Plus coupler		PVC-U outer pipe, spray protection with EPDM rubber collar (not to be applied when there are axial forces)	
	SDR11, SDR17, SDR17.6			
	Pre-test	Main test	Pre-test	Main test
Water	≤ Pp (perm)	≤ 0.85 Pp (perm)	1 bar	1 bar
Inert gas	0.5 bar	0.5 bar	0.3 bar	0.3 bar

Testing time

The piping system is kept under the test pressure until all connection parts of the piping system like flanges, unions, valves, etc. are inspected for tightness using a foam-building agent. A soap solution, which can be removed simply with water after the test, is best.

⚠ Commercial leak detection sprays can cause stress cracks in plastics. If these sprays are used, remove any residues after testing.

No overloading of the components

Please consider that the test pressure has to be adapted to the installed components: for example where fitting or valves are installed a maximum test pressure of 6 bar is admissible for the protective pipe.

Test medium for double containment valves	PE100 outer pipe, pressure-resistant welded with ELGEF Plus coupler		PVC-U outer pipe, spray protection with EPDM rubber collar (not to be applied when there are axial forces)	
	SDR11, SDR17, SDR17.6			
	Pre-test	Main test	Pre-test	Main test
Water	6 bar	6 bar	1 bar	1 bar
Inert gas	0.5 bar	0.5 bar	0.3 bar	0.3 bar

1.10 Static evidence

The questionnaire for static evidence is used by GF Piping Systems to determine if the selected piping system is resistant under the given operating conditions. For fix-point installation (inhibited longitudinal expansion), it is necessary to calculate the stresses and forces on the outer pipe fittings, which the fix-point pipe brackets are required to absorb.

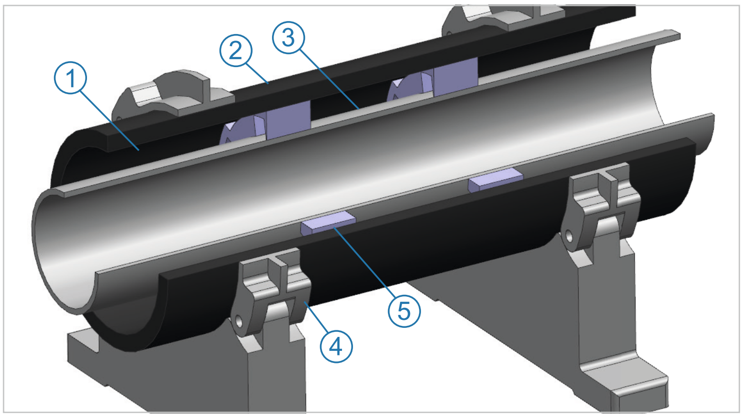
The fixed point for the inner pipe is already built into each fitting by means of a support ring. If he calculated stress on the pipe is too high, the operating conditions or the material must be changed. The calculation also indicates the distances between spacers for the inner pipe and the distances between pipe brackets for the outer pipe as well as the forces on fixed points. Expansion in the piping system need not be taken into consideration; no additional expansion loops or compensators are allowed. To prevent the pipe from sagging because of bending or not exactly aligned installation, it is advisable to install guide supports between the fixed points, designed for lateral forces of around 15 % of the axial forces, acting on the fixed points.

Double containment system fixed point

The following factors can influence the stability of the CONTAIN-IT Plus system:
- Medium, pressure, temperature, time
- Stresses resulting from impeded thermal expansion
- Kink resistance
- External pressure stability
- Intermittent stressing
- Special case of EPDM collar

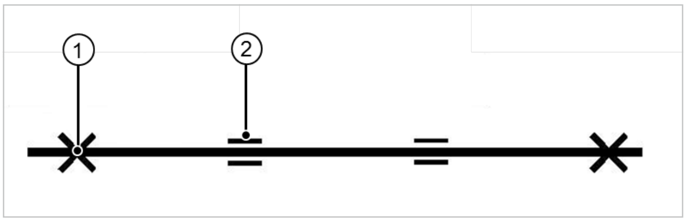
1.10.1 CONTAIN-IT Plus system

Components of the CONTAIN-IT Plus system



1. Monitoring space
2. Outer pipe
3. Inner pipe
4. Pipe bracket
5. Spacer

> ⚠ The double containment system must be a fixed installation (no expansion loop or compensator is allowed)!
>
> Background: There are different expansions by using different materials for inner and outer pipe.



1. Fixed point
2. Guide supports

1.10.2 Questionnaire for static evidence

GF Piping Systems

+GF+

CONTAIN-IT Plus Systems

Questionnaire for Static Evidence and Stress Calculation DVS 2210-2

General project information

Project name	
Customer	
CRM/Order number	

Flow Media

Flow media		%
Density (in g/cm^3)		
MSDS (Material Safety Data Sheet) attached?	Yes	No

Operation conditions			Total load time	
Maximum working temperature		°C	in percent	%
Minimum working temperature		°C	in percent	%
Maximum working pressure		bar	in percent	%
Minimum working pressure		bar	in percent	%
Period w/o media/empty			in percent	%
Ambient temperature	Minimum	°C	Maximum	°C
Required service life	10 years	25 years		

Parameter pipes	Inner pipe	Outer pipe	
Material		PE-100	PVC-U (transparent)
Outer diameter d			
Wall thickness e			
Nominal pressure PN			
Standard dimension ratio (SDR)			

Installation details	Installation detail 1		Installation detail 2	
Additional system data	Above the ground	In the ground (buried)	In building	Outdoor
	Longest straight pipe run >10m?		Yes	No
	Heat tracing?		Yes	No
	Insulation thickness			mm
Installation temperature	Minimum	°C	Maximum	°C

Leak detection information

Leak detection information	Optical	Sensor	Detection cable
	Overpressure difference	[mbar]	No pressure
	Underpressure		

Comments	
Attachements	Isometric drawing

Your contact

Georg Fischer Piping Systems Ltd.
Ebnatstrasse 111, 8201 Schaffhausen / Switzerland
gss@georgfischer.com / www.gfps.com

Disclaimer
The scope of engineering services provided by Georg Fischer Piping Systems Ltd. is as follows: verification of above and below ground piping systems according to the given conditions. The static evidence provided complies with following criteria and is mainly based on DVS 2210-1: (static evidence and stress calculation for flexible and axially clamped sections with consideration of permissible change in length and deflection / generation of pipe support concept incl. support spacing, piping reactions and optimization / clear overview of load cases and assumptions / clarification of calculation / verifiability of calculation steps and non-generally accepted codes of practice / summary of results).

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On the basis of the customer data entered in the questionnaire, the calculation program provides static evidence. The static evidence is sent to the customer.

1.11 Welding machines for butt-, socket- and IR-fusion

Application	Fusion machine	Dimension range (mm)
Socket fusion	**SG 125**	d20/50 – d75/125
Socket fusion	**SG 160** 	d20/50 – d110/160
Butt fusion		d32/63 – d110/160
Butt fusion	**IM 160 / IM 315** 	IM 160 d32/63 – d110/160
		IM 315 d90/140 – d200/280
Butt fusion	**CNC 4.0 400 - 500 - 630** 	d225/315
Infrared fusion (IR) Note: Special half shells are required for the double containment system!	**IR-63 Plus / IR-110 Plus / IR-225 Plus** 	IR-63 Plus d20/50 – d40/75
		IR-110 Plus d20/50 – d50/90
		IR-225 Plus d63/110 – d125/180

1.12 Double containment special components

Double containment valves are available in the following versions:

- Pneumatic actuator
- Electric actuator
- Hand-operated
- PVC-U PN 6 protective case
- Internal ball valve: can be radially installed and removed
- Manual override with ratchet setting

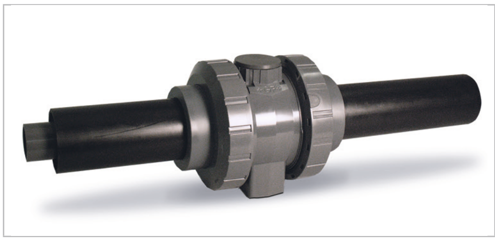
Double containment valves from GF Piping Systems are supplied as a ready-to-install system unit and the jointing technology used is similar to that for a double containment fitting. The principle used by GF Piping Systems is that the inner pipe is first joined according to the jointing technology which you have selected.

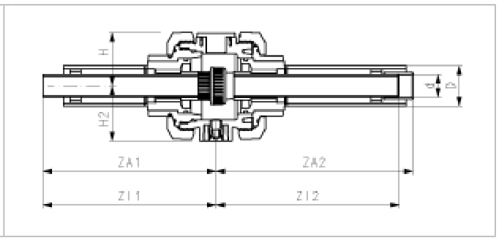
The following jointing methods and materials can be selected:

Jointing method inner pipe	Material
Butt fusion	PE100, PP-H, PVDF
IR fusion	PE100, PP-H, PVDF, ECTFE
Socket fusion	PE80, PP-H, PVDF
Socket cementing	PVC-C, PVC-U

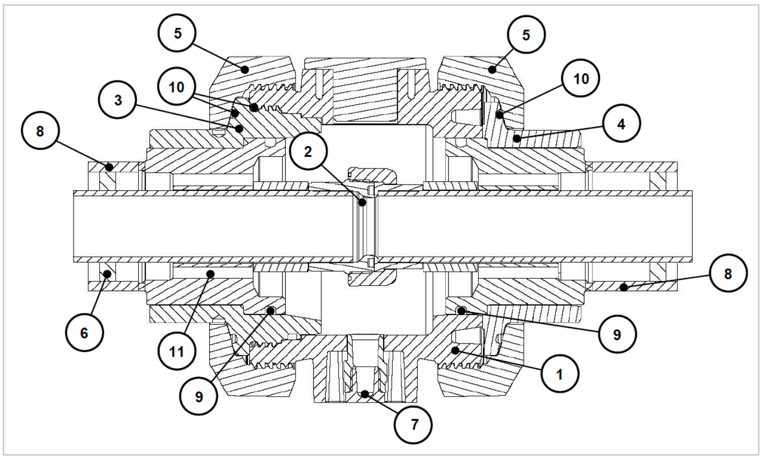
1.12.1 CONTAIN-IT Plus mechanical joint

The CONTAIN-IT Plus mechanical joint is used for retrofit extension or repair





Design



① Protective housing
② Union
③ Union bush
④ Union end
⑤ Union nut of protective housing
⑥ Spacer
⑦ Adaptor for ½" leak detection or PVC-U ½" plug
⑧ PE support pieces
⑨ O-ring PE connecting element
⑩ O-rings for union bush/ union end
⑪ Bore-hole for leak detection of inner pipe

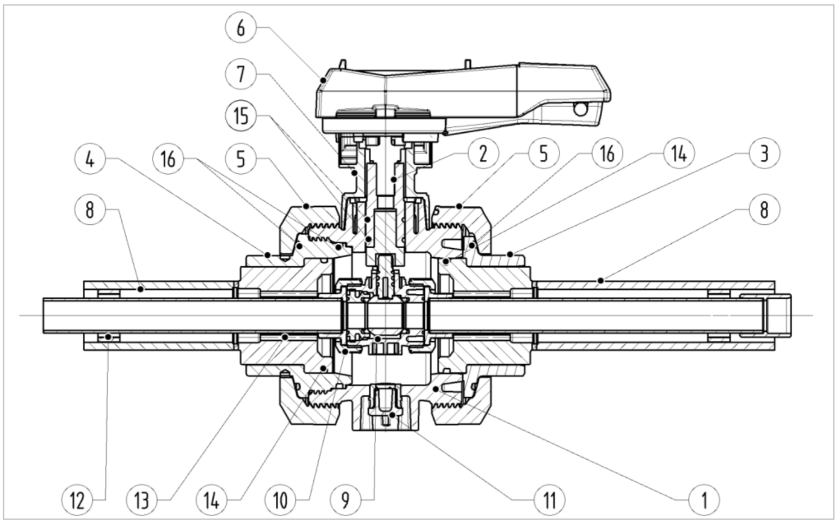
Jointing methods inner pipe

Dimension (mm)	Socket cementing		Socket fusion			Butt fusion IR fusion			
	PVC-U Tangit/ Dytex	PVC-C Tangit/ Dytex	PP-H	PE	PVDF	PP-H	PE	PVDF	ECTFE
d20/D50	✓	✓	✓	✓	✓	✓	✓	✓	✓
d25/D50	✓	✓	✓	✓	✓	✓	✓	✓	✓
d32/D63	✓	✓	✓	✓	✓	✓	✓	✓	✓
d40/D75	✓	✓	✓	✓	✓	✓	✓	✓	✓
d50/D90	✓	✓	✓	✓	✓	✓	✓	✓	✓
d63/D110	✓	✓	✓	✓	✓	✓	✓	✓	✓

Installation, pressure test and maintenance must be performed according to the corresponding installation manual. The installation manual is part of the product, see also the online product catalog at www.gfps.com

1.12.2 CONTAIN-IT Plus double containment ball valve

Design



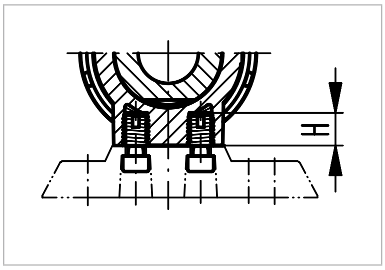
1. Protective housing
2. Stem
3. Union end
4. Union bush
5. Union nut of protective housing
6. Hand lever
7. Nuts and screws (to fix the hand lever)
8. PE supports
9. Ball valve type 546 (central part)
10. Ball valve type 546 coupling nut
11. Adaptor for ½" leak detection or PVC-U ½" plug
12. Spacer
13. Bore-hole for leak detection of inner pipe
14. O-ring PE connecting element
15. O-rings for stern
16. O-rings for union bush/ union end

V

Ball valve installation notes

Maximum insertion depth of the screws into the ball valve:

Dimension (mm)	Screw	Insertion depth H (mm)
d10/DN15	M6	12
d20/DN25	M6	12
d32/DN40	M8	15
d50	M8	15

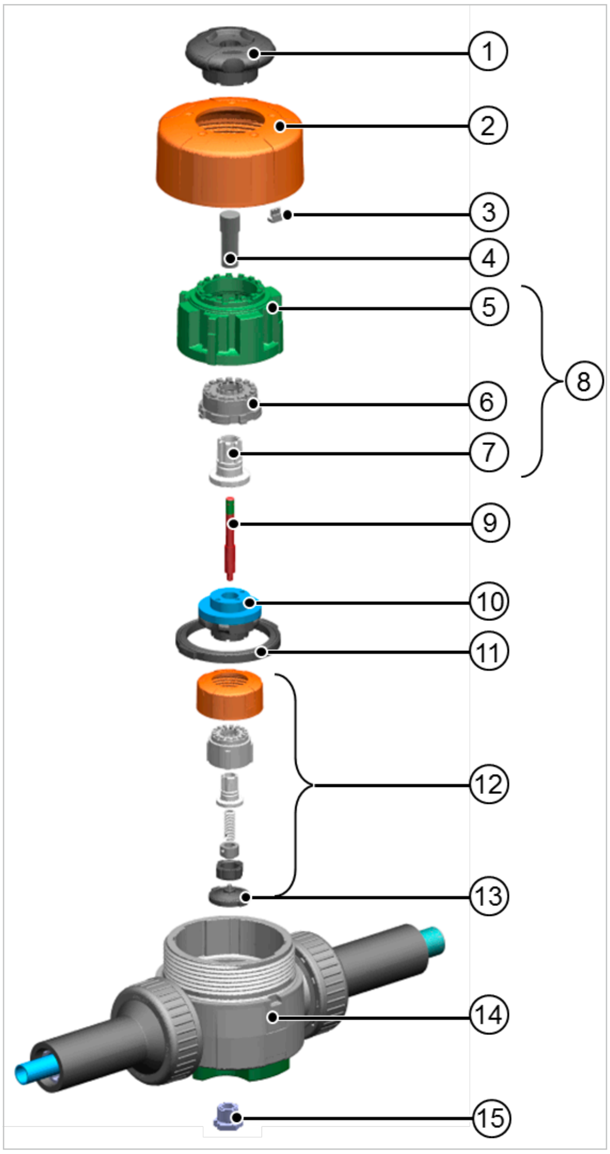


Installation, pressure test and maintenance must be performed according to the corresponding installation manual. The installation manual is part of the product, see also the online product catalog at www.gfps.com

Replacement of the inner line ball valve: When replacing an inner line ball valve in the dimension d63/D110, it is mandatory to contact the GF Global Service & Support Team. In this case, a slightly modified inner pipe ball valve must be used!

1.12.3 CONTAIN-IT Plus diaphragm valve

Design



1. Hand wheel with locking device
2. Housing nut
3. Index plate
4. Sightglass
5. Outer housing
6. Inner housing
7. Spindle nut
8. Spindle assembly
9. Indicator pin
10. Flange
11. Gasket
12. Inner diaphragm valve
13. Diaphragm
14. CONTAIN-IT Plus housing diaphragm valve
15. Leak plug

V

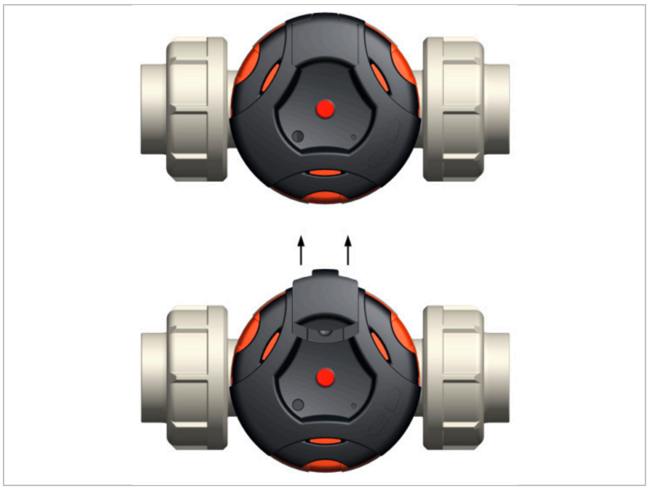
Jointing method inner pipe

Dimension (mm)	Socket cementing		Socket fusion		Butt fusion	
	PVC-U Tangit/Dytex	PVC-C Tangit/Dytex	PP-H	PVDF	PP-H	PVDF
d20/D50	✓	✓	✓	✓	✓	✓
d25/D50	✓	✓	✓	✓	✓	✓

Manual locking

Hand wheel unlocked

Hand wheel locked



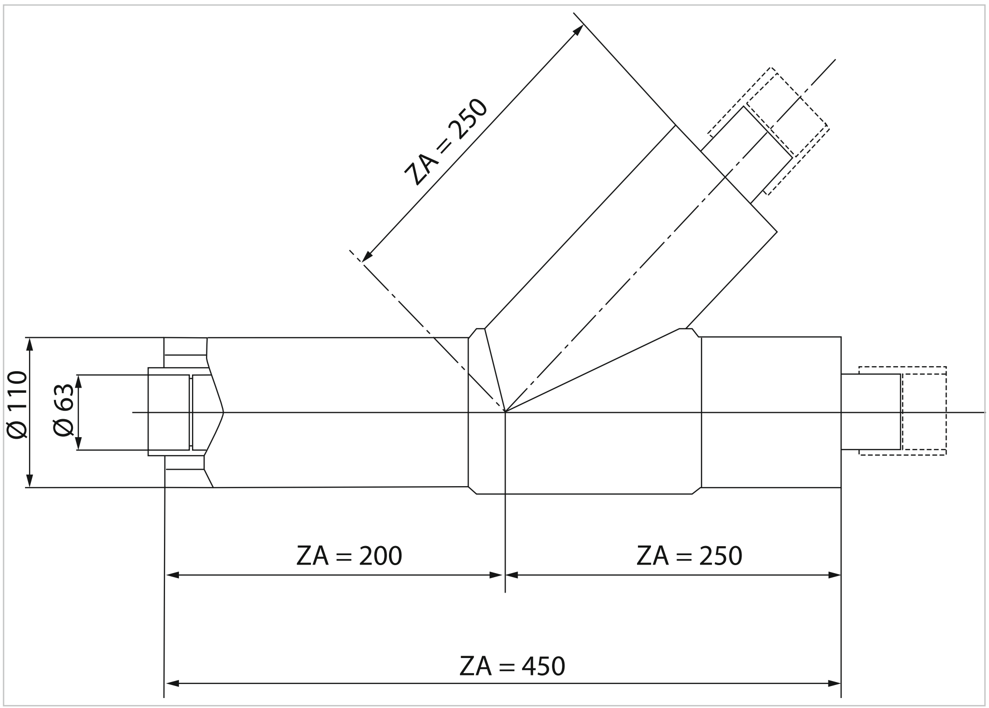
Installation, pressure test and maintenance must be performed according to the corresponding installation manual. The installation manual is part of the product, see also the online product catalog at www.gfps.com

1.12.4 Customized fittings

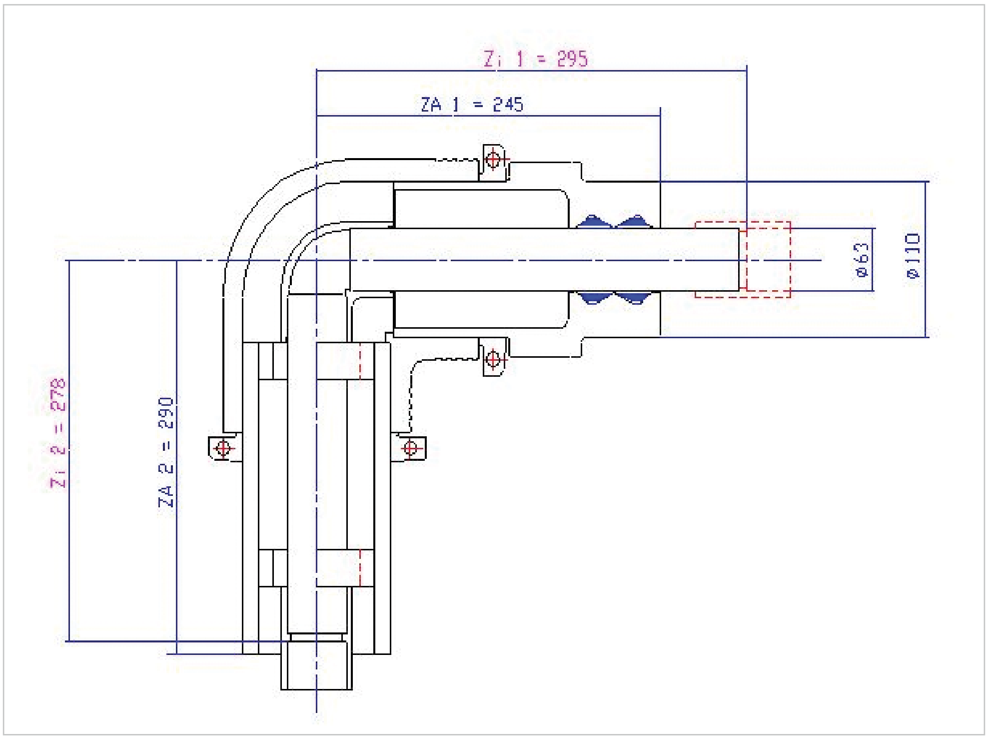
A large number of components in the double containment range are manufactured to customer requirements. Prefabricated tapping pieces, reducing T-pieces, termination fittings integrated into the preform or the prefabrication of entire sub-assemblies offer simplified installation on the construction site.

> ⚠ Customized fittings may require the inclusion of a reduction factor.
>
> Contact your GF Piping Systems representative for additional information.

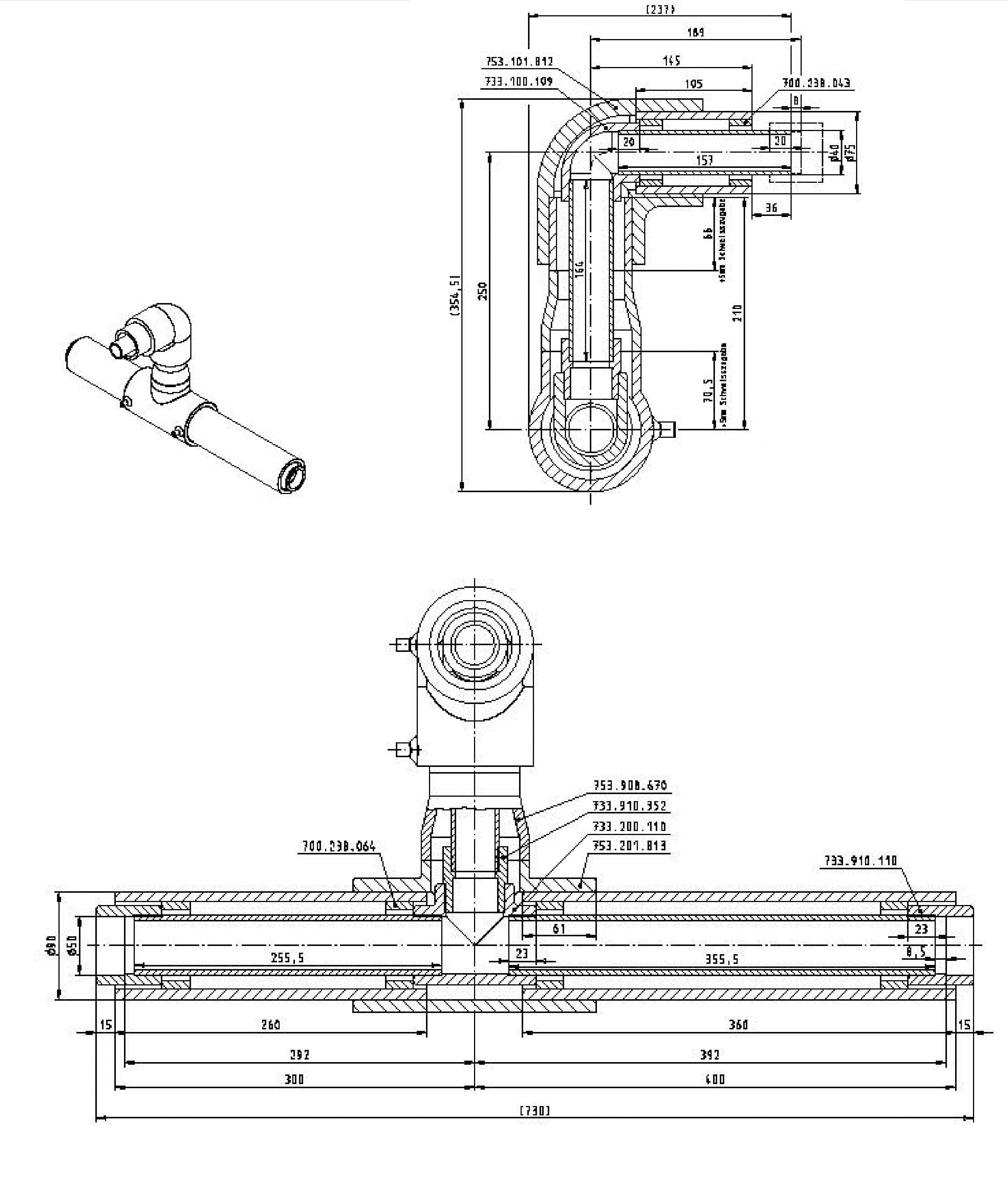
T-piece with 45° tapping point



90° elbow including termination fitting



Double containment T 90° reduced with elbow



Installation, pressure test and maintenance must be performed according to the corresponding installation manual. The installation manual is part of the product, see also the online product catalog at www.gfps.com

2 COOL-FIT 2.0

2.1 General Information

COOL-FIT 2.0 is a pre-insulated piping system for the delivery of secondary refrigerants. Thanks to its insulation thickness of 20 mm, the system can be used in air-conditioning systems with secondary refrigerant temperatures above 0 °C. COOL-FIT 2.0 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 / Jacket tube – installation time is kept very short.

The system consists of pipe, fittings, valves, flexible hoses and transition fittings. All components are pre-insulated or supplied with mountable insulation shells. The COOL-FIT 2.0 tools allow for fast and safe installation of the system.

The COOL-FIT 2.0 system is a completely pre-insulated plastic piping system for secondary refrigerant circuits run with water, brine, or Glycol based solutions.

The COOL-FIT 2.0 system is suitable for use in applications like:

Comfort Cooling	Safe Cooling
• Air conditioning • Airports • Apartments • Hospitals • Industrial buildings	• Data centers • Hotels • Shopping centers • Sports center / leisure center • Universities • Bank / public institutions

2.2 System Specification

Specification		COOL-FIT 2.0	COOL-FIT 2.0F
Materials[1]	Pipe	PE100	PE100
	Insulation	GF-HE foam, halogen free, closed-cell	GF-HE foam, halogen free, closed-cell
	Outer jacket	Pipe HDPE	Flame retardant - GF-FR
		Fitting GF-HE	
Size [2]		d32DN25 – d140DN125 mm	d32DN25 – d140DN125 mm
Connection techno-logy		Electrofusion	Electrofusion
Nominal pressure[3]		16 bar, SDR 11	16 bar, SDR 11
Temperature	Medium	0 °C bis +60 °C	0 °C bis +60 °C
	Environment	0 °C bis +55 °C	0 °C bis +55 °C
Insulation	Thermal conductivity $\lambda_{20°C}$		
	PE Inner pipe	0.38 W/mK	0.38 W/mK
	HE Foam	0.022 W/mK	0.022 W/mK
	PE jacket	0.38 W/mK	
	GF-FR jacket		0.15 W/mK
	Density	≥ 70 kg/m³	≥ 70 kg/m³
	Foam cell size	max. Ø 0.5 mm	max. Ø 0.5 mm
	Nominal thickness	22 mm	22 mm
Mechanical strength (from insulation)	Axial shear strength	≥ 0.12 N/mm²	> 0,12 N/mm²
	Compressive strength	≥ 0.3 N/mm²	≥ 0.3 N/mm²
Colour	Outer jacket	Black	Black
Weight (without medium)	Pipe d32	1.12 kg/m	1.06 kg/m
	Pipe d110	5.5 kg/m	5.39 kg/m
Oxygen diffusion at ≤ 5°C	ISO 17455	≤ 0.083 mg/(m² d)	≤ 0.083 mg/(m² d)
Fire classification [4]	EN 13501-1 [4]	E	B - s2, d0

1) All three materials are firmly bonded together.

2) Bigger dimensions available via COOL-FIT 4.0 and COOL-FIT 4.0F product range

3) At 20 ° C, medium water, the specified value is valid for all system components, with the exception of the butterfly valves, PN10 applies to the nominal pressure and for flexible hoses with maximum pressure according product datasheet.

4) Additional information in chapter "Fire behavior and fire prevention measures".

Specification		COOL-FIT 2.0	COOL-FIT 2.0F
Environment	Stability	Moisture and vapor-tight	Moisture and vapor-tight
	Wheather/UV resistance	for indoor use	for indoor use
	Ozone Depletion Potential	Zero	Zero
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 EN ISO 16136 EN ISO 16137 EN ISO 16138	Industrial valves ... – Ball valves made of thermoplastics – Butterfly valves made of thermoplastics – Backflow protection made of thermoplastics – Diaphragm valve 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 Green buildings		BNB BN 2015 BREEAM Int 2016 DGNB 2015 DGNB 2018 LEED V3 LEED V4 WELL V1 2019	
eco-bau	(BKP 240, 244, 250)	201710.1516	201908.5715

2.3 Technical Details

2.3.1 COOL-FIT 2.0

COOL-FIT 2.0 pipe

COOL-FIT 2.0 pipes are made from PE 100. The high efficiency GF-HE hard foam insulation exhibits a thermal conductivity λ of 0.022 W/mK. The pipes are protected by a impact 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 pipes are available in 5 m lengths.

Pipe size (mm)	Inner Pipe d x e (mm)	Inner Pipe d_i (mm)	Outer jacket D x e1 (mm)	Weight empty (kg/m)	Weight with water (kg/m)	Volume (l/m)	Insulation thickness (mm)	Heat transfer coefficient (U) (W/m K)	Fire load (kWh/m)
d32/75	32 x 2.9	26.2	75 x 3	1.12	1.66	0.54	18.5	0.16	12.41
d40/90	40 x 3.7	32.6	90 x 3	1.50	2.34	0.83	22.0	0.17	16.55
d50/90	50 x 4.6	40.8	90 x 3	1.67	2.98	1.31	17.0	0.24	18.91
d63/110	63 x 5.8	51.4	110 x 3.4	2.47	4.54	2.07	20.1	0.25	27.91
d75/125	75 x 6.8	61.4	125 x 3.8	3.24	6.20	2.96	21.2	0.28	36.88
d90/140	90 x 8.2	73.6	140 x 4	4.17	8.43	4.25	21.0	0.32	47.91
d110/160	110 x 10	90.0	160 x 4	5.50	11.86	6.36	21.0	0.38	63.47
d140/200	140 x 12.7	114.6	200 x 5	8.71	19.02	10.31	25.0	0.47	100.88

d	Nominal outer diameter of the PE pipe
d_i	Nominal inside diameter of the pipe
D	Nominal outside diameter of the outer PE jacket
e, e1	Nominal wall thickness

COOL-FIT 2.0 fittings

General

The media fitting and insulation used for COOL-FIT 2.0 fittings fulfill the same specifications as the COOL-FIT 2.0 pipe. The COOL-FIT 2.0 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 2.0 fittings are available in two types:

Type A:

Electrofusion fitting with integrated resistance wires for direct electrofusion pipe-to-fitting connections.

90° elbow as an example

Type B:

Spigot fitting with free ends for pipe-to-fitting electrofusion with COOL-FIT 2.0 electrofusion fittings.

90° elbow as an example

Usefull functions - Fittings type A:

Fusion indicators

After welding, check whether there is wear to the fusion indicators. After the welding process, the indicator pin shows clearly that energy has been applied to the welding zone.

Sealing lip

The sealing lip can be used to check whether the insulation has been properly sealed. If they bulge after the fitting has been pushed up to the end stop on the pipe, the installation is correct. By labelling the lip end on the pipe any changes in position of the fitting can be monitored.

For direct fitting-to-fitting or fitting-to-valve connections, the sealing lip can be removed beforehand during electro-fusion fitting.

Label

The fittings have abrasion-resistant marking.

Trace code

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

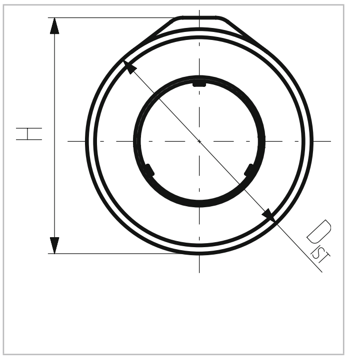
373603063 160120 76701000325 Traceability

Angle marking

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

All Type A fittings feature a dome surrounding the welding connectors. It tops the outer diameter of a fitting, thus increases the total height (H) of a fitting in this specific section. The outer diameter of a fitting (D_{Ist}) is slightly larger than the nominal outer diameter (D) of the system. See dimension table for Type A fittings:

d/D (mm)	D_{Ist} (mm)	H (mm)
32/75	82	87
40/90	97	99
50/90	97	105
63/110	117	123
75/125	132	139
90/140	147	154
110/160	168	177
140/200	208	208



d/D Nominal inner- / outer diameter COOL-FIT 2.0 System

D_{Ist} Effective outer diameter fitting Type A

H Fitting height at welding connector section

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 coupler to a pipe (see chapter below "components").

Fitting-to-fitting

Two COOL-FIT 2.0 fittings are usually connected by using a piece of COOL-FIT 2.0 pipe with free ends or a short piece of ecoFIT PE pipe and an insulation ring (e.g. ring removed with the foam removal tool). The shortest connection between two COOL-FIT 2.0 Type A fittings can be achieved by cutting off the sealing lips and using a barrel nipple and an adhesive ring for the vapor seal (see components).

Two COOL-FIT 2.0 Type B fittings can be joined using an electrofusion coupler (see components).

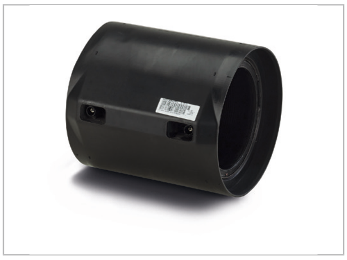
The connection of a COOL-FIT 2.0 fitting Type A and Type B is also possible.

Components

Fittings can be connected to either pipe or other fittings using the parts described below:

COOL-FIT 2.0 Electrofusion coupler

COOL-FIT 2.0 electrofusion couplers are used to connect pipe and components with free ends like type B fittings, valves and transition fittings.



COOL-FIT 2.0 Elbows 45° and 90°

(Refer to „General“ chapter above)

COOL-FIT 2.0 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 outlets can be connected to the type A fitting, so all combinations are possible.

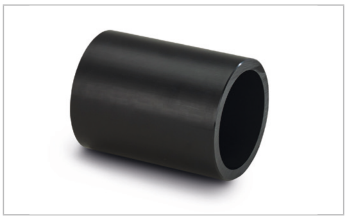
The type B fittings with free fusion spigots can be connected to all type A fittings.

COOL-FIT 2.0 reducer

The COOL-FIT 2.0 reducer can be used to reduce the flow of the starting size by up to three to four sizes (e.g. from d140 up to d63 or from d75 up to d32).

COOL-FIT 2.0 barrel nipple

COOL-FIT 2.0 barrel nipple serves as a compact direct connector for type A fittings.



Combination of T90° and Reducer

If a reduction step should be done after the branch of a T90°, either a COOL-FIT 2.0 T90° reduced, or a COOL-FIT 2.0 T90° reduced/ equal connected to a reducer should be used.

Run Branch	40	50	63	75	90	110	140
32	Δ	Δ	Δ	Δ	Δ	Δ	O
40		X	X	O	O	O	O
50			X	O	O	O	O
63				Δ	Δ	Δ	Δ
75					Δ	Δ	Δ
90						Δ	Δ
110							Δ

X T90°- equal + reducer
O T90°- reduced + reducer
Δ T90°- reduced

V

Accessories

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.)

Adhesive ring

With a compact connection with a barrel nipple (fitting-to-fitting), this adhesive ring is used to ensure that the connection is water and vapor tight after the removal of the sealing lip.

Cement

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

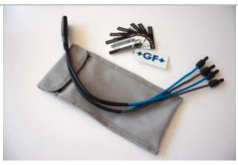
Adhesive tape

Optional for covering hand-cut faces.

Y-Cable kit for COOL-FIT Fixpoints

Cuts the welding time by 50% and includes the required welding adapters.

Article no.: 790 156 032.



COOL-FIT 2.0 valves

COOL-FIT 2.0 valves are based on GF Standard plastic valves. The valves are supplied including GF-HE insulation shells with a protective PE jacket. The sealing faces between the shells and the valve 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 – d140DN125 permit the pre-insulated shells to be fitted to and removed from the valves easily, allowing easy maintenance.

The insulated ball valve in PVC-U is available in sizes d32DN25 – d90DN80, and the butterfly valve in sizes d110DN100 – d140DN125. Manual versions or such ISO 5211 interface are available. The interface is suitable for electric actuators from GF as well as for 3rd party actuators.

Interfaces:

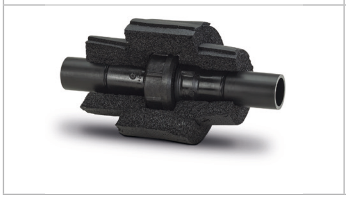
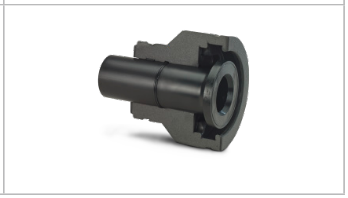
F03 and F05 for ball valves d32DN25 – d63DN50

F07 for all ball- and butterfly valves d75DN65 – d90DN80

COOL-FIT 2.0 transition fittings, flange connectors

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. All listed components are supplied with insulation in NBR foam:



Thread type/connector/ pitch circle	Size	Material	Thread type/connector/ pitch circle
Transition fittings for metal*	d32 – d63 ½" – 2 ¾"	PE – stainless steel PE – brass	Male thread (R), Female thread (Rp), Loose union nut (G)
Transition fittings to iFIT or Sanipex MT*	d32 1"	Stainless steel Brass	iFIT, Sanipex MT
Union plastic - plastic*	d32 – d110 1" – 4 "	PE – PE, PE – ABS	Welding spigots Cementing socket
Adaptor union to metal*	d32 – d63 1" – 2 "	PE – stainless Steel	Internal thread (Rp), External thread (R)
Flange joints**	d32 – d140	PE	Bolt circle PN 10/16

* NBR foam insulation
** Insulation half shells similar to valve insulations

COOL-FIT 2.0 flex hoses

The flexible hose in EPDM with stainless stell protection permit mobile access to devices such as fancoils, compensating for expansion or contraction within the system. The tear-resistant protective tissue jacket and NBR insulation (19mm, $\lambda_{10°C} \leq$ 0.036 W/mK) ensure the temperature of the cooling medium remains unchanged. Versatile connectivity options mean that system connection is ensured:
G thread (external thread + loose nut)

d (mm)	DN (mm)	Thread	Length (mm)	Max. compensation ΔL (mm)	R_{min} (min. bending radius) (mm)
20	15	½"	1000	276	119
25	20	¾"	1000	161	156
32	25	1"	1000	68	192
40	32	1 ¼"	1500	233	252
50	40	1 ½"	2000	396	312
63	50	2"	2000	233	372

COOL-FIT 2.0 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 female thread.

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

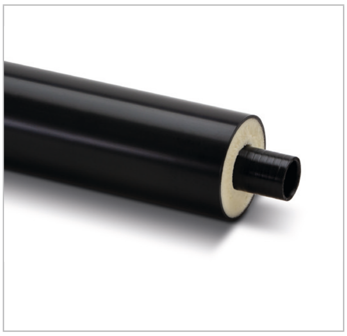
2.3.2 COOL-FIT 2.0F

COOL-FIT 2.0F pipe

COOL-FIT 2.0F inner pipe is made from PE100. The insulation made of highly efficient GF HE rigid foam has a thermal conductivity λ of 0.022 W/mK. The pipe is protected by the GF-FR fire retardant jacket.

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

The pipes are available in 5m legths and can be connected with all fittings from COOL-FIT 2.0.



Pipe size (mm)	Inner Pipe d x e (mm)	Inner Pipe d_i (mm)	Outer jacket D x e1 (mm)	Weight empty (kg/m)	Weight with water (kg/m)	Volume (l/m)	Insulation thickness (mm)	Heat transfer coefficient (U) (W/m K)	Fire load (kWh/m)
d32/75	32 x 2.9	26.2	75 x 1.8	1.06	1.60	0.54	19.7	0.16	7.54
d40/90	40 x 3.7	32.6	90 x 1.8	1.43	2.27	0.83	23.2	0.17	10.65
d50/90	50 x 4.6	40.8	90 x 1.8	1.60	2.91	1.31	18.2	0.23	13.01
d63/110	63 x 5.8	51.4	110 x 1.8	2.27	4.34	2.07	21.7	0.24	19.20
d75/125	75 x 6.8	61.4	125 x 1.8	2.88	5.84	2.96	23.2	0.26	25.29
d90/140	90 x 8.2	73.6	140 x 2.5	4.09	8.34	4.25	22.5	0.30	35.87
d110/160	110 x 10	90.0	160 x 2.5	5.39	11.76	6.36	22.5	0.36	49.65
d140/200	140 x 12.7	114.6	200 x 2.5	8.05	18.37	10.31	27.5	0.44	76.84

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

2.3.3 COOL-FIT tools

Electrofusion Machines

Electrofusion machines are required to join COOL-FIT 2.0 components. The range includes dedicated and multipurpose electrofusion machines which are reliable and easy to use.

GF recommends: MSA-Series electrofusion machines.

Foam removal tool and peeling tool – manually operated

The foam removal tool is used to prepare shortened COOL-FIT 2.0 / 2.0F 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 – d140.

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.

2.4 Dimensioning and design

The following section describes only the COOL-FIT specific planning fundamentals. For prevailing information see general GF planning fundamentals.

2.4.1 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 2.0 are very robust systems, care should be taken to avoid damage during handling and transportation.

For over 50 years, GF 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 GF Piping Systems representative. Additional information is available on the official GF Piping Systems website.

2.4.2 COOL-FIT 2.0 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.

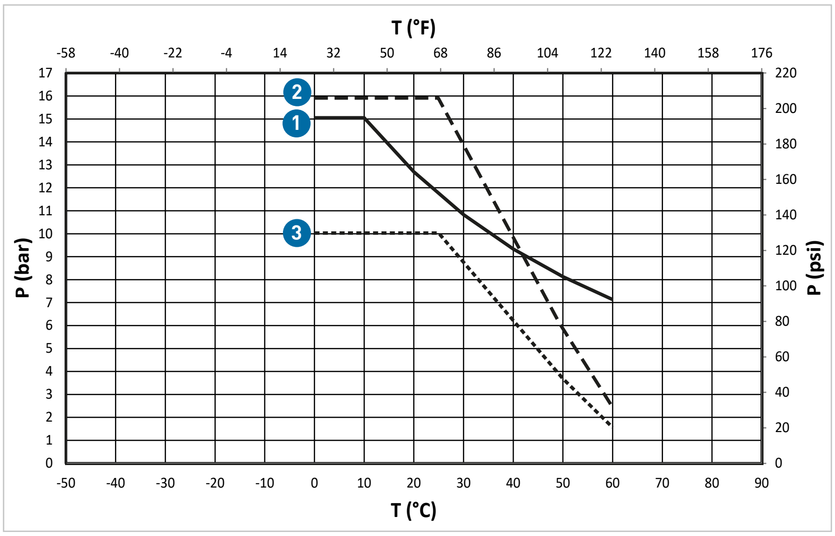
The graph shows the maximum permissible pressure for COOL-FIT 2.0 pipe, fittings and valves at various temperatures, up to the maximum permissible media temperature of +60 °C. The table is based on an ambient temperature of +20 °C. A safety factor of 1.6 and a minimum lifespan of 25 years have been allowed for in all calculations.

The values given in this chapter apply to both COOL-FIT 2.0 and COOL-FIT 2.0F.

Pressure/temperature limits for COOL-FIT 2.0 fittings, pipe, valves – water coolant

Limits for COOL-FIT 2.0: 25-year values allowing for the safety factor (with water as the coolant).

In case of long-term operating pressure at temperatures above 47 °C, please contact your authorized GF Piping Systems representative.



P Allowable pressure (bar, psi)
T Temperature (°C, °F)
C Safety factor
① COOL-FIT pipe and fitting C=1.6, SDR11
② COOL-FIT 2.0 ball valve PN16
③ COOL-FIT butterfly valve PN10

The butterfly valves used for the COOL-FIT 2.0 system exhibit lower pressure-temperature ratings than the rest of the components. If valves are used, it is necessary to refer to the data in the diagram above.

Influence of secondary refrigerants with antifreeze additives

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

COOL-FIT 2.0 is generally resistant to secondary coolants such as glycol and brines. For some secondary coolants 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[1]

Inorganic salt solutions	F = 1
Organic salt solutions	F = 1
Glycol solutions (max. 50 %)	F = 1.1

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

[1] Valid for materials HD-PE, EPDM, PVC-U, metals

Glycol solutions

COOL-FIT 2.0 / 2.0F can be used with glycol solutions with concentrations up to 50%. The chemical resistance of COOL-FIT 2.0 systems is suitable for the following antifreeze types:

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

When using other coolants, compatibility with COOL-FIT 2.0 should be clarified with GF Piping Systems.

Example – glycol dissolved in water

For water-glycol mixture ≤ 50%, the reduction factor for the pressure-temperature diagram is 1.1. Thus, at +10 °C, with a minimum life of 25 years, the maximum allowable working pressure is reduced as follows:

$$P_{AF} = \frac{15\text{ bar}}{1.1} = 13.6\text{ bar}$$

Organic salt solutions

These media are usually potassium formates or potassium acetates: aqueous solutions with low viscosity at low temperatures. COOL-FIT 2.0 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
Temper	Temper	Brine
Hycool	Addcon	Brine

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

2.4.3 Polyethylene (PE)

The dominant material for the COOL-FIT 2.0 / 2.0F 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/cm³	EN ISO 1183-1
Yield stress at 23 ° C	25	N/mm²	EN ISO 527-1
Tensile modulus at 23 ° C	900	N/mm²	EN ISO 527-1
Charpy notched impact strength at 23 ° C	83	kJ/m²	EN ISO 179-1/1eA
Charpy notched impact strength at -40 ° C	13	kJ/m²	EN ISO 179-1/1eA
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 - 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 CnH_2n 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: $-(CH_2-CH_2)n$. 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.

In industrial piping, high molecular weight types have resulted in medium to high density. The types are classified by their creep rupture strength into PE80 (MRS 8 MPa) and PE100 (MRS 10 MPa). The latter are also called 3rd generation types of PE, while PE80 types are primarily associated with the 2nd generation. There are barely any first generation PE types – PE63 under the modern classification – remaining on the market. Creep rupture strength has been tested by long-term tests as per ISO 1167, and calculated in accordance with ISO 9080. 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

Chemical resistance

Polyethylene exhibits good resistance to a wide range of media. For detailed information, please see the detailed chemical resistance list from GF Piping Systems, or contact the person responsible at GF 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 properties 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 3.5×10^{16} Ωcm, the surface resistance 101^{3} Ω. This must be taken into account in applications where there is danger of fire or explosion.

2.4.4 Fire behavior and fire prevention measures

Firestop classes

Classification of fire behavior

Construction materials are classified into different firestop classes depending on their fire behavior. The classification is decisive for whether specific materials may be legally used for construction in certain areas of construction projects.

European classification according to EN 13501-1

In the year 2001, the EN 13501-1 was introduced, a European classification system for construction materials. EN 13501-1 defines 6 construction material classes from A to F:

A	No contribution to the development of a fire (A1, A2)
B	Very little contribution to the development of a fire
C	Limited contribution to the development of a fire
D	Acceptable contribution to the development of a fire
E	Acceptable fire behavior
F	No performance criteria detected

In addition to the fire behavior, the European standard also rates fire side effects: smoke release (s1, s2, s3) and burning droplets (d0, d1, d2).

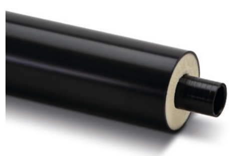
Smoke release:

s1	limited smoke release
s2	average smoke release
s3	high smoke release, or smoke release not tested

Burning droplets:

d0	no burning droplets/fall off within 600 seconds
d1	no burning droplets/fall off with an afterglow time of more than 10 seconds within 600 seconds
d2	No performance criteria detected

Fire prevention classes EN13501-1, VKF and British building codes

	COOL-FIT 2.0	COOL-FIT 2.0F	COOL-FIT 2.0/ mineral wool [2]
			
EN 13501-1	E	B – s2, d0	A2$_L$
VKF	RF3*	RF2	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

* d32 + d140 and COOL-FIT 4.0 d >= d160mm

Thermal load

The thermal load corresponds to a thermal potential (energy release) related to a specific base area, fire section area in m^2, for example an escape route. The physical unit for the thermal load is energy per surface area kWh/m^2. The calculative thermal load is equivalent to the sum of the different thermal potentials of all used combustible used elements, such as pipelines. When the energy released per running meter of the pipe (kWh/m) is known, the thermal load of the pipe is calculated from the used pipe length.

d/D (mm)	32/75	40/90	50/90	63/110	75/125	90/140	110/160	140/200
Thermal load COOL-FIT 2.0 pipes (kWh/m)	12.02	15.97	18.43	29.38	36.84	46.93	62.32	99.14

d/D (mm)	32/75	40/90	50/90	63/110	75/125	90/140	110/160	140/200
Thermal load COOL-FIT 2.0F pipes (kWh/m)	7.54	10.65	13.01	19.20	25.29	35.87	49.65	76.84

Fire resistance of components

While the fire behavior characterizes individual materials, the fire resistance must be considered for entire assemblies, for example a solid wall with pipe penetrations. The fire resistance is equivalent to the amount of time in which a component maintains its function during a standard fire.

The European system allows classification according to different criteria, stating the respective fire resistance duration in minutes.

Fire resistance and classification according to the European standards

Pipe insulation systems are exposed to a standard fire according to EN 1363-3. Classification is according to EN 13501-2 and generally includes the criteria integrity (E, Étanchéité) and thermal insulation (I, Insulation).

Abbreviation	Criterion	Rating
E – Étanchéité	Flame protection or integrity	Measurement of an element's capacity of preventing the passage of gases and flames in case of fire.
I – Insulation	Insulation or thermal insulation	Measurement of the insulation capacity of an element, i.e. the duration in which the side of the element facing away from the fire does not exceed 180° C + the ambient temperature.

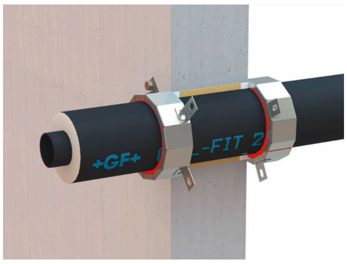
V

Firestop collars/Fire sealing

When pipes are installed through fire-rated assemblies, whose reliable functioning must not be affected, firestop collars that comply with local requirements and legislation must be used.

Hilti firestop

System description



The firestop collar (inlc.fastening hook) is made of galvanized steel sheet into which strips of intumescent material (i.e. that swells in case of fire) are inserted.

The fire retardation sealing with straight pipes is regulated in conjunction with the following products in the individual countries:

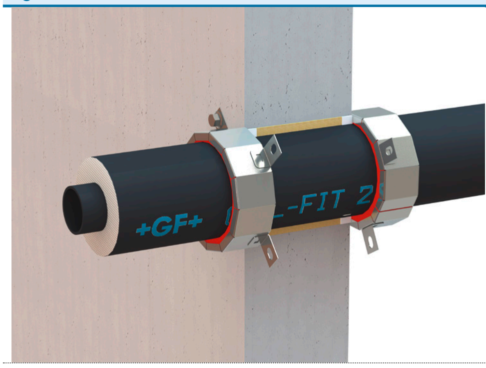
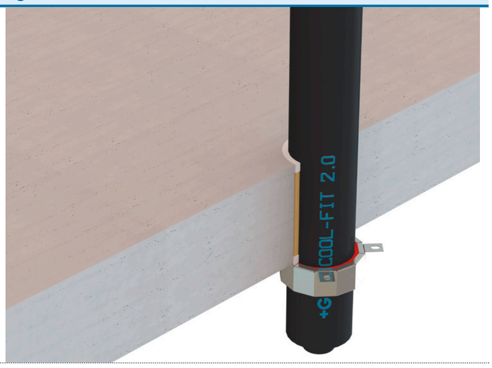
Product	Proof of applicability	Countries
Hilti firestop collar CP 644	Allgemeine Bauartgenehmigung (aBg) Z-19.53-2330	DE
Hilti firestop collar CP 644	VKF Technische Auskunft 14108	CH
Hilti firestop collar CFS-C P	ETA-10/0404	EU

The respective details of the proofs of application must be taken into account.

Additional information is available at Hilti online or from your Hilti contact person.

Hilti CP 644	Hilti CFS-C P
Info | Shop qr.hilti.com/r3069	Info | Shop qr.hilti.com/r4831

The following applications are regulated via the above proofs of application:

Rigid wall, thickness ≥ 100 mm	Rigid floor, thickness ≥ 150 mm
	

Fire-retarding sealing

COOL-FIT 2.0 pipes up to and including an outside diameter D of 200mm, can be sealed in rigid walls and rigid floors by a Hilti firestop collar.

Rigid wall ≥ 100mm solid		Product DE, CH	Product EU	Fire resistance	Mounting
d (mm)	**D (mm)**	**CP 644**	**CFS-C P**		**Number of hooks**
32	75	CP 644-75/2.5"	CFS-C P 75/2.5"	EI 120-U/C	3
40	90	CP 644-90/3"	CFS-C P 90/3"	EI 120-U/C	3
50	90	CP 644-90/3"	CFS-C P 90/3"	EI 120-U/C	3
63	110	CP 644-110/4"	CFS-C P 110/4"	EI 120-U/C	4
75	125	CP 644-125/5"	CFS-C P 125/5"	EI 120-U/C	4
90	140	CP 644-160/6"	CFS-C P 160/6"	EI 120-U/C	6
110	160	CP 644-160/6"	CFS-C P 160/6"	EI 90-U/C	6
140	200	CP 644-200/8"	CFS-C P 200/8"	EI 120-U/C*	8

Rigid floor ≥ 150mm solid		Product DE, CH	Product EU	Fire resistance	Mounting
d (mm)	**D (mm)**	**CP 644**	**CFS-C P**		**Number of hooks**
32	75	CP 644-75/2.5"	CFS-C P 75/2.5"	EI 120-U/C	3
40	90	CP 644-90/3"	CFS-C P 90/3"	EI 120-U/C	3
50	90	CP 644-90/3"	CFS-C P 90/3"	EI 120-U/C	3
63	110	CP 644-110/4"	CFS-C P 110/4"	EI 120-U/C	4
75	125	CP 644-125/5"	CFS-C P 125/5"	EI 90-U/C	4
90	140	CP 644-160/6"	CFS-C P 160/6"	EI 120-U/C	6
110	160	CP 644-160/6"	CFS-C P 160/6"	EI 120-U/C	6
140	200	CP 644-200/8"	CFS-C P 200/8"	EI 60-U/C*	8

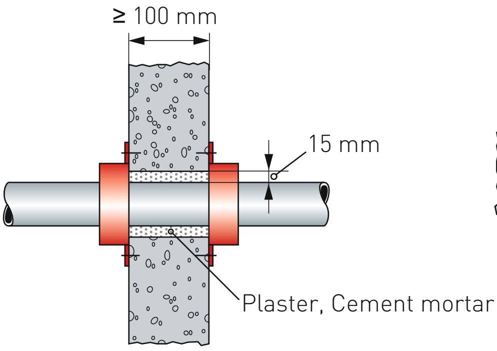
* here exclusively gap sealing with non-combustible construction materials

Annular gap sealing

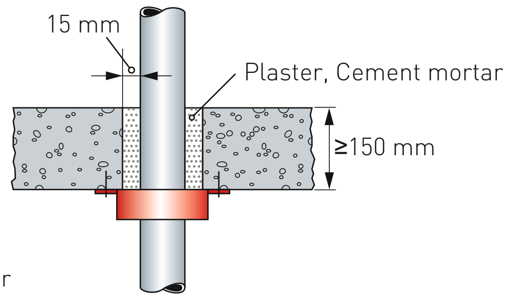
For the installation situations there are several options for sealing gaps against smoke gas.

Gap sealing with non-combustible construction materials:

Rigid wall

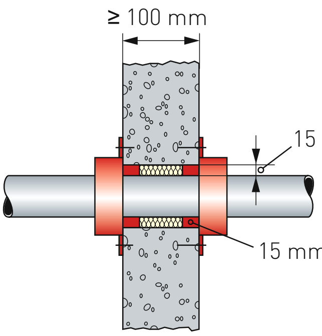


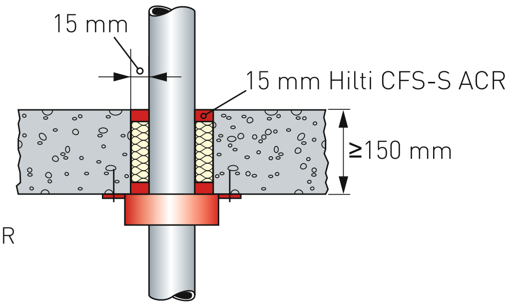
Rigid floor



Joint closure with Hilti firestop sealant CFS-S ACR and mineral wool backfill up to 15mm annular gap width for Hilti firestop collar CP 644 and CFS-C P.

Rigid wall	Rigid floor



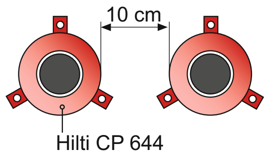


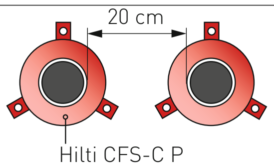
Distance regulations

The distance of the component openings to be closed to other openings or installed elements must comply with the data provided in the following table.

Distance of the pipe sealing to	Size of the adjacent openings	Distance between the openings DE, CH	Distance between the openings EU
Other cable or pipe sealing	one/both openings > 40cm x 40cm	≥ 20cm	≥ 20cm
	Both openings ≤ 40cm	≥ 10cm	
Other openings or installed elements	one/both openings > 20cm x 20cm	≥ 20cm	≥ 20cm
	Both openings ≤ 20cm	≥ 10cm	

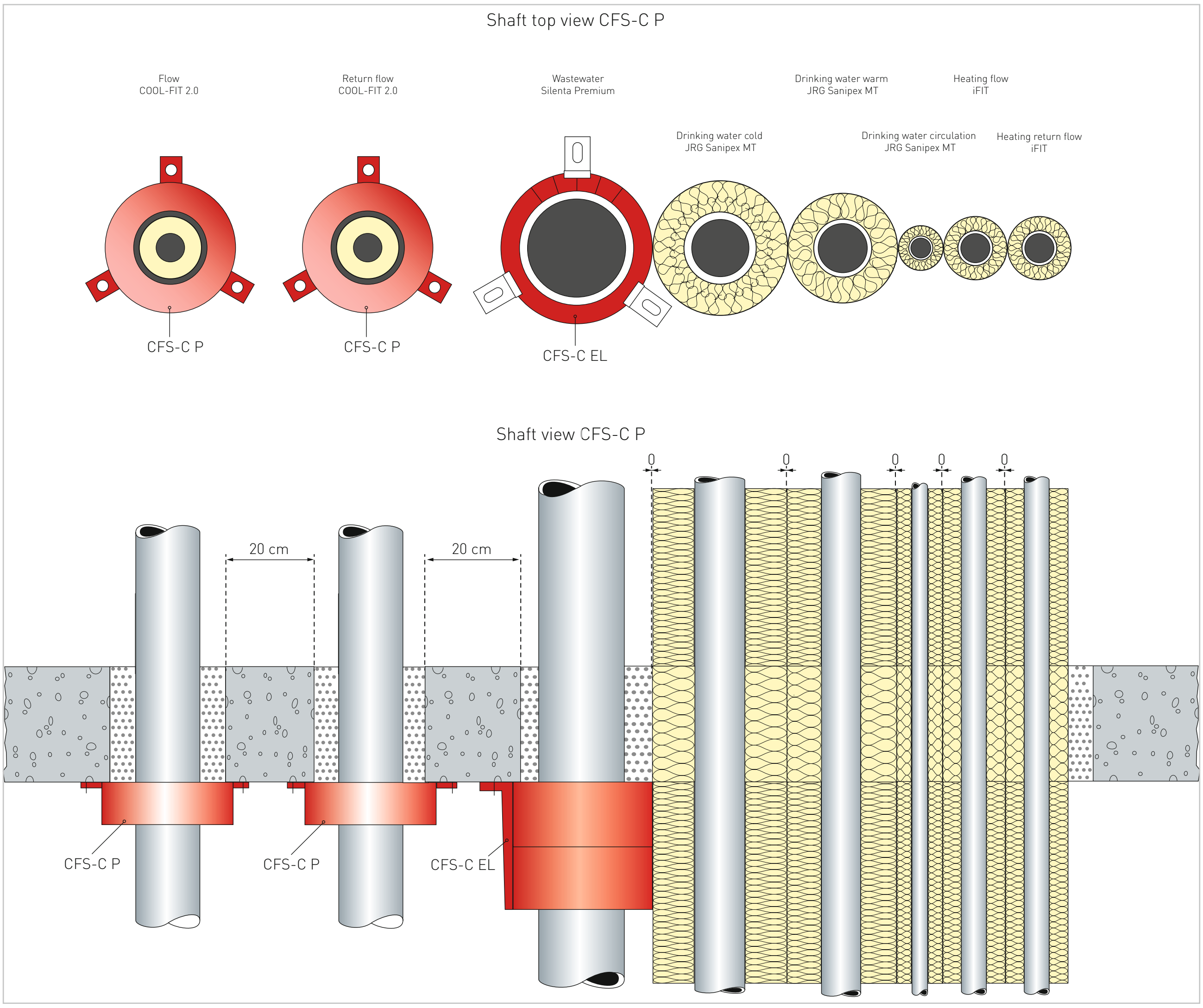
The following pipe distances between the openings of the pipe lead through are derived from this for pipe sealing with the Hilti firestop collar for COOL-FIT 2.0:

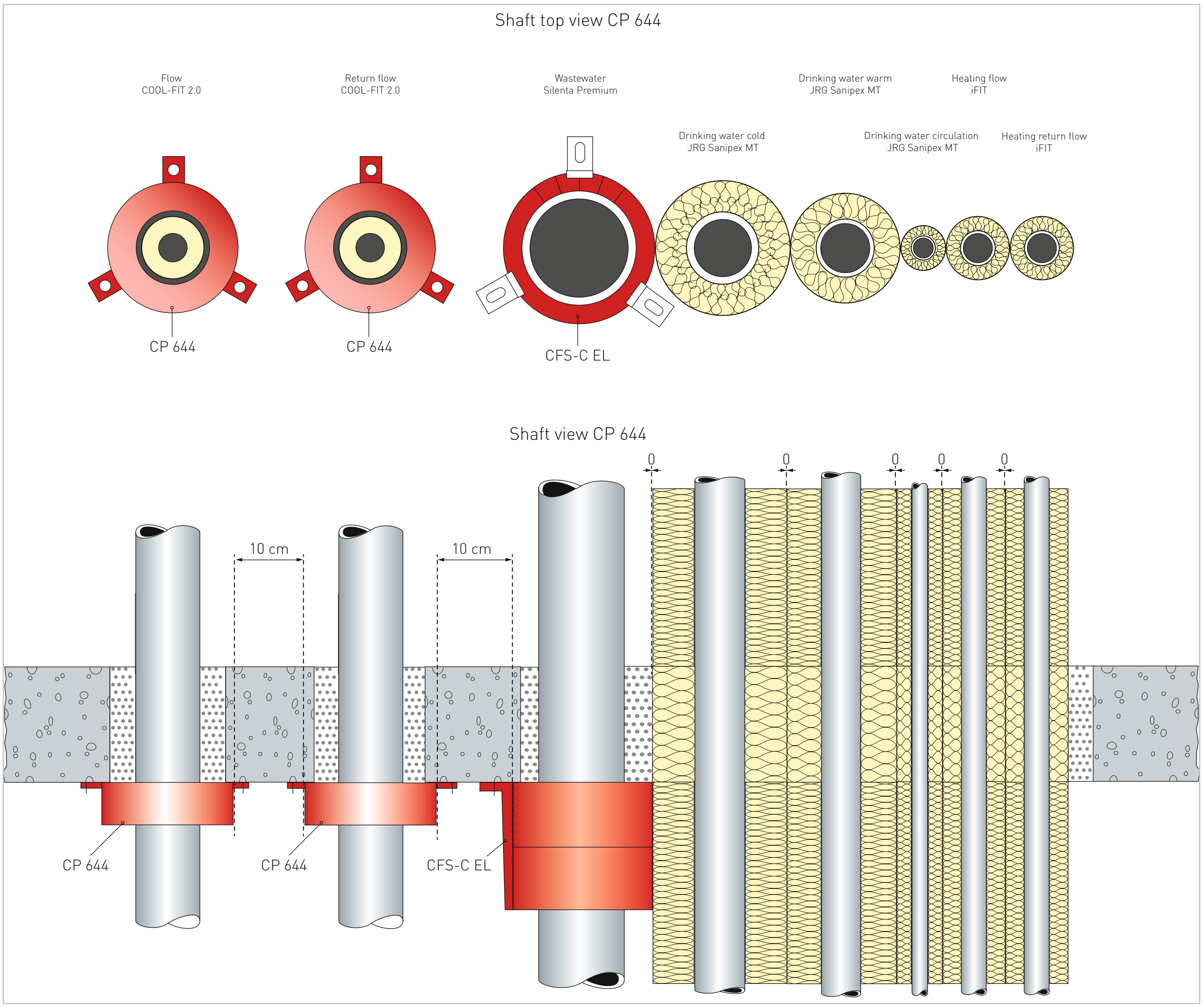




Shaft installation

A shaft installation with additional pipelines, for example for heating and drinking water, may look as follows:





Additional tested fire-retarding sealing

The following firestop collars were tested with COOL-FIT 2.0/2.0F pipes.

Fire-retarding sealing	Manufacturer	Approval
ROKU ® AWM II	Rolf Kuhn GmbH	ETA 17/0753
BIS Pacifyre ® AWM II	Walraven	ETA 17/0753

The firestop system ROKU® R – type AWM II carries the European technical approval ETA 17/0753. COOL-FIT 2.0/2.0F was tested with AWM II firestop collars.

For detailed product information on AWM II see www.kuhnbrandschutz.com.

ROKU® System AWM II

System description

The ROKU® system AWM II consists of a firestop collar housing, which is equipped on the inside with several layers of the highly effective intumescent material "ROKU® Strip." In case of fire, the foaming material reacts with a strong foaming pressure and permanently seals the construction component opening against fire and smoke. On walls, one collar should be fitted on each side, and on ceilings only one collar underneath the ceiling.

Application areas

- Sealing of plastic pipes up to Ø 400 mm in solid walls, light partition walls, and solid ceilings
- For plastic pipes, mineral fiber-reinforced plastics, plastic composite pipes
- Suitable for insulated and non-insulated plastic pipes and acoustically insulating sewage pipes

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

2.4.5 Hydraulic design

Determination of pipe diameter based on flow rate (l/s)

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

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

v	flow velocity (m/s)
di	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 2.0 pipe	SDR11
Flow rate Q_2	8 l/s
Usual flow velocity v	1.5 m/s

$$d_i = 35.7 \cdot \sqrt{\frac{8}{1.5}} = 82.4 \text{ mm}$$

A pipe with d90/d140 is used. After the internal diameter has been determined that way, the actual flow rate is determined with the following formula:

$$v = 354 \cdot \frac{Q_1}{d_i^2} = 1.9\ \frac{m}{s} \quad \text{or} \quad v = 1275 \cdot \frac{Q_2}{d_i^2} = 1.9\ \frac{m}{s}$$

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

Determination of pipe diameter based on cooling capacity (kW)

As a first approximation, the required pipe cross section for a certain cooling capacity 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/m^3)
v	Flow velocity (m/s)

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

Cooling capacity Q_L	200 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

$$di = 18.8 \cdot \sqrt{\frac{\left(\frac{200 \cdot 3600}{10 \cdot 4.187 \cdot 998.2}\right)}{1.5}} = 18.8 \cdot \sqrt{\frac{17.227}{1.5}} = 63.71\ \text{mm}$$

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

Gases

v = 10 – 30 m/s

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.

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

Correlation of outer diameter - inner diameter

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

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

Correlation between pipe external and internal diameter

d_i (mm)	16	20	26	33	41	52	61	74	90	102	115
d (mm)	20	25	32	40	50	63	75	90	110	125	140

2.4.6 Nomogram for easy calculation of diameter and pressure loss

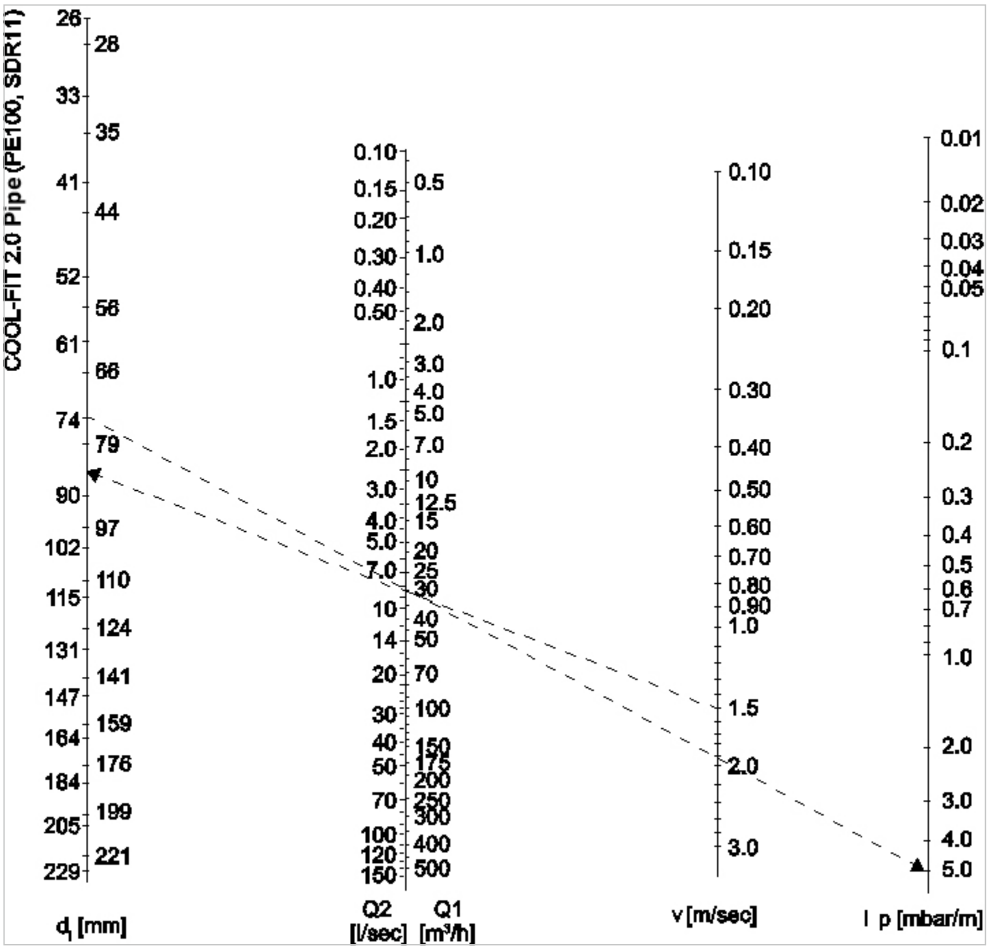
The nomogram below can be used to simplify the determination of the diameter required .The pressure loss in the pipe can be read off per meter of the pipe length.

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 2.0 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".

2.4.7 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:

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

ΔpR	Pressure loss in the straight pipe run (bar)
λ	Pipe friction factor = 0.02
L	Length of the straight pipe section (m)
d_i	Inner diameter of the pipe (mm)
ρ	Density of the flow material (kg/m^3) ($1\ g/cm^3 = 1000\ kg/m^3$) for water 20°C = 998.2 kg/m^3
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 $\lambda = 0.02$ 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 (enlargement)	1.0	
Connections (couplers, unions, flanges)	d20: 1.0 d25: 0.9 d32: 0.8 d40: 0.7	d50: 0.6 d63: 0.4 d75: 0.3 d90: 0.1 >d90: 0.1
Flexible hoses	½": 2.0 ¾": 1.8 1": 1.4	1 ¼": 1.1 1 ½": 1.0 2": 0.8

1) For a more detailed view, differentiate between coalescence and separation. Values for z up to a maximum of 1.3 can be found in the respective literature. Usually the part of a tee in the overall pressure loss is very small, therefore in most cases $\zeta = 1.3$ can be used.

V

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:

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

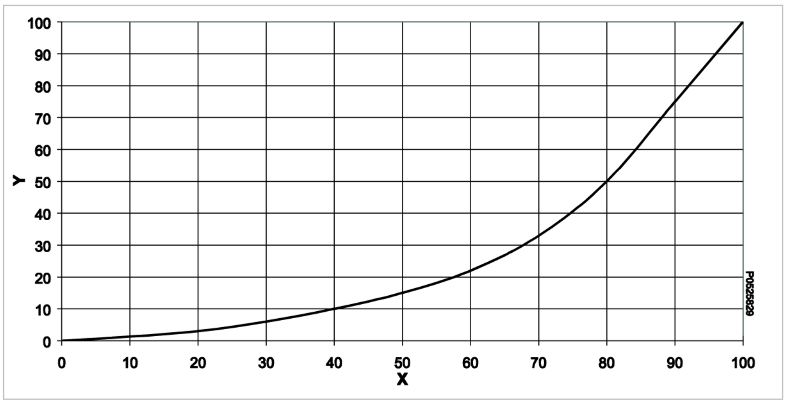
Δp_{Ar}	Pressure loss for the valve (bar)
Q	Flow rate (m^3/h)
ρ	Density of the conveyed medium (kg/m^3) ($1\ g/cc = 1000\ kg/m^3$)
k_v	Valve characteristic value (m^3/h)

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
125[2]	5	140	8600	602	516

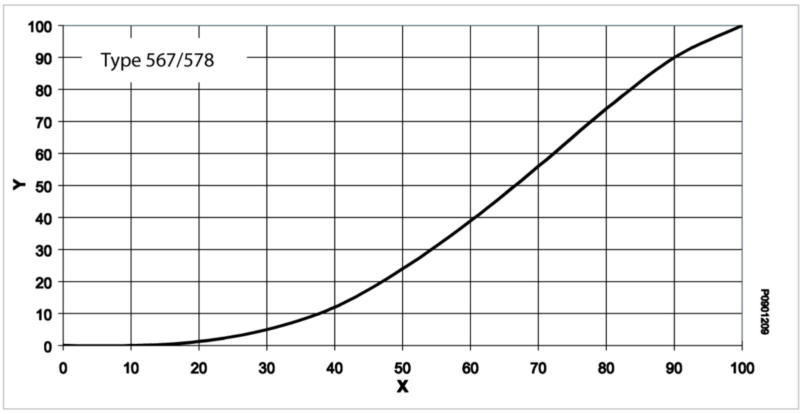
[1] COOL-FIT 2.0 Ball valve
[2] COOL-FIT 2.0 Butterfly valve

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 2.0 pipe	d40 mm	12 x 90° angle
SDR11 – flow rate	1.5 l/s	4 x 45° angle
Medium	Wasser	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:

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

The inner diameter of the piping system is as follows:

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

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

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

Formulas for calculating pressure losses

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% open angle a percentile kv value of 50 % can be read out, that means 50 % of the kv 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

2.4.8 Dimension comparison COOL-FIT 2.0 / 2.0F vs metal

COOL-FIT 2.0 / 2.0F			Stainless steel		Copper pipe
d (mm)	d_i (mm)	DN	Inch	da (mm	da (mm)
32	26.3	25	1	33.4	28
40	32.6	32	1¼	42.2	35
50	40.8	40	1½	48.3	42
63	51.4	50	2	60.3	54
75	61.4	65	2½	73.0	76.1
90	73.6	80	3	88.9	88.9
110	90.0	100	4	114.3	108
140	114.6	125	5	141.3	

d Nominal external diameter of PE pipe

d_i Nominal internal diameter of pipe

2.4.9 Z-dimension method

Overview

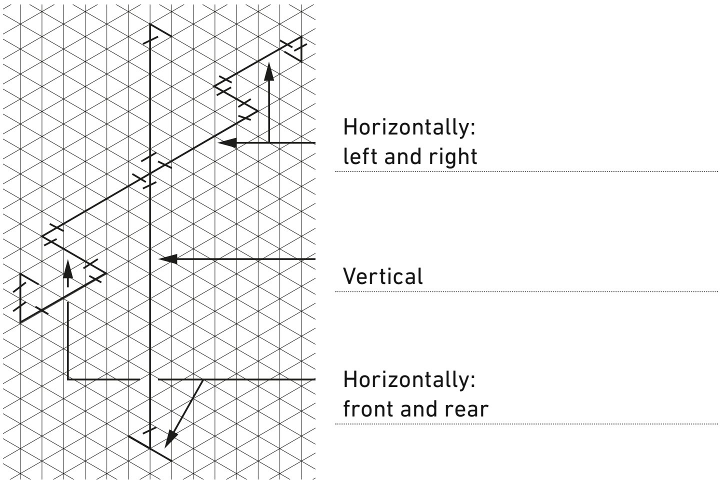
The pressure of competition and high costs on site makes it essential to install piping system systems efficiently. The GF Piping

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.

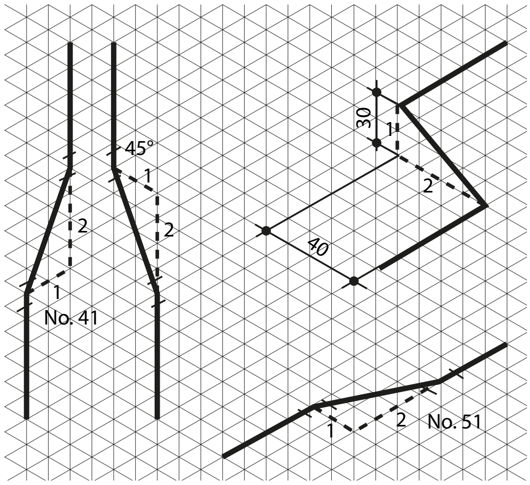
The respective pipe group with the corresponding design dimensions and cut lengths can be entered in the isometric paper of GF Piping Systems.

Please adhere to the following guidelines for drawing:

Pipe running perpendicular to one another



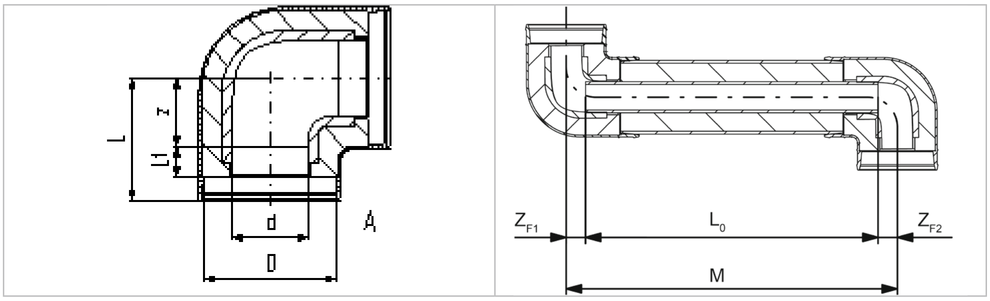
Pipe running diagonally



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



L laid pipe length

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

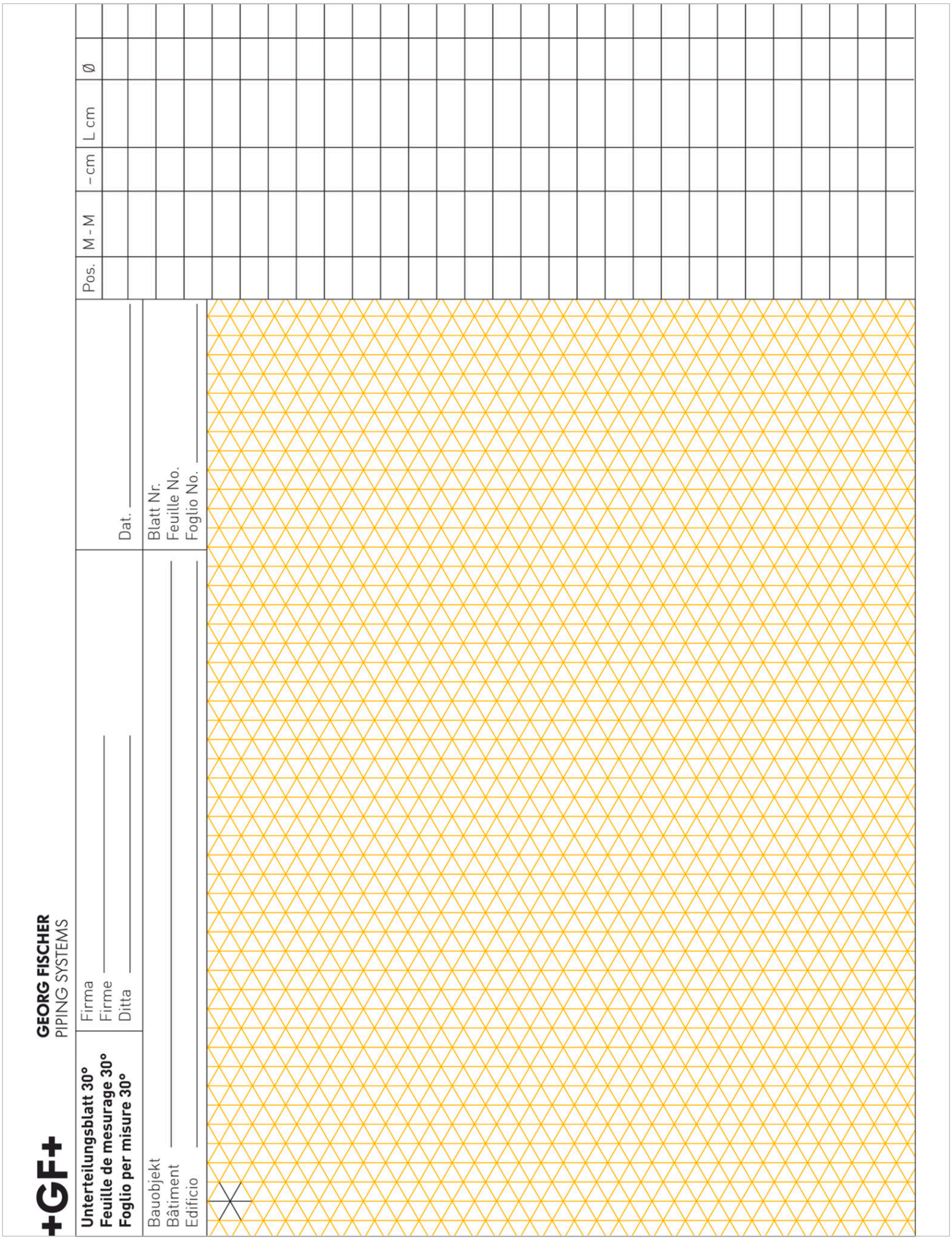
Example

Dimension	d32/D75
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



2.4.10 Length changes and flexible sections

Overview

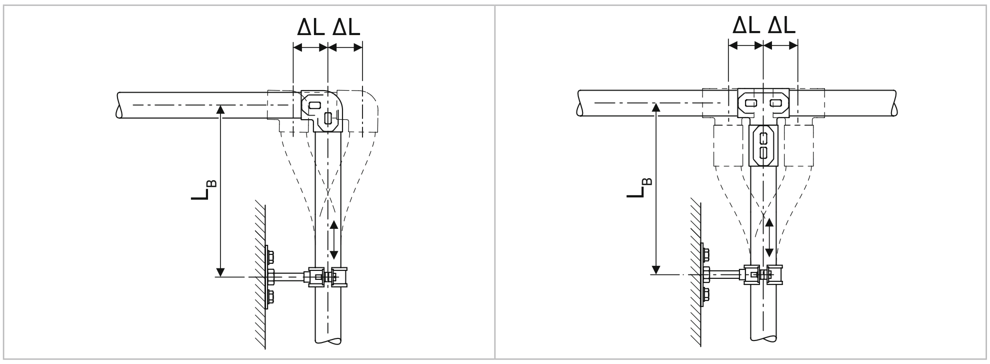
Length changes ΔL and expansion bend L_B - General

Thermoplastics are subject to higher 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

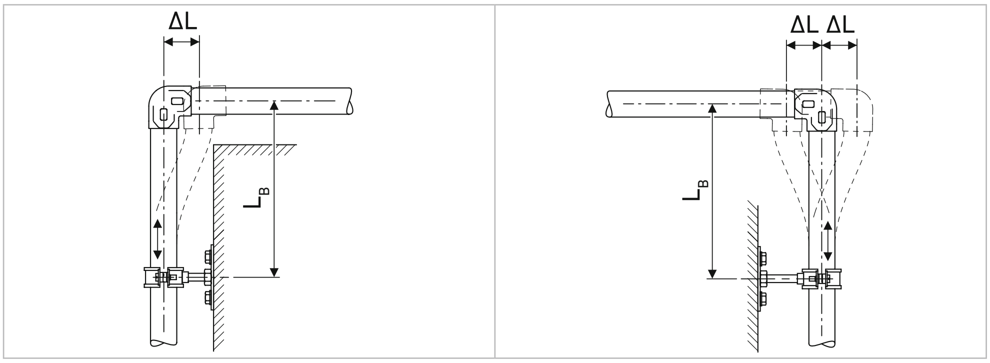
Flexible sections are the most common, the simplest and the most economical solution. The calculations for and the positioning of flexible sections are therefore described in detail.



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.

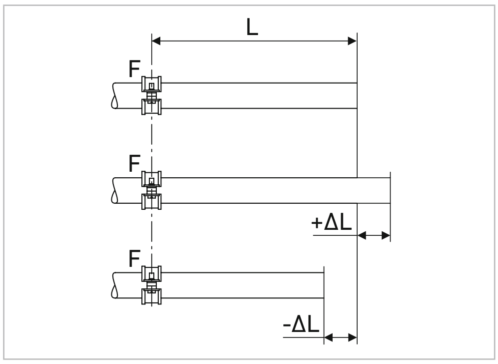


Flexible sections arise naturally at any branching or change in direction of the piping system. The movement LB of the flexible section as a result of a change ΔL in the length must not be restrained by fixed pipe brackets, wall protrusions, girders or the like.

Calculation of length changes

To determine the **change in length due to temperature** ΔL (mm) of COOL-FIT 2.0 / 2.0F pipe, the following temperatures must be known:

1. **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 Calculation Tool can be used. Contact your GF Piping Systems representative or visit www.gfps.com

Example of use:

Installation temperature	25 °C
Max. flow temperature	25 °C
Min. flow temperature	See table
Max. ambient temperature	25 °C
Min. ambient temperature	25 °C

Length change ΔL (mm) at 20° C flow temperature

L (m)	25	50	100	150
d32	-5	-10	-21	-31
d40	-6	-12	-24	-36
d50	-8	-16	-32	-48
d63	-8	-17	-34	-51
d75	-9	-18	-36	-54
d90	-10	-20	-40	-59
d110	-11	-22	-44	-66
d140	-11	-23	-45	-68

Length change ΔL (mm) at 15° C flow temperature

L (m)	25	50	100	150
d32	-11	-21	-42	-63
d40	-12	-25	-49	-74
d50	-16	-32	-65	-97
d63	-17	-35	-69	-104
d75	-18	-36	-73	-109
d90	-20	-40	-80	-120
d110	-22	-45	-90	-134
d140	-23	-46	-91	-137

L laid pipe length

Length change ΔL (mm) at 10° C flow temperature

L (m)	25	50	100	150
d32	-16	-32	-65	-97
d40	-19	-38	-75	-113
d50	-25	-49	-99	-148
d63	-26	-53	-105	-158
d75	-28	-55	-111	-166
d90	-30	-61	-122	-183
d110	-34	-68	-136	-203
d140	-34	-69	-138	-207

Length change ΔL (mm) at 5° C flow temperature

L (m)	25	50	100	150
d32	-22	-44	-88	-132
d40	-26	-51	-102	-154
d50	-33	-67	-133	-200
d63	-36	-71	-142	-213
d75	-37	-75	-149	-224
d90	-41	-82	-164	-246
d110	-46	-91	-182	-273
d140	-46	-93	-185	-278

L laid pipe length

COOL-FIT 2.0F

L laid pipe length

Length change ΔL (mm) at 20° 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	-3	-6	-12	-17	d32	-6	-12	-24	-36
d40	-4	-7	-14	-21	d40	-7	-15	-29	-44
d50	-5	-10	-20	-29	d50	-10	-20	-40	-60
d63	-6	-12	-23	-35	d63	-12	-24	-47	-71
d75	-7	-13	-26	-39	d75	-13	-27	-54	-80
d90	-6	-13	-25	-38	d90	-13	-26	-52	-78
d110	-7	-15	-30	-45	d110	-15	-31	-61	-92
d140	-9	-17	-34	-51	d140	-17	-35	-70	-104

L laid pipe length

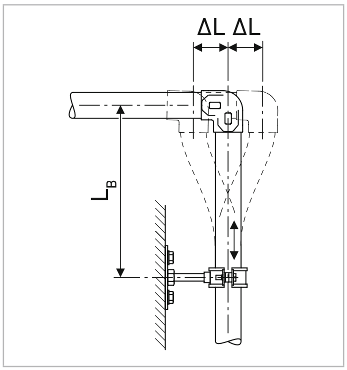
Length change ΔL (mm) at 10° C flow temperature					Length change ΔL (mm) at 5° C flow temperature				
L (m)	25	50	100	150	L (m)	25	50	100	150
d32	-9	-18	-37	-55	d32	-13	-25	-51	-76
d40	-11	-23	-45	-68	d40	-15	-31	-62	-92
d50	-15	-31	-62	-93	d50	-21	-42	-84	-126
d63	-18	-36	-73	-109	d63	-25	-49	-99	-148
d75	-20	-41	-82	-123	d75	-28	-56	-111	-167
d90	-20	-40	-80	-120	d90	-27	-54	-109	-163
d110	-23	-47	-93	-140	d110	-32	-63	-127	-190
d140	-26	-53	-106	-159	d140	-36	-72	-143	-215

Flexible sections for COOL-FIT 2.0 and COOL-FIT 2.0F

Flexible section for COOL-FIT 2.0

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
d32/75	71	101	123	142	159	174	188	201	214	225	276	318	390
d40/90	78	110	135	156	174	191	206	221	234	247	302	349	427
d50/90	78	110	135	156	174	191	206	221	234	247	302	349	427
d63/110	86	122	149	172	193	211	228	244	259	273	334	386	472
d75/125	92	130	159	184	206	225	243	260	276	291	356	411	503
d90/140	97	138	168	195	218	238	257	275	292	308	377	435	533
d110/160	104	147	180	208	233	255	275	294	312	329	403	465	570
d140/200	116	164	201	233	260	285	308	329	349	368	450	520	637



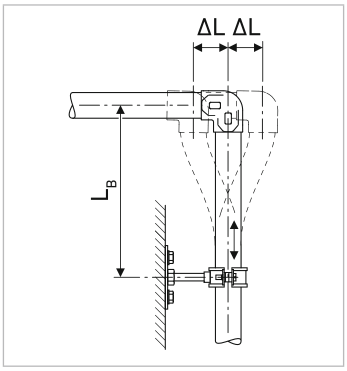
V

Flexible section for COOL-FIT 2.0F

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)

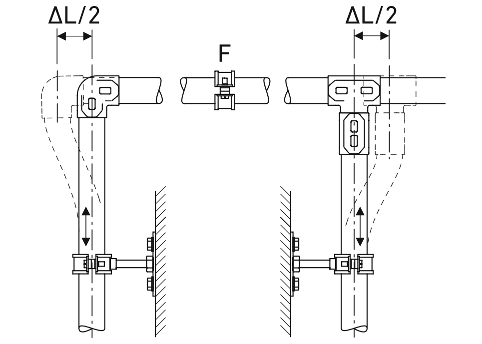
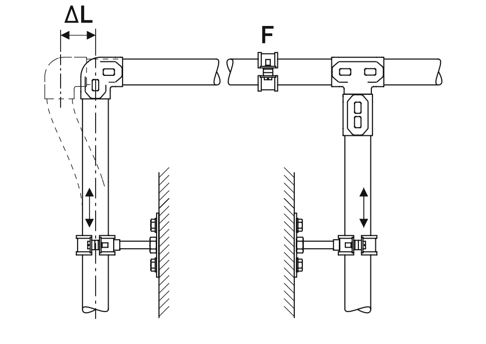
ΔL (mm)	10	20	30	40	50	60	70	80	90	100	150	200	300
d32/75	92	130	159	183	205	225	243	259	275	290	355	410	503
d40/90	101	142	174	201	225	246	266	284	302	318	389	449	550
d50/90	101	142	174	201	225	246	266	284	302	318	389	449	550
d63/110	111	157	192	222	248	272	294	314	333	351	430	497	609
d75/125	118	168	205	237	265	290	313	335	355	375	459	530	649
d90/140	125	177	217	251	280	307	332	355	376	396	485	561	687
d110/160	134	190	232	268	300	328	355	379	402	424	519	599	734
d140/200	150	212	259	300	335	367	396	424	449	474	580	670	821



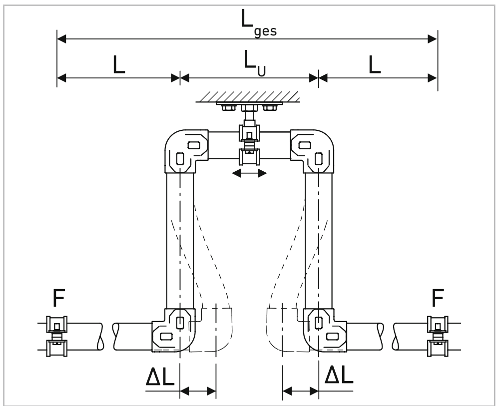
2.4.11 Installation

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 L_B, as illustrated in the next example:

Example

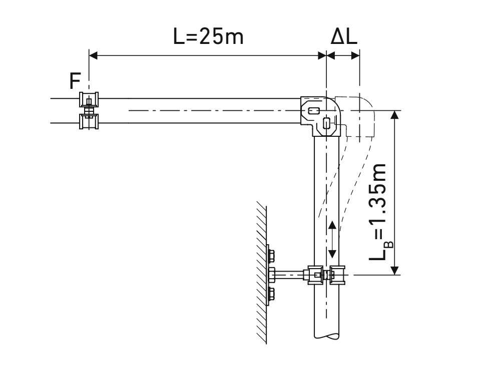
Pipe length L	25 m
Diameter	d50/D90 mm
Installation temperature	25 °C
Min ambient temperature	25 °C konstant
Max ambient temperature	25 °C konstant
Min flow temperature	10 °C
Max flow temperature	25 °C

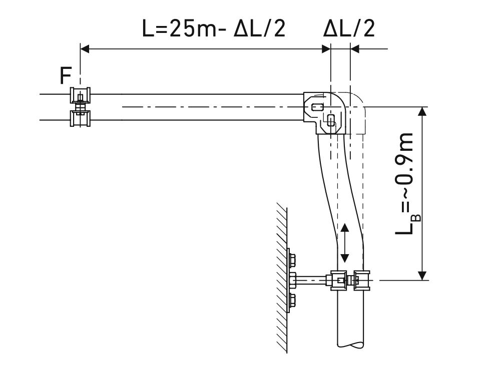
Change in length from the table or Cooling Calculation Tool:
-ΔL = 29 mm

A flexible section to take up a change in length of +/- ΔL = 29 mm needs to be L_B (mm) = ~1350 mm long according to the table.

If the flexible section is pre-tensioned to ΔL/2, the flexible section required is reduced to ~94 cm. The change in length starting from the 0 position is then +/- ΔL/2 = 29/2 = 14.5 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.





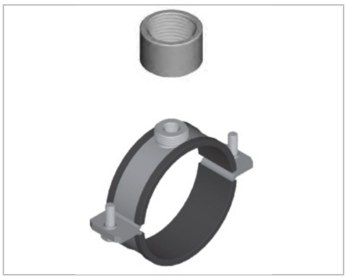
2.4.12 Pipe bracket spacing and support of piping systems

Overview

Installation of plastic pipe

COOL-FIT 2.0 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.

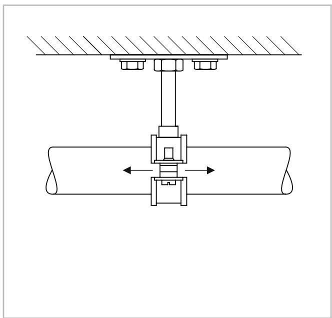
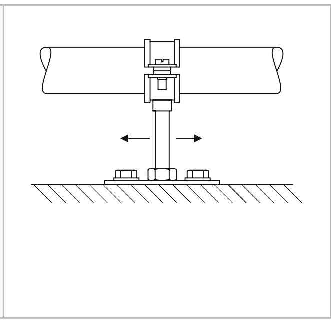
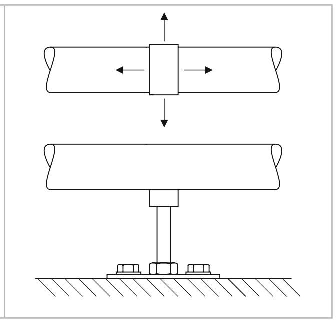
Thanks to the excellent insulating properties of the COOL-FIT 2.0 pipe and its hard, impact resistant outer jacket, standard pipe clamps may be used. Special insulation pipe clamps or cold clamps are not necessary.



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.

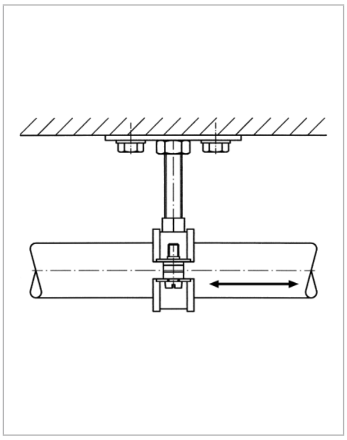
		
Axial displacement of the pipe in the clamp.	Pipe clamp fitted rigidly to the pipe, axial displacement in the suspension of the pipe clamp.	Displacement of the pipe in 2 axes.

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

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.

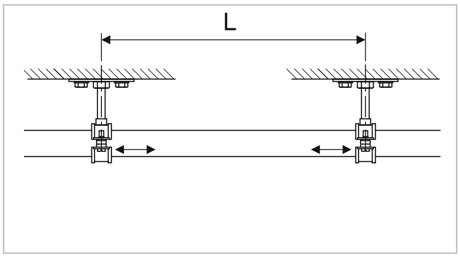


Spacers prevent pinching the pipe

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 2.0 pipe is always consistent independent of pressure and temperature.



L Pipe clamp spacing

Pipe clamp intervals L for COOL-FIT 2.0

d/D (mm)	32/75	40/90	50/90	63/110	75/125	90/140	110/160	140/200
L (mm)	1600	1700	1700	1850	1950	2000	2100	2350

Pipe clamp intervals L for COOL-FIT 2.0F

d/D (mm)	32/75	40/90	50/90	63/110	75/125	90/140	110/160	140/200
L (mm)	2200	2300	2300	2400	2500	2600	2700	2900

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.

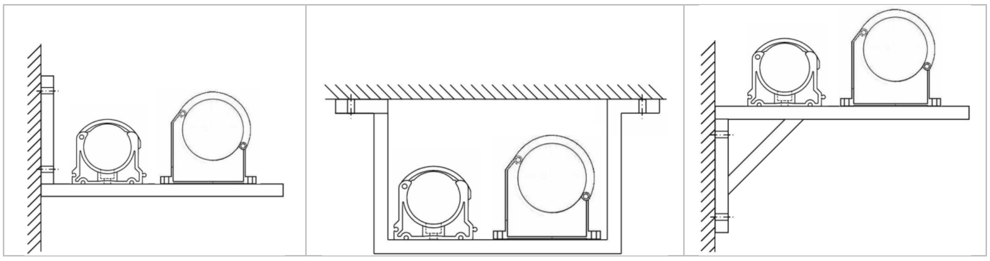
⚠ Pipe which are axially clamped and rigidly fixed must be tested for their resistance to kinking. In most cases, this test results in a reduction of the maximum internal pressure and more tightly spaced supports. The forces acting on the fixed points should be considered.

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 GF 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.



* max. allowed force for fixpoint exceeded

Arranging fixed points

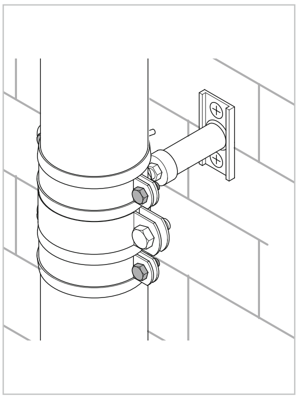
A fixed point is a bracket which prevents the pipe from moving in any direction. The purpose of a fixed point is to control tension caused by temperature changes and guide elongation in a certain direction.

> ⚠ Fixed point 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 2.0 fixed point

Fixed points for COOL-FIT 2.0 are established with the special COOL-FIT 2.0 fixed points. The product consists of fusion bands 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 GF Piping Systems, use the y-cable kit wit code No. 790 156 032. Please take note of the maximum allowed forces in the table below.



Diameter (mm)	d32/ D75	d40/ D90	d50/ D90	d63/ D110	d75/ D125	d90/ D140	d110 / D160	d140 / D200
Maximum force F (kN)	2.0	3.0	5.0	8.0	10.0	10.0	10.0	10.0

> ⚠ COOL-FIT 2.0 fixed points must be calculated on the basis of the application. Fixed point brackets and cross braces are not included.

Scope of delivery

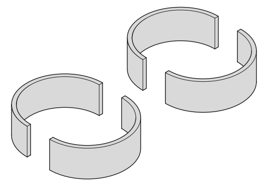
① Clamps to maintain fusion pressure
② Electrofusion band

Y-cable kit for COOL-FIT fixed points

The COOL-FIT Y-cables can be used for a faster installation of COOL-FIT 2.0 fix points. Since electrofusion bands always come in pairs, Y-cables allow for a simultaneous fusion process, cutting fusion time in half.

COOL-FIT 2.0F fixed points

Four half shells which are cemented on both sides to the fixed point pipe clamp.



Diameter (mm)	d32/ D75	d40/ D90	d50/ D90	d63/ D110	d75/ D125	d90/ D140	d110 / D160	d140 / D200
Maximum force F (kN)	2.0	3.0	5.0	8.0	10.0	10.0	10.0	10.0

COOL-FIT 2.0F fixed points must be calculated on the basis of the application. Fixed point brackets and cross braces are not included.

Rigidly fixed installations

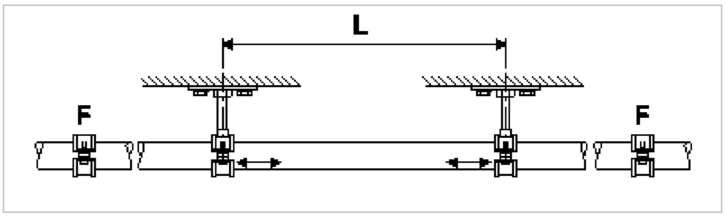
Pipe which are axially clamped and rigidly fixed must be tested for their resistance to kinking. In most cases, this test results in a reduction of the maximum internal pressure and more tightly spaced supports. The forces acting on the fixed points should be considered.

COOL-FIT 2.0 / 2.0F pipes 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



Fixed installation, maximum axial forces (kN) at 15°C fluid temperature

d/D (mm)	d32/75	d40/90	d50/90	d63/110	d75/125	d90/140	d110/160	d140/200
F (kN)	0.38	0.59	0.87	1.38	1.92	2.74	4.06	6.54
L (mm)	1600	1700	1700	1850	1950	2000	2100	2350

Fixed installation, maximum axial forces (kN) at 10°C fluid temperature

d/D (mm)	d32/75	d40/90	d50/90	d63/110	d75/125	d90/140	d110/160	d140/200
F (kN)	0.58	0.92	1.36	2.15	2.99	4.28	6.33	10.21*
L (mm)	1600	1700	1700	1850	1950	2000	2100	2350

Fixed installation, maximum axial forces (kN) at 5°C fluid temperature

d/D (mm)	d32/75	d40/90	d50/90	d63/110	d75/125	d90/140	d110/160	d140/200
F (kN)	0.81	1.27	1.88	2.98	4.13	5.92	8.76	14.13*
L (mm)	1600	1700	1700	1850	1950	2000	2100	2350

* max allowed force for COOL-FIT fixed point exceeded

V

COOL-FIT 2.0F

Fixed installation, maximum axial forces (kN) at 15°C fluid temperature								
d/D (mm)	d32/75	d40/90	d50/90	d63/110	d75/125	d90/140	d110/160	d140/200
F (kN)	0.38	0.60	0.88	1.39	1.93	2.75	4.07	6.56
L (mm)	2200	2300	2300	2400	2500	2600	2700	2900

Fixed installation, maximum axial forces (kN) at 10°C fluid temperature								
d/D (mm)	d32/75	d40/90	d50/90	d63/110	d75/125	d90/140	d110/160	d140/200
F (kN)	0.59	0.93	1.37	2.17	3.01	4.29	6.35	10.25*
L (mm)	2200	2300	2300	2400	2500	2600	2700	2900

Fixed installation, maximum axial forces (kN) at 5°C fluid temperature								
d/D (mm)	d32/75	d40/90	d50/90	d63/110	d75/125	d90/140	d110/160	d140/200
F (kN)	0.81	1.28	1.89	2.99	4.16	5.94	8.78	14.18*
L (mm)	2200	2300	2300	2400	2500	2600	2700	2900

* max allowed force for COOL-FIT fixed point exceeded

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

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

2.4.14 COOLING Tool-Box

The GF Piping Systems Cooling Calculation Tool is used to help in the dimensioning and design of cooling systems.

The Cooling Calculation Tool 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

The most common coolants are already stored in the calculation tool. It calculates all system components, such as pipe, fittings and valves. Its menu-based navigation is available in nine languages and allows for efficient and optimized dimensioning of a system. Data for the most commonly used coolants are already stored in the calculation tool. It calculates all system components such as pipe, fittings and valves. The menu is available in nine different languages. It allows system design to be efficient and optimized.

The "comparison" function compares a COOL-FIT system to a steel, stainless steel or copper system.

Cooling Calculations Tool: Get it contact to your GF Piping Systems representative or visit www.gfps.com

2.5 Jointing and Installation

2.5.1 Jointing of COOL-FIT 2.0/2.0F

For general notes and 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 cleaning agents suitable for PE must be used.

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

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

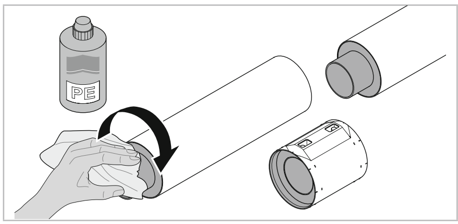
If necessary, prepare the pipe for fusion joints using the Foam removal tool (foam removal, cutting the jacket and peeling the media pipe) and check afterwards that the shaving thickness is 0.2 – 0.4 mm and that the minimum permissible external diameter after peeling is met:

- **COOL-FIT 2.0 valves and COOL-FIT 2.0 fittings (type B and barrel nipple) do not need to be peeled.**

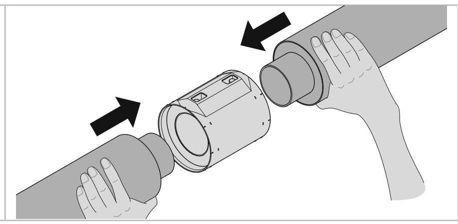
Minimum permitted pipe external diameter after peeling for COOL-FIT 2.0/2.0F:

d/D (mm)	32/75	40/90	50/90	63/110	75/125	90/140	110/160	140/200
Min. d (mm)	31.5	39.5	49.5	62.5	74.4	89.4	109.4	139.4

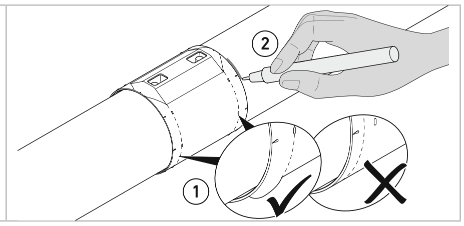
Cleaning and installation for welding preparation



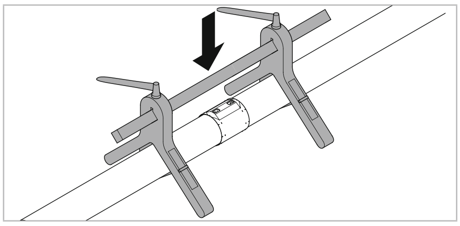
Step 1
Clean the fusion area of the components with PE cleaner and lintfree colourless and clean cloth in circumferential direction.



Step 2
Insert pipe in clamping tool and align free of stress. Push fitting up to the limit stop on the pipe.

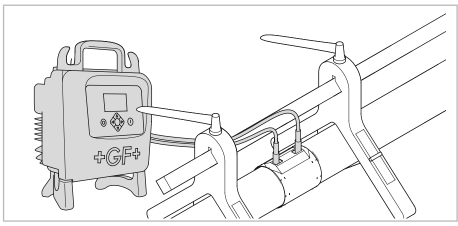


Step 3
Pay attention that the sealing lip arches upwards. Mark end of lip on pipe (to check the change in position during welding).

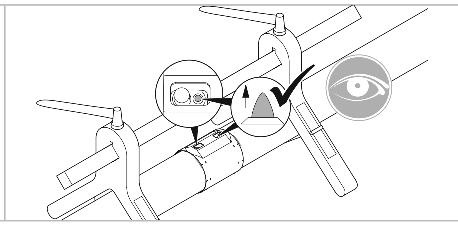


Step 4
Take care for low stress installation and secure the pipe and fitting against dislocation. Tight clamps of clamping tool.

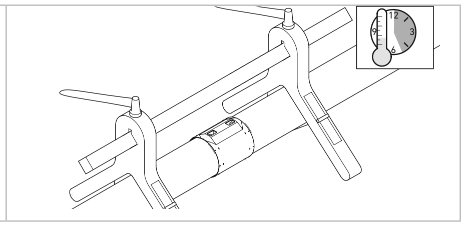
Fusion process



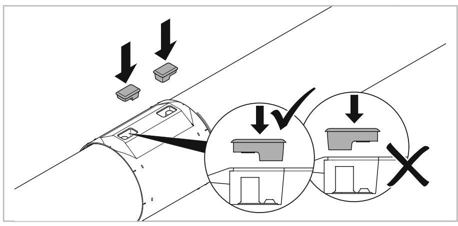
Step 5
Fuse in accordance to the operating instructions of the fusion unit.



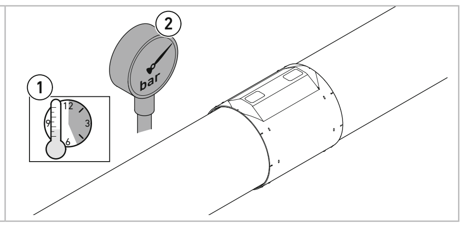
Step 6
During and after fusion, check fusion indicators on the electrofusion fitting and note the messages on the display of the electrofusion machine.
Afterwards mark the fitting with following information
- Date
- Welder/ Weld number
- Time at the end of cooling time



Step 7
Ensure fusion area remains stress free and avoid dislocation until cooling time has elapsed.



Step 8
After fusion process, fit the insulation of the weld pins onto the fusion contacts and remove retaining device



Step 9
After cooling perform pressure tests as per table.

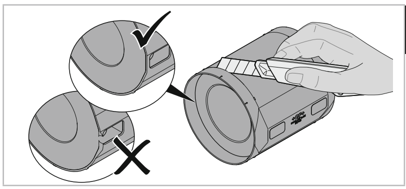
Cooling times before removing retention device and pressure/leak testing

d (mm)	Cooling time before Remove retention device (min.)	Cooling time before internal pressure test at ≤ 6 bar (min.)	Cooling time before internal pressure test at ≤ 18 bar (h)
32	10	15	3
40	10	15	5
50	10	15	4
63	10	20	5
75	15	25	6
90	20	35	8
110	30	35	8
140	45	60	8

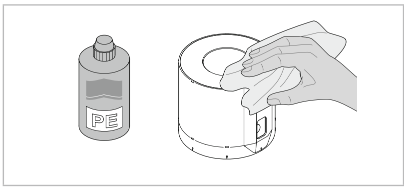
The values are valid for pressure tests using a liquid at ≤ 20 ° C. For testing with gas a cooling time of 12 hours is recommended.

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

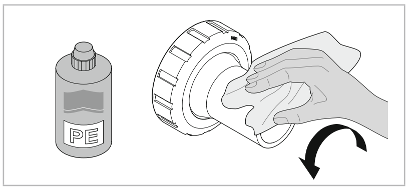
1



2



3

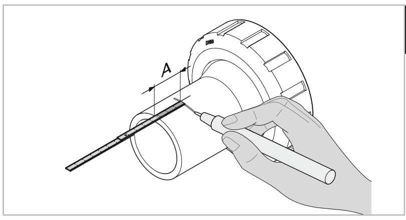


For the jointing to a valve or flange adaptor, the sealing lip of the fitting has to be removed at the valve or flange adaptor side and sealing and fusion surfaces have to be cleaned.

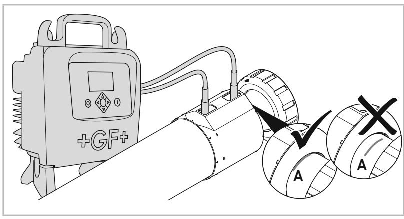
Standard fusion

Fuse both valve ends without valve mounted

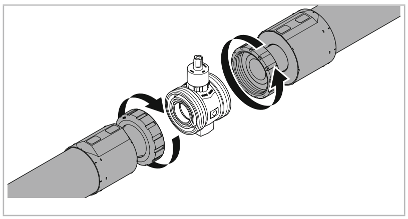
4



5



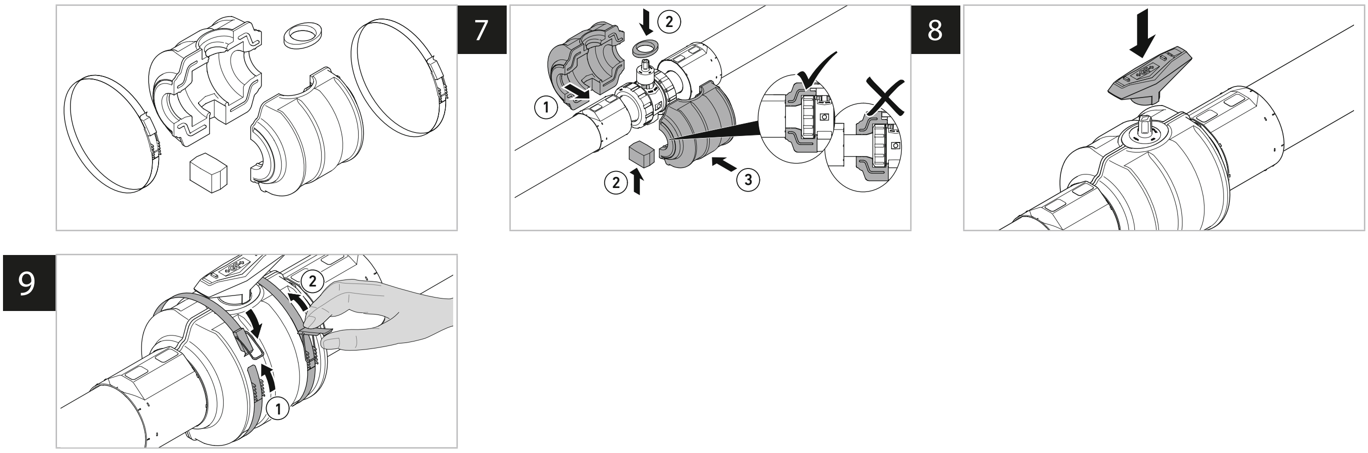
6



Following insertion depths are valid for COOL-FIT 2.0 components:

d/D (mm)	32/75	40/90	50/90	63/110	75/125	90/140	110/160	140/200
A (mm)	36	40	44	48	55	62	72	84

Mounting the valve insulation



Further information can be found in the assembly instructions. "Insalation for Ball Valve" and "Isalation for Butterfly Valve and Flange Adapter".

Compact connection fitting-to-fitting

When there is enough space, Fitting-to-Pipe-to-Fitting connections can be realized using a short COOL-FIT 2.0 pipe. The foam removal tool enables the foam removal of pipe lengths of ~110mm for the dimensions d32-d90, or respectively ~170mm for the dimensions d110-d140.

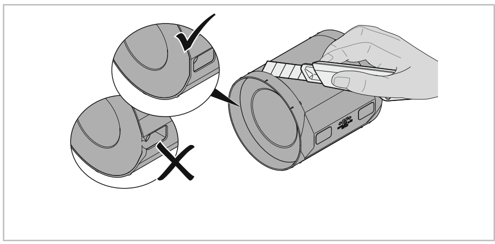
- **Shorter connections Fitting-to-Pipe-to-Fitting can be realized using an un-insulated PE100 SDR11 pipe in combination with a piece of insulation that results of an foam removal process of the foam removal tool.**

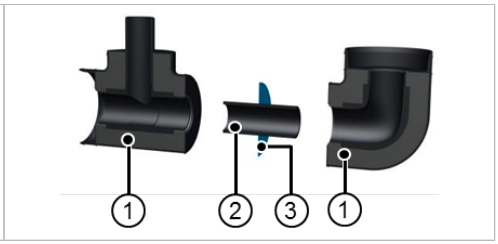
After the peeling of the oxid layer of the un-insulated PE pipe, the insulation ring is pulled over the pipe and the pipe is welded with the fitting.

d	d32	d40	d50	d63	d75	d90	d110	d140
L (mm)	108	120	132	144	165	186	216	252

L : Length of un-insulated PE100 SDR11 pipe needed

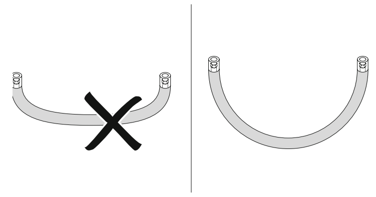
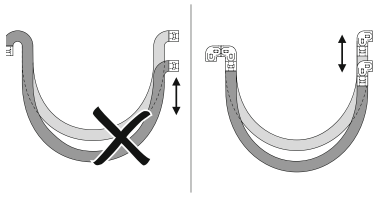
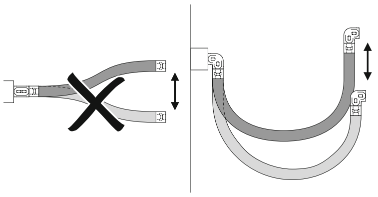
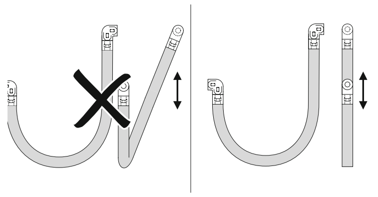
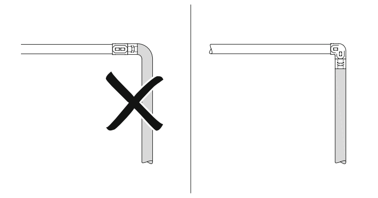
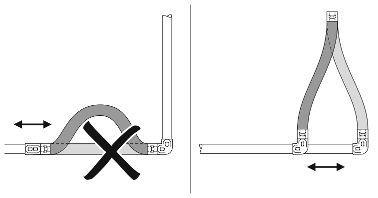
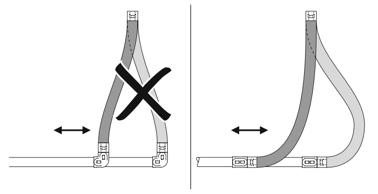
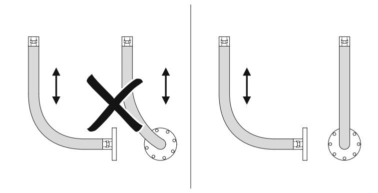
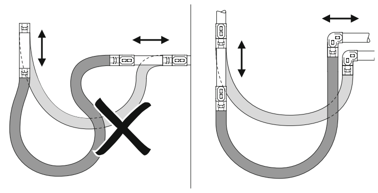
For situations with very limited space the sealing lip at the fittings can be removed at the respective side. The jointing of the Fitting-to-Fitting is performed using a barrel nipple, the sealing of the insulation is being done with an adhesive ring which is to adhered to the cleaned surface of the fittings.





1. Fittings
2. Barrel nipple
3. Adhesive ring

Hoses

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.
	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 GF 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 and R 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 and brass connecting elements for transitions to non-ferrous metals.

Combining G and R threads

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

Connecting the insulations of Transition Fittings and jointing elements of Flexible Hoses

The NBR insulation of the COOL-FIT 2.0 Transition Fittings is applied following the jointing of the COOL-FIT 2.0 Transition Fittings with the COOL-FIT 2.0 Fitting Type A, and the mechanical jointing of the threaded components of Hose and Transition Fitting. The NBR insulation of Transition Fittings is supplied with axial adhesive tapes. The adhesive tapes are used for a condensation proof axial sealing of the NBR insulation. The radial jointing of the jointing face of the NBR insulation can be applied either by adhesive cement of by adhesive tape.

On joining transition fittings to flexibler hoses, the insulation of the flexible hoses can be jointed directly at the COOL-FIT electrofusion fitting using asdhesive cement or 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 – 0.25kg/m^2.

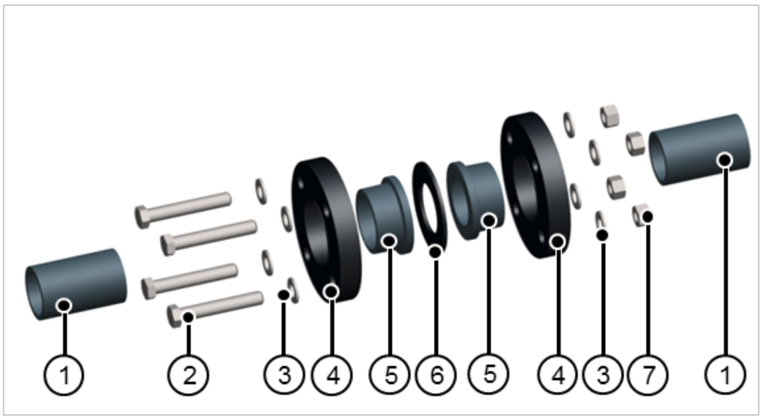
The open joint time is about 3:15 minutes depending on temperature and humidity of air.

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 connections

Flanges with sufficient thermal and mechanical stability must be used. The different flange types by GF 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 higher 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

Comparison of flange connections

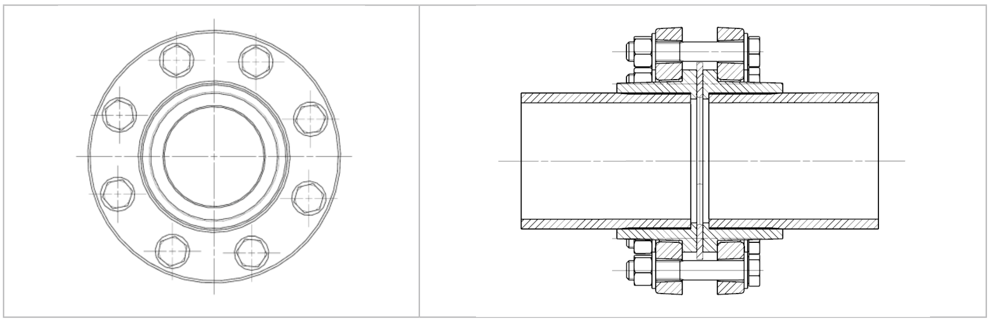
Flange connection	Properties
PP-V flange	• Corrosion-free all-plastic flange made of polypropylene PP-GF30 (fiber-glass reinforced) • High chemical resistance (hydrolysis-resistant) • Maximum possible break resistance due to elasticity (deforms if it is tightened too much) • Use for ambient temperatures up to 80 °C • UV-stabilized • With integrated bolt-fixing • Self-centering aid of the backing flange on the flange adapter • Symmetric design allows assembly on either side: A "reverse" installation is never possible. All important information is readable • V-groove (patented) • Even distribution of forces across the backing flange (conserves components) • Supports a longer-lasting torque for a safe joint
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) • Maximum ambient temperature 80 °C • 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 pipings 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 following 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.
- In practice, deviations from this may occur, e.g. due to the use of difficult screws that are difficult to turn or due to non-aligned pipe axles. The Shore hardness of the seal also influences the necessary tightening force.
- 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.

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

i In the area of flexible sections and expansion loops, no bolt connections or flange connections should be used since the bending stress may cause leaks.

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

The indicated torques are recommended by GF 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 GF 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, 125	DN100	35	20	20
d140	DN125	45	25	25

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 2.0 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 a COOL-FIT 2.0 Flange adaptors used together with PP-Steel backing flanges, the following bolt lengths can be used.

Dimension	d32	d40	d50	d63	d75	d90	d110	d140
Screws	M12x80	M16x80	M16x90	M16x90 or M16x100	M16x100	M16x100	M16x100	M16x130

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.

GF 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.

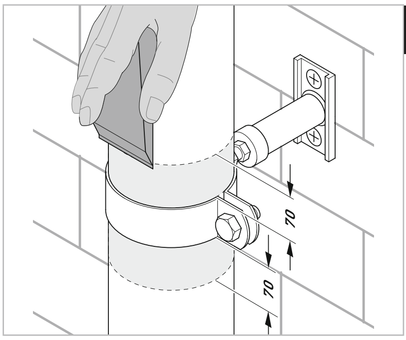
On installing Installation fittings in horizontal piping systems, the sensors should be in 1 – 5 or 7 – 11 clock position.

⚠ 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.

Installation of COOL-FIT 2.0 fixed points

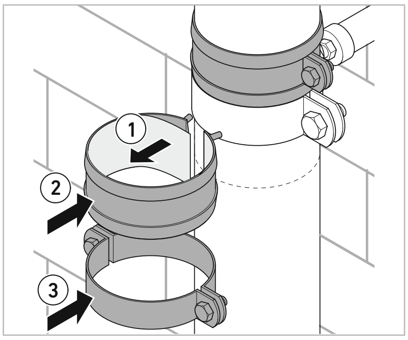
The COOL-FIT pipe shall be intstalled with a standard fix point as shown below.

1



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

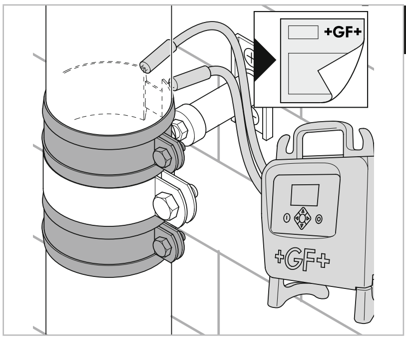
2



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.

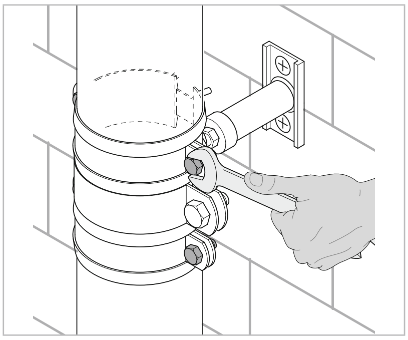
Note: The necessary welding pressure on the clean and dry COOL-FIT pipe is achieved by tightening the pipe clips. Take care that between fixed point clip and weld band there are no visible holes.

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.

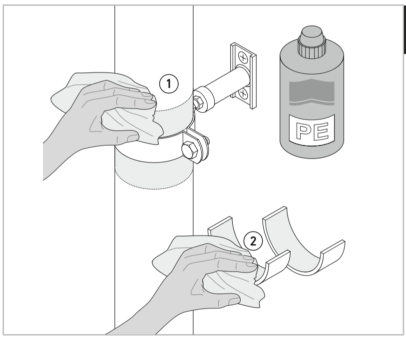
4



Step 4
Retighten the pipe clips after 10 minutes.

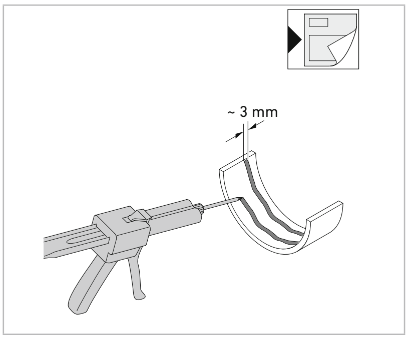
Installation of COOL-FIT 2.0F fixed points

1



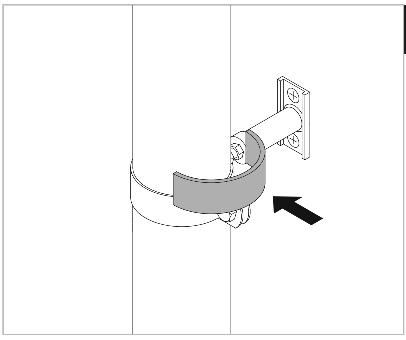
Step 1
Clean the cementing area on the pipe and the components with Tangit PE cleaner and lintfree colourless and clean cloth in circumferential direction.

2



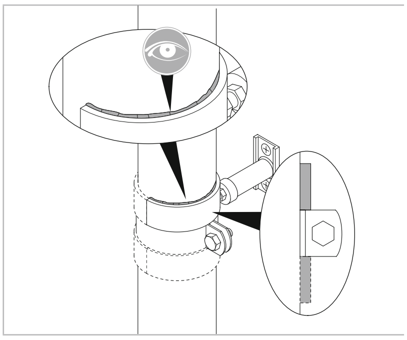
Step 2
Place the Tagit RAPID in about 3mm stripes on the inner side of the fixed point set half shells.

3



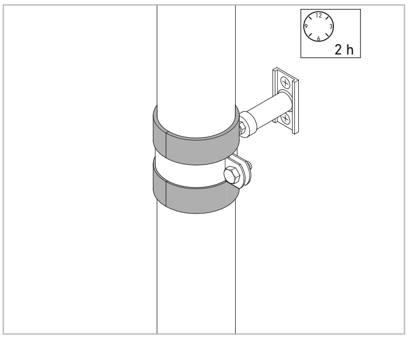
Step 3
Cement the half shelfs on the pipe next to the pipe clamp.

4



Step 4
Check the cementing and ensure the fixed point half shells are next to the pipe clamp.

5



Step 5
Let the fixed point dry for minimum 2hours.

2.5.2 Pressure test

Internal pressure test

For internal pressure testing and commissioning, the same conditions apply for COOL-FIT 2.0 / 2.0F as for the non-insulated ecoFIT system (PE).

2.5.3 Internal pressure and leak testing

Introduction to the pressure test

Overview of the various test methods

Leakage test	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	High	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	Gering

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 p_p (depends on the pipe wall temperature and the permitted test pressure of the installed components, see "determination of the test pressure")	≤ $P_{p\,(zul)}$	≤ 0.85 $P_{p\,(zul)}$
Test duration (depends on the length of the pipe sections)	L ≤ 100 m: 3 hrs 100 m < L ≤ 500 m: 6 hrs	L ≤ 100 m: 3 hrs 100 m <L ≤ 500 m: 6 hrs
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 2.0 / 2.0F	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 pipping 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.

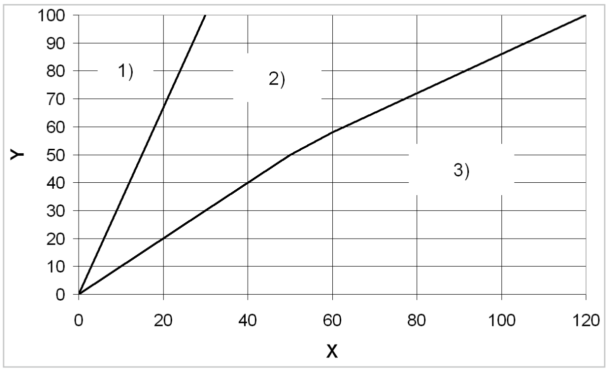
Reference values for the filling volume are given in the table below.

d (mm)	V (l/s)
≤ 90	0.15
110	0.3
140	0.7

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:

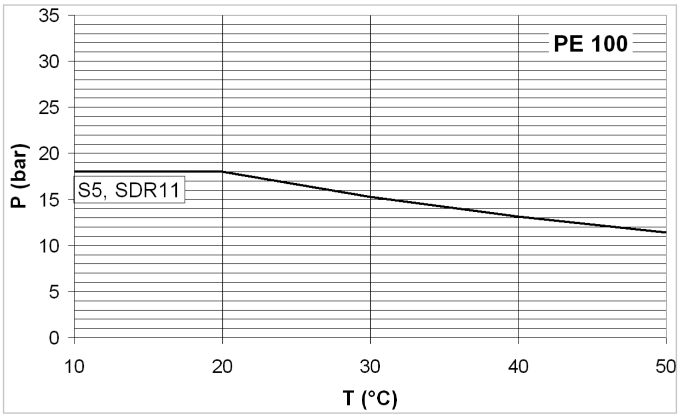
$$P_{p(zul)} = \frac{1}{SDR} \cdot \frac{20 \cdot \sigma_{v(T,\,100\,h)}}{S_p \cdot A_G}$$

$\sigma_{v(T,\,100\,h)}$ Creep strength for the pipe wall temperature
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
PE100	1.25
PVC-U	2.5

V

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:

8. Internal pressure at the absolute lowest point of the piping system
9. Medium and ambient temperature
10. Water volume input
11. Water volume output
12. Pressure drop rates

2.5.4 Start-up with secondary coolants

Secondary coolants such as glycol solutions must only introduced in liquid, pre-mixed form into COOL-FIT 2.0 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 Venting

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

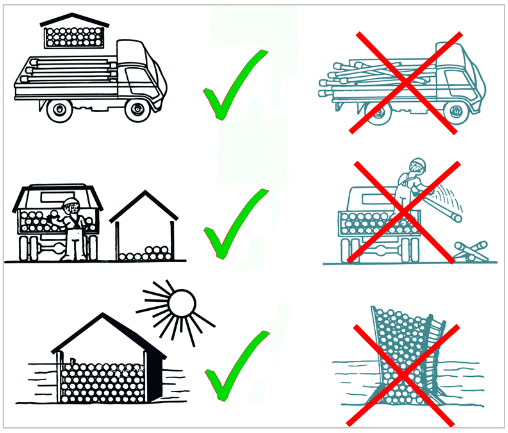
2.6 Transport and Stocking

2.6.1 Transport

On trucks/in crates, manual transport

2.6.2 Storage

All plastic pipe including pre-insulated plastic pipe such as COOL-FIT 2.0 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.



2.7 Environment

The materials used for COOL-FIT 2.0 are suitable for recycling. GF Piping Systems aims to satisfy its customer's wishes concerning environmental aspects.

i For more information at www.coolfit.georgfischer.com

3 COOL-FIT 4.0

3.1 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 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

V

3.2 System Specification

Specification		COOL-FIT 4.0		COOL-FIT 4.0F
Materials[1]	Pipe	PE100		PE100
	Insulation	GF-HE foam, halogen free, closed-cell		GF-HE foam, halogen free, closed-cell
	Outer jacket	Pipe	HDPE	Flame retardant - GF-FR
		Fitting	GF-HE	
Size		d32DN25 – d450DN450		d160DN150 + d225DN200
Connection technology		Electrofusion		Electrofusion
Nominal pressure[2]	16 bar, SDR 11 10 bar, SDR17	d32DN25-d110DN100 d160DN150-d450DN450		- d160DN150 + d225DN200
Temperature	Medium	-50 °C bis +60 °C		0 °C bis +60 °C
	Environment	-30 °C bis +65 °C		0 °C bis +55 °C
Insulation	Thermal conductivity $\lambda_{20°C}$ PE Inner pipe HE Foam PE jacket GF-FR jacket	 0.38 W/mK 0.022 W/mK (32-d110); 0.026 W/mK (d160-d450) 0.38 W/mK		 0.38 W/mK 0.026 W/mK 0.15 W/mK
	Density	≥ 70 kg/m³		≥ 70 kg/m³
	Foam cell size	max. Ø 0.5 mm		max. Ø 0.5 mm
	Nominal thickness	40 mm		40 mm
Mechanical strength (from insulation)	Axial shear strength	≥ 0.12 N/mm²		≥ 0.12 N/mm²
	Compressive strength	≥ 0.3 N/mm²		≥ 0.3 N/mm²
Colour	Outer jacket	Black		Black
Weight (without medium)	Pipe d32	1.39 kg/m		
	Pipe d110	6.12 kg/m		
	Pipe d225	16.42 kg/m		19.84 kg/m
Oxygen diffusion at ≤ 14.5°C	ISO 17455	≤ 0.32 mg/(m² d)		≤ 0.32 mg/(m² d)
Fire classification[3]	EN 13501-1	E		B-s2, d0

1) All three materials are firmly bonded together.

2) At 20 ° C, medium water, the specified value is valid for all system components, with the exception of the butterfly valves, PN10 applies to the nominal pressure and for flexible hoses with maximum pressure according product datasheet.

3) Additional information in chapter "Fire behavior and fire prevention measures".

Specification		COOL-FIT 4.0	COOL-FIT 4.0F
Environment	Stability	Moisture and vapor-tight	Moisture and vapor-tight
	Resistance	Weather resistant UV resistant	
	Ozone Depletion Potential	Zero	Zero
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 EN ISO 16136 EN ISO 16137 EN ISO 16138	Industrial valves ... – Ball valves made of thermoplastics – Butterfly valves made of thermoplastics – Backflow protection made of thermoplastics – Diaphragm valve 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 Green buildings		BNB BN 2015 BREEAM Int 2016 DGNB 2015 DGNB 2018 LEED V3 LEED V4 WELL V1 2019	
eco-bau	(BKP 240, 244, 250)	201710.1518	201908.5716

3.3 Technical Details

3.3.1 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 pipes are available in 5m lengths for dimensions d32 to d225, and in 5.9m for dimensions d250 to d450. The pipe have free, uninsulated ends, prepared already for the jointing with the COOL-FIT 4.0 fittings.

Standard range (inner pipe SDR17 for d160-d450mm)	Inner pipe	Inner pipe	Pipe class	Outer jacket	Weight empty	Weight with water	Volume	Insulation thickness	Heat transfer coefficient (U)	Fire load
(mm)	d x e (mm)	d_i (mm)	SDR	D x e1 (mm)	(kg/m)	(kg/m)	(l/m)	(mm)	(W/m K)	(kWh/m)
d32/90	32 x 2.9	26.2	11	90 x 3	1.39	1.93	0.54	26.0	0.13	14.96
d40/110	40 x 3.7	32.6	11	110 x 3.4	2.02	2.85	0.83	31.6	0.14	21.66
d50/110	50 x 4.6	40.8	11	110 x 3.4	2.19	3.49	1.31	26.6	0.18	24.02
d63/125	63 x 5.8	51.4	11	125 x 3.8	2.94	5.02	2.07	27.2	0.21	32.72
d75/140	75 x 6.8	61.4	11	140 x 4	3.70	6.66	2.96	28.5	0.23	41.35
d90/160	90 x 8.2	73.6	11	160 x 4	4.75	9.00	4.25	31.0	0.24	53.07
d110/180	110 x 10	90.0	11	180 x 4	6.12	12.48	6.36	31.0	0.28	68.94
d160/250	160 x 9.5	141.0	17	250 x 5	9.81	25.42	15.61	40.0	0.37	109.29
d225/315	225 x 13.4	198.2	17	315 x 6	16.42	47.27	30.85	39.0	0.50	187.00
d250/355	250 x 14.8	220.4	17	355 x 5.1	19.04	57.19	38.15	47.4	0.47	213.97
d280/400	280 x 16.6	246.8	17	400 x 6.3	24.67	72.51	47.84	53.7	0.47	277.80
d315/450	315 x 18.7	277.6	17	450 x 6.4	30.42	90.95	60.52	61.1	0.47	341.40
d355/500	355 x 21.1	312.8	17	500 x 7.4	38.35	115.20	76.85	65.1	0.49	432.43
d400/560	400 x 23.7	352.6	17	560 x 8.4	48.40	146.05	97.65	71.6	0.50	546.74
d450/630	450 x 26.7	396.6	17	630 x 7.6	58.19	181.72	123.54	82.4	0.49	653.01

Extended range (inner pipe SDR11 for d160-d450mm)	Inner pipe	Inner pipe	Pipe class	Outer jacket	Weight empty	Weight with water	Volume	Insulation thickness	Heat transfer coefficient (U)	Fire load
(mm)	d x e (mm)	d_i (mm)	SDR	D x e1 (mm)	(kg/m)	(kg/m)	(l/m)	(mm)	(W/m K)	(kWh/m)
d160/250	160 x 14.6	130.8	11	250 x 5	11.88	25.31	13.44	40	0.37	134.53
d225/315	225 x 20.5	184	11	315 x 6	20.47	47.06	26.59	39	0.49	236.4
d250/355	250 x 22.7	204.6	11	355 x 5.1	24.05	56.92	32.88	47.4	0.46	275.1
d280/400	280 x 25.4	229.2	11	400 x 6.3	30.93	72.18	41.26	53.7	0.46	354.06
d315/450	315 x 28.6	257.8	11	450 x 6.4	38.33	90.53	52.2	61.1	0.46	437.89
d355/500	355 x 32.2	290.6	11	500 x 7.4	48.34	114.67	66.33	65.1	0.48	554.36
d400/560	400 x 36.3	327.4	11	560 x 8.4	61.19	145.37	84.19	71.6	0.49	702.72
d450/630	450 x 40.9	368.2	11	630 x 7.6	74.39	180.87	106.48	82.4	0.49	850.72

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

Energy Saving Ordinance EnEV

COOL-FIT 4.0 meets the specifications of the Energy Saving Ordinance EnEV 2014 for cold distribution and cold water pipes.

Please contact Georg Fischer Piping Systems when using COOL-FIT 4.0 according to EnEV 2014 specification for heating cables.

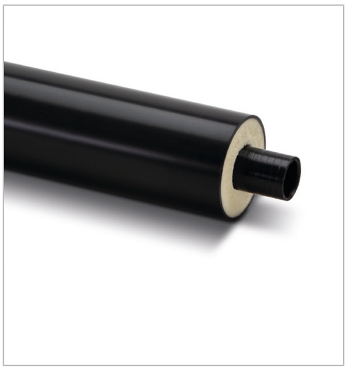
3.3.2 COOL-FIT 4.0F

COOL-FIT 4.0F pipe

COOL-FIT 4.0F inner pipe is made from PE100. The GF-HE foam insulation has a thermal conductivity λ of 0.026 W/mK. The pipe is protected by the GF fire retardant GF-FR jacket.

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

The pipes are available in 5m bars and are already prepared for jointing. They can be connected with all fittings from COOL-FIT 4.0.



Pipe size	Inner Pipe	Inner Pipe	Outer jacket	Weight empty	Weight with Water	Volume	Insulation thickness	Heat transfer coefficient (U)	Fire load
(mm)	d x e (mm)	d_i (mm)	D x e1 (mm)	(kg/m)	(kg/m)	(l/m)	(mm)	(W/m K)	(kWh/m)
d160/250	160 x 9.5	141.0	250 x 3	9.48	25.09	15.61	42.0	0.36	81.51
d225/315	225 x 13.4	198.2	315 x 3.5	15.79	46.65	30.85	41.5	0.48	144.33

d Nominal outer diameter of the PE pipe
d_i Nominal inside diameter of the pipe
D Nominal outside diameter of the outer PE jacket
e, e1 Nominal wall thickness

COOL-FIT 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.

Reduction as an example

Usefull functions

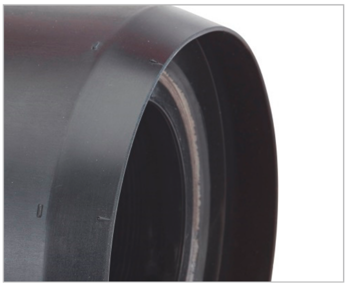
Fusion indicators

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.

373603063 160120 76701000325 Traceability

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

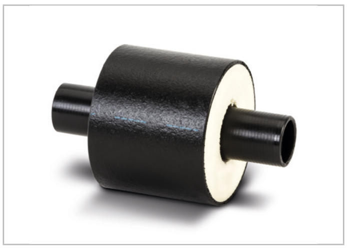
The equal and reduced type A 90° tees have, like the coupler, resistance wires for electrofusion. The central branches can be connected to the type A fitting, so all combinations are possible.

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.



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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

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

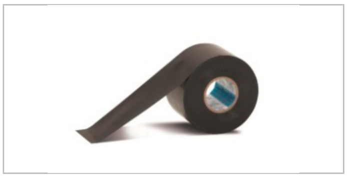
The Transition of insulation is used for a moisture-proof and vapour tight sealing of the interface of COOL-FIT 4.0 Fitting to COOL-FIT 2.0 pipe.

Cement

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

Adhesive tape

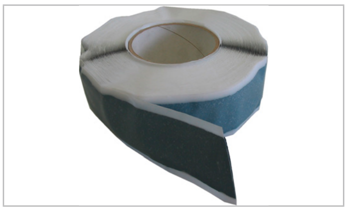
Optional for covering hand-cut faces as well as for bonding of the insulations of transition fittings to the insulation of flexible hoses.



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 respective welded joints 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

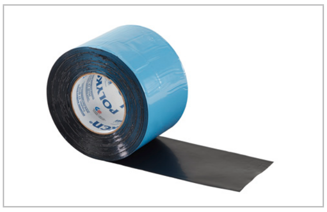
End caps are used to cap the pre-insulated system. They seal the PUR insulation and prevent moisture from entering. Sealing PUR is achieved by using a suitable sealant.

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.

Cold shrink tape

The cold shrink tape is used on the respective welded joints for the water- and vapor-tight sealing of the outer jacket. It is only suitable for indoor applications and can be applied by hand without heat.

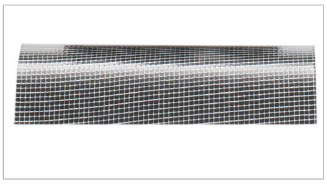


Hot shrink tape

The heat shrink tape is used on the respective welded joints for the water and vapor tight sealing of the outer jacket. The adhesive-coated tape must be glued with a sealing patch and shrunk under the influence of heat.

Sealing patch

The sealing patch is used to close the heat-shrink tape. One patch must be used per sealing.



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COOL-FIT 4.0 Heat Tracing

Frozen pipes can cause high costs. When water-filled COOL-FIT pipes are exposed to temperatures below zero °C without circulation and for extended periods of time, the water freezes and proper operation of the cooling system can no longer be maintained.
The heat-tracing system for COOL-FIT 4.0 offers an effective solution for the freeze protection of COOL-FIT lines. The self-regulating heating tape in combination with the insulation of the COOL-FIT 4.0 pipe system prevents the cooling pipe from freezing.

With the COOL-FIT 4.0 heat tracing, reliable frost protection down to -30°C ambient temperature is provided across all COOL-FIT 4.0 dimensions from d32 - d450.

Please contact GF if you need antifreeze protection at ambient temperatures below -30°C.

Tracing cable

The COOL-FIT heat-tracing system uses a self-regulating heat-tracing cable installed inside the pipe. This efficiently protects the medium from freezing directly and without heat loss through the pipe wall insulation.

Cable glands

The entry and exit of the cable into the COOL-FIT system is performed via cable glands, which are connected to the COOL-FIT system via metallic thread transitions.

Thermostat

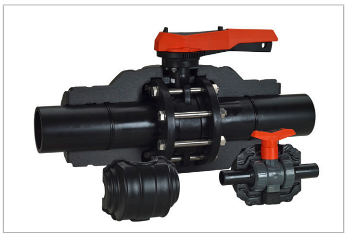
The thermostat is designed to provide userfriendly measurement and control for the self regulating heating cable for COOL-FIT. It can be chosen between efficient temperature control via the media temperature or proportional ambient sensing control (PASC) algorithm for enhanced energy savings in ambient sensing mode.

Cold lead connection and end seal kit

The kit contains all necessary components like crimps and shrink sleeves for the joining of the heating cable to power cable as well as for the end seal of the heating cable.

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.

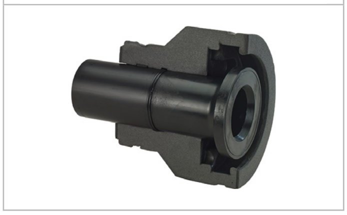
The insulated ball valve in ABS is available in sizes d32DN25 – d90DN80. For the sizes d110DN100 – d225DN125, butterfly valves kits are available that consist of butterfly valve, flange adaptor, backing flange PP-St, screw-kits and insulation half shells.
Both valve types are available either as manually 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 EPDM insulation ($\lambda_{0°C} \leq 0.036$ 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)

d (mm)	DN (mm)	Thread	Length (mm)	Max. compensation ΔL (mm)	Rmin (min. bending radius) (mm)
d20	DN15	½"	1000	276	119
d25	DN20	¾"	1000	161	156
d32	DN25	1"	1000	68	192
d40	DN32	1 ¼"	1500	233	252
d50	DN40	1 ½"	2000	396	312
d63	DN50	2"	2000	233	372

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.

3.3.3 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.

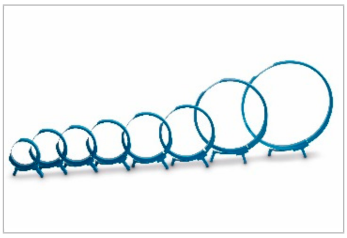
Long Fusion adaptors

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.

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.

3.4 Dimensioning and Design

3.4.1 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, GF 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 GF Piping Systems representative. Additional information is available on the official GF Piping Systems website.

3.4.2 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.

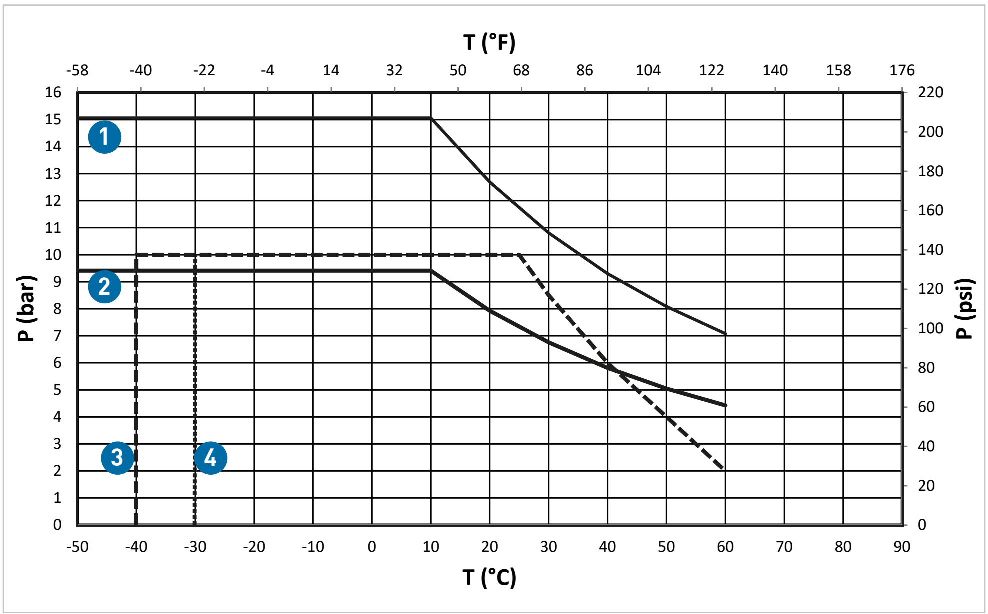
The graph shows the maximum permissible pressure for COOL-FIT 4.0 pipe and fittings at various temperatures, up to the maximum permissible media temperature of +60 °C. The graph is based on an ambient temperature of +20 °C. A safety factor of 1.6 and a minimum lifespan of 25 years have been allowed for in all calculations.

The values given in this chapter apply to both COOL-FIT 4.0 and COOL-FIT 4.0F.

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).

In case of long-term operating pressure at temperatures above 47 °C, please contact your authorized GF Piping Systems representative.



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

① COOL-FIT 4.0 Pipe and fitting d32 – d450, 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
Temper	Temper	Brine
Hycool	Addcon	Brine

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

3.4.3 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

V

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 3.5×10^{16} Ωcm, the surface resistance 10^{13} Ω. This must be taken into account in applications where there is danger of fire or explosion.

3.4.4 Fire behavior and fire prevention measures

Firestop classes

Classification of fire behavior

Construction materials are classified into different firestop classes depending on their fire behavior. The classification is decisive for whether specific materials may be legally used for construction in certain areas of construction projects.

European classification according to EN 13501-1

In the year 2001, the EN 13501-1 was introduced, a European classification system for construction materials. EN 13501-1 defines 6 construction material classes from A to F:

A	No contribution to the development of a fire (A1, A2)
B	Very little contribution to the development of a fire
C	Limited contribution to the development of a fire
D	Acceptable contribution to the development of a fire
E	Acceptable fire behavior
F	No performance criteria detected

In addition to the fire behavior, the European standard also rates fire side effects: smoke release (s1, s2, s3) and burning droplets (d0, d1, d2).

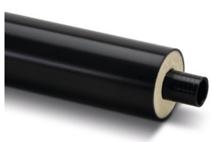
Smoke release:

s1	Limited smoke release
s2	Average smoke release
s3	High smoke release, or smoke release not tested

Burning droplets:

d0	No burning droplets/fall off within 600 seconds
d1	No burning droplets/fall off with an afterglow time of more than 10 seconds within 600 seconds
d2	No performance criteria detected

Fire prevention classes COOL-FIT 4.0 EN13501-1, VKF and British building codes

	COOL-FIT 4.0	COOL-FIT 4.0F	COOL-FIT 4.0/ mineral wool [2]
			
EN 13501-1	E	B – s2, d0	$A2_L$
VKF	RF3cr*	RF2	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

V

Thermal load

The thermal load corresponds to a thermal potential (energy release) related to a specific base area, fire section area in m^2, for example an escape route. The physical unit for the thermal load is energy per surface area kWh/m^2. The calculative thermal load is equivalent to the sum of the different thermal potentials of all used combustible used elements, such as pipelines. When the energy released per running meter of the pipe (kWh/m) is known, the thermal load of the pipe is calculated from the used pipe length.

d/D (mm)	32/90	40/110	50/110	63/125	75/140	90/160	110/180
Thermal load COOL-FIT 4.0 SDR11 pipes (kWh/m)	15.0	21.7	24.0	32.7	41.4	53.1	68.9

d/D (mm)	160/250	225/315	250/355	280/400	315/450	355/500	400/560	450/630
Thermal load COOL-FIT 4.0 SDR17 pipes (kWh/m)	109.3	187.0	214.0	277.8	341.4	432.4	546.7	653.0

d/D (mm)	160/250	225/315	250/355	280/400	315/450	355/500	400/560	450/630
Thermal load COOL-FIT 4.0 SDR11 pipes (kWh/m)	134.5	236.4	275.1	354.1	437.9	554.4	702.7	850.7

d/D (mm)	160/250	225/315
Thermal load COOL-FIT 4.0F pipes (kWh/m)	106.75	193.73

Fire resistance of components

While the fire behavior characterizes individual materials, the fire resistance must be considered for complete components, for example a solid wall with pipe perforations. The fire resistance is equivalent to the amount of time in which a component maintains its function during a standard fire.

The European system allows classification according to different criteria, stating the respective fire resistance duration in minutes.

Fire resistance and classification according to the European standards

Pipe insulation systems are exposed to a standard fire according to EN 1363-3. Classification is according to EN 13501-2 and generally includes the criteria integrity (E, Étanchéité) and thermal insulation (I, Insulation).

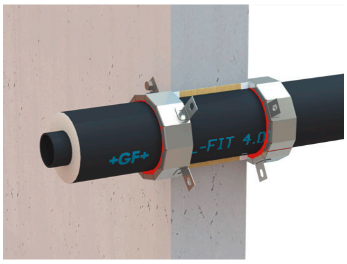
Abbreviation	Criterion	Rating
E – Étanchéité	Flame protection or integrity	Measurement of an element's capacity of preventing the passage of gases and flames in case of fire.
I – Insulation	Insulation or thermal insulation	Measurement of the insulation capacity of an element, i.e. the duration in which the side of the element facing away from the fire does not exceed 180° C + the ambient temperature.

Firestop collars/Fire sealing

When pipes are installed through fire-rated assemblies, whose reliable functioning must not be affected, firestop collars that comply with local requirements and legislation must be used.

Hilti firestop

System description



The firestop collar (inlc.fastening hook) is made of galvanized steel sheet into which strips of intumescent material (i.e. that swells in case of fire) are inserted.

The fire retardation sealing with straight pipes is regulated in conjunction with the following products in the individual countries:

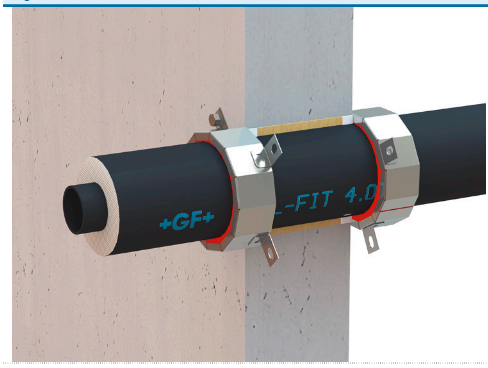
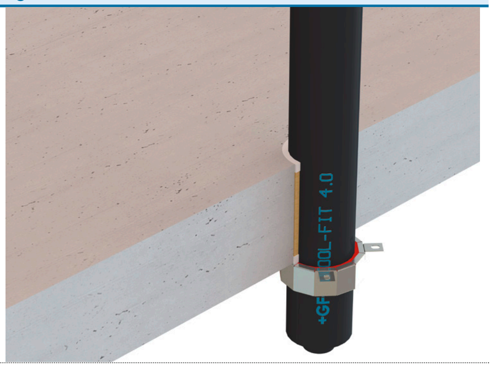
Product	Proof of applicability	Countries
Hilti firestop collar CP 644	Allgemeine Bauartgenehmigung (aBg) Z-19.53-2330	DE
Hilti firestop collar CP 644	VKF Technische Auskunft 14108	CH
Hilti firestop collar CFS-C P	ETA-10/0404	EU

The respective details of the proofs of application must be taken into account.

Additional information is available at Hilti online or from your Hilti contact person.

Hilti CP 644	Hilti CFS-C P
Info | Shop	Info | Shop
qr.hilti.com/r3069	qr.hilti.com/r4831

The following applications are regulated via the above proofs of application:

Rigid walls, thickness ≥ 100 mm	Rigid floor, thickness ≥ 150 mm
	

Fire-retarding sealing

COOL-FIT 4.0 pipes up to and including an outside diameter D of 250mm*, can be sealed in rigid walls and D of 140mm in rigid floors by a Hilti fire protection collar.

Wall ≥ 100mm solid		Product DE, CH	Product EU	Fire resistance	Mounting
d [mm]	**D (mm)**	**CP 644**	**CFS-C P**		**Number of hooks**
32	90	CP 644-90/3"	CFS-C P 90/3"	EI 120-U/C	3
40	110	CP 644-110/4"	CFS-C P 110/4"	EI 120-U/C	4
50	110	CP 644-110/4"	CFS-C P 110/4"	EI 120-U/C	4
63	125	CP 644-125/5"	CFS-C P 125/5"	EI 120-U/C	4
75	140	CP 644-160/6"	CFS-C P 160/6"	EI 120-U/C	6
90	160	CP 644-160/6"	CFS-C P 160/6"	EI 120-U/C	6
110	180	CP 644-180/7"	CFS-C P 180/7"	EI 120-U/C	8
160	250	CP 644-250/10"	CFS-C P 250/10"	EI 120-U/C	12

Ceiling ≥ 150mm solid		Product DE, CH	Product EU	Fire resistance	Mounting
d (mm)	**D (mm)**	**CP 644**	**CFS-C P**		**Number of hooks**
32	90	CP 644-90/3"	CFS-C P 90/3"	EI 120-U/C	3
40	110	CP 644-110/4"	CFS-C P 110/4"	EI 120-U/C	4
50	110	CP 644-110/4"	CFS-C P 110/4"	EI 120-U/C	4
63	125	CP 644-125/5"	CFS-C P 125/5"	EI 120-U/C	4
75	140	CP 644-160/6"	CFS-C P 160/6"	EI 120-U/C	6

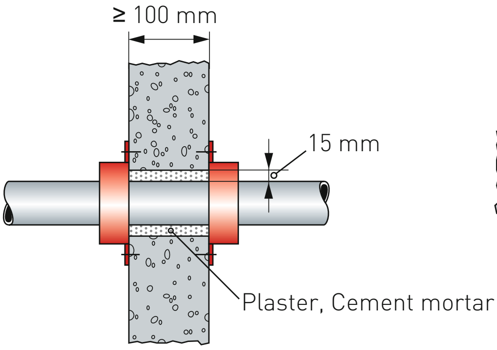
* For bigger dimensions see chapter "Additional approved fire retarding sealing".

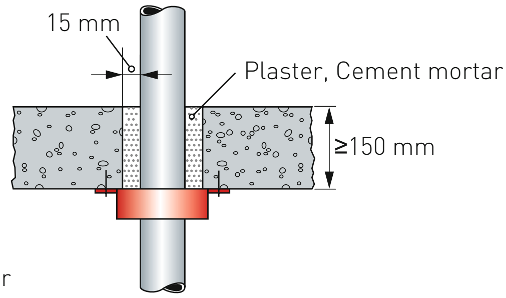
Gap sealing

For the installation situations there are several options for sealing gaps against smoke gas.

Gap sealing with non-combustible construction materials:

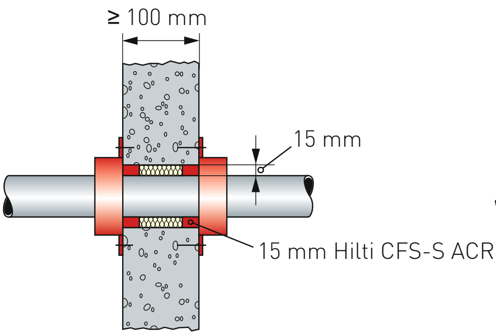
Rigid wall	Rigid floor

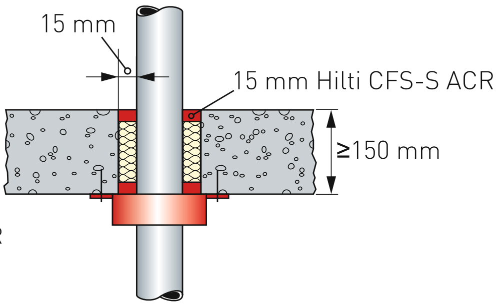




Joint closure with Hilti firestop sealant CFS-S ACR and mineral wool backfill up to 15mm annular gap width for Hilti firestop collar CP 644 and CFS-C P.

Rigid wall	Rigid floor



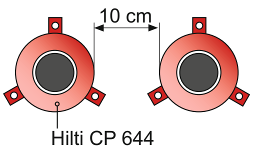


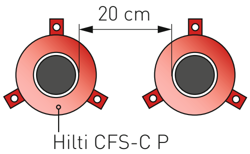
Distance regulations

The distance of the component openings to be closed to other openings or installed elements must comply with the data provided in the following table.

Distance of the pipe sealing to	Size of the adjacent openings	Distance between the openings DE, CH	Distance between the openings EU
Other cable or pipe sealing	one/both openings > 40cm x 40cm	≥ 20cm	≥ 20cm
	Both openings ≤ 40cm	≥ 10cm	
Other openings or installed elements	one/both openings > 20cm x 20cm	≥ 20cm	≥ 20cm
	Both openings ≤ 20cm	≥ 10cm	

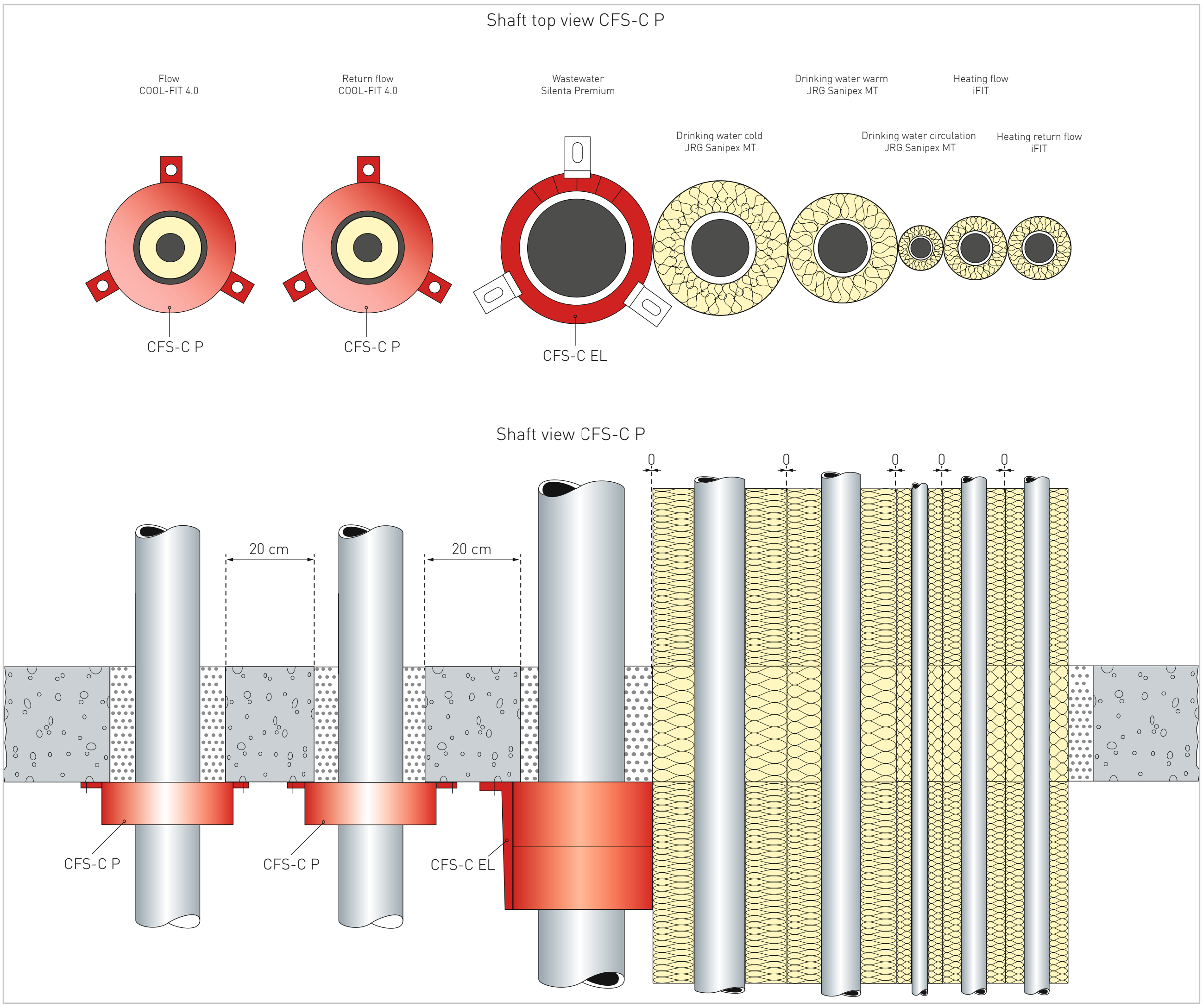
The following pipe distances between the openings of the pipe lead through are derived from this for pipe sealing with the Hilti firestop collar for COOL-FIT 4.0:

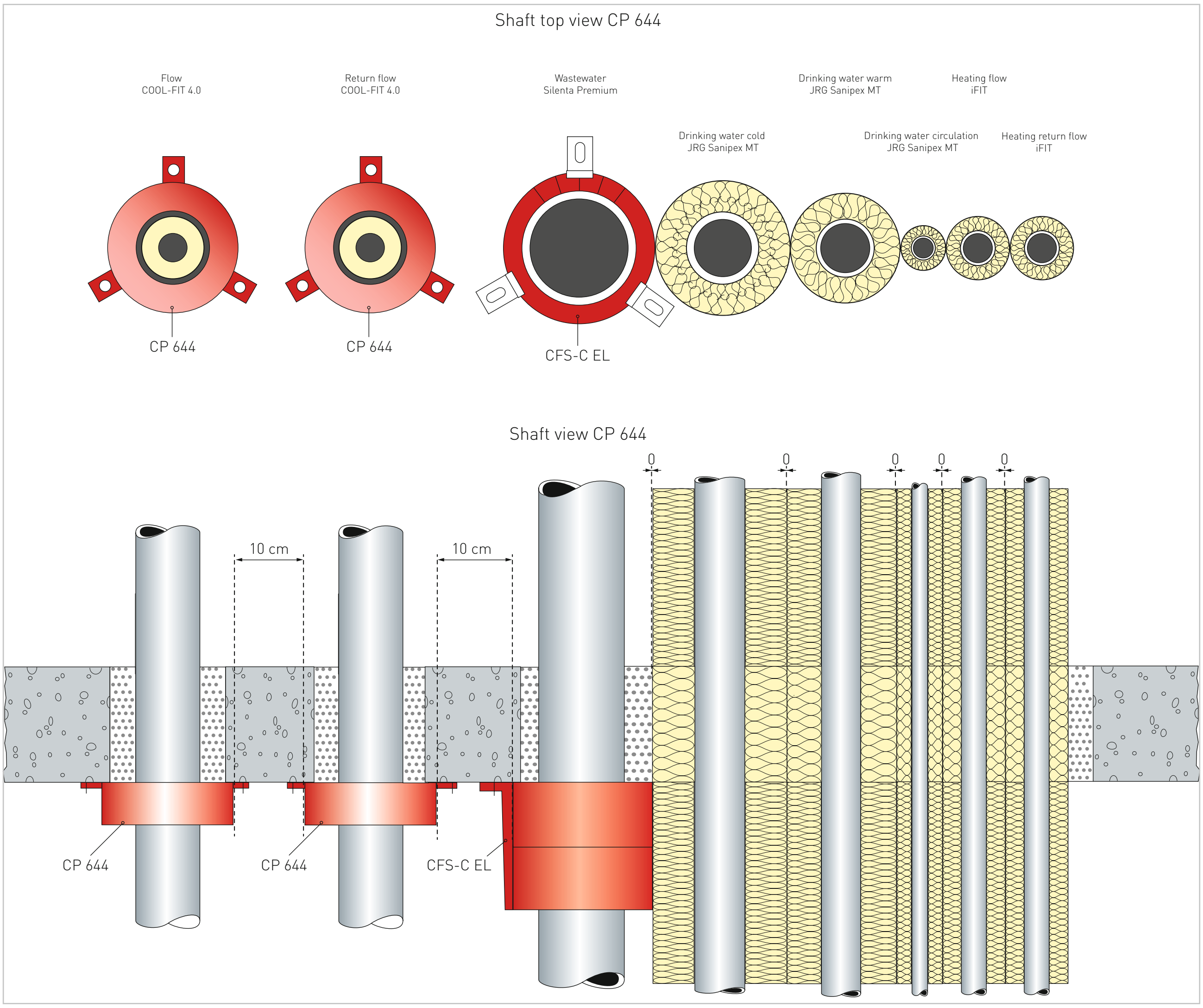




Shaft installation

A shaft installation with additional pipelines, for example for heating and drinking water, may look as follows:





Additional approved fire retarding sealing

The following firestop collars were tested with COOL-FIT 4.0 / 4.0F pipes.

Fire-retarding sealing	Manufacturer	Approval
ROKU ® AWM II	Rolf Kuhn GmbH	ETA 17/0753
BIS Pacifyre ® AWM II	Walraven	ETA 17/0753

The firestop system ROKU® R – type AWM II carries the European technical approval ETA 17/0753. COOL-FIT 4.0 (up to dimensions d355/D500) and 4.0F was tested with AWM II firestop collars.

For detailed product information on AWM II see www.kuhnbrandschutz.com.

ROKU® System AWM II

System description

The ROKU® system AWM II consists of a firestop collar housing, which is equipped on the inside with several layers of the highly effective intumescent material "ROKU® Strip." In case of fire, the foaming material reacts with a strong foaming pressure and permanently seals the construction component opening against fire and smoke. On walls, one collar should be fitted on each side, and on ceilings only one collar underneath the ceiling.

Application areas

- Sealing of plastic pipes up to Ø 400 mm in solid walls, light partition walls, and solid ceilings
- For plastic pipes, mineral fiber-reinforced plastics, plastic composite pipes
- Suitable for insulated and non-insulated plastic pipes and acoustically insulating sewage pipes

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.

3.4.5 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 capacity

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/m^3)
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.

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

Correlation of outer diameter - inner diameter

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

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

Correlation between pipe external and internal diameter

d (mm)	32	40	50	63	75	90	110
di SDR11 (mm)	26.2	32.6	40.8	51.4	61.4	73.6	90
di SDR17 (mm)							

d (mm)	160	225	250	280	315	355	400	450
di SDR11 (mm)	130.8	184	204.6	229.2	257.8	290.6	327.4	368.2
di SDR17 (mm)	141	198.2	220.4	246.8	277.6	312.8	352.6	396.6

3.4.6 Nomogram for easy calculation of diameter and pressure loss

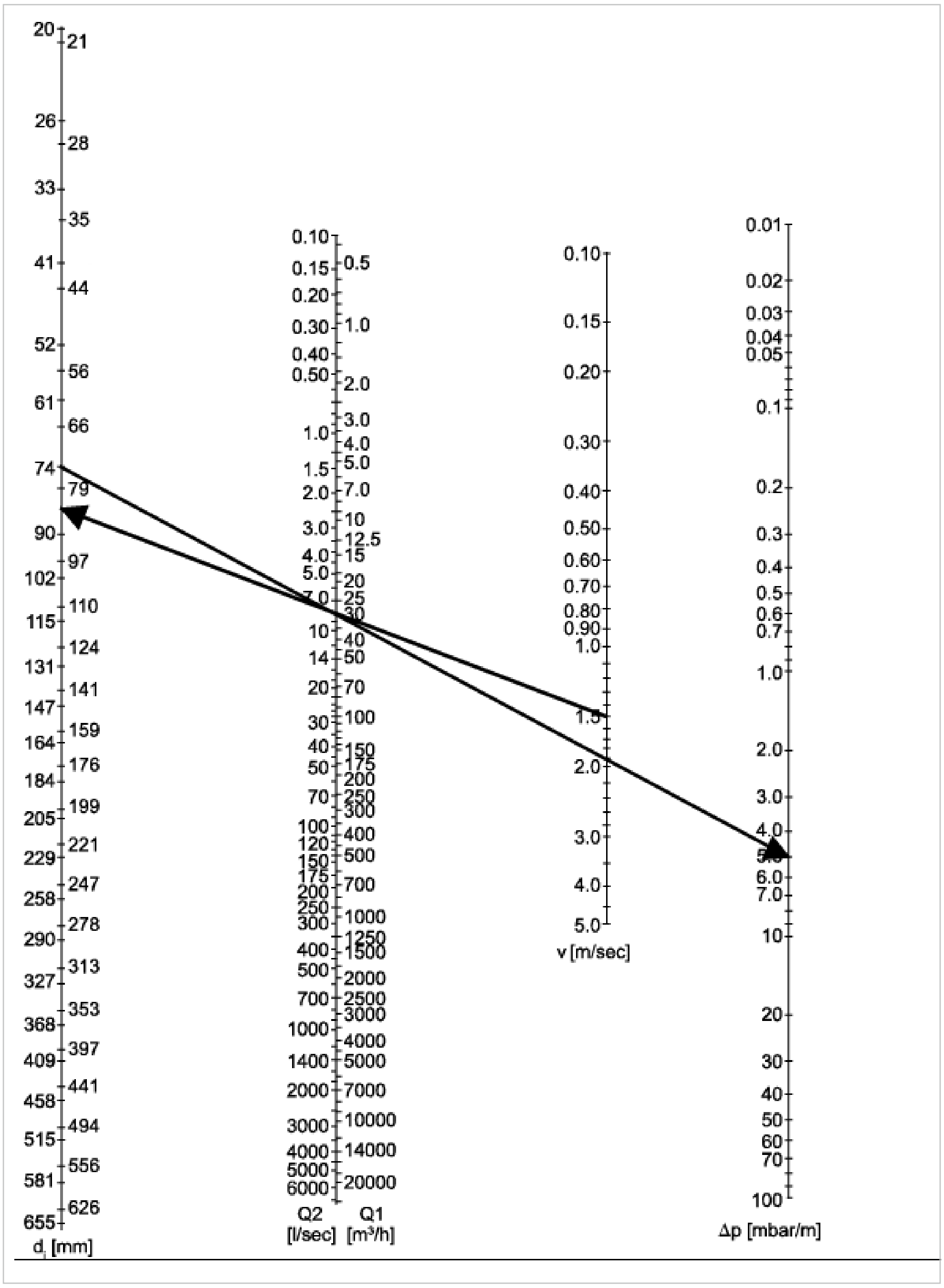
The nomogram below can be used to simplify the determination of the diameter required .The pressure loss in the pipe can be read off per meter of the pipe length.

> The pressure loss calculated using the nomogram only applies to flows of substances with density 1000 kg/m^3, 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 m^3/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



V

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

3.4.7 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
Flexible hoses	½": 2.0 ¾": 1.8 1": 1.4	1 ¼": 1.1 1 ½": 1.0 2": 0.8

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/m³ (1 g/cm³ = 1000 kg/m³)

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:

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

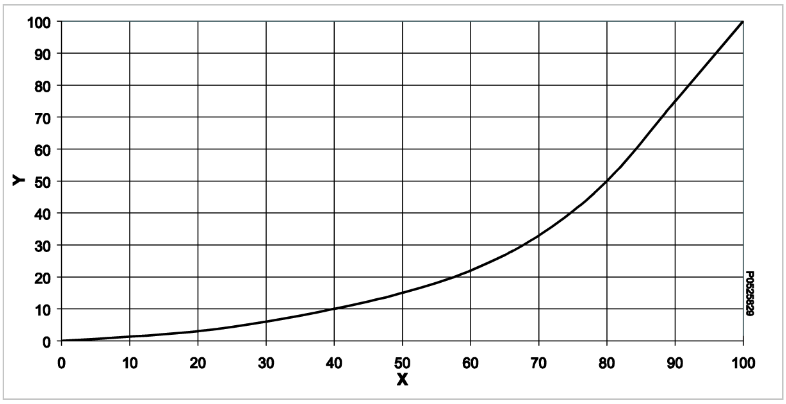
Δp_{Ar}	Pressure loss for the valve (bar)
Q	Flow rate (m³/h)
ρ	Density of the conveyed medium (kg/m³) (1 g/cc = 1000 kg/m³)
k_v	Valve characteristic value (m³/h)

k_v 100-Werte

DN (mm)	Zoll (inch)	d (mm)	k_v 100 (l/min)	Cv 100 (gal/min)	k_v 100 (m³/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

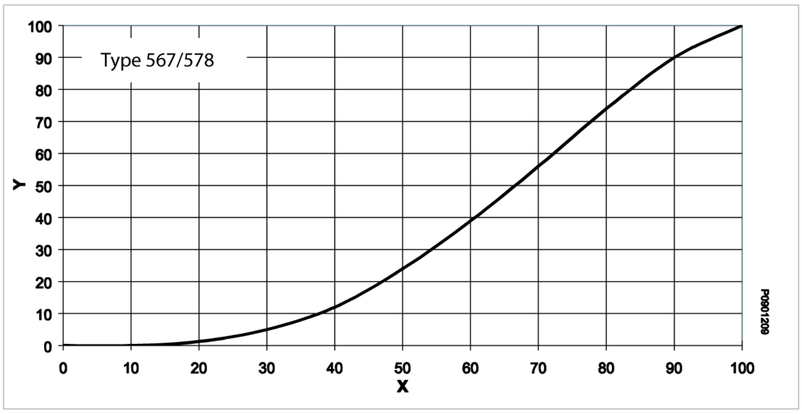
Flow characteristic Ball valve



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

V

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

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/cm^3	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:

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

The inner diameter of the piping system is as follows:

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

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

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

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

3.4.8 Dimension comparison COOL-FIT 4.0 metal

COOL-FIT 4.0		Stainless steel	
d (mm)	DN	inches	da (mm)
32	25	1	33.4
40	32	1 ¼	42.2
50	40	1 ½	48.3
63	50	2	60.3
75	65	2 ½	73.0
90	80	3	88.9
110	90	4	114.3
160	150	6	168.3
225	200	8	219.1
250	250	10	244.5
280	250	10	273.1
315	300	12	323.9
355	350	14	355.6
400	400	16	406.4
450	450	18	457.2

d Nominal external diameter of PE pipe

V

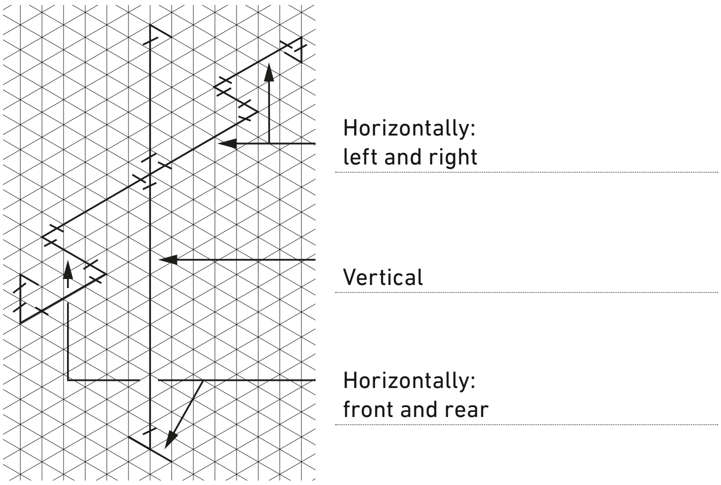
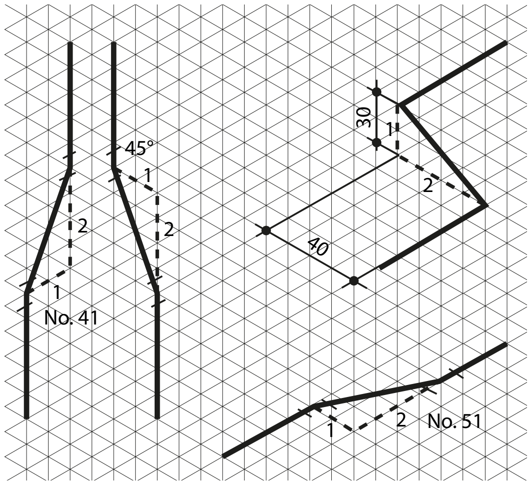
3.4.9 Z-dimension method

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 415.

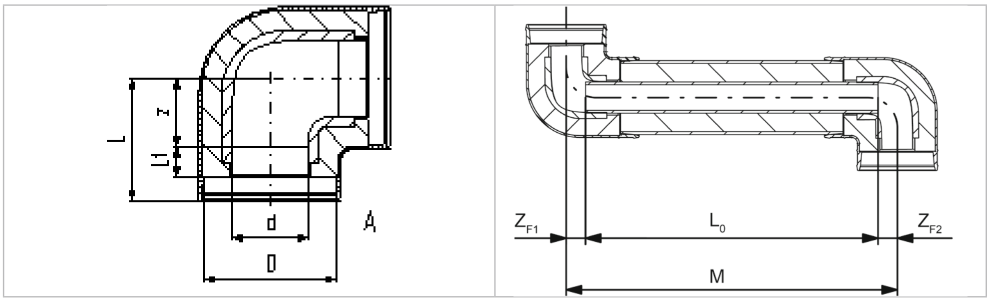
Please adhere to the following guidelines for drawing:

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

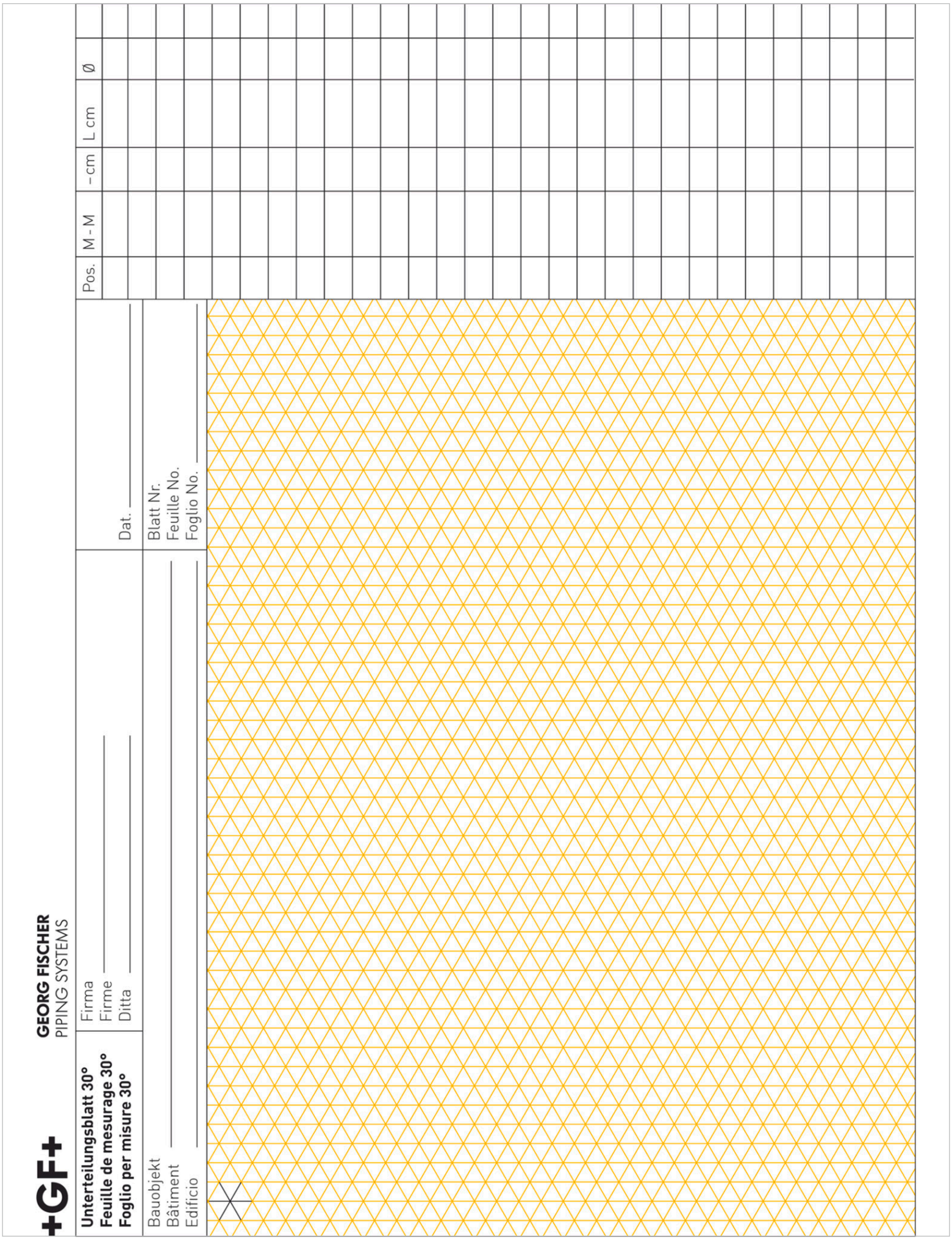
Dimension	d32/D90
Center to center distance M	1000 mm
z measurement for 90° elbow z_{F1}	20 mm
z measurement for 90° elbow z_{F2}	20 mm

M = 1000 mm; L_0 = ?

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

V

Measuring Sheet



3.4.10 Length changes and flexible sections

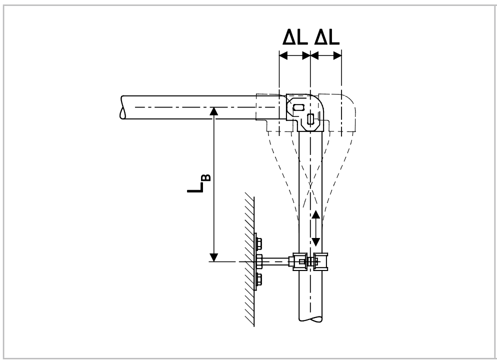
Overview

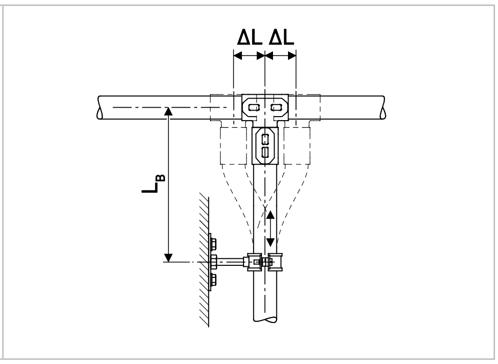
Length changes ΔL and expansion bend L_B – General

Thermoplastics are subject to higher 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.

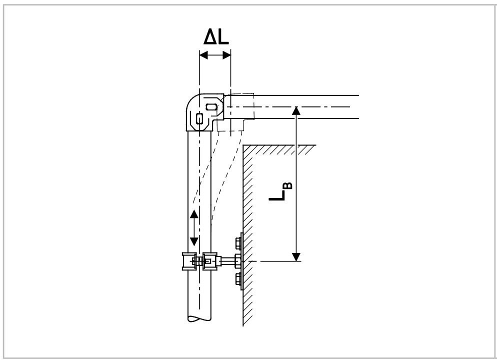


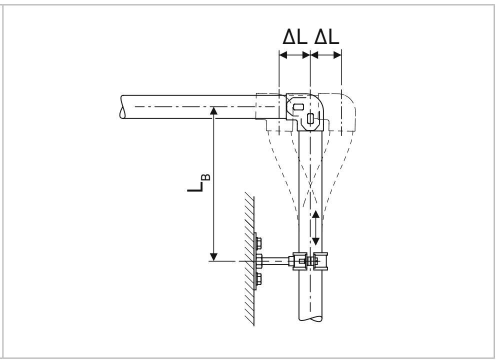


ΔL Change in length
L_B Flexible section

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.





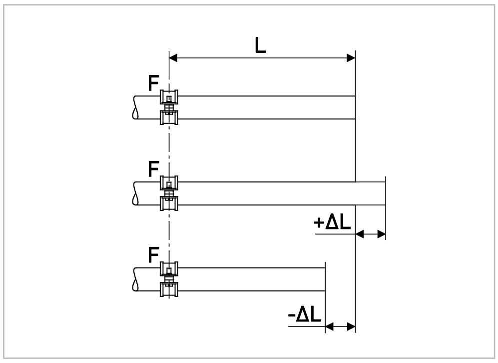
Flexible sections arise naturally at any branching or change in direction of the piping system. The movement L_B of the flexible section as a result of a change ΔL in the length must not be restrained by fixed pipe brackets, wall protrusions, girders or the like.

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 GF 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
Pipe class	d32 - d110 SDR11 and d160 - d450 SDR17

L Laid pipe length

Length change ΔL (mm) at 20° C flow temperature

L (m)	25	50	100	150
d32	-4	-9	-18	-27
d40	-5	-10	-19	-29
d50	-6	-13	-26	-38
d63	-7	-15	-29	-44
d75	-8	-16	-32	-48
d90	-9	-18	-36	-54
d110	-10	-20	-41	-61
d160	-9	-18	-37	-55
d225	-11	-21	-43	-64
d250	-11	-23	-45	-68
d280	-11	-22	-44	-66
d315	-11	-22	-45	-67
d355	-11	-23	-45	-68
d400	-11	-23	-45	-68
d450	-12	-24	-48	-72

Length change ΔL (mm) at 15° C flow temperature

L (m)	25	50	100	150
d32	-9	-18	-37	-55
d40	-10	-20	-40	-59
d50	-13	-26	-52	-78
d63	-15	-30	-60	-90
d75	-16	-33	-65	-98
d90	-18	-36	-73	-109
d110	-21	-41	-82	-124
d160	-19	-37	-75	-112
d225	-22	-43	-86	-129
d250	-23	-46	-91	-137
d280	-22	-44	-89	-133
d315	-23	-45	-91	-136
d355	-23	-46	-91	-137
d400	-23	-46	-92	-137
d450	-24	-48	-96	-144

L Laid pipe length

Length change ΔL (mm) at 10° C flow temperature

L (m)	25	50	100	150
d32	-14	-28	-56	-84
d40	-15	-30	-61	-91
d50	-20	-40	-80	-120
d63	-23	-46	-91	-137
d75	-25	-50	-100	-150
d90	-28	-55	-111	-166
d110	-31	-62	-125	-187
d160	-28	-57	-114	-171
d225	-33	-65	-130	-196

Length change ΔL (mm) at 5° C flow temperature

L (m)	25	50	100	150
d32	-19	-38	-76	-115
d40	-21	-41	-83	-124
d50	-27	-54	-109	-163
d63	-31	-62	-124	-185
d75	-34	-67	-135	-202
d90	-37	-75	-149	-224
d110	-42	-84	-168	-252
d160	-38	-77	-154	-230
d225	-44	-88	-175	-263

Length change ΔL (mm) at 10° C flow temperature				
L (m)	25	50	100	150
d250	-34	-69	-138	-207
d280	-34	-67	-134	-201
d315	-34	-69	-138	-206
d355	-35	-69	-138	-207
d400	-35	-69	-139	-208
d450	-36	-73	-145	-218

Length change ΔL (mm) at 5° C flow temperature				
L (m)	25	50	100	150
d250	-46	-93	-185	-278
d280	-45	-90	-180	-270
d315	-46	-92	-185	-277
d355	-46	-93	-186	-278
d400	-46	-93	-186	-279
d450	-49	-97	-195	-292

Length change ΔL (mm) at 0° C flow temperature				
L (m)	25	50	100	150
d32	-24	-49	-97	-146
d40	-26	-53	-105	-158
d50	-34	-69	-138	-207
d63	-39	-78	-157	-235
d75	-43	-85	-171	-256
d90	-47	-94	-189	-283
d110	-53	-106	-212	-318
d160	-48	-97	-194	-291
d225	-55	-110	-221	-331
d250	-58	-116	-233	-349
d280	-57	-113	-226	-340
d315	-58	-116	-232	-348
d355	-58	-117	-233	-350
d400	-58	-117	-234	-350
d450	-61	-122	-244	-367

Length change ΔL (mm) at -5° C flow temperature				
L (m)	25	50	100	150
d32	-30	-59	-119	-178
d40	-32	-64	-128	-192
d50	-42	-84	-168	-252
d63	-48	-95	-190	-286
d75	-52	-104	-207	-311
d90	-57	-114	-228	-342
d110	-64	-128	-256	-384
d160	-59	-117	-234	-352
d225	-67	-133	-266	-399
d250	-70	-140	-280	-420
d280	-68	-136	-273	-409
d315	-70	-140	-279	-419
d355	-70	-140	-281	-421
d400	-70	-141	-281	-422
d450	-73	-147	-294	-441

L Laid pipe length

Length change ΔL (mm) at -10° C flow temperature				
L (m)	25	50	100	150
d32	-35	-71	-141	-212
d40	-38	-76	-152	-228
d50	-50	-99	-198	-297
d63	-56	-112	-225	-337
d75	-61	-122	-244	-366
d90	-67	-134	-268	-402
d110	-75	-150	-300	-450
d160	-69	-138	-275	-413
d225	-78	-156	-312	-467
d250	-82	-164	-328	-491
d280	-80	-160	-319	-479
d315	-82	-163	-327	-490
d355	-82	-164	-328	-492
d400	-82	-164	-329	-493
d450	-86	-172	-343	-515

Length change ΔL (mm) at -15° C flow temperature				
L (m)	25	50	100	150
d32	-41	-82	-163	-245
d40	-44	-88	-176	-264
d50	-57	-115	-229	-344
d63	-65	-130	-259	-389
d75	-70	-140	-281	-421
d90	-77	-154	-308	-463
d110	-86	-172	-344	-516
d160	-79	-158	-316	-475
d225	-89	-178	-357	-535
d250	-94	-187	-375	-562
d280	-91	-183	-366	-549
d315	-93	-187	-374	-561
d355	-94	-188	-376	-563
d400	-94	-188	-376	-564
d450	-98	-196	-392	-588

L Laid pipe length

COOL-FIT 4.0F

Length change ΔL (mm) at 20° C flow temperature				
L (m)	25	50	100	150
d160	-6	-12	-25	-37
d225	-7	-15	-30	-45

Length change ΔL (mm) at 15° C flow temperature				
L (m)	25	50	100	150
d160	-13	-25	-51	-76
d225	-15	-30	-61	-91

L Laid pipe length

Length change ΔL (mm) at 10° C flow temperature				
L (m)	25	50	100	150
d160	-19	-39	-77	-116
d225	-23	-47	-93	-140

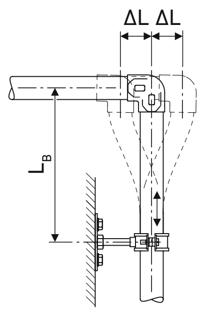
Length change ΔL (mm) at 5° C flow temperature				
L (m)	25	50	100	150
d160	-26	-53	-105	-158
d225	-32	-63	-126	-189

Flexible sections for COOL-FIT 4.0

Flexible Section L_B

Valid for SDR11 and SDR17. 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	78	110	135	156	174	191	206	221	234	247	302	349	427
d40	86	122	149	172	193	211	228	244	259	273	334	386	472
d50	86	122	149	172	193	211	228	244	259	273	334	386	472
d63	92	130	159	184	206	225	243	260	276	291	356	411	503
d75	97	138	168	195	218	238	257	275	292	308	377	435	533
d90	104	147	180	208	233	255	275	294	312	329	403	465	570
d110	110	156	191	221	247	270	292	312	331	349	427	493	604
d160	130	184	225	260	291	318	344	368	390	411	503	581	712
d225	146	206	253	292	326	357	386	413	438	461	565	653	799
d250	155	219	268	310	346	379	410	438	465	490	600	693	848
d280	164	233	285	329	368	403	435	465	493	520	637	735	901
d315	174	247	302	349	390	427	461	493	523	552	675	780	955
d355	184	260	318	368	411	450	486	520	552	581	712	822	1007
d400	195	275	337	389	435	477	515	550	584	615	754	870	1066
d450	206	292	357	413	461	505	546	584	619	653	799	923	1130

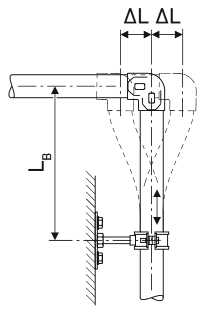


Flexible sections for COOL-FIT 4.0F

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:

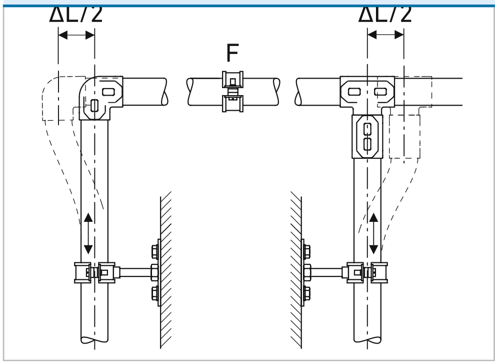
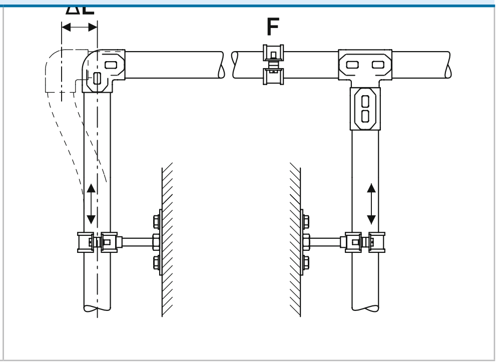
Flexible section L_B (cm)													
ΔL (mm)	10	20	30	40	50	60	70	80	90	100	150	200	300
d160	168	237	290	335	375	410	443	474	503	530	649	749	917
d225	188	266	326	376	420	461	497	532	564	595	728	841	1030



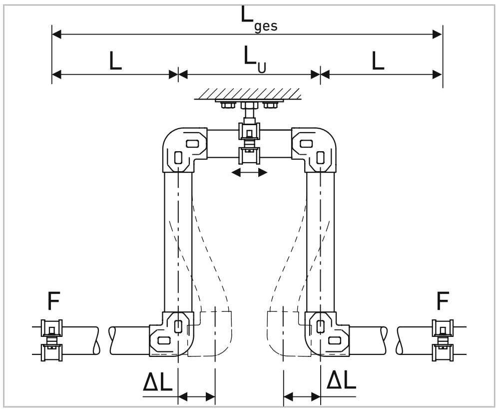
3.4.11 Installation

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

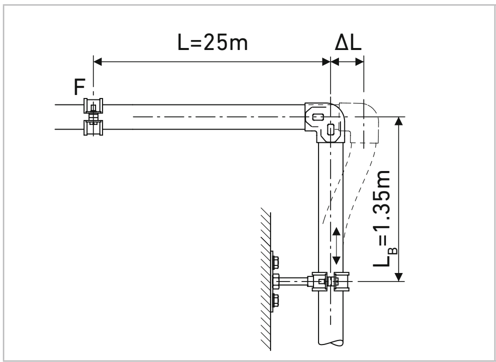
Pipe length L	25 m
Diameter	d225/D315 mm
Installation temperature	25 °C
Min ambient temperature	25 °C constant
Max ambient temperature	25 °C constant
Min flow temperature	10 °C
Max flow temperature	25 °C

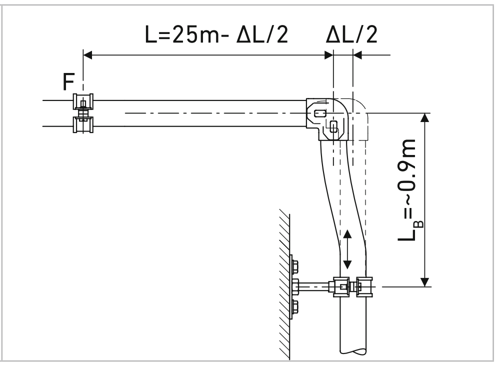
Change in length from the table or COOLING Tool-Box:
-ΔL = 39 mm

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.





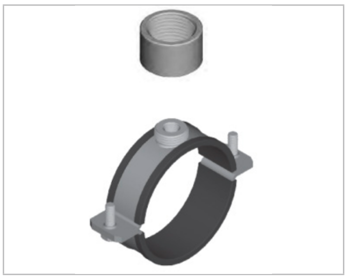
3.4.12 Pipe bracket spacing and support of piping systems

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.

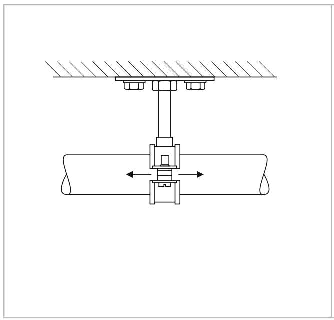
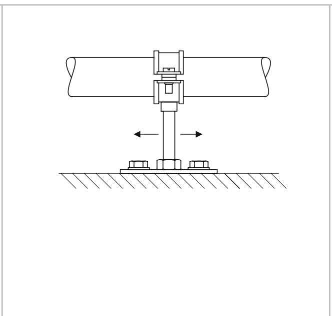
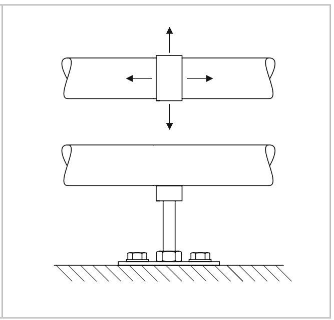
Thanks to the excellent insulating properties of the COOL-FIT 4.0 pipe and its hard, impact resistant outer jacket, standard pipe clamps with hard plastic inlay may be used. Special insulation pipe clamps or cold clamps are not necessary.



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.

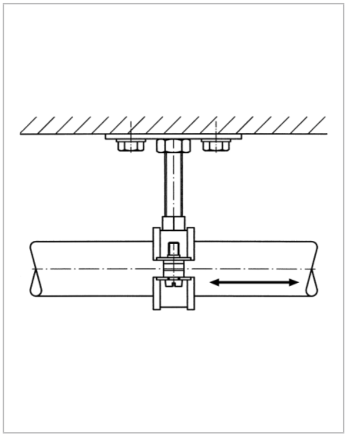
		
Axial displacement of the pipe in the clamp.	Pipe clamp fitted rigidly to the pipe, axial displacement in the suspension of the pipe clamp.	Displacement of the pipe in 2 axes.

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

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.



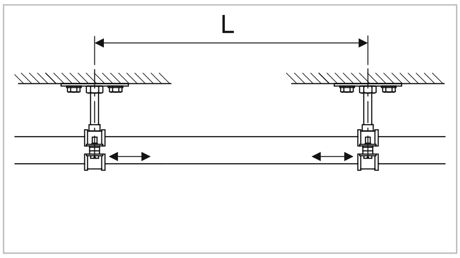
Spacers prevent pinching the pipe

V

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

Pipe bracket intervals L for COOL-FIT 4.0F

d/D (mm)	160/250	225/315
L (mm)	3400	3700

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.

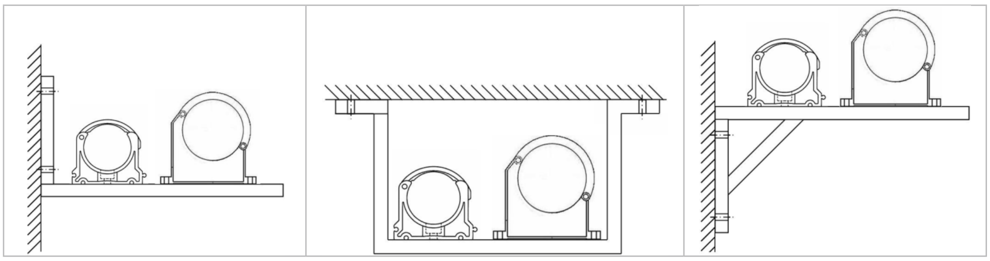
Valid for SDR11 and SDR17.

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.

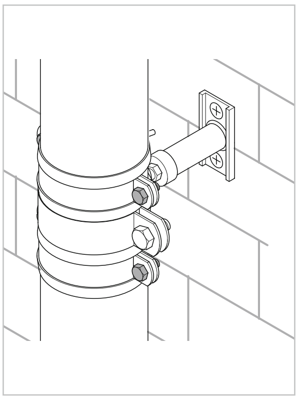
⚠ **Fixpoint design**

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	10.0	10.0	10.0	10.0	10.0	10.0

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

Scope of delivery

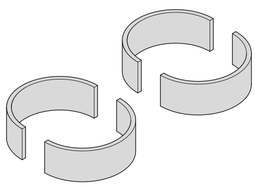
① Clamps to maintain fusion pressure
② Electrofusion band

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.

COOL-FIT 4.0F fixed points

Four half shells which are cemented on both sides to the fixed point pipe clamp.



Diameter (mm)	d160/ D250	d225/ D315
Maximum force F (kN)	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.

Rigidly fixed installations

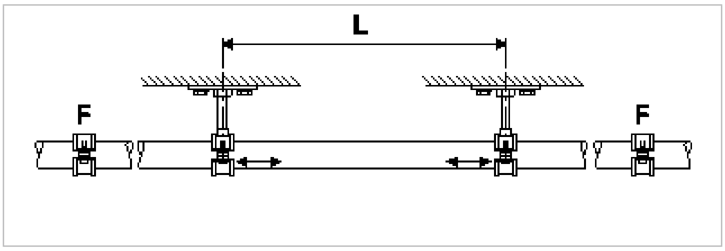
> ⚠ Pipe which are axially clamped and rigidly fixed must be tested for their resistance to kinking. In most cases, this test results in a reduction of the maximum internal pressure and more tightly spaced supports. The forces acting on the fixed points should be considered.

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
Pipe class d32 - d110 SDR11 and d160 - d450 SDR17	



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	250/355	280/400	315/450	355/500	400/560	450/630
F (kN)	0.4	0.6	0.9	1.4	2.0	2.8	4.1	6.0	11.6*	14.3*	18.0*	22.8*	29.0*	36.6*	46.4*
L (mm)	1800	1950	1900	2000	2100	2150	2200	2600	2850	3300	3500	3700	3900	4100	4300

Fixpoint forces F and maximal pipe bracket spacing L at 10 °C flow temperature

d/D (mm)	32/90	40/110	50/110	63/125	75/140	90/160	110/180	160/250	225/315	250/355	280/400	315/450	355/500	400/560	450/630
F (kN)	0.6	1.0	1.4	2.2	3.0	4.4	6.4*	9.3*	18.1*	22.3*	28.1*	36.6*	45.1*	57.1*	72.5*
L (mm)	1800	1950	1900	2000	2100	2150	2200	2600	2850	3300	3500	3700	3900	4100	4300

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	250/355	280/400	315/450	355/500	400/560	450/630
F (kN)	0.9	1.4	2.0	3.1	4.2	6.1	8.9*	12.9*	25.1*	30.9*	38.9*	49.3*	62.5*	79.0*	100.2*
L (mm)	1800	1950	1900	2000	2100	2150	2200	2600	2850	3300	3500	3700	3900	4100	4300

Fixpoint forces F and maximal pipe bracket spacing L at 0 °C flow temperature

d/D (mm)	32/90	40/110	50/110	63/125	75/140	90/160	110/180	160/250	225/315	250/355	280/400	315/450	355/500	400/560	450/630
F (kN)	1.1	1.8	2.5	3.9	5.5	7.8	11.5*	16.7*	32.4*	40.0*	50.3*	63.7*	80.8*	102.2*	130.0*
L (mm)	1800	1950	1900	2000	2100	2150	2200	2600	2850	3300	3500	3700	3900	4100	4300

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	250/355	280/400	315/450	355/500	400/560	450/630
F (kN)	1.4	2.2	3.1	4.9	6.8	9.7*	14.3*	20.7*	40.2*	49.5*	62.2*	79.0*	100.0*	126.6*	160.6*
L (mm)	1800	1950	1900	2000	2100	2150	2200	2600	2850	3300	3500	3700	3900	4100	4300

Fixpoint forces F and maximal pipe bracket spacing L at -10 °C flow temperature

d/D (mm)	32/90	40/110	50/110	63/125	75/140	90/160	110/180	160/250	225/315	250/355	280/400	315/450	355/500	400/560	450/630
F (kN)	1.6	2.6	3.8	5.9	8.1	11.6*	17.2*	24.8*	48.3*	59.3*	74.8*	94.9*	120.3*	152.1*	193.0*
L (mm)	1800	1950	1900	2000	2100	2150	2200	2600	2850	3300	3500	3700	3900	4100	4300

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	250/355	280/400	315/450	355/500	400/560	450/630
F (kN)	1.9	3.0	4.4	6.9	9.5	13.7*	20.2*	29.2*	56.8*	70.0*	87.9	111.5*	141.4*	178.8*	226.8*
L (mm)	1800	1950	1900	2000	2100	2150	2200	2600	2850	3300	3500	3700	3900	4100	4300

* max allowed force for COOL-FIT fixed point exceeded

COOL-FIT 4.0F

Fixpoint forces F and maximal pipe bracket spacing L at 15 °C flow temperature		
d/D (mm)	d160/250	d225/315
F (kN)	6.01	11.65*
L (mm)	3400	3700

Fixpoint forces F and maximal pipe bracket spacing L at 10 °C flow temperature		
d/D (mm)	d160/250	d225/315
F (kN)	9.37	18.18*
L (mm)	3400	3700

Fixpoint forces F and maximal pipe bracket spacing L at 5°C flow temperature		
d/D (mm)	d160/250	d225/315
F (kN)	12.95*	25.14*
L (mm)	3400	3700

* max allowed force for COOL-FIT fixed point exceeded

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

3.4.13 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

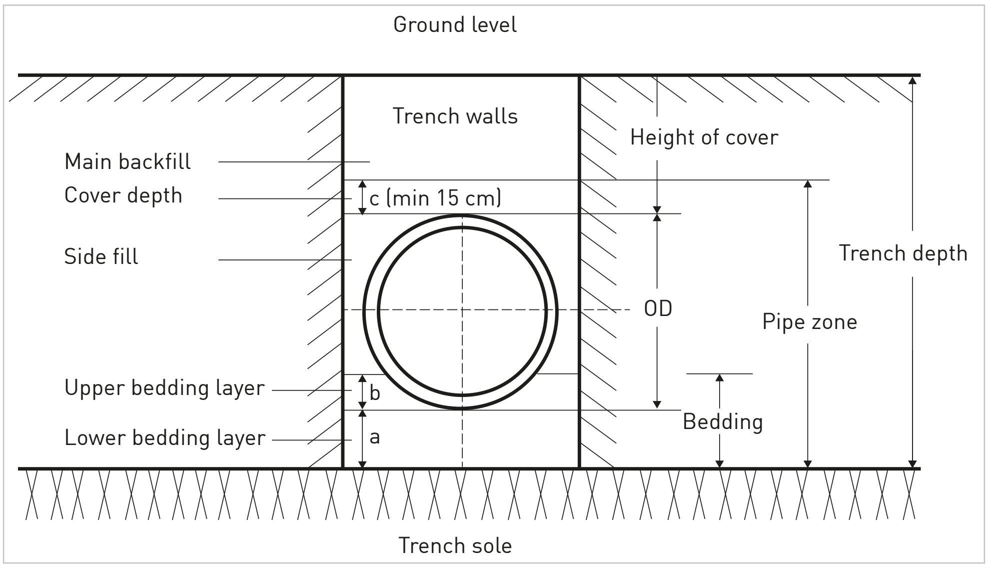
- Store in a cool, dry and dust-free area; avoid direct sunlight or ultraviolet irradiation; protect from nearby heat sources. Piping must not come into contact with substances that can cause damage.
- Hoses and hose assemblies must be stored horizontally, free of tension or bending forces.

Maintenance

We recommend a regular visual inspection of the hose line in case of high temperature fluctuations.

3.4.14 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.

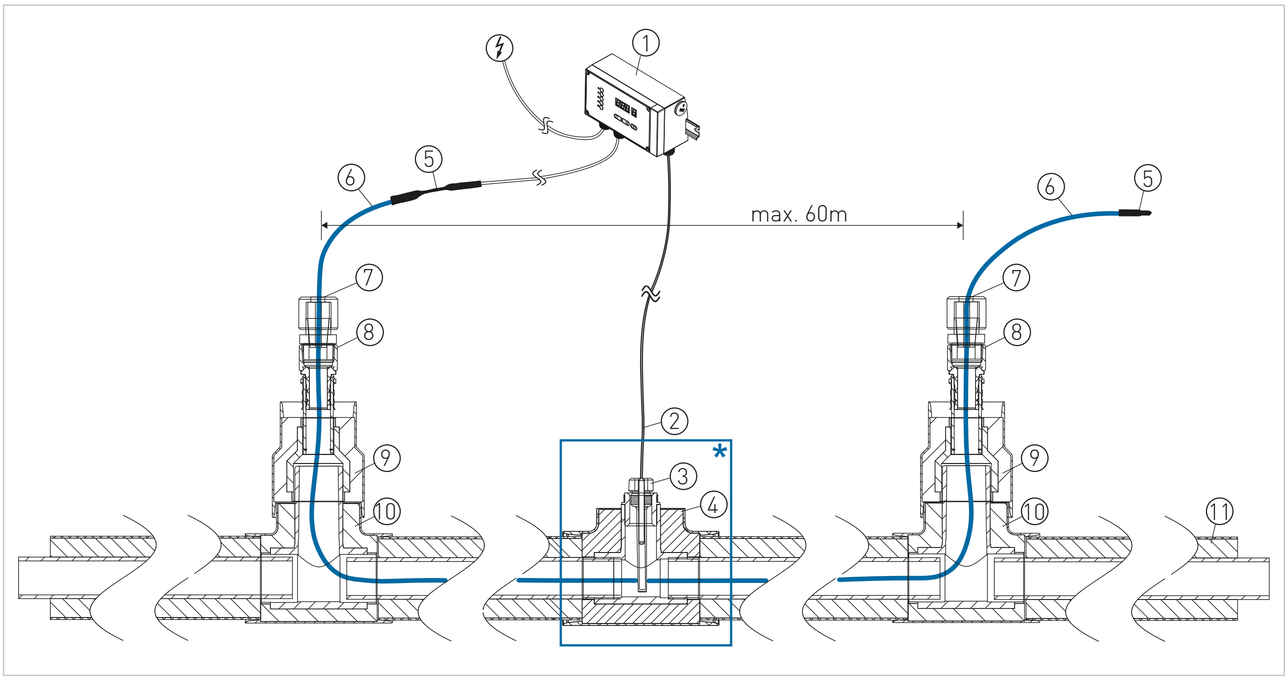
No building materials with components exceeding the following ranges may be used:
- 22 mm for DN ≤ 200

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.

3.4.15 COOL-FIT 4.0 Heat Tracing Installation



No.	Designation	No.	Designation
①	Thermostat	⑦	Cable glands ¾“ male thread R
②	Temperature sensor	⑧	Adaptor fitting d32-¾“ female thread Rp
③	Immersion sleeve for sensor*	⑨	COOL-FIT 4.0 Reducer to d32
④	COOL-FIT 4.0 Installation fitting ½“ Rp*	⑩	COOL-FIT 4.0 T90°
⑤	Cold lead connection and end seal kit	⑪	COOL-FIT 4.0 pipe
⑥	Heating cable		

Components installation

General notes:

Installation instructions included in the kit must be followed, including those for preparation of the heating cable conductors for connections. Before assembly, use the guide given in the instructions to ensure that the kit is correct for the heating cable and environment.

▶ Self-regulating and power-limiting heating cables are parallel circuit design. Do not twist the conductors together as this will result in a short circuit.

Components required

For the installation of all components refer to the relevant component installation instructions.
Required for each heating cable run:

- Cold lead connection and end seal kit
- Cable entry and exit
- Fittings for inlet and outlet

Required for the installation of the temperature sensor of each thermostat (for control via the media temperature):

- COOL-FIT 4.0 Installation fitting ½“ Rp
- Immersion sleeve for PT sensor

Procedure

- Insert the heat tracing cable into the inner pipe during installation of the piping components and out again at the end of the heating circuit. If there are more than 2 changes in the direction of the pipe equipped with the heating tape, the use of a suitable lubricant is recommended for simpler installation.
- Note that the heating cable must not be routed through the inside of valves. If using COOL-FIT valves, the cable must be routed outwards on both sides of the valve end.

Thermostats and control systems

- Follow the installation instructions supplied with the thermostat or control. Use the proper wiring diagram for for the heating cable layout and control method desired.
- After switching on the heating cable, the cable ends must be warm after 5 to 10 minutes.

* For the freezer protection on pipe sections, for each pipe dimension a separate heating circle with temperature sensor is recommended.

3.4.16 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 GF Piping Systems representative or visit www.gfps.com

3.5 Jointing and Installation

3.5.1 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

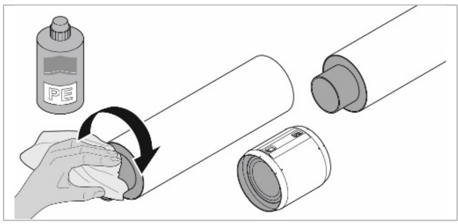
If necessary, prepare the pipe for fusion joints using the Foam removal tool (foam removal, cutting the jacket and peeling the media pipe) and check afterwards that the shaving thickness is 0.2 – 0.4 mm and that the minimum permissible external diameter after peeling is met:

- **COOL-FIT 4.0 already factory-set free pipe ends, 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.**

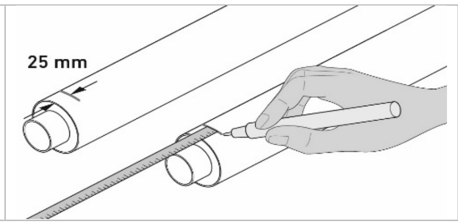
Minimum permitted pipe external diameter after peeling for COOL-FIT 4.0

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

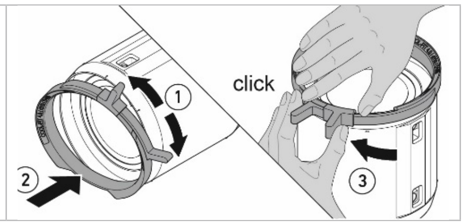
2 Cleaning and installation for welding preparation



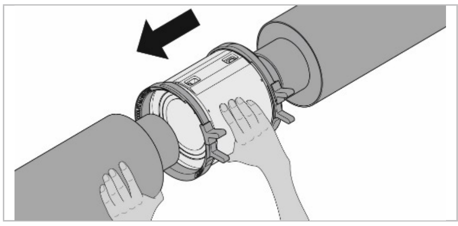
Step 1
Clean the fusion area of the components with Henkel Tangit PE cleaner and lintfree colourless and clean cloth in circum-ferential direction.



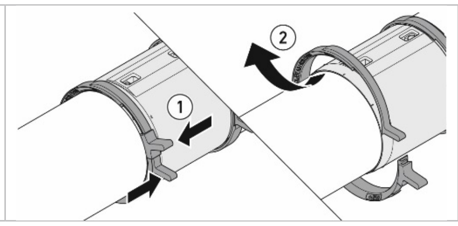
Step 2
Mark the jacket pipe at a distance of 25 mm



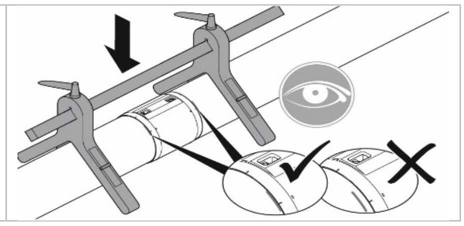
Step 3
Mount the assembly aids on the sealing lips of the COOL-FIT 4.0 fitting



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

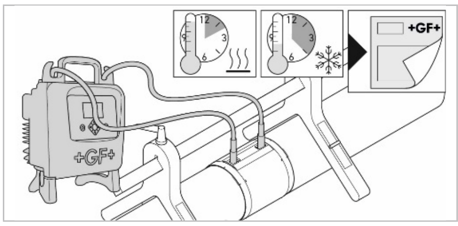


Step 5
Remove the assembly aids

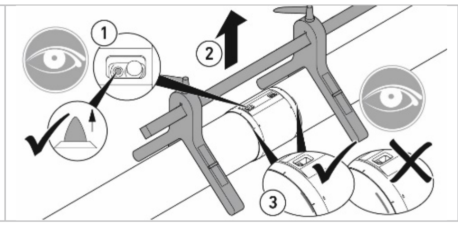


Step 6
Take care for low stress installation and secure the pipe and fitting against dislocation. Check insertions depths of both pipe into the fitting

3 Fusion process

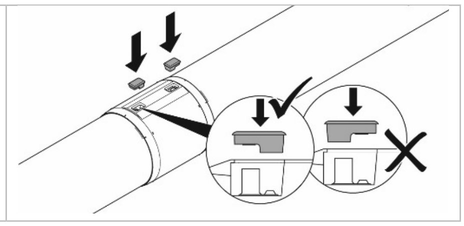


Step 1
Fuse in accordance to the operating instructions of the fusion unit. Use long fusion adaptors (790128035). Pay attention to fusion and cooling time.

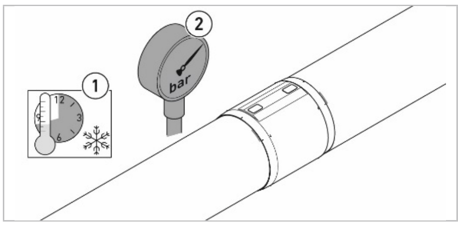


Step 2
After fusion, check fusion indicators on the electrofusion fitting and note the messages on the display of the electro-fusion machine.
Mark the fitting with following informa-tion
- Date
- Welder/ Weld number
- Time at the end of cooling time

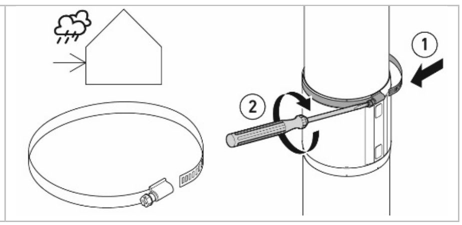
Remove the clamping tool after cooling time



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



Step 4
After cooling perform pressure tests as per table.

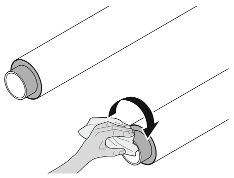
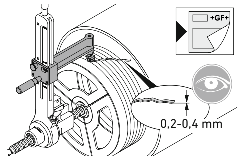
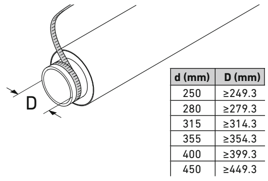


Step 5 (optional)
For vertical installations outside, mount sealing clamps tightly at the top lip of the fitting.
Alternatively to sealing clamps, sealing tapes, 25 mm width can be mounted underneath the top lip of the fittings.

Jointing d250 – d450

Hint: Factory-set free pipe ends at pipe and fittings type B have to be peeled for jointing before.

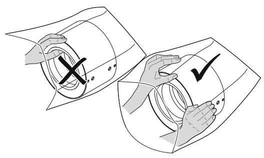
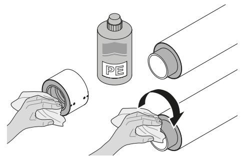
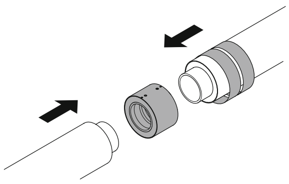
1 Preparation

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.	Peel the media pipe as well as the fittings type B with the peeler, if not already done with foam removal. Observe min. peel removal of 0.2 to 0.4mm.	Check the pipe outer diameter before and after peeling with a circumferential measuring tape.

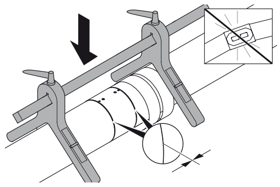
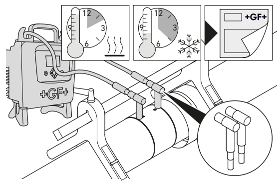
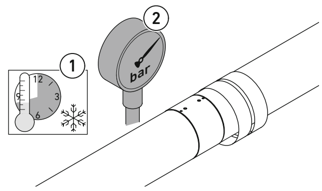
Overview of pipe outer diameter and open spigot length

Dimension (mm)	Minimum permissible pipe outer diameter after peeling (mm)	Factory-set spigot length (mm)
d250	249.3	120-126
d280	279.3	123-129
d315	314.3	129-137
d355	354.3	144-152
d400	399.3	145-155
d450	449.3	160-170

2 Cleaning and installation

Step 1	Step 2	Step 3
		
Unpack the coupler. Pay attention that you don't touch the inner surface of the coupler.	Clean fusion area of the electrofusion coupler, the pipe and as well of the fittings type B with Tangit PE cleaner and lint-free cloth and allow to air out.	Slide on the shrink sockets and afterwards the electrofusion coupler up to the insulation without touching the fusion area.

3 Fusion process

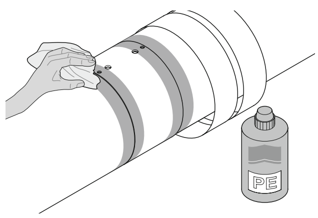
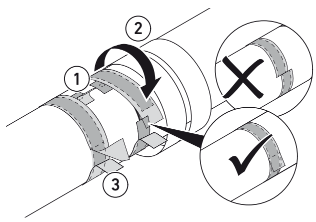
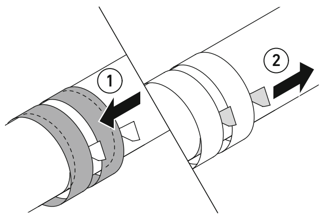
Step 1	Step 2	Step 3
		
Take care for low stress installation and secure the pipe and fitting against dislocation. There must be no gap between coupler and pipes.	Fuse in accordance to the operating instructions of the fusion unit. Use long fusion adaptors (790128035). Pay attention to fusion and cooling time.	After cooling perform pressure tests as per table.

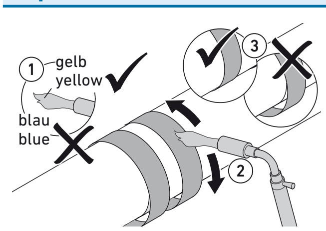
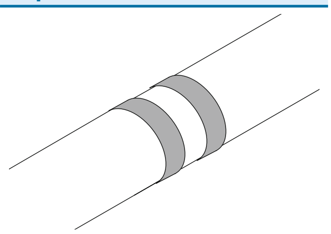
Cooling times before removing clamping tool and pressure/leak testing

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)	Cooling time before internal pressure test at ≤ 11 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	12	8
225	45	90	12	9.5
250	30	90	12	9.5
280	30	90	12	9.5
315	30	90	12	9.5
355	60	100	12	9.5
400	75	110	12	9.5
450	75	125	12	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.

4 Sealing

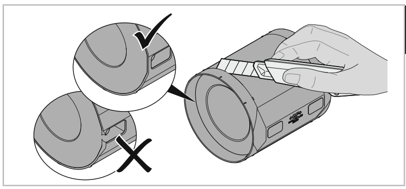
Step 1	Step 2	Step 3
		
Clean the pipe/fitting type B and partially the coupler over the gap with Tangit PE cleaner.	Affix the sealing tape centered over the gap and overlap it at the end. Press it on well and smooth out folds.	Position the shrink socket centered over the sealing tape, than remove the white separating tape.

Step 4	Step 5
	
The yellow flame of the gas burner or hot-air stream must strike the shrink socket as vertically as possible. Avoid applying unnecessary heat to the fitting.	The jointing is now finished.

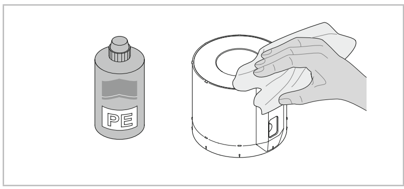
Valves and flange joints

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

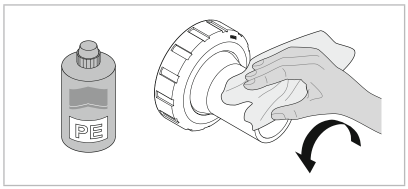
1



2



3

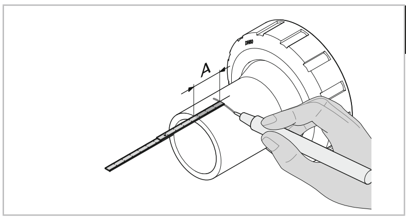


For the jointing to a valve or flange adaptor, the sealing lip of the fitting has to be removed at the valve or flange adaptor side and sealing and fusion surfaces have to be cleaned.

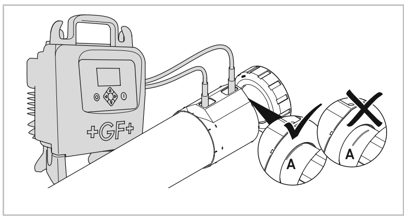
2 Standard fusion

Fuse both valve ends without valve mounted.

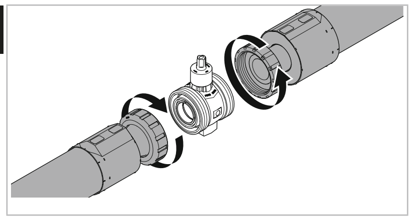
4



5



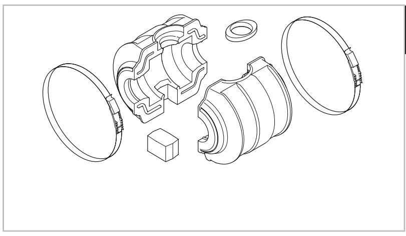
6



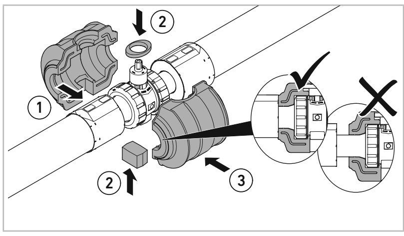
Following insertion depths A are valid for COOL-FIT 4.0 components:

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

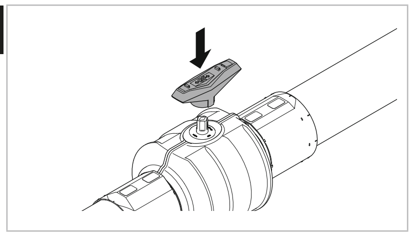
3 Mounting the valve/flange insulation



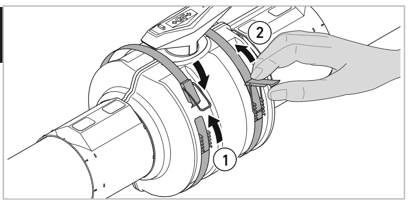
7



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.

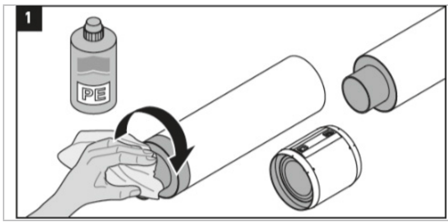
For compact fitting-to-fitting joints, COOL-FIT 4.0 barrel nipple can be used.

- **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.

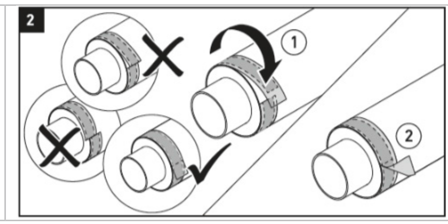
d	d75	d90	d110	d160	d225
L (mm)	165	186	216	270	330

L: Length of un-insulated PE100 SDR11 pipe needed

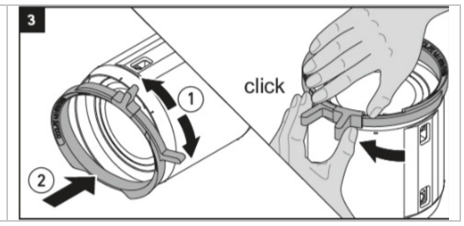
Mounting of sealing tape and transition of insulation



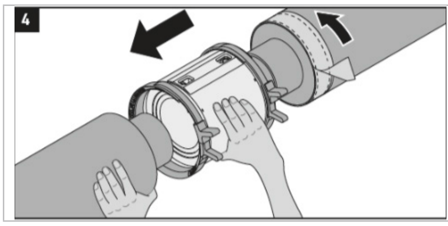
Step 1
In addition to the fusion zone, also clean the jacket of the pipe



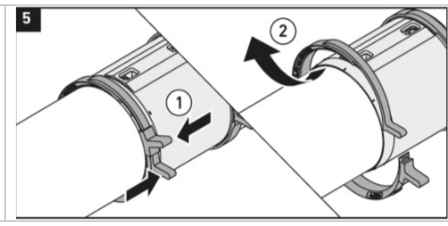
Step 2
Mount sealing tape/ transition of insulation, end to end without offset and fold down liner



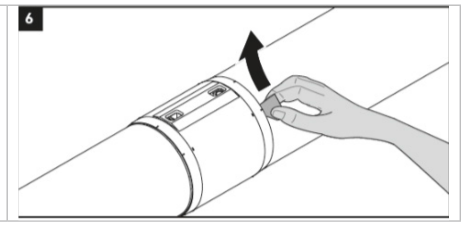
Step 3
Mount the assembly aids on the sealing lips of the COOL-FIT 4.0 fitting



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



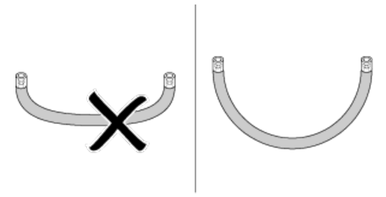
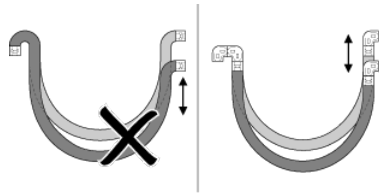
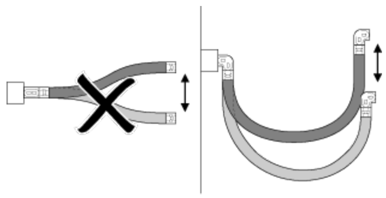
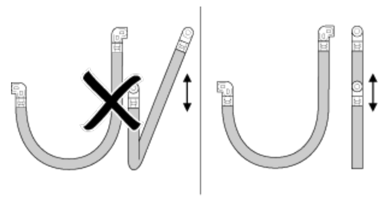
Step 5
Remove the assembly aids

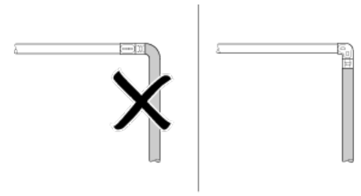
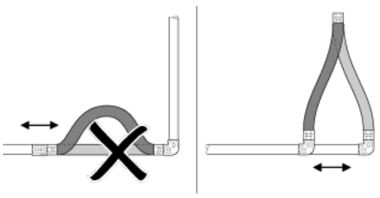
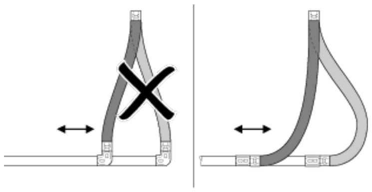
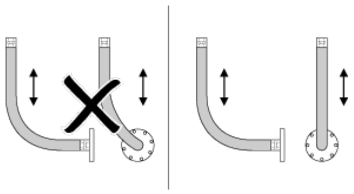
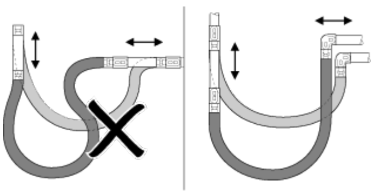


Step 6
Pull off the liner after removal of assembly aids

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 flexible hoses

The length of the insulation of flexible hoses enabels a direct jointing at the face of the electrofusion fitting.

The radial jointing of the jointing face of the EPDM 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/m².

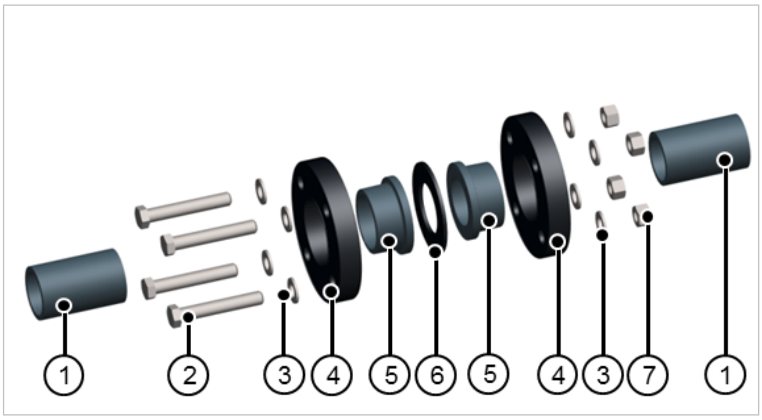
The open joint time is about 3 to 15 minutes depending on temperature and humidity of air.

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 higher 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

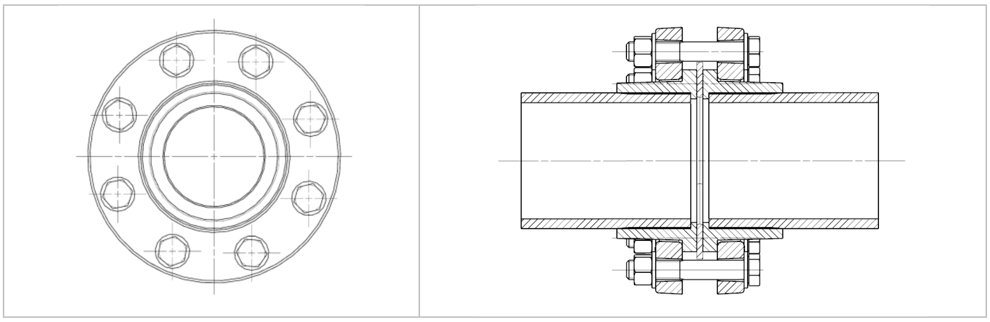
Flange	Properties
PP-steel flange	• Very robust and stiff due to the steel inlay • Corrosion-free plastic flange made of polypropylene PP-GF30 (fiber-glass reinforced) with steel inlay • High chemical resistance (hydrolysis-resistant) • UV-stabilized

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.

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

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

V

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.

Bolt tightening torque guidelines for ISO flange connections

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

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.

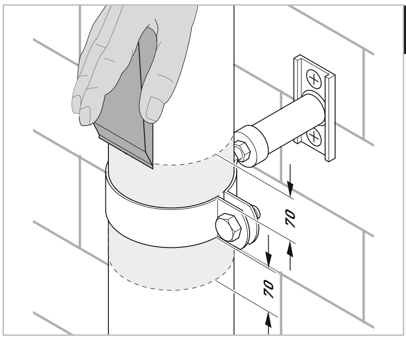
On installing Installation fittings in horizontal piping systems, the sensors should be in 1 – 5 or 7 – 11 clock position.

⚠ 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

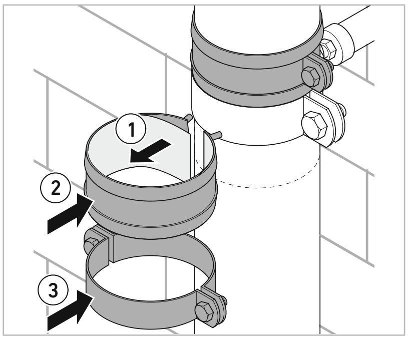
The COOL-FIT piping system must me mounted in final position in the regular fixpoint clamp.

1



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

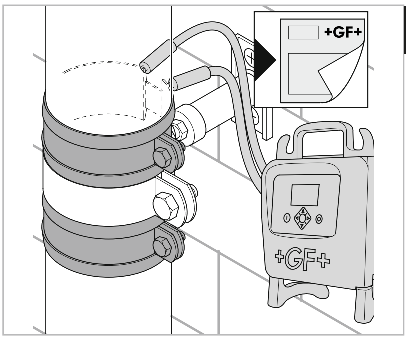
2



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.

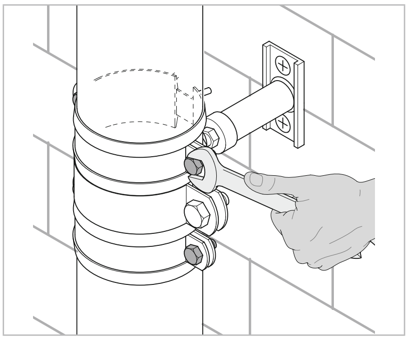
Note: The necessary welding pressure on the clean and dry COOL-FIT pipe is achieved by tightening the pipe clips. Take care that between fixed point clip and weld band there are no visible holes.

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.

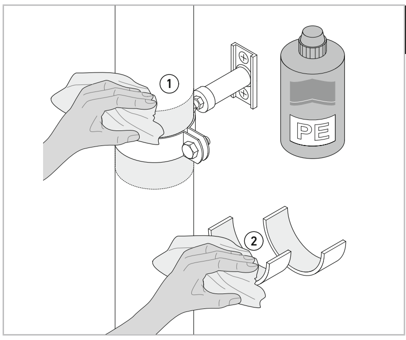
4



Step 4
Retighten the pipe clips after 10 minutes

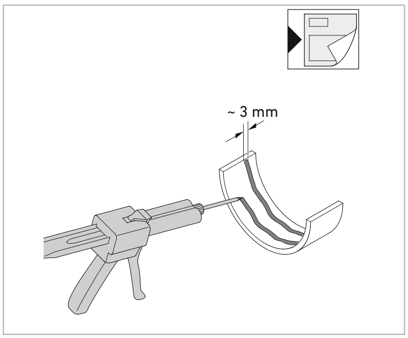
Installation of COOL-FIT 4.0F fixed points

1



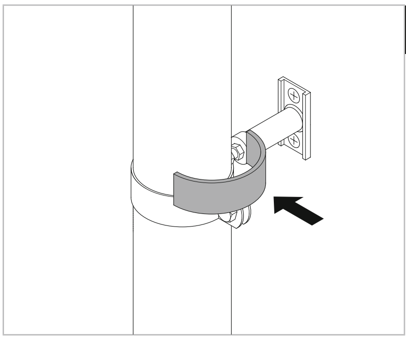
Step 1
Clean the cementing area on the pipe and the components with Tangit PE cleaner and lintfree colourless and clean cloth in circumferential direction.

2



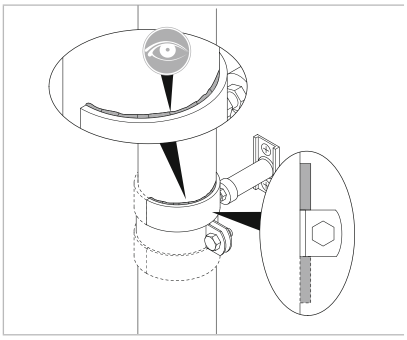
Step 2
Place the Tagit RAPID in about 3mm stripes on the inner side of the fixed point set half shells.

3



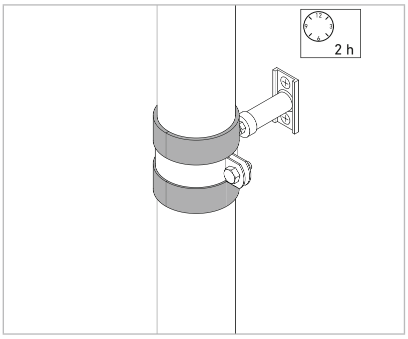
Step 3
Cement the half shelfs on the pipe next to the pipe clamp.

4



Step 4
Check the cementing and ensure the fixed point half shells are next to the pipe clamp.

5



Step 5
Let the fixed point dry for minimum 2 hours.

3.5.2 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).

3.5.3 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 • $P_{p\,(perm)}$	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")	$\leq P_{p\,(perm)}$	$\leq 0.85\ P_{p\,(perm)}$
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.

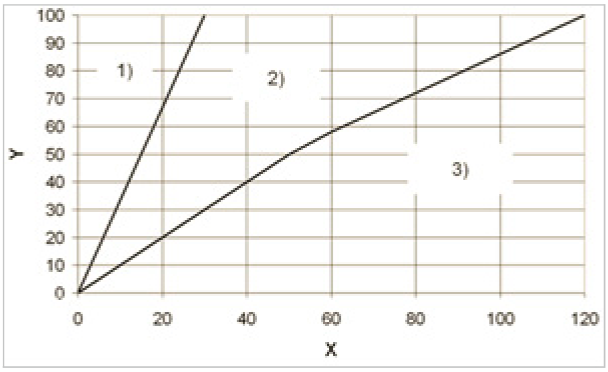
Reference values for the filling volume are given in the table below:

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

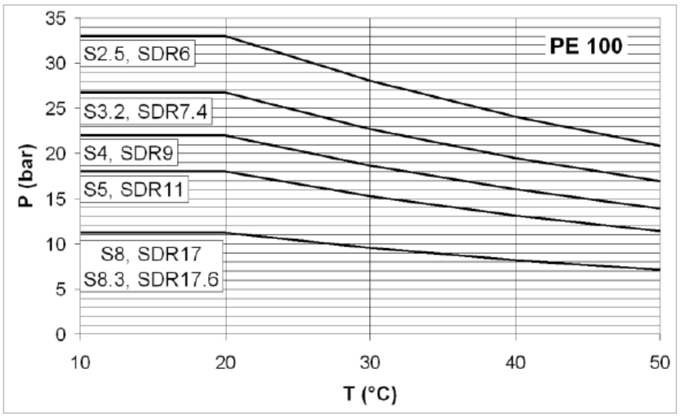
The permissible test pressure is calculated using the following formula:

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

$\sigma_{v(T,\,100\,h)}$ 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

3.5.4 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

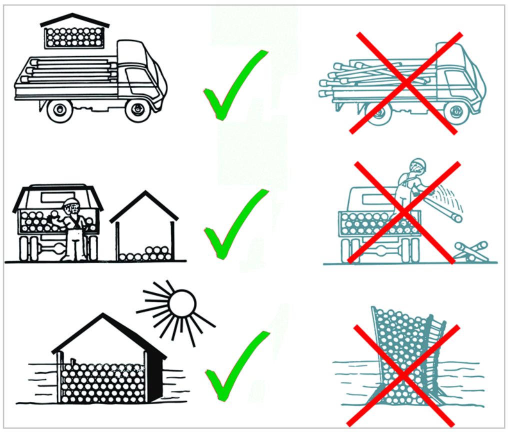
3.6 Transport, Handling and Storage

3.6.1 Transport

On trucks/in crates, manual transport

3.6.2 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.



3.7 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.

i For more information at www.coolfit.georgfischer.com

Index

A

A

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