

Industry
Design and Installation

Plan, Build, Operate

Planning Fundamentals

Industrial Piping Systems
Design and Installation

+GF+

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Planning Fundamentals

Industrial Piping Systems

Planning Fundamentals

Industrial Piping Systems

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Preface

GF Industry & Infrastructure Flow Solutions 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 Industry & Infrastructure Flow Solutions in its mission to delivering more value to customers, through superior piping systems.

Schaffhausen, 09/2026

Introduction

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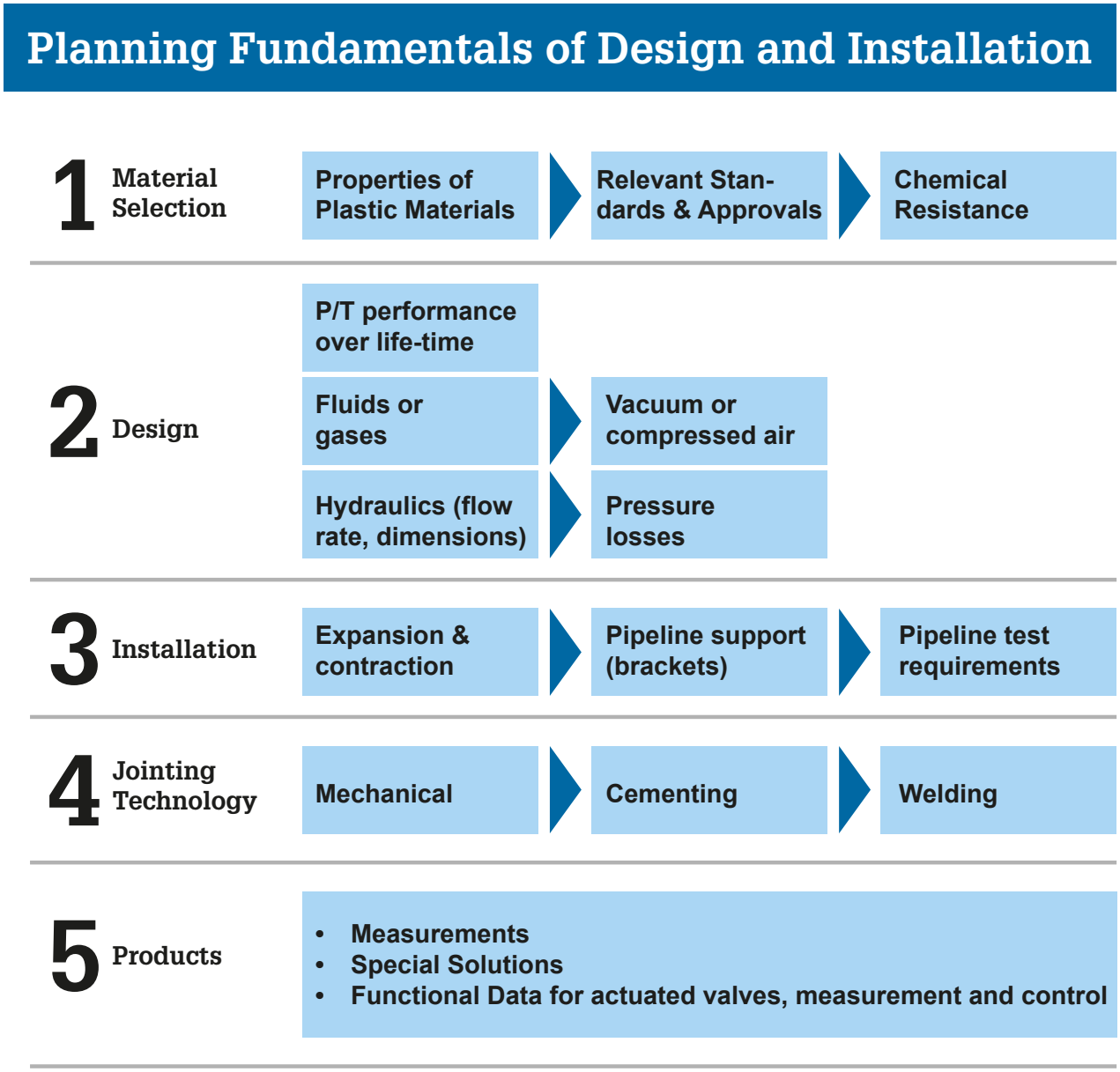
1 How to use

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

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

2 GF Industry & Infrastructure Flow Solutions

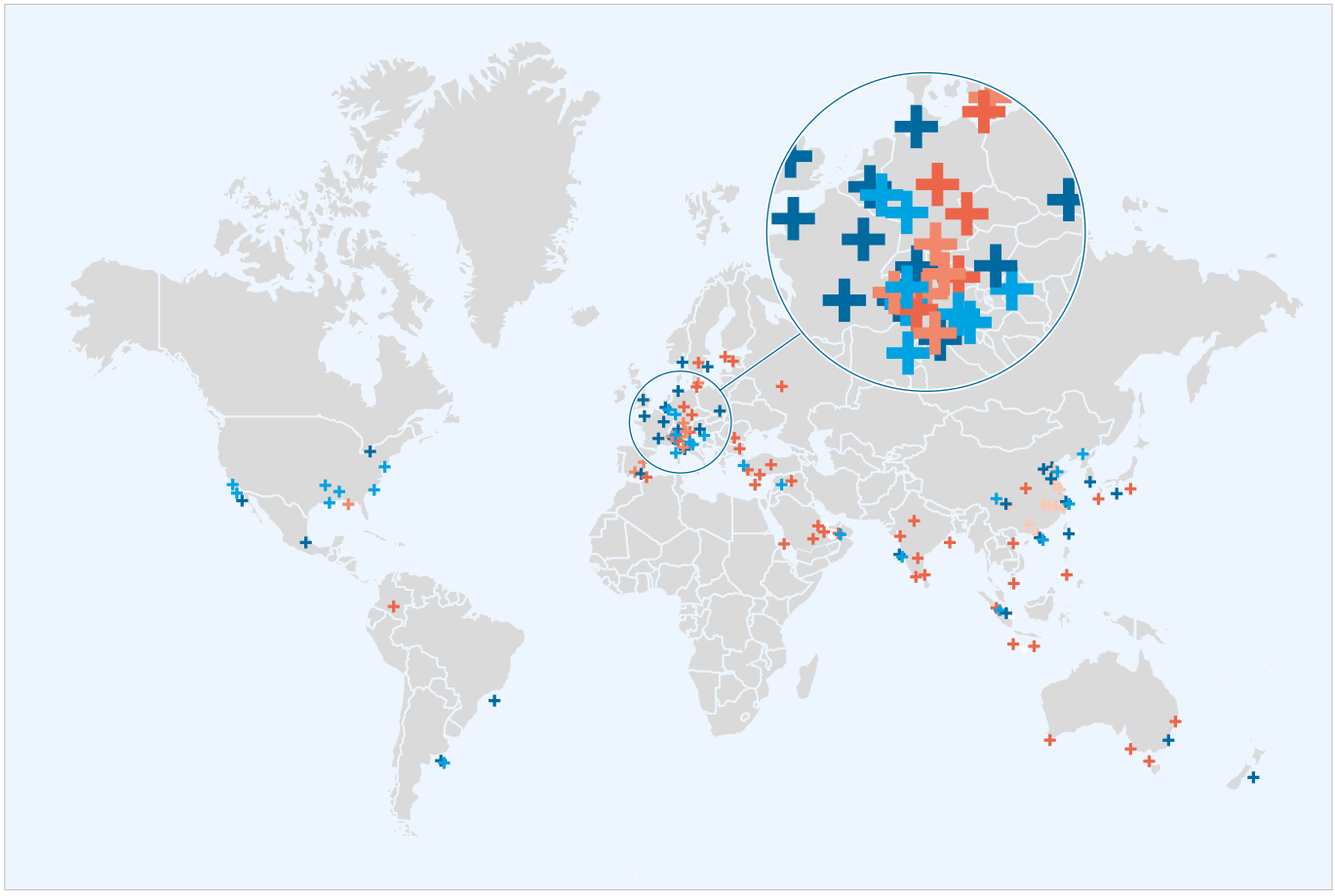
2.1 Global presence

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 Industry & Infrastructure Flow Solutions specialists are always close by.

2.2 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.



3 Quality

3.1 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 Industry & Infrastructure Flow Solutions 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.

3.2 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 Industry & Infrastructure Flow Solutions 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.

3.3 Accredited test center

The test center of GF Industry & Infrastructure Flow Solutions 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.

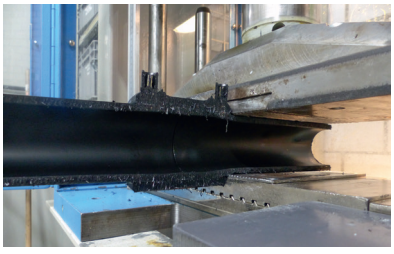
STS 094

Customers for test laboratory programs are the R&D departments, manufacturing plants, as well as end-users of GF Industry & Infrastructure Flow Solutions 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.



4 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.

4.1 Environment

For GF Industry & Infrastructure Flow Solutions, 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.

4.2 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 Industry & Infrastructure Flow Solutions operates with this responsibility as its premise. With locations in over 30 countries, GF Industry & Infrastructure Flow Solutions 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 Industry & Infrastructure Flow Solutions throughout the world.

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

5 Specialized Solutions

5.1 Condition Analysis

Partners in Project Execution



Integrity of a piping system is essential for owner/operators of water, gas and chemical process plants. GF Industry & Infrastructure Flow Solutions specialists can checkup welds on the field or inspect samples in our state of the art accredited materials testing laboratory offering a ‚Fit for Service' certification via microscopic analysis, visual inspections and practical testing. This attention to detail enables informed decisions throughout a project's operation. Performance assured, for your peace of mind.

Resolve threats to your assets

Receive the necessary information to make informed decisions during the design, operation and maintenance of your installation.

A proven supplier and a name you can trust

We are plastic piping application specialists with 60+ years of experience.

When integrity of the piping is essential

We ensure constant operation for water, gas and chemical applications.

Peace of mind

Samples are inspected in our state-of-the-art testing laboratory.

5.2 Digital Libraries

Partners in Project Execution



The libraries cover three key areas for the design, creation, and maintenance of a project: Building Information Modeling, the Plant Design Software, and the CAD Library, helping you reduce costs and construction times.

Optimization for operations

Reduce facility downtime and support environmental, quality and safety regulations.

The perfect start

Reduce time and effort while ensuring design accuracy and integrity.

Supply chains that deliver

Lean supply chain activities and elimination of shortages and surpluses.

Streamline processes

Efficient planning and implementation of installation.

The libraries cover three key areas. BIM - offering a process to design, coordinate, create and maintain a project with the use of an intelligent 3D model. This tool makes it possible for everyone in a project to understand a building through the use of a digital model. Plant design software provides the equipment for creating an entire plant design, but also allows the modelling of equipment, structures and communications with accuracy and confidence. The CAD library delivers the basis for the above, comprising over 25'000 drawings and technical data on pipes, fittings, measurement and control technology, as well as manual and actuated valves.

GF Industry & Infrastructure Flow Solutions is continuously developing digital libraries with all of our product design drawings. Our files are fully compatible with Autodesk Revit, AVEVA, Intergraph, Autodesk AutoCAD Plant 3D and Trimble SketchUp with 3Skeng to provide proper engineering design tools used by planners, architects, owners and operators for BIM and Plant Design.

5.3 Pre-fabrication and Custom Product Design

Partners in Project Execution

Having your individual needs and application in focus, our customizing teams forge the solution that fits you best, developing custom-made parts to complete systems or special solutions produced in small series, individual consulting and off-site prefabrication. Through our global network of flexible locations, we offer a wide range of comprehensive solutions. Tailored innovation, inspired by you.



Higher quality and consistency

Provide a long-term high-quality solution preventing downtimes. Ultrasonic NDT can be used to further prevent the cost of non-quality.

Labor advantages to saving time

Shortens the time of on-site installation and allows flexibility to build in areas with local shortages or skilled expensive labor.

First class quality ensured

Develop tailor-made factory tested products that comply with your standard and market regulations.

Global one-stop shopping

Reduce interfaces and friction with suppliers.

With the help of our customizing teams, we develop the precise solution that suits you best. GF Industry & Infrastructure Flow Solutions delivers the creative solution for your challenge, from the first briefing via design, manufacture and testing, up to delivery. Based on a customer's specific needs, we can customize parts from the product library to ideally suit an application.

Helping speed up site work activities by prefabricating systems and standard products, including complete modules and installation sections offsite and delivering them directly to the place of use. With prefabrication workshops situated around the globe, customers not only save costs and time, but also increase their system reliability with proven and certified GF Industry & Infrastructure Flow Solutions quality.

5.4 Proposal and Detail Engineering

Partners in Project Execution



Increase the efficiency of your project with the tailor-made analysis packages from GF Industry & Infrastructure Flow Solutions and decide which offer is right for you according to your needs. You have the choice between Project Analysis and Advanced Engineering, thus always receiving the appropriate support in every phase of your project. Established knowledge, guiding you through.

Effective personnel deployment

External plastic systems specialists can be added to a customer team –target-oriented for the duration of the project.

Faster project implementation

Thanks to years of experience, complex calculations and planning are carried out quickly and reliably.

Durable, safe and reliable investment

Piping system delivery of the highest quality, selected by experts.

Minimized project risks

Diminish incorrect calculations, improper design or wrong material selection due to ignorance or lack of experience.

Starting at the front end of a project, GF Industry & Infrastructure Flow Solutions supports engineering and designing to ensure a sustainable and efficient solution is available. Our competence in all applications and proven references throughout the entire product range ensures the highest quality of management during project planning and execution.

The name of the game is to prevent design errors from happening. This is where GF Industry & Infrastructure Flow Solutions specialists can bring tremendous value, by accounting for the specificity of piping systems design. An even more specific science within this focus lies in the peculiarities of plastics. Would you for instance not calculate with both short term and long term E-modulus, design errors would not only be possible but probable. If the devil is in the details, you certainly don't want to miss a chance to have our dedicated engineering team take a close look at the design and calculations of your piping system.

Modular Solutions

GF Industry & Infrastructure Flow Solutions offers a choice of tailor-made analysis packages in order to increase the efficiency of a project. Project Analysis covers a basic analysis of the piping system and recommendations based on the technical manuals for up to four hours per project. Advanced Engineering provides a Comprehensive analysis and planning support for applications with particularly challenging and demanding environments.

6 Global Academy

About GF Industry & Infrastructure Flow Solutions Global Academy

The Global Academy provides a unique opportunity for professionals to enhance their skills, advance in their careers, and become certified in the latest industry techniques and standards. With a focus on providing technical training, the academy aims to help these professionals keep pace with the rapidly evolving world of plastic piping systems and stay competitive in the labor market. By becoming certified through the academy, our graduates demonstrate a commitment to excellence, increase their marketability, and provide greater value to their clients.

Advantages for everyone

Owners



Ensure the operation of your sites run smoothly and efficiently. Provide professionals in charge of your piping systems with the critical skills to install, maintain, and repair equipment properly - preventing downtime and maximizing production.

Design Engineers



Gain in-depth knowledge and advanced skills for designing plastic piping systems for various customer applications - enabling you to secure a long-lasting service life for your customers.

QA/QC Inspectors



Stay up-to-date with industry standards and practices, as well as the latest tools and techniques on the design and installation of plastic piping systems. Gain the skills you need to effectively monitor the quality of your applications, identify and resolve issues, and ensure you meet customer requirements.

Installers



Boost your career by certifying your professional skills. Every day, project managers and owners are investing more in skilled professionals for the installation, maintenance, and operation of their plastic piping systems, as it is crucial for the success and longevity of any industrial plant or distribution network.

Certification



Upon successful completion of all steps, learners will be awarded a certificate by the Global Academy. There are several levels of certification available in each field of study, with different validity periods depending on the technology. Our certificates are recognized globally and are even required by some of the most prominent organizations in certain industries.

Industries

of GF Industry & Infrastructure Flow Solutions

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1 Introduction

1.1 System and Product Solutions

GF Industry & Infrastructure Flow Solutions 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.

1.2 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

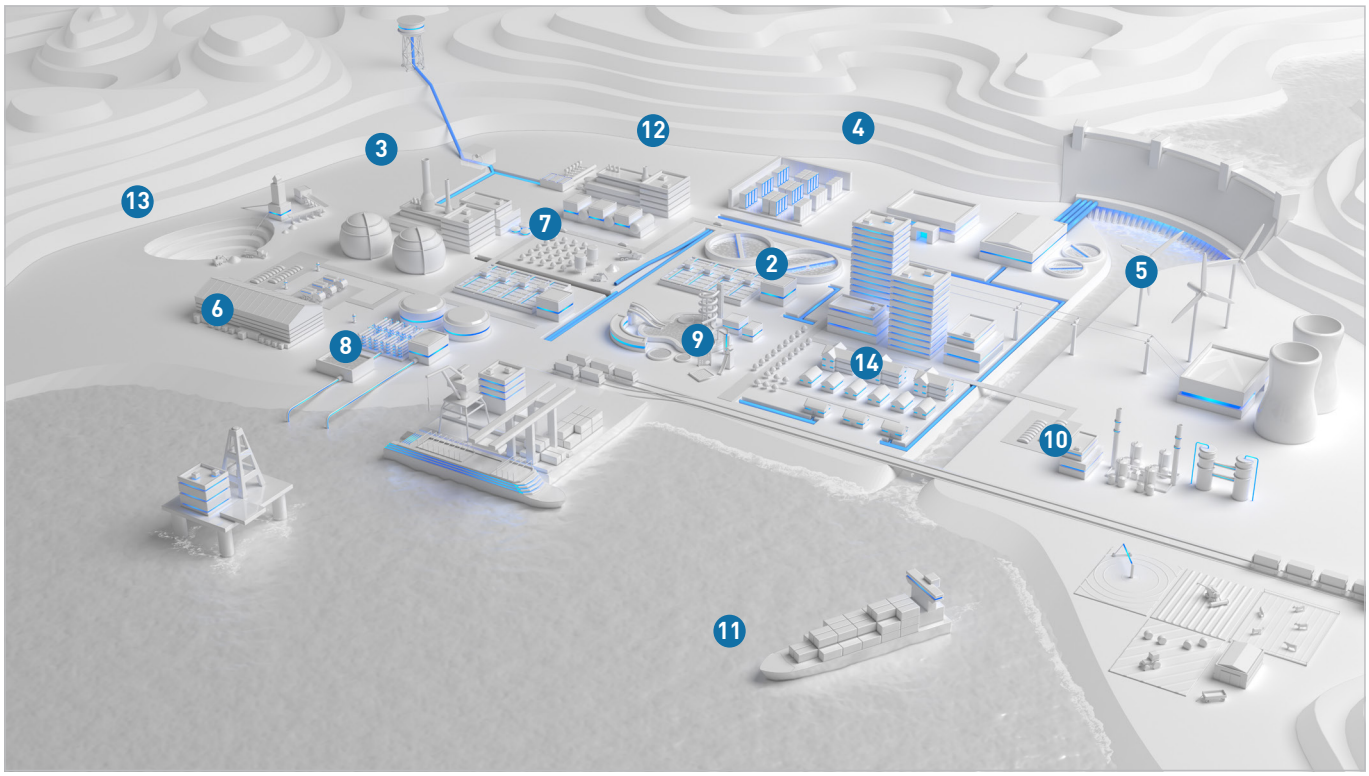
Complete solutions

- 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

High quality

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

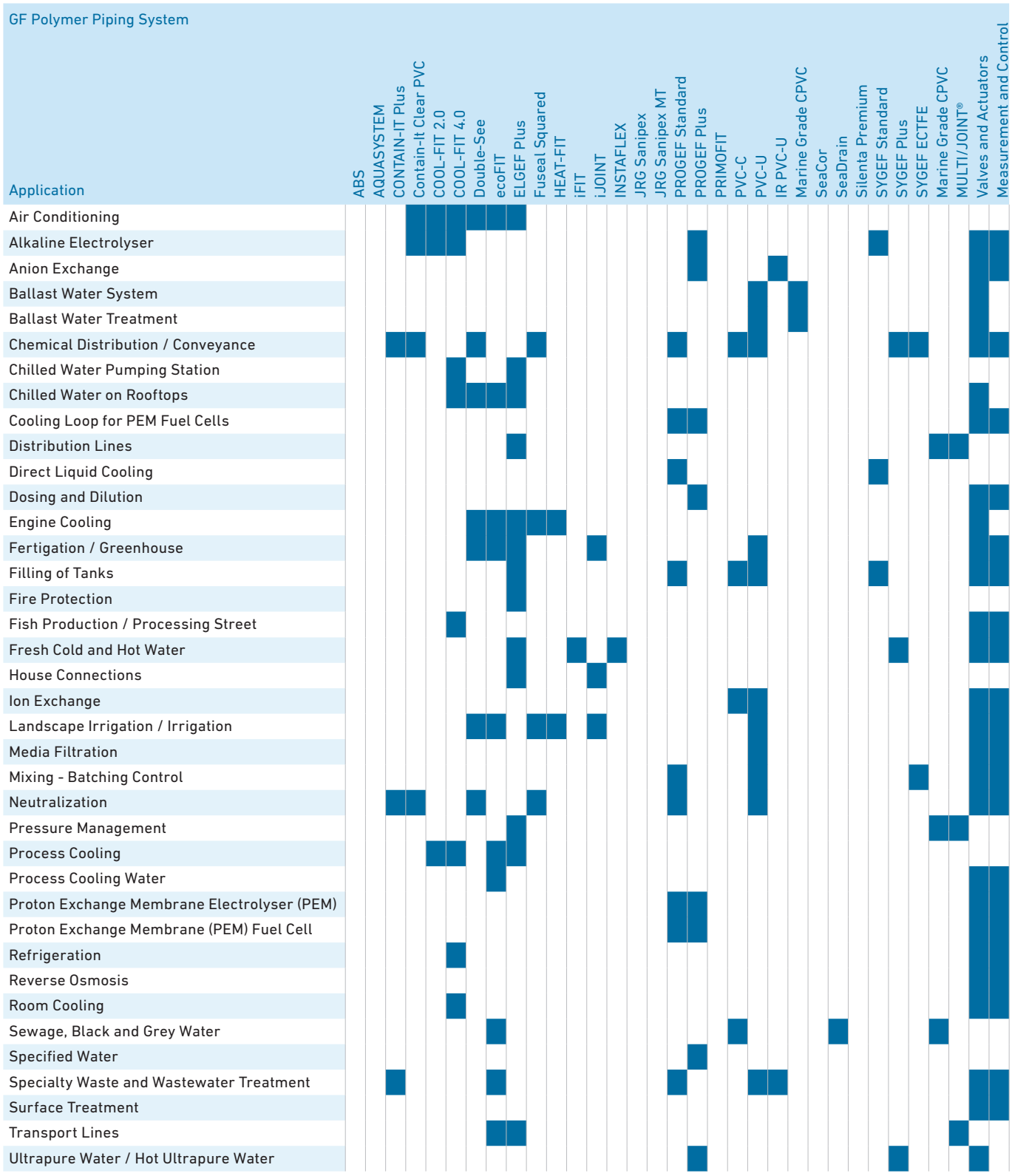
1.3 Industries Overview



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1.4 Applications for GF Polymer Piping Systems



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

2 Battery Production



With more than 60 years of experience in plastic piping systems, GF Industry & Infrastructure Flow Solutions supports the battery production and recycling industry's efforts to build the most sustainably managed factories worldwide. Our global teams developed application-oriented plastic piping solutions that are a corrosion-free alternative to traditional metal solutions. High-performance, lightweight thermoplastics, prefabrication capabilities, expertise, and speed of delivery enable performance beyond expectations.

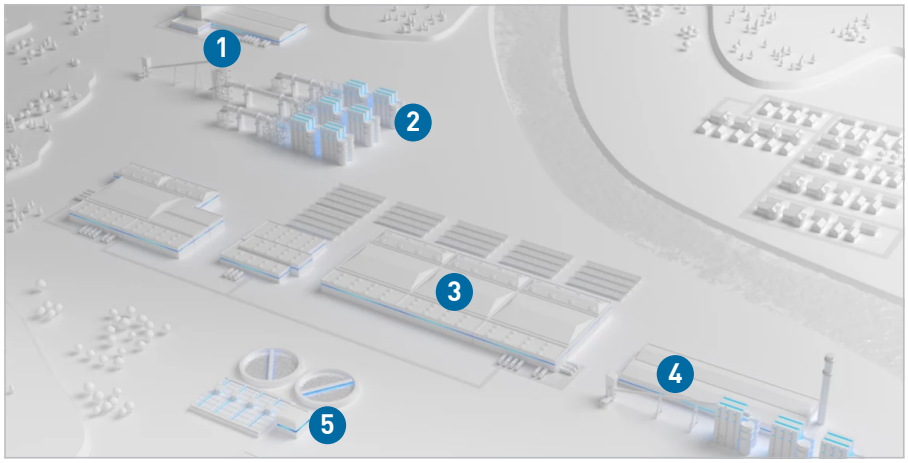


Main GF Industry & Infrastructure Flow Solutions Benefits

+ **High Performance:** Durable, metal-free, ISO-certified piping.
+ **High Efficiency:** Pre-insulated solutions, lightweight materials with automation for reduced costs and improved media flow.
+ **Custom Design:** 3D libraries, engineering support, and prefabrication ensure tailored, efficient project execution.
+ **Global Reach:** Local support in 33 countries with 40 production sites for swift time-to-market.
+ **Sustainability:** Lightweight thermoplastics with low CO_2 impact, backed by Environmental Product Declarations.
+ **Long Service Life:** Corrosion- and maintenance-free systems with a 25+ year lifespan.
+ **Fast Installation:** Fast installation with electrofusion and advanced jointing methods, even in tight spaces.



Segments for Battery Production



1 Lithium extraction

Plastic piping systems and process automation capabilities help to safely and reliably transport water and chemicals in the demanding lithium extraction process. Measurement and control solutions help to improve the water quality and to guarantee the most efficient extraction process.

2 Material preparation

Material preparation requires precise control over various parameters, such as composition, purity, and particle size, to ensure consistent and reliable battery performance. Highquality plastic piping solutions are chemically resistant and can handle highly abrasive media and are corrosion-free, which makes them an all-round solution for complex material preparation processes.

3 Battery production

Assembly in lithium-ion battery production refers to the process of assembling the various components of a lithiumion battery to create the final product. In this process, reliable cooling systems are necessary. GF's piping systems are free of copper, zinc, and nickel and can be installed in any environment with open cell production where material deposition is a concern.

4 Battery recycling

In a market where material supply is critical, retrieving valuable metals and materials from used batteries is a critical step towards a clean circular economy. Plastic piping solutions have a reduced environmental impact compared to metal and help to pave the path toward a greener future production.

5 Water recycling

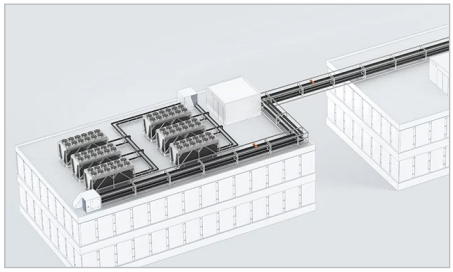
Water recycling is critical to sustainable battery production and demands new advanced treatments, such as membrane and physicochemical treatments. GF Industry & Infrastructure Flow Solutions' comprehensive offering is optimally adapted for improving water quality to reduce its impact on processes and the environment.

Application Examples



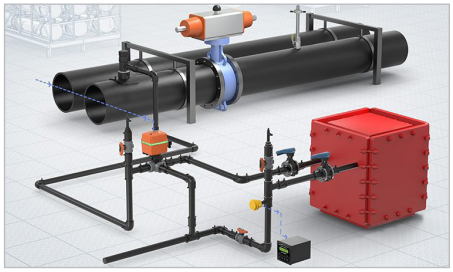
Cleanroom

We provide cutting-edge technology to meet the high, conditioned standards of battery cell production. Pre-insulated pipes, fittings, valves, and process automation help with a fast installation and maintenance-free operation in clean environments without compromising energy efficiency.



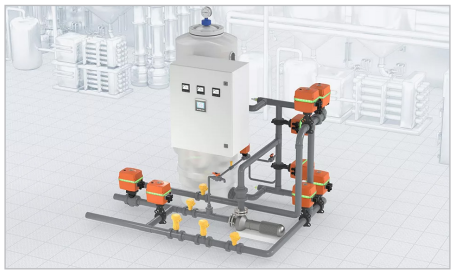
HVAC

GF Industry & Infrastructure Flow Solutions offers high-performance piping systems for distributing heated and chilled water in climatization applications that meet the latest building standards in terms of sustainability. When a shortage of space is an issue, jointing technologies like electrofusion ease the installation process.



Process cooling

The harsh environment in a production area makes insulation protection mandatory. COOL-FIT 4.0 from GF Industry & Infrastructure Flow Solutions optimizes any industrial refrigeration set-up. Choose corrosion-free plastic piping systems to avoid metal contamination in clean manufacturing areas and reduce heat loss.



Media Filtration

Media filtration is a water treatment process that can be used as a pre-treatment or polishing step in battery production applications. Due to the need for several flow processes, choosing appropriate piping systems, automated valves, and actuators and using adapted measurement and control techniques is important. Doing so will increase your productivity.



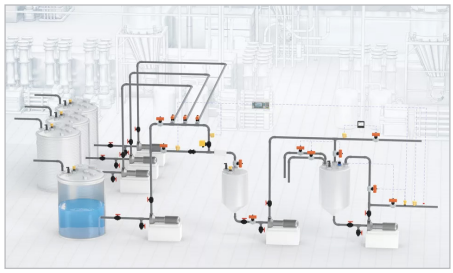
Ion Exchange

Water purification, separation, and decontamination are important in water and wastewater treatment areas. The compact construction of ion exchange plants requires flexible piping solutions and components. GF Industry & Infrastructure Flow Solutions provides complete solutions of high-quality piping systems warranting maximum flexibility while ensuring an entirely safe plant operation with maximum uptime.



Mixing – Batching control

When mixing a range of chemicals, batching is a cost-effective method to consider. In this process, each chemical line is equipped with an actuated valve and flow meter that are connected to a controller. By controlling the opening times of each line, the GF controller ensures an accurate mixture of chemicals based on a pre-determined recipe.



Dilution plant

Diluting chemicals requires highly specialized and reliable workflows, especially when working with aggressive media. With a selective combination of pressure control valves, actuators, flow meters, and control instrumentation, media flow is under constant control.

Leading GF Polymer Piping Systems

PVC-C system



Cemented system for applications in the temperature range of 0°C to 80°C

PVC-U system



Cemented system with excellent properties in the temperature range of 0°C to 60°C

COOL-FIT 2.0
Pre-insulated system



Pre-insulated, corrosion-free piping system for chilled water, ideal for diverse building applications

COOL-FIT 4.0
Pre-insulated system



Pre-insulated, corrosion-free piping system for commercial and industrial refrigeration setups

ecoFit I Industry
PE piping system



Polyethylene piping system for industrial use in water, wastewater, and chemical applications

SYGEF Plus
PVDF-HP High Purity



System with System with high mechanical and chemical resistance for high purity applications

SYGEF ECTFE



Ideal for highly concentrated media under high pressure and temparatures

PROGEF Standard
PP system



Unmatched chemical resistance and durability ensure reliable, cost-effective, high-performance solutions trusted industry-wide

PROGEF Plus
PP-H High Purity



Specified PP-H production and packaging, certified leach-out results, and LABS compliance ensure top quality and safety

Valves and Actuation



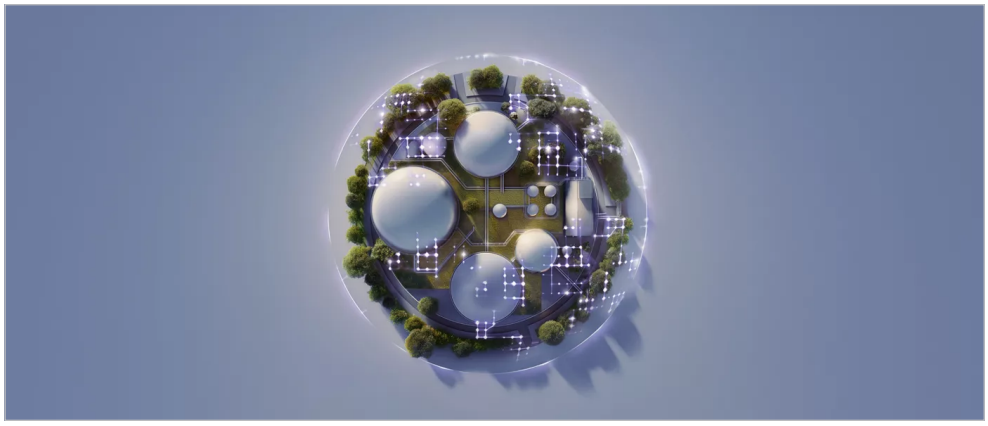
A wide range of valve types, with modular pneumatic and electric actuators and control units for automated industrial processes

Measurement and Control



Precision solutions for monitoring flow, pressure, temperature, and complete liquid analysis for optimal process control

3 Chemical Process Industry



The continuous improvement of plant performance, safety, and risk management, and the increasing pressure to meet environmental, social, and governance (ESG) targets are key for the chemical industry. Right and easy material compatibility is at the base of cost-effective processes. With our comprehensive portfolio of corrosion-free piping systems and solutions for process automation, including valves and measurement solutions, we empower our customers to achieve their business goals and redefine the chemical industry to achieve a sustainable future. Long-term partnerships with our customers enabled us to provide you with our current high-quality portfolio tailored to the needs of the chemical industry.

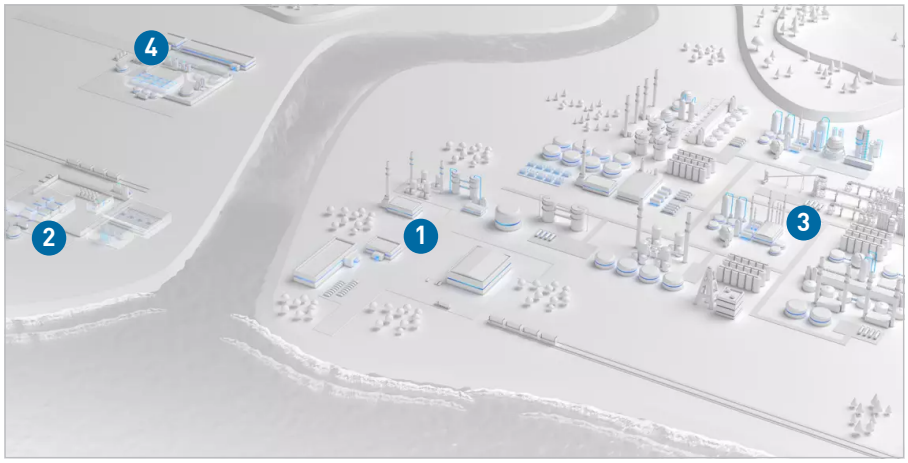


Main GF Industry & Infrastructure Flow Solutions Benefits

+ **Process Safety:** Corrosion-resistant systems for safe handling of hazardous chemicals, reducing leaks, spills, and maintenance costs over a 25+ year lifespan.
+ **Innovation & Technology:** Advanced, energy-efficient products with smart monitoring for real-time optimization and global support for rapid market access.
+ **Environmental Sustainability:** Long-lasting systems with full lifecycle support, minimizing waste and meeting strict industry regulations.
+ **Supply Chain Optimization:** Comprehensive engineering, prefabrication, and certification services, with local expertise and global availability to ensure regulatory compliance.



Segments for Chemical Process Industry



1 Chemical Production

The piping systems in chemical production are subjected to extreme conditions. Aggressive substances need to be transported and processed, which places high demands on the system solutions. In addition to being very reliable, these need to afford safety, efficiency, and maximum corrosion protection. Our pipings, valves, and measurement solutions are the preferred choice in key applications such as filling of tanks, dosing, and dilution, mixing batch control, distribution of chemicals, deionization, Ph neutralization, and fume scrubbing.

2 Chemical Distribution

Transporting chemicals from their storage place to the actual process application must be planned and carried out reliably and safely. For the components of the piping system this means the materials used must be one hundred percent compatible with the properties of the chemicals. For this subsegment we provide pipings, valves and measurement solutions for key applicaitons such us fillign of tanks, dilution, draw off, batch control and neutralization.

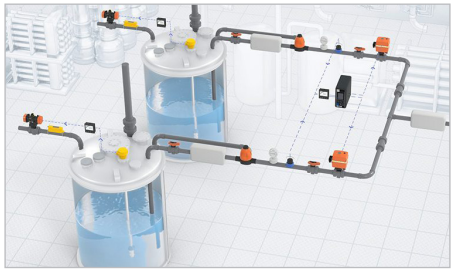
3 Petrochemical

The petrochemical industry is an industry branch that produces organic intermediate products such as refinery products, natural gas, plastic packaging, synthetic rubber, and fiber raw materials. Our pipings, valves, and measurement solutions are the preferred choice in applications such us the filling of tanks, chemical conveyance, process cooling water, demineralization and firefighting.

4 Wet Chemicals

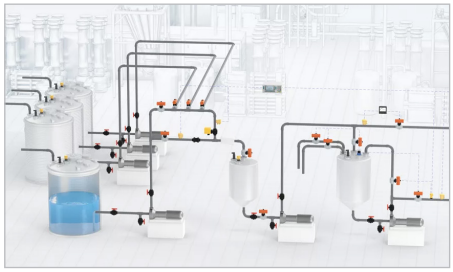
Wet Chemicals is a complex domain of the chemical industry. It comprises four steps: surface preparation, rinsing, electroplating and finishing. Corrosion is an important issue in this sector of industry. The highest level of quality and absolutely reliable products are demanded. Our piping systems, valves, and measurement solutions are durable and reliable.

Application Examples for Chemical Production



Mixing Ratio Control

The mixing of chemicals using a ration controller is a safe and highly cost effective method. Two process lines can be mixed in a static in-line mixer. The upper and lower lines are conveying different media, where ratio controller simply compares the flow rates of both lines to a present rate.



Dosing and Dilution

Dosing and diluting chemicals requires highly specialized and reliable workflows, especially with aggressive chemicals. Concentrated chemicals in small amounts are dosed inline or through a static mixer that ensures correct dilution.



Mixing Batching Control

In processes where a variety of chemicals are mixed, a cost effective way of doing this is batching. Here, each chemical line hs an actuated valve and flow meter wired to a controller. The controller controls the opening times of each line, hence a recipe of chemicals is accurately mixed.



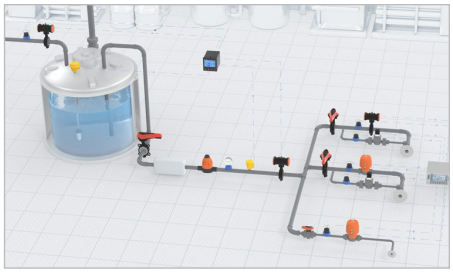
Sodium Hypochlorite Dosing

Aggressive media such as sodium hypochlorite are used as a process media. These substances require piping systems place high demands regarding chemical resistance and safety on the piping system.



Sulfuric Acid Storage Tanks

In every manufacturing and processing plan, there is a tank required to store liquid media. We offer fast, reliable, and safe tools for filling and emptying tanks. The product range comprises a large spectrum of piping systems including measurement, control and actuation technology and an extensive array of valve solutions fro demanding applications.



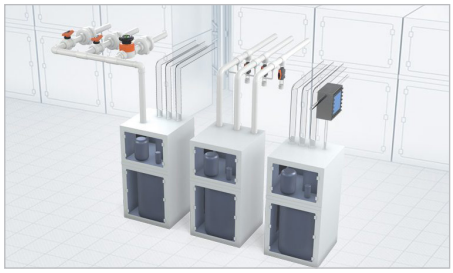
Draw-Off Station

Piping systems in draw-off stations must be resilient and low-maintenance. With quick and economical filling, a major requirement, the two stage shut down function can help eliminate over and under filling. Furthermore, no maintenance costs are incurred and no contamination of moving parts (rust,incrustation) takes place. The drawing-off process itself, however, requires reliable system components for smooth operation. Flow controllers and sensors permit drawing off precise preset amounts.



Filling of Tanks

In manufacturing and processing plants, tanks are required to store liquid media. GF Industry & Infrastructure Flow Solutions offers fast, reliable, and safe tools for filling and emptying tanks. Our range comprises a large spectrum of piping system, including measurement and control technologies, actuated and manual valves as well as an extensive array of valves for demanding applications.



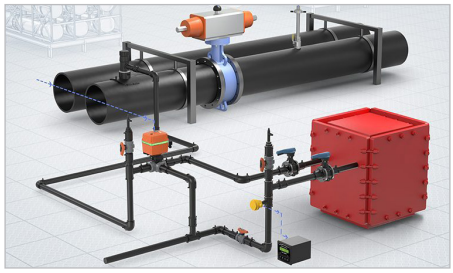
Distribution of Chemicals

Transporting chemicals in the highest quality, different concentrations, and exact dosing are mandatory. Choosing the appropriate piping system including automation offers many advantages such as increased productivity, decreased production and maintenance costs and improved product quality.



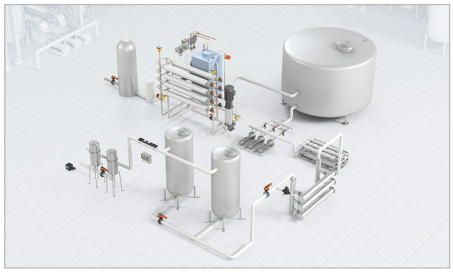
Neutralization

Local water authorities require the neutralization of industrial wastewater discharge to protect the ecological systems in the surrounding lakes, rivers and oceans or protect the local sewer networks and treatment plants. the neutralization process can be different for each industrial location. Operators must meet environmental health and safety requirements to prevent fines and penalties. Reporting effluent discharge is important in the process.



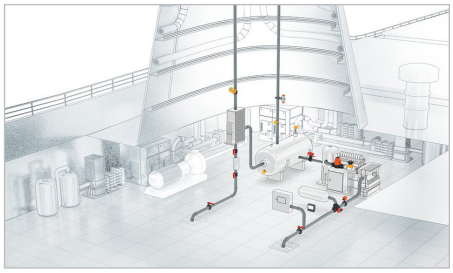
Process Cooling Water

Cooling the media, single components or entire systems is an integral part of many industrial processes. Elements can either be cooled directly or via secondary systems that cool process surroundings.



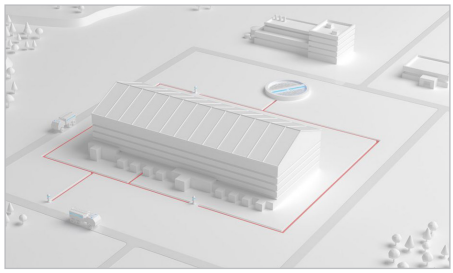
Demineralization

Completely controlled processes with the highest purity and quality standards require process water of specified qualities at different levels. GF provides high-quality systems for these demanding binding and filter processes, meeting all relevant industry standards.



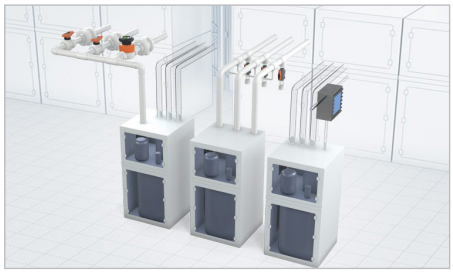
Fume Scrubber

Properly designed fume scrubbers are very effective in removing particles, dust, aerosols, and oxides that are smaller than 10 microns. To effectively remove particles, proper contact time between the gas or liquid is very important. Precise measurement is key in this application.



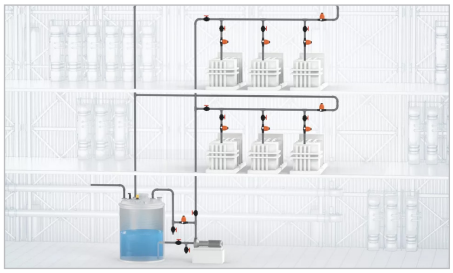
Fire Fighting

In manufacturing and processing plants, tanks are required to store liquid media. GF Industry & Infrastructure Flow Solutions offers fast, reliable, and safe tools for filling and emptying tanks. Our range comprises a large spectrum of piping system, including measurement and control technologies, actuated and manual valves as well as an extensive array of valves for demanding applications.



Surface Treatment

In surface treatment the process is subjected to stringent control to avoid cont. To convey chemical media, high-quality system solutions and components made of plastics are, therefore, the perfect choice. GF Industry & Infrastructure Flow Solutions has numerous measurement and control technology devices on offer, from simple pressure sensors to fully automated and networked control systems, enabling our customers to optimize their processes. Using dedicated jointing technology, system life can be improved.



Mechanical pressure control

Maintaining proper pressure in a system ensures safety and longevity. GF Industry & Infrastructure Flow Solutions' pressure regulating valves provide precise, reliable control, whether reducing or retaining system pressure. Their compact design guarantees maximum performance with minimal space, making them ideal for efficient mechanical pressure regulation across various applications.

Leading GF Polymer Piping Systems

COOL-FIT 2.0
Pre-insulated system



Pre-insulated, corrosion-free piping system for chilled water, ideal for diverse buildings and applications

COOL-FIT 4.0
Pre-insulated system



Pre-insulated, corrosion-free piping system for commercial and industrial refrigeration setups

Contain-It™ Clear PVC Secondary Containment



Clear PVC secondary containment system, installed over virtually any primary piping system

CONTAIN-IT Plus



Dual protection for hazardous fluids with a chemical-resistant inner pipe and containment layer

PVC-C system



Cemented system for applications in the temperature range of 0°C to 80°C

PVC-U system



Cemented system with excellent properties in the temperature range of 0°C to 60°C

PROGEF Plus PP-H High Purity



Specified PP-H production and packaging, certified leach-out results, and LABS compliance ensure top quality and safety

ecoFit I Industry PE piping system



Polyethylene piping system for industrial use in water, wastewater, and chemical applications

Valves and Actuation



A wide range of valve types, with modular pneumatic and electric actuators and control units for automated industrial processes

Measurement and Control



Precision solutions for monitoring flow, pressure, temperature, and complete liquid analysis for optimal process control

Fuseal 25/50™ PVDF Special Waste Piping System



PVDF piping system, designed for return air plenums and aggressive chemicals, offering thermal stability and low flame spread

SYGEF Standard PVDF system



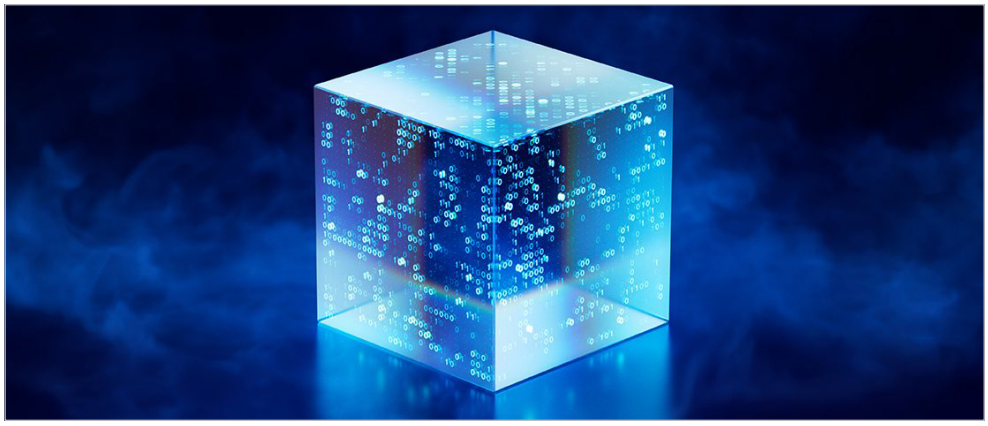
Reliable PVDF system with exceptional chemical and temperature resistance

MULTI/JOINT I Pipe connection system



Tool-free connections for gas or water pipe networks, accommodating various materials and diameters without the need for thrust blocks

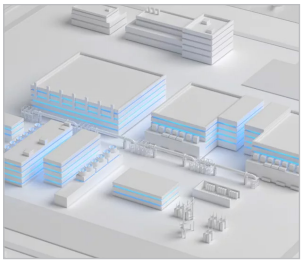
4 Data Centers



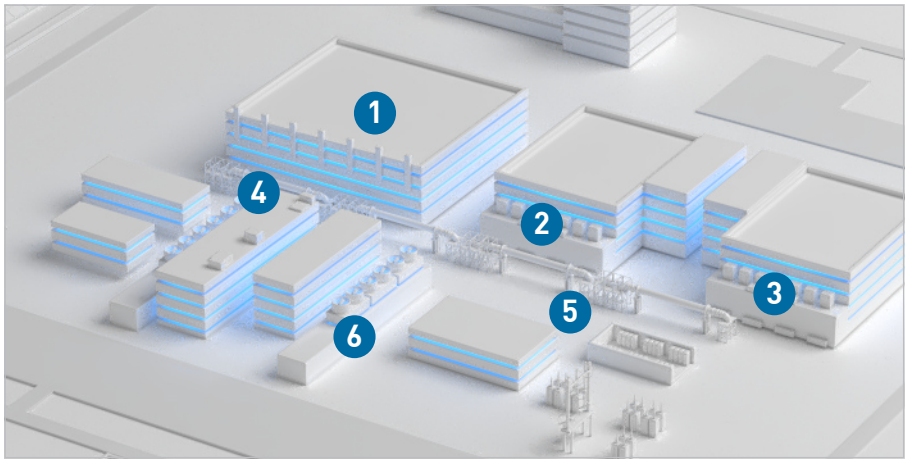
GF Industry & Infrastructure Flow Solutions has more than 30 years of experience serving the semiconductor industry's most advanced microchip fabrication facilities. This experience informs the solutions we deploy in the world's top-tier data centers, where we cool the chips that our clients manufacture with our products. Our technical experts leverage GF's global presence and mission-critical experience to help our clients realize their environmental and sustainability goals by reducing their carbon footprint and enhance their reliable and energy-efficient operations.

Main GF Industry & Infrastructure Flow Solutions Benefits

+ **Efficiency:** Energy-saving, digital solutions reduce ownership costs and improve reliability.
+ **Manufacturing:** Off-site production of pump skids and manifolds speeds up projects and reduces bottlenecks.
+ **Innovation:** Ultrapure materials support safe, efficient cooling for next-gen CPUs and GPUs, enabling net-zero data centers.
+ **Sustainability:** Low-carbon, long-lasting infrastructure minimizes environmental impact across the entire product lifecycle.

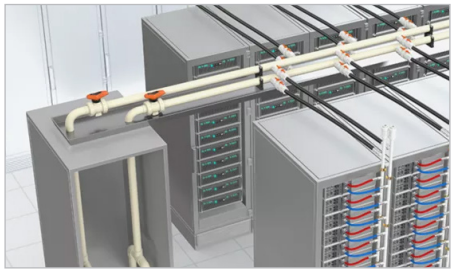


Solutions for Hyperscale and Co-Location Projects



1 Computer Rooms
2 Data hall AHU connection
3 Roofline piping modules
4 Chiller plant
5 Cooling tower yard
6 Condensed water plant room

Application Examples for Data Centers



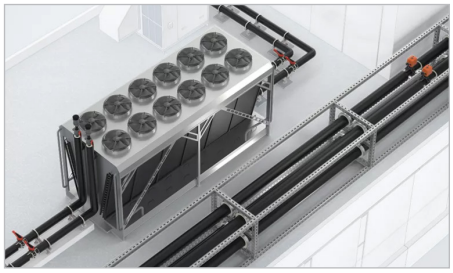
Direct Liquid Cooling

Liquid cooling boosts efficiency but also raises safety concerns with pressurized water near CPUs. GF Industry & Infrastructure Flow Solutions is the world's expert in high-quality pressure-bearing plastic pipe systems and has years of experience in the semiconductor manufacturing industry, offering maintenance-free and user-tailored solutions for reliable data centers.



Chilled Pumping Stations

Prefabricating pump station skids off-site with plastic pipes and valves offers significant advantages. The lightweight plastic allows large skids to be delivered and installed easily. ecoFIT PE-100, being UV and impact resistant, is ideal.
GF Industry & Infrastructure Flow Solutions offers compatible manual and actuated plastic and metal valves, seamlessly integrating into the system.



Chilled Rooftop Water

Pipe systems on rooftops for chillers and condenser units are open to environmental conditions daily and seasonally with temperatures hitting -25°/-13°F to +70°C / +158°F. Harsh temperatures and general weathering (wind, rain, UV light) create demanding conditions that can be solved by GF Industry & Infrastructure Flow Solutions PE-100 black and COOL-FIT (life-span of 25 years) .

Leading GF Polymer Piping Systems

COOL-FIT 2.0
Pre-insulated system



Pre-insulated, corrosion-free piping system for chilled water, ideal for diverse buildings and applications

COOL-FIT 4.0
Pre-insulated system



Pre-insulated, corrosion-free piping system for commercial and industrial refrigeration setups

Contain-It™ Clear PVC Secondary Containment



Clear PVC secondary containment system, installed over virtually any primary piping system

CONTAIN-IT Plus



Dual protection for hazardous fluids with a chemical-resistant inner pipe and containment layer

PVC-C system



Cemented system for applications in the temperature range of 0°C to 80°C

PVC-U system



Cemented system with excellent properties in the temperature range of 0°C to 60°C

Double-See Double Containment Vinyl Piping System



Durable and versatile PVC double containment system with a centering design that compensates thermal expansion

ecoFit I Industry PE piping system



Polyethylene piping system for industrial use in water, wastewater, and chemical applications

JRG Sanipex MT



Multilayer pipes and fittings with flared clamp connections are ideal for water, heating, cooling, and compressed air

ChlorFIT® CPVC Schedule 80 Corzan® Piping System



Superior chlorine and corrosion resistance, durability, and built-in insulation for a reliable, cost-effective solution

Industrial Schedule 40 CPVC Piping System



Ductile system with excellent chemical resistance, ideal for a wide range of low-pressure applications

Fuseal® PP Special Waste Piping System



Reliable electrofusion piping system for special waste drainage, interchangeable with mechanical joint fittings

Fuseal 25/50™ PVDF Special Waste Piping System



PVDF piping system, designed for return air plenums and aggressive chemicals, offering thermal stability and low flame spread

Fuseal Squared™ Double Containment PP Special Waste Piping System



PP double containment system, perfect for special waste systems requiring secondary containment.

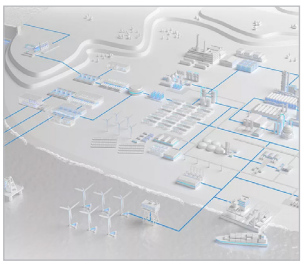
5 Energy



GF Industry & Infrastructure Flow Solutions offers modular piping solutions for multiple energy applications ranging from renewable energy production and energy storage to hydrogen and biofuels. Our engineering capabilities help optimize space and reliability while meeting the sector's stringent operational demands. We enhance battery energy storage solutions through advanced thermal management and efficient electrolyte distribution, and our leak-free systems prevent environmental contamination and operational interruptions in the biofuel sector, supporting sustainable practices and the circular economy. We are committed to driving the global shift towards a more sustainable energy future.

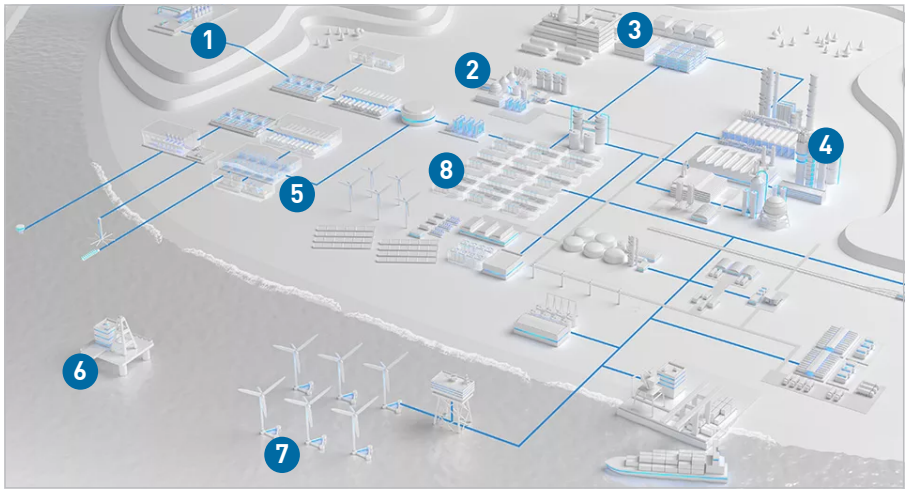


Main GF Industry & Infrastructure Flow Solutions Benefits



+ **Enhanced Efficiency:** Cutting-edge, durable piping solutions that optimize energy transfer and system performance in power plants and renewable energy projects.
+ **Sustainability:** Our innovative piping solutions contribute to the global shift towards sustainable energy by reducing environmental impact across various industries, including renewable energy and energy storage.
+ **Operational Safety:** We deliver reliable, corrosion-resistant piping systems designed to ensure the highest safety standards in the energy sector, protecting infrastructure, people, and the environment.
+ **Longevity through Durability:** Our robust piping solutions enhance the efficiency and longevity of flow batteries and thermal management systems.
+ **Versatile Application Support:** From district heating and cooling to hydrogen production, our versatile piping solutions meet the energy sector's diverse needs, fostering innovation and sustainability in all applications.

Segments for Energy



1 Pumped Storage Hydropower

Our advanced piping solutions are integral to the efficiency and success of pumped storage hydropower projects, supporting sustainable energy generation and storage. Our solutions are designed for high performance and reliability, and the integration of our sensors and automation technology enhances the operational efficiency of pumped storage systems.

2 Biofuels

Our corrosion-resistant piping solutions ensure the safe handling of aggressive chemicals, efficient transport of materials, and reliable containment to prevent leaks. Integrated with smart technology for automation and monitoring, our solutions enhance process efficiency and safety standards, ultimately supporting the biofuels industry in achieving higher productivity and operational reliability.

3 Power Plants

We supply robust and durable piping systems for conventional and nuclear power plants, helping to maintain high safety and performance standards.

4 Geothermal Energy Production

Our piping solutions are tailored to the unique demands of geothermal applications. Our high-temperature and corrosion-resistant materials ensure long-term reliability and reduce maintenance costs. Our systems integrate smart technology for real-time monitoring and automation, enhancing control and efficiency, customizable to specific project needs.

5 Hydrogen

In this transformative energy landscape, we are your preferred partner for hydrogen projects around the globe as a leading supplier of piping systems for the safe and reliable transport of liquids and gases. With more than 60 years of thermoplastic expertise, we offer corrosion-free polymer solutions across the hydrogen value chain for seamless and efficient integration into your hydrogen applications.

6 Oil and Gas

We deliver high-performance piping solutions for offshore and onshore applications, supporting the safe and efficient transport of hydrocarbons. Additionally, our FM-approved polyethylene system provides the highest safety and reliability for firefighting water systems.

7 Floating Offshore Wind

Floating offshore wind farms can benefit from easy-to-install piping solutions with automation capabilities, enabling autonomous operations. Our solutions for offshore energy include lightweight, corrosion- and maintenance-free plastic piping systems with a long service life for safety and efficiency at sea.

8 Energy Storage

Lithium-Ion Battery Storage

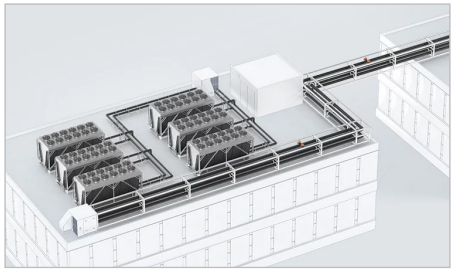
By using our innovative piping solutions within Lithium-ion battery storage units, you can be assured of the thermal management of energy storage systems, ensuring that they operate within safe temperature ranges. Our world-leading cooling systems are essential for maintaining the performance and longevity of large-scale battery storage units.

Flow Batteries

Our engineering teams can design and deliver prefabricated solutions utilizing our leading piping systems, helping to minimize pump and shunt losses and maximize your process efficiency. Our material expertise ensures the correct system selection regarding chemical performance and the right components, including actuated valves and sensors with industrial protocol communications standards to integrate seamlessly into your wider network.

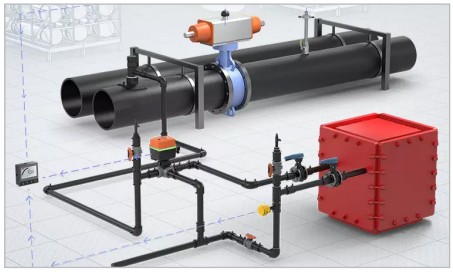
Application Examples

Electricity Production



HVAC

We offer high-performance piping systems for distributing heated and chilled water in climatization applications. These systems meet the latest building standards in terms of sustainability. When a shortage of space is an issue, jointing technologies like electrofusion ease the installation process.



Process Cooling

Cooling the media, single components or entire systems is an integral part of many industrial processes. Elements can either be cooled directly or via secondary systems that cool process surroundings.



Deionized Water

Completely controlled processes with the highest purity and quality standards require process water of specified qualities at different levels. We provide high-quality systems for these demanding binding and filter processes, meeting all relevant industry standards.



Storage Tanks

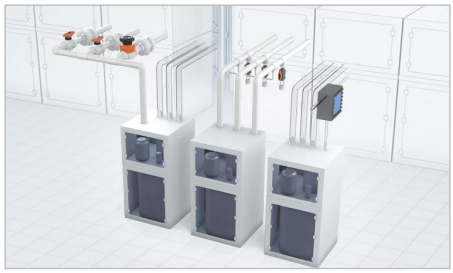
In every manufacturing and processing plant, a tank is required to store liquid media. GF offers fast, reliable, and safe tools for emptying tanks. Our piping systems comprise many products, including measurement, control, actuation technology, and automatic and manual valves for demanding applications.



Water Intake and Outfall

Water intake lines convey raw water from the source, rivers, or sea to the storage area before its treatment. Inhibitors such as biocides are added to prevent biofilm build-up and incrustation. Since long distances are bridged, a corrosion-free solution, often involving large diameters, is needed.

Consumable Fuels



Chemical Distribution / Conveyence

Transporting chemicals from storage to the process application must be planned and carried out reliably and safely. The material selected for the transport lines must be compatible with the chemical's properties. We meet these stringent specifications regarding chemical resistance, temperature, pressure, optimal quality, and safety.



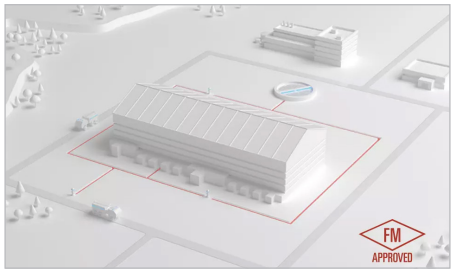
Emergency Showers

Safety showers are an essential part of industrial health and safety concepts. We offer an energy-efficient and durable solution with our preinsulated COOL-FIT system. Under certain conditions, COOL-FIT can be an alternative to conventional heat tracing on metal pipes.



Speciality Waste

In many water treatment processes, the water must be adapted to a pH value that complies with treatment specifications. For example, wastewater must be neutralized before it is fed into public treatment plants. Adjusting the pH value regulates the alkaline or acidic wastewater. Our measurement and control technology offers high process reliability and cost optimization in this cost-intensive area.



Underground Fire Protection System

In case of fire, a secure and reliable water supply for underground distribution and above-ground sprinkler systems is crucial for emergency management. The complete system relies on a consistent water supply with adequate pressure and the right flow rate. Our PE underground systems are FM-approved and provide the highest level of safety and reliability for firefighting water systems.



Air Cleaning

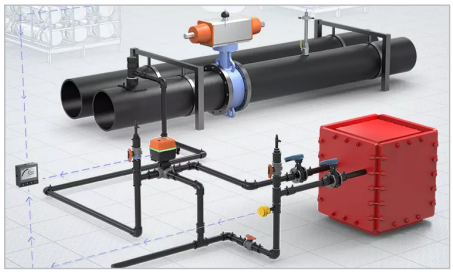
Piping solutions enable effective air cleaning measures that ensure compliance with environmental standards and a healthier environment. Our high-performance, corrosion-resistant piping materials withstand the harsh chemicals and conditions involved in exhaust gas scrubbing, ensuring the longevity and reliability of the scrubber systems.

Energy Storage



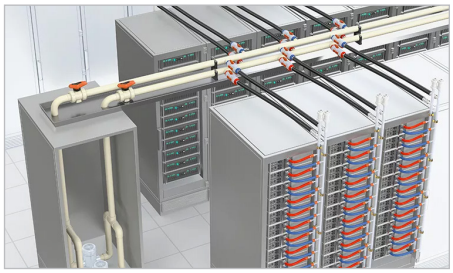
Rooftop Chilled Water

Rooftop chillers and condenser units are open to environmental conditions. Extreme temperatures and general weathering (wind, rain, UV light) create demanding conditions. GF Industry & Infrastructure Flow Solutions' PE-100 black and COOL-FIT are designed for a 25-year lifespan with continued high performance under such harsh conditions.



Process Cooling

Process cooling water is used extensively throughout the energy sector as it's crucial for thermal management, ensuring safe operating temperatures. Thermoplastic systems provide an excellent alternative to metal systems in terms of speed of installation, cost to install and operate, and ease of completing system expansions.



Direct Liquid Cooling

While using liquid-cooled servers offers clear efficiency benefits, it also raises safety and reliability issues as pressurized water moves closer and closer to the CPUs. Our expertise in high-quality pressure-bearing polymer solutions leads the industry, ensuring user and application-specific systems deliver real added value for all stakeholders.



Electrolyte Distribution

In flow batteries, high-quality polymer systems ensure the safe and uniform flow distribution of the electrolyte solutions. Measurement and control solutions help regulate the flow, temperature, and replenishment of the electrolytes, ensuring the safe and efficient operation of the battery. Additionally, corrosion-free components and cooling systems support the longevity of the containerized solution ensuring operational security and a lower total cost of ownership.



Air Cleaning

Exhaust gases must be cleaned before being released into the atmosphere. Regardless of the type of gas, a combination of chemicals is used to neutralize the harmful substances. Our high-performance, corrosion-resistant piping materials withstand the harsh chemicals and conditions involved in exhaust gas scrubbing, ensuring the longevity and reliability of the scrubber systems.

Leading GF Polymer Piping Systems

ABS system



Energy-efficient system with low thermal conductivity, ideal for use at low temperatures

CONTAIN-IT Plus



Dual protection for hazardous fluids with a chemical-resistant inner pipe and containment layer

COOL-FIT 2.0
Pre-insulated system



Pre-insulated, corrosion-free piping system for chilled water

COOL-FIT 4.0
Pre-insulated system



Pre-insulated, corrosion-free piping system for commercial and industrial refrigeration setups

ecoFit I Industry PE piping system



Polyethylene piping system for industrial use in water, wastewater, and chemical applications

ELGEF Plus I Electrofusion PE piping system



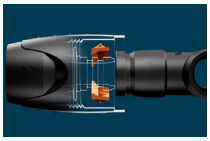
The reliable, modular PE system provides corrosion-free solutions for water and gas applications

AQUASYSTEM



Ideal solution for hot and cold water applications in residential, commercial, healthcare, and marine facilities

iFIT
Push-fit system



System for flexible connections of PB and multilayer composite pipes with PPSU, brass, and bronze fittings using modular push-fit adapters

iJoint I Compression fitting



Compression fittings for easy and secure connection of PE pipes in applications such as drinking water supply, irrigation, and mining

INSTAFLEX
PB Polybutene system



PB system for building applications, including cold and hot water, cooling systems, and compressed air lines

JRG Sanipex MT



Multilayer pipes and fittings with flared clamp connections are ideal for water, heating, cooling, and compressed air

MULTI / CLAMP I Stainless steel repair



Stainless steel repair clamps for repairing and drilling unpressurized or pressurized pipelines

MULTI/JOINT I Pipe connection system



Tool-free connections for gas or water pipe networks, accommodating various materials and diameters without the need for thrust blocks

PRIMOFIT I Cast iron compression fitting



Robust compression fitting for connecting steel, PE, and lead pipes with black or galvanized surfaces

PROGEF Plus PP-H High Purity



Specified PP-H production and packaging, certified leach-out results, and LABS compliance ensure top quality and safety

PVC-U system



Cemented system with excellent properties in the temperature range of 0°C to 60°C

SYGEF ECTFE



Ideal for highly concentrated media under high pressure and temparatures

6 Food and Beverage



Food and Beverage producers face demanding challenges such as rising energy and personnel costs, stringent hygiene and environmental regulations, and increasingly complex production processes. As a trusted full-solution provider, GF Industry & Infrastructure Flow Solutions offers customized, corrosion-free piping solutions tailored to meet these challenges. Our innovative and energy-efficient systems are designed to enhance product quality, minimize downtime risks, and optimize overall operational efficiency. With GF Industry & Infrastructure Flow Solutions, you can ensure compliance with industry standards, safeguard your production processes, and achieve sustainable, high-performance results across your enterprise.



Main GF Industry & Infrastructure Flow Solutions Benefits



+ **Non-corrosive system solutions:** Due to our pre-insulated piping systems, the installation will be corrosion-free the entire lifespan of the installation (at least 25 years). You no longer need to worry about leaks or serious accidents.
+ **High efficiency:** Smooth inner surfaces guarantee good pressure loss characteristics and no encrustation on the internal surfaces of the pipe. The low heat conductivity of plastics helps improve efficiency.
+ **Low installation costs:** We offer you system solutions designed for specific applications. For each application, we provide the appropriate jointing technology to ensure low installation times and reduced downtime costs.
+ **Safe production:** Food and beverage produced in a safe way is key to ensure good quality. Contaminations need to be avoided as well as leakages which can damage the environment, health, safety, and quality.

Segments for Food & Beverage



1 Agriculture and Farming

In agriculture and farming, reliable and efficient water management systems are essential for crop irrigation, livestock hydration, and overall farm operations. GF Industry & Infrastructure Flow Solutions offers innovative piping solutions that are corrosion-free and capable of withstanding harsh environmental conditions. Our systems support various applications, including fertigation, drainage, and wastewater management, ensuring optimal resource utilization and sustainability. By delivering robust and customizable piping solutions, we help farmers enhance productivity, reduce maintenance costs, and achieve better yields.

2 Breweries and Carbonated Drinks

Breweries and carbonated drink producers require precise temperature control and hygiene to ensure the quality and consistency of their beverages. GF Industry & Infrastructure Flow Solutions offers specialized piping solutions that prevent contamination and are corrosion-free, essential for brewing processes and carbonation. Our systems include pre-insulated pipes for efficient cooling and fermentation processes, ensuring the integrity of the production environment. With our expertise, breweries can optimize their operations, reduce energy consumption, and maintain the highest standards of quality and safety.

3 Wineries and Distilleries

Wine and spirit production requires precise control over environmental conditions and hygiene. GF Industry & Infrastructure Flow Solutions offers custom piping solutions tailored to the specific needs of wineries and distilleries. Our corrosion-free and easy-to-clean piping systems ensure the purity and quality of the final product. From fermentation to bottling, our solutions help maintain consistent temperatures and prevent contamination, enabling producers to achieve the desired flavor profiles and product excellence.

4 Food Processing, Bakeries and Dairies

Food processing facilities, bakeries, and dairies require robust and hygienic piping systems to handle a variety of applications such as ingredient transport, CIP processes, and cooling. GF Industry & Infrastructure Flow Solutions delivers customized solutions that enhance operational efficiency and ensure compliance with strict hygiene standards. Our corrosion-free and durable pipes support seamless production processes, reduce downtime, and improve energy efficiency, helping food manufacturers deliver safe and high-quality products to consumers.

5 Cold Stores

Cold storage facilities are critical for preserving the freshness and quality of perishable goods. GF Industry & Infrastructure Flow Solutions offers advanced piping solutions for refrigeration and climate control in cold stores. Our pre-insulated and leak-proof systems ensure efficient temperature regulation and energy savings. By providing reliable and maintenance-free piping solutions, we help cold storage operators maintain optimal storage conditions, minimize energy costs, and extend the shelf life of stored products.

6 Supermarkets

Supermarkets require efficient and reliable refrigeration systems to keep food products fresh and safe for consumers. GF Industry & Infrastructure Flow Solutions provides state-of-the-art piping solutions for supermarket refrigeration and HVAC systems. Our corrosion-free and energy-efficient piping systems ensure consistent temperature control, reduce maintenance needs, and enhance the overall operational efficiency of supermarkets. With our solutions, supermarkets can maintain high standards of food safety, improve energy efficiency, and deliver a better shopping experience to their customers.

7 Aquaculture

Aquaculture, the farming of aquatic organisms such as fish and algae, is essential to the global food supply. GF Industry & Infrastructure Flow Solutions offers corrosion-free, long-lasting piping systems that have been specifically developed for aquaculture facilities. These systems help lock in high water quality, optimal growth conditions and effective water treatment, supporting sustainable and healthy aquaculture practices.

Application Examples

Cold District Water

Cold district water systems are crucial for maintaining optimal temperatures in agricultural processes. GF Industry & Infrastructure Flow Solutions provides robust, corrosion-free piping solutions designed for efficient thermal management and reduced energy consumption, ensuring reliable and sustainable cooling for agricultural applications.

Refrigeration

Refrigeration systems are crucial for storing ingredients and finished products at optimal temperatures. GF Industry & Infrastructure Flow Solutions provides advanced, energy-efficient piping solutions that ensure reliable and consistent refrigeration. Our systems help preserve the freshness and quality of products, extending life and reducing spoilage and extending shelf life.

Landscape Irrigation / Irrigation

Irrigation involves drainage, soil reclamation, and erosion control. Neglecting these can reduce agricultural productivity. It requires integrating technical and non-technical disciplines efficiently. GF Industry & Infrastructure Flow Solutions offers top-quality products for both new and existing irrigation networks, ensuring seamless operation and maintenance.

Media Filtration / Ultrafiltration

Media filtration and ultrafiltration systems are essential for achieving high water quality in agricultural operations. GF Industry & Infrastructure Flow Solutions provides advanced solutions designed to remove impurities and contaminants, ensuring clean water supply for crops, reducing maintenance, and meeting environmental regulations.

Water Intake and Outfall

Efficient water intake and outfall systems are crucial for sustainable agricultural operations. GF Industry & Infrastructure Flow Solutions provides robust, corrosion-free piping solutions designed to ensure reliable water supply and effective wastewater management. Our systems support optimal irrigation, reduce environmental impact, and enhance the overall productivity and sustainability of agricultural practices.

Process Cooling

Process cooling is essential for maintaining the quality and consistency of goods. GF Industry & Infrastructure Flow Solutions offers reliable, corrosion-free piping solutions designed to deliver efficient cooling during production processes. Our systems ensure precise temperature control, helping bakeries achieve consistent results and improve overall operational efficiency.

Room Cooling

Room cooling is vital for creating a controlled environment in the production and storage areas. GF Industry & Infrastructure Flow Solutions offers robust piping solutions designed for effective room cooling. Our systems ensure even temperature distribution, enhancing working conditions and maintaining the quality of temperature-sensitive carbonation processes.

Waste Water Treatment

Wastewater treatment is crucial for breweries to manage effluents and comply with environmental regulations. GF Industry & Infrastructure Flow Solutions provides comprehensive piping solutions for efficient wastewater treatment. Our systems are designed to handle the specific needs of brewery wastewater, ensuring effective treatment, recycling, and discharge while minimizing environmental impact.

Leading GF Polymer Piping Systems

CONTAIN-IT Plus



Dual protection for hazardous fluids with a chemical-resistant inner pipe and containment layer

COOL-FIT 2.0
Pre-insulated system



Pre-insulated, corrosion-free piping system for chilled water, ideal for diverse buildings and applications

COOL-FIT 4.0
Pre-insulated system



Pre-insulated, corrosion-free piping system for commercial and industrial refrigeration setups

ecoFit I Industry PE piping system



Polyethylene piping system for industrial use in water, wastewater, and chemical applications

Fuseal® PP Special Waste Piping System



Reliable electrofusion piping system for special waste drainage, interchangeable with mechanical joint fittings

PROGEF Plus PP-H High Purity



Specified PP-H production and packaging, certified leach-out results, and LABS compliance ensure top quality and safety

PVC-U system



Cemented system with excellent properties in the temperature range of 0°C to 60°C

iJoint I Compression fitting



Compression fittings for easy and secure connection of PE pipes in applications such as drinking water supply, irrigation, and mining

ELGEF Plus I Electrofusion PE piping system



The reliable, modular PE system provides corrosion-free solutions for water and gas applications

7 Gas Utilities





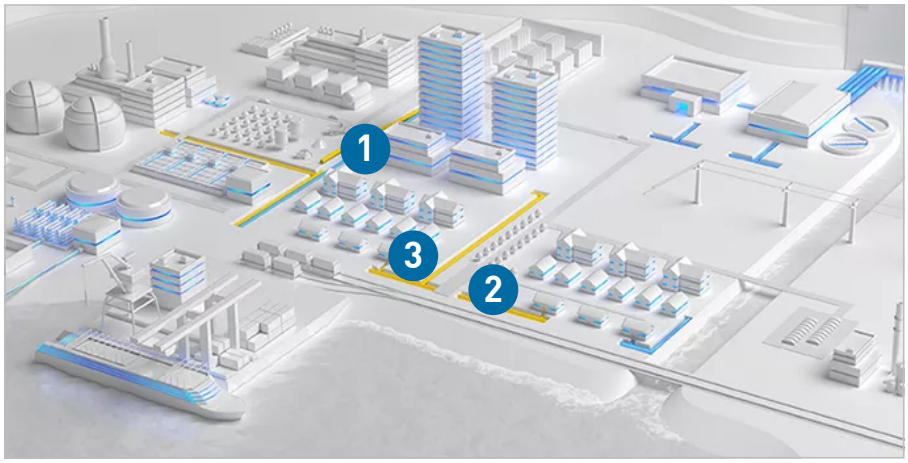
GF Industry & Infrastructure Flow Solutions leads the way in long-lasting, corrosion, and maintenance-free solutions for gas distribution by offering fast, safe and customized installations. Our comprehensive piping components, jointing technologies and specialized solutions, increase efficiency, reliability, safety, and longevity. Polyethylene (PE) piping systems are designed for an impressive 100-year lifespan, offering exceptional durability and reducing maintenance and replacement needs for gas grids. Their lightweight nature lowers energy costs for transportation and installation, while their corrosion resistance ensures long-term reliability. These attributes contribute to a lower carbon footprint and enhance sustainability. Our thermoplastic solutions demonstrate our commitment to both economic efficiency and environmental responsibility for the gas industry.

Main GF Industry & Infrastructure Flow Solutions Benefits



+ **Safe Operation for Gas Networks:** Durable, impact-resistant PE pipes ensure reliable, low-maintenance gas distribution.
+ **Easy and Fast Installation:** Prefabrication and advanced training enable quick, quality installations with minimal on-site work.
+ **Elevating the Support From Planning to Installation:** End-to-end project assistance with digital design tools, customized engineering, and operator training.
+ **Sustainable Solutions:** Leak-tight, long-lasting components reduce waste, emissions, and overall carbon footprint.

Segments for Gas Utilities









1 Gas Transportation Lines

A distribution system is a crucial part of the gas supply network. It ensures that the medium, like gas, reaches consumers for residential, industrial, cooling, and firefighting needs.

2 Gas Distribution Lines

Gas is fed into the local public network at a location on the outskirts of town. Supply stations reduce the pressure of the gas to make it compatible with the distribution system and, at the same time, meter the gas flow. Gas distribution lines generally operate at 0.1 to 5 bar and are typically dimensioned in the range of d90 to d225.

3 Gas House Connections

In the last stage of the grids, service lines transport gas from distribution systems into houses, buildings or plants, passing through the meter, located either inside or outside the buildings.

Application Examples

House Connections/Service Lines



Ideal for extending or replacing house connections



Suitable for hot-tapping under working pressure



Seamless transition from metal to PE pipes



Installation ease and additional safety mechanisms



Broad portfolio for every installation need



100% tightness to the outside, even under extreme conditions

Distribution Lines



Enhanced ease of installation for long-lasting connections



Versatility for all pipe materials



Shaping the future with tool-less assembly

Transport Lines



Flexible branching, distributing, connecting, reducing or changing of direction



Smooth transition between different dimensions



Changing direction efficiently



Safe connections for large dimensions



ELGEF Plus Branch Saddle Toploaded

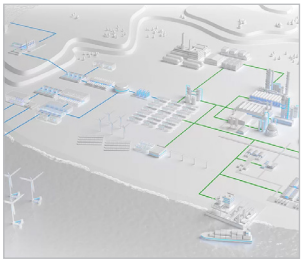
Leading GF Polymer Piping Systems

ELGEF Plus I Electrofusion PE piping system	MULTI/JOINT I Pipe connection system	ecoFit I Industry PE piping system	iJoint I Compression fitting
			
The reliable, modular PE system provides corrosion-free solutions for water and gas applications	Tool-free connections for gas or water pipe networks, accommodating various materials and diameters without the need for thrust blocks	Polyethylene piping system for industrial use in water, wastewater, and chemical applications	Compression fittings for easy and secure connection of PE pipes in applications such as drinking water supply, irrigation, and mining

8 Hydrogen



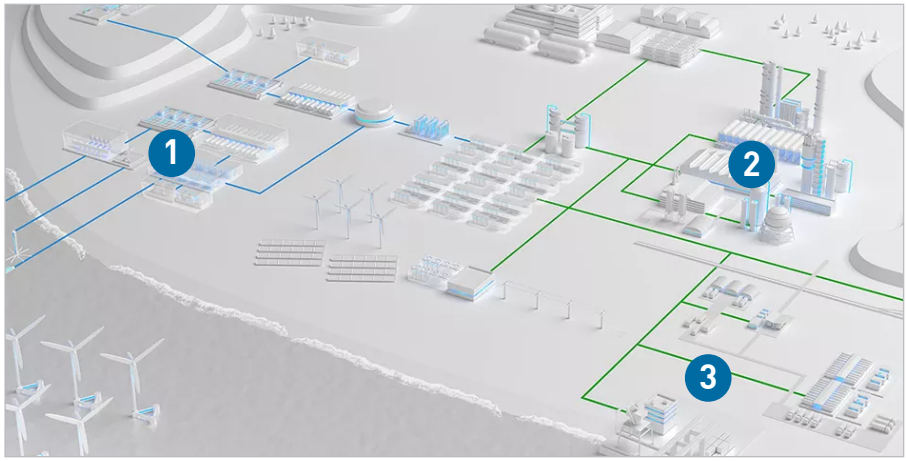
In the accelerating global energy transition, hydrogen has emerged as the potential missing piece to decarbonize even the most difficult-to-abate industries. This small molecule is considered as a key enabler to reaching net zero by 2050. In this transformative energy landscape, GF Industry & Infrastructure Flow Solutions is your preferred partner for hydrogen projects as a global supplier of piping systems for the safe and reliable transport of liquids and gases. With more than 60 years of thermoplastic expertise, we offer corrosion-free polymer solutions across the hydrogen value chain for seamless and efficient integration into your hydrogen applications.



Main GF Industry & Infrastructure Flow Solutions Benefits

+ **Performance:** Durable plastic components prevent contamination and corrosion in electrolyser systems, ensuring efficient hydrogen production.
+ **Safety:** Chemically resistant polymers secure safe transport of media like KOH and ammonia, reducing risks like hydrogen embrittlement and leaks.
+ **Sustainability:** Low-carbon, long-lasting plastic systems cut repair costs and environmental impact, supported by life cycle assessments and EPDs.
+ **Engineering:** Advanced planning and 3D tools optimize hydrogen systems with stress analysis, flow evaluations, and precise sensor calibration.
+ **Installation:** Prefabricated, plug-and-play solutions and rapid installation reduce lead times and speed time to market.
+ **Expertise:** Global reach with support in 31+ countries, offering consistent project quality and timely delivery worldwide.

Segments for Hydrogen



1 Hydrogen Production

Green hydrogen is produced by harnessing clean energy from renewable sources, such as solar, wind and hydropower, and then employing electrolysis to split water into two hydrogen atoms and one oxygen atom. Water intended for electrolysis typically undergoes purification using standard reverse osmosis processes, often necessitating additional deionization steps to eliminate any remaining ions. We contribute to these applications with our solutions in the transportation of deionized water to scale up production while simultaneously reducing the capital cost of green hydrogen overall.

2 Hydrogen Distribution

Hydrogen transportation is largely facilitated via large pipelines in combination with other carriers such as ammonia and Liquid Organic Hydrogen Carriers (LOHC). The repurposing of natural gas pipelines for hydrogen transportation faces some technical challenges, such as hydrogen embrittlement and permeation. Our polymer utility products have been certified “hydrogen ready” for low-pressure distribution applications, according to the requirements and regulations of our customers.

3 Hydrogen Usage

Hydrogen boasts high versatility as one of its key strengths. It can be used for stationary applications for heat generation or introduced into fuel cells to directly generate electricity via an electrochemical process – all with high efficiency and low power losses. Hydrogen fuel cells are an extremely environmentally friendly technology, emitting only water and heat as byproducts. Storing compressed hydrogen in lightweight composite cylinders allows for enhanced payload capacity and facilitates large-scale storage and transportation. We provide inner pipes for high-pressure tank liners, ensuring superior gas barrier properties and impact resistance. Our hydrogen tank liners, made from polyamide resins, accommodate various diameters and lengths for applications in hydrogen.

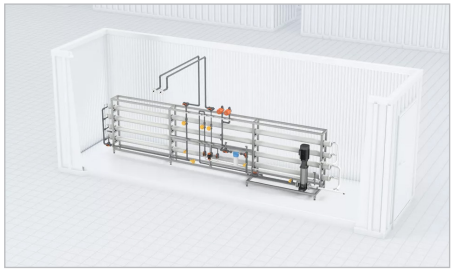
Application Examples for Hydrogen

Ultra-Pure Water



Ion Exchange

Ion exchanger secures the production of pure process water in industrial settings. They remove unwanted ions through selective resin beads and regenerate them during the process. The compact construction of ion exchange plants requires various piping solutions and components. GF Industry & Infrastructure Flow Solutions provides complete solutions of high-quality piping systems, giving the maximum flexibility, while ensuring an entirely safe plant operation with a maximum uptime.



Reverse Osmosis

Reverse Osmosis technology is a filtering method by which contaminated water passes through a very fine membrane under high pressure and removes nearly all water pollution, such as minerals, bacteria, and other particles. Based on selective porosity of a semi-permeable membrane, impurities will be removed from a pressurized liquid. As this process requires no additional chemicals, energy consumption is low and handling is easy.



Media Filtration

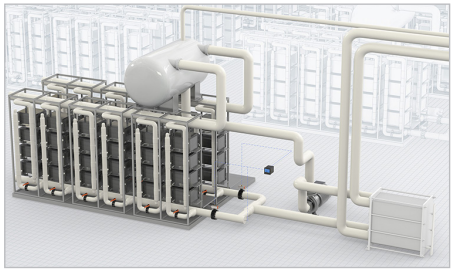
Media filtration removes suspended particles, and microorganisms. Using layers of sand, gravel, or activated carbon, it enhances water clarity, reduces contaminants. This process is essential for ensuring safe, clean, and potable water for public consumption.

Solutions for All



Alkaline Eletrolyser

Utilizing a liquid electrolyte solution such as potassium hydroxide or sodium hydroxide mixed with water, alkaline electrolysers (AEL, atmospheric) generate hydrogen in cells composed of an anode, cathode and membrane. These cells are typically arranged in series to produce hydrogen and oxygen simultaneously. The application of current prompts hydroxide ions to move through the electrolyte, producing hydrogen gas on the cathode side and oxygen gas on the anode.



Proton Exchange Membrane Electrolyser

Proton Exchange Membrane (PEM) electrolyser employ a proton exchange membrane and a solid polymer electrolyte. Water splits into hydrogen and oxygen upon applying a current, with hydrogen protons passing through the membrane to form hydrogen gas on the cathode side. The efficiency and lifespan of PEM electrolysis depend significantly on the quality of the water input. High-purity water is crucial for optimal performance.

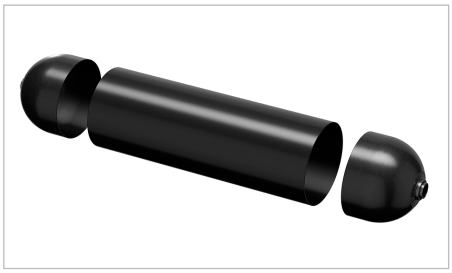


Anion Exchange Membrane Electrolyser

Anion Exchange Membrane Electrolyser (AEM), a low-temperature electrolysis method, utilizes polymeric AEM and cost-effective electrodes in a membrane electrode assembly. The anodic half-cell contains a dilute KOH electrolyte, while the cathodic half-cell, without liquid, produces hydrogen from water permeating the membrane. Oxygen is released from the anodic side.

Tank IV Hydrogen Tanks





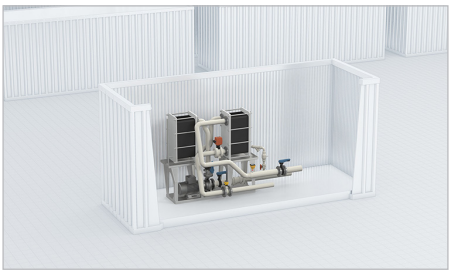
Energised Hydrogen Storage

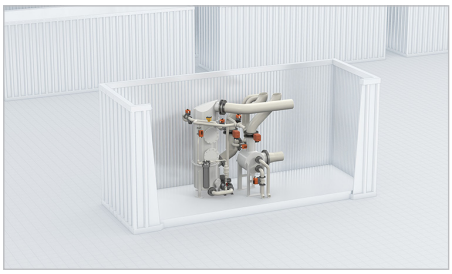
Hydrogen, as the lightest element, naturally exists in a gaseous state under ambient conditions, albeit with low volumetric energy density. Despite the advantages of various storage methods, challenges persist. Compressed Gaseous Hydrogen (CGH2), stored in high-pressure vessels, emerges as a viable option for both stationary and transport applications, such as buses and trucks.

High Pressure Inner Liner Tank Components

GF Industry & Infrastructure Flow Solutions specializes in high-quality, high-pressure tank liners for storage at 700 bar, suitable for transport applications. Crafted from different grades of PA and PE, our products offer both - unparalleled gas barrier properties but also exceptional impact resistance. Furthermore, we are dedicated to producing domes for Type IV hydrogen tanks, ensuring dependable storage solutions for a wide range of applications such as automotive, hydrogen transportation, and stationary storage.

Proton-Exchange-Membrane (PEM) Fuel Cell Systems





Cooling Circuits in a PEM Fuel Cell System

The presence of cooling loops is of utmost importance within PEM fuel cell systems, as they serve to regulate the operating temperature of the cells. These loops play a pivotal role in dissipating excess heat generated during the electrochemical reactions within the fuel cell stack. A coolant, typically a liquid such as water or a water-glycol mixture, circulates through the fuel cell stack to absorb excess heat generated during operation. By maintaining optimal operating temperatures, cooling loops ensure the efficiency and longevity of the PEM fuel cell system. They prevent thermal issues, provide structural integrity and reliability, are vital for consistent power output, and minimize the risk of overheating.

Efficient Media Transport in a PEM Fuel Cell

When combined with a hydrogen storage system, Proton Exchange Membrane (PEM) fuel cell systems have the capacity to facilitate the generation of environmentally friendly energy. These versatile systems can be applied across a spectrum of uses, ranging from small-scale individual cells to large-scale virtual power plants, providing heat and power for buildings, off-grid applications, as well as propulsion for vehicles, planes, and ships. It is evident that there is a growing interest in the potential of hydrogen in the realm of transportation, which has consequently drawn significant attention to fuel cells.

Leading GF Polymer Piping Systems

PROGEF Plus
PP-H High Purity



Specified PP-H production and packaging, certified leach-out results, and LABS compliance ensure top quality and safety

SYGEF Standard
PVDF system



Reliable PVDF system with exceptional chemical and temperature resistance

ELGEF Plus I Electrofusion PE piping system



The reliable, modular PE system provides corrosion-free solutions for water and gas applications

MULTI/JOINT I Pipe connection system



Tool-free connections for gas or water pipe networks, accommodating various materials and diameters without the need for thrust blocks

COOL-FIT 2.0
Pre-insulated system



Pre-insulated, corrosion-free piping system for chilled water, ideal for diverse buildings and applications

COOL-FIT 4.0
Pre-insulated system



Pre-insulated, corrosion-free piping system for commercial and industrial refrigeration setups

PVC-U system



Cemented system with excellent properties in the temperature range of 0°C to 60°C

Valves and Actuation



A wide range of valve types, with modular pneumatic and electric actuators and control units for automated industrial processes

Measurement and Control



Precision solutions for monitoring flow, pressure, temperature, and complete liquid analysis for optimal process control

PRIMOFIT I Cast iron compression fitting



Robust compression fitting for connecting steel, PE, and lead pipes with black or galvanized surfaces

9 Leisure and Life Support



Whether it's maintaining the health of animal life or ensuring the safety and enjoyment of swimmers and visitors, GF Industry & Infrastructure Flow Solutions' solutions are at the forefront of sustaining water quality. Our highly accurate sensors are globally trusted by aquarium, swimming pool and theme park professionals to ensure optimal water conditions and reliable systems. With a comprehensive portfolio of lightweight plastic piping, our pipes can facilitate easy installation of large-scale systems. In addition, our plastic pipes are low leach-out which helps ensure comprehensive water purity, while their exceptional resistance to disinfection media meet the stringent requirements of demanding operational conditions and building planning constraints.

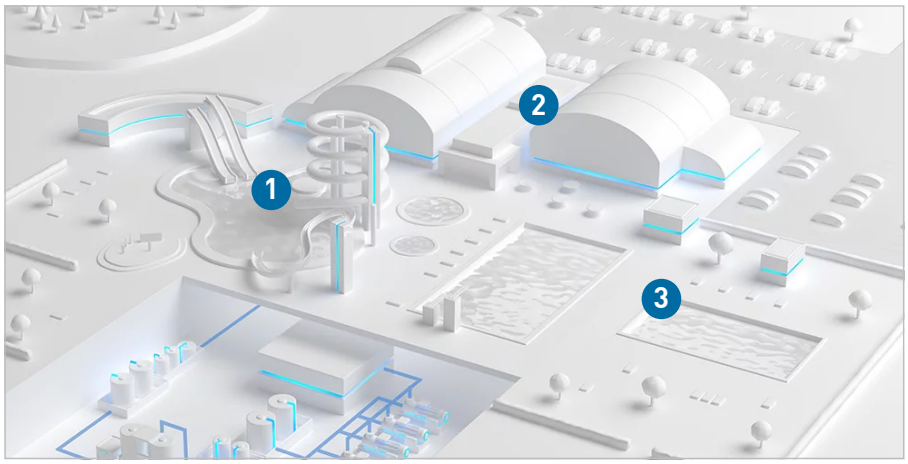


Main GF Industry & Infrastructure Flow Solutions Benefits

+ **Extensive Portfolio:** With over 60,000 products, GF Industry & Infrastructure Flow Solutions delivers complete, customizable solutions for pools, aquariums, theme parks, and zoos, using durable, maintenance-free components to lower costs.
+ **Reliable Measurement:** GF's precise tools ensure safe, clean water and controlled flow rates, essential for health and safety in recreational and aquatic facilities.
+ **Global Support and Custom Solutions:** Trusted worldwide, GF Industry & Infrastructure Flow Solutions provides local support, repairs, and tailored, sustainable solutions to optimize efficiency and design.



Segments for Leisure and Life Support





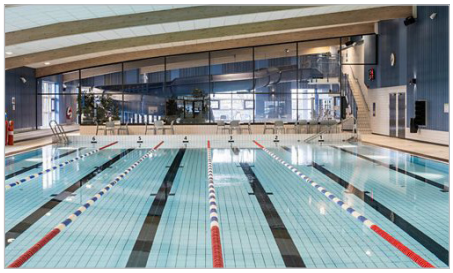
1 Theme Parks and Water Parks

Prioritizing safety, efficiency, and guest experience is crucial for theme parks and water parks. GF Industry & Infrastructure Flow Solutions helps ensure the secure transport of water and chemicals with maintenance-free plastic piping systems which are corrosion-resistant and durable. Additionally, GF's portfolio includes instrumentation, fittings, and valves to help prevent leaks and ensure reliability. Adequate flow is also essential for guest safety. By offering complete water distribution solutions, GF Industry & Infrastructure Flow Solutions can help measure and control flow capacity, minimizing risks and enhancing the overall park experience.



2 Life Support Systems

Aquariums and zoos life support teams need to maintain optimum water quality. GF Industry & Infrastructure Flow Solutions' lightweight, plastic solutions allow easy installation and low leach-out. With a robust product portfolio including pipes, fittings, valves, and instrumentation GF's solutions can be the single source partner to meet the requirements of highly demanding conditions to ensure animal welfare.



3 Commercial Swimming Pools

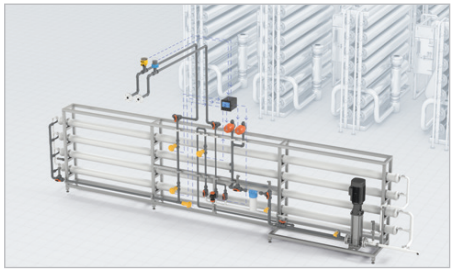
Swimming pools operators often face a difficult choice between price and quality. Choosing reliable and high-quality components helps ensure guest safety and cleanliness and while avoiding costly maintenance. GF Industry & Infrastructure Flow Solutions' well-proven product portfolio of standards-compliant PVC-U valves and fittings offers the perfect solution for these requirements in addition to instrumentation to manage flow and pH levels. The pool range by GF provides maximum safety and reliability while being economically viable as well.

Example Applications



Media filtration

Media filtration removes suspended particles, and microorganisms. Using layers of sand, gravel, or activated carbon, it enhances water clarity, reduces contaminants. This process is essential for ensuring safe, clean, and potable water for public consumption.



Reverse osmosis

Reverse osmosis (RO) is crucial in drinking water applications for its ability to remove contaminants like salts, bacteria, and chemicals, ensuring safe, clean water. It works by forcing water through a semi-permeable membrane, leaving impurities behind. RO enhances taste, odor, and safety, making it essential for providing high-quality drinking water.



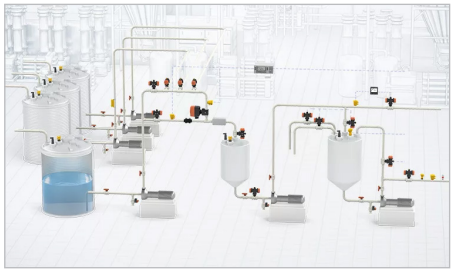
Ion exchanger

The system removes undesirable ions like calcium and magnesium and contaminants like lead and nitrates. It softens hard water, preventing scale buildup in piping systems, and ensures safe, palatable water by exchanging harmful ions with harmless ones, improving water quality and safety.



Neutralization

Neutralization adjusts pH levels to make the water safe and palatable. It prevents corrosion or scaling in pipes, enhances disinfection efficiency, and ensures regulatory compliance. Proper pH balance is crucial for protecting public health and maintaining infrastructure.



Dosing / Dilution

Chemical dosing and dilution in drinking water applications are crucial for ensuring water safety and quality. Proper dosing adds precise amounts of chemicals, such as disinfectants and coagulants, to eliminate pathogens and remove impurities. Dilution ensures these chemicals are evenly distributed, preventing overdosing or underdosing, which could compromise water quality and safety.

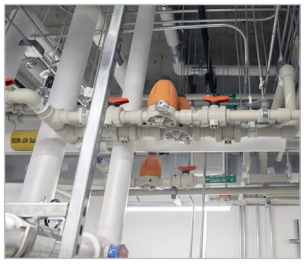
Leading GF Polymer Piping Systems

Valves and Actuation	Measurement and Control	ELGEF Plus I Electrofusion PE piping system	PVC-U system	ELGEF Plus I Electrofusion PE piping system
				
A wide range of valve types, with modular pneumatic and electric actuators and control units for automated industrial processes	Precision solutions for monitoring flow, pressure, temperature, and complete liquid analysis for optimal process control	The reliable, modular PE system provides corrosion-free solutions for water and gas applications	Cemented system with excellent properties in the temperature range of 0°C to 60°C	The reliable, modular PE system provides corrosion-free solutions for water and gas applications

10 Life Sciences



GF Industry & Infrastructure Flow Solutions is the leading manufacturer of thermoplastic piping systems for laboratory special waste, process water and process cooling water in Life Sciences and Institutional markets. We are the only manufacturer of complete piping system product offerings, allowing specification engineers and facilities personnel to ensure all components and joining tools for a specified system will be from a single source.



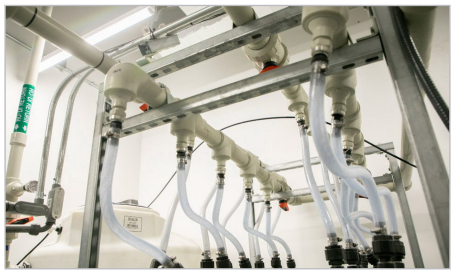
Main GF Industry & Infrastructure Flow Solutions Benefits



+ **A Diverse Market:** Life Sciences & Institutional markets cover pharmaceuticals, biotech, cosmetics, personal care, and laboratory/cleanroom facilities in research and healthcare.
+ **Superior Systems and Joining:** BCF, IR, and Socket Fusion joining for SYGEF® and PROGEF® systems reduce contamination risks in RO/DI applications.
+ **Safety and Code Compliance:** Fuseal® and Double-See meet strict standards for safe corrosive media transport and pH discharge control.
+ **System Approach:** Over 60,000 products in various materials provide complete solutions for diverse Life Sciences applications.
+ **Technical and Engineering Support:** Technical teams assist with high-quality RO/DI and waste systems, ensuring regulatory compliance for lab discharges.

Segments for Life Sciences









1 Education

GF products deliver the highest purity water solutions essential for cutting-edge research in universities, and special waste piping/neutralization systems for both university and high school facilities. GF products ensure reliable and consistently safe conveyance. GF offers top tier single wall and double wall solutions for special waste.

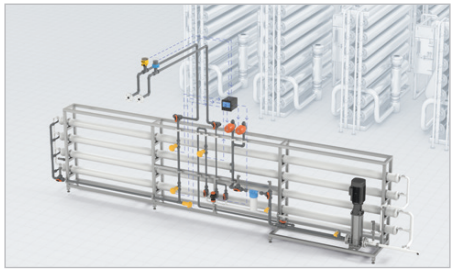
2 Healthcare

GF Industry & Infrastructure Flow Solutions is the leading manufacturer of thermoplastic piping systems for laboratory special waste, process water, process cooling water and commercial water in Life Sciences & Institutional markets. We are the only manufacturer of complete piping system product offerings, allowing specification engineers and facilities personnel to ensure all components and joining tools for a specified system will be from a single source.

3 Pharma

GF Industry & Infrastructure Flow Solutions is the leading manufacturer of thermoplastic piping systems for laboratory special waste, process water and process cooling water in Life Sciences & Institutional markets. We are the only manufacturer of complete piping system product offerings, allowing specification engineers and facilities personnel to ensure all components and joining tools for a specified system will be from a single source.

Application Examples



RO/DI Piping

GF provides polymer PVDF and PP solutions with advanced reverse osmosis deionized water systems. Our experts offer comprehensive technical assistance, addressing dead leg concerns and optimizing system design. We also provide the industry's most extensive on-site training and certification programs, prior to installation, ensuring proper performance and integrity for all systems.



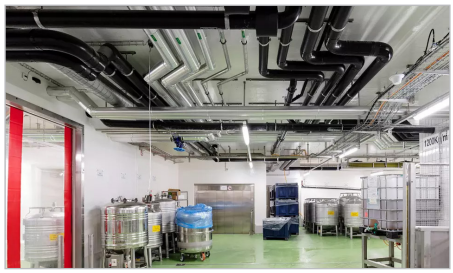
Special Waste

GF offers top-tier single and double wall solutions for special waste. Our advanced neutralization, leak detection systems, Double Containment piping, and robust pressure-rated fittings ensure your operations are safe, efficient, and compliant. Benefit from our expert technical assistance and the industry's most comprehensive on-site training and certification programs.



Neutralization

GF provides various treatment and monitoring solutions for facility special waste discharges to ensure regulatory compliance. Our design team collaborates with engineering or facilities management to outline system options based on waste flow parameters and chemistries, reviewing specifications and recommending the most suitable installation.



Pre-Insulated Piping Solutions

GF offers a wide range of factory insulated piping solutions with all types of carrier pipe, optimized insulation, numerous jacket materials and in-house design/supply of integral heat tracing. Process cooling, glycol secondary cooling loops, transport of high viscosity or high freezing temperate fluids, are some of the many applications we have been supplying for more than 50 years.

Leading GF Polymer Piping Systems

AquaTap™ Recirculating Faucet



Recirculating laboratory faucet with Inline Flow Diverters (IFD) eliminates dead-legs, maintaining purity throughout the DI water loop

PROGEF Standard PP system



Unmatched chemical resistance and durability ensure reliable, cost-effective, high-performance solutions trusted industry-wide

PROGEF Natural PP system



Transparent, pigment-free PP system with a high surface finish and exceptional chemical resistance meets purity standards for various applications

PROGEF Plus PP-H High Purity



Specified PP-H production and packaging, certified leach-out results, and LABS compliance ensure top quality and safety

SYGEF Standard PVDF system



Reliable PVDF system with exceptional chemical and temperature resistance

SYGEF Plus PVDF-HP High Purity



System with high mechanical and chemical resistance for high purity applications

Fuseal® PP Special Waste Piping System



Reliable electrofusion piping system for special waste drainage, interchangeable with mechanical joint fittings

Fuseal 25/50™ PVDF Special Waste Piping System



PVDF piping system, designed for return air plenums and aggressive chemicals, offering thermal stability and low flame spread

Fuseal Squared™ Double Containment PP Special Waste Piping System



PP double containment system, perfect for special waste systems requiring secondary containment.

Contain-It™ Clear PVC Secondary Containment



Clear PVC secondary containment system, installed over virtually any primary piping system

Double-See Double Containment Vinyl Piping System



Durable and versatile PVC double containment system with a centering design that compensates thermal expansion

COOL-FIT® PE Plus

Pre-insulated system



Pre-insulated, corrosion-free system, designed for efficient, low-maintenance refrigeration in commercial and industrial applications

Design-Flow IPS HDPE



High density Polyethylene system with superior chemical resistance and robust physical properties

ecoFit I Industry PE piping system



Polyethylene piping system for industrial use in water, wastewater, and chemical applications

11 Marine



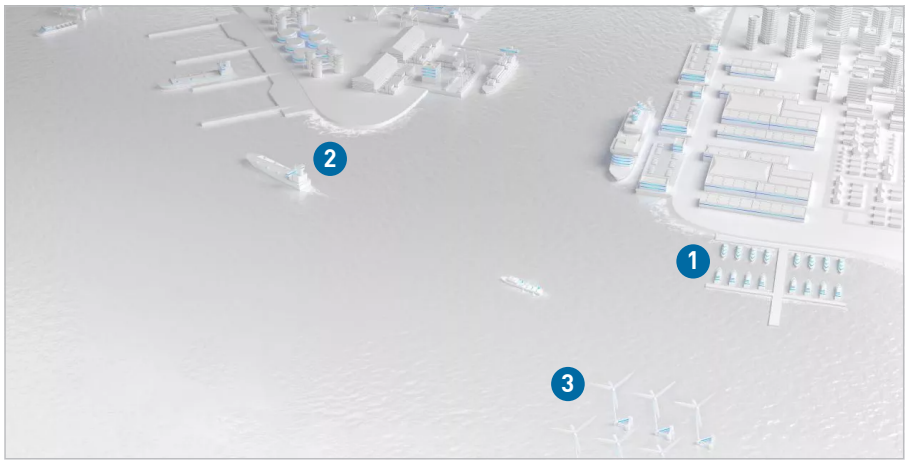
We are committed to enabling the safe and sustainable transport of water, gas, and chemicals at sea that are compliant with the latest regulations. Our teams develop application-oriented thermoplastic piping solutions for essential- and non-essential applications that enable fast and easy installation, profitable operations, and environmental benefits. We support our customers in implementing sustainable, future-oriented, and well-designed piping concepts with state-of-the-art planning techniques to optimize the economic efficiency of processes.

Main GF Industry & Infrastructure Flow Solutions Benefits



+ **Future Reliability:** We empower sustainable transition and digital transformation for the maritime industry. Our first-in-class plastic piping systems ensure the sustainable treatment and transportation of fluids onboard cruise ships, merchant vessels, offshore platforms, and wind farms at sea.
+ **Future Sustainability:** Lightweight thermoplastic piping systems have a lower GHG footprint than metal alternatives. Our piping systems comply with the Green Ship Passport and are made of recyclable materials and we provide environmental product declarations.
+ **Future Automation:** Our experts provide a deep application knowledge of the entire process within the water treatment onboard. We offer a true partnership with a unified vision toward active water conservation. Our solutions for automated flow processes ease the way toward autonomous vessels.
+ **Future Integration Partner:** With 36 production facilities and a global presence of our sales representatives in 31 countries, we help you realize your new build or retrofit project from planning to commissioning.

Segments for Marine





1 Cruise and Ferries

Thermoplastic and multilayer piping systems safely convey the transport of water onboard passenger ships like cruise liners, mega yachts, or ferries and provide a lightweight, soundproof, and corrosion-free alternative to metal piping systems.



2 Merchants

Corrosion- and maintenance-free thermoplastic piping systems have a long service life and help lower the maintenance time and cost of merchant's vessels, bulk carriers, trawlers, and LNG carriers to a minimum.



3 Offshore Energy

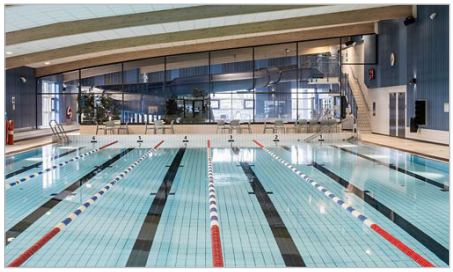
Floating wind farms, offshore support vessels, floating cranes, or oil platforms can benefit from the easy-to-install piping solutions with automation capabilities, enabling the way to autonomous operations.

Application Examples



Fresh cold and hot water

Plastic pipes and fittings are ideally suited for a safe and efficient drinking water supply for all types of ships' cabins, kitchens, restaurants, and bars. The material's high flexibility and easy installation technology minimize time and costs.



Pools and Spa Areas

Maintain hygienic pools & spas with our high perfomance plastic piping solutions (PVC-U, PVC-C, or PP), which is easy to install, resist disinfectants & ensure long life for clean, healthy water. Our products meet the requirements for highly demanding operating conditions.



Brine and Water Treatment

Comprehensive solutions for all applications throughout the water cycle, from chemical dosing systems and media filtration applications to ion exchangers. Automize processes with our system of pipes, fittings, valves, jointing technology and a selection of components.



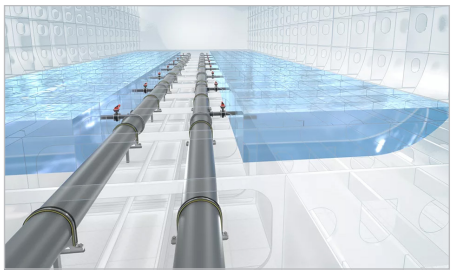
Air Conditioning (HVAC)

Achieve healthy and pleasant temperature and humidity using our energyefficient flow solutions that helps lower overall energy efficiency of cooling applications. Our pre-insulated systems, planning and installation time can reduce the HVAC system by up to 50%.



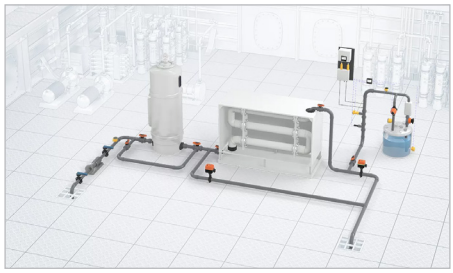
Sewage, black and grey water

Wastewater from sinks and showers create grey and black water that has to be conveyed safely to the wastewater treatment system on board. Our thermoplastic piping systems withstand aggressive chemicals and stresses, helping to convey and treat wastewater safely.



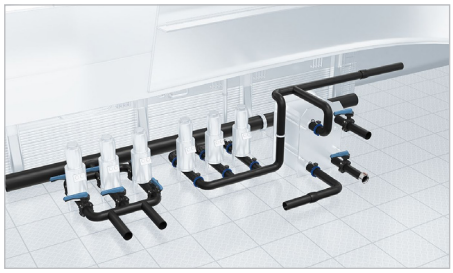
Ballast Water System

We offer durable plastic pipes (0-40°C) for efficient ballast water management. Resistant to seawater & chemicals, they ensure a long, maintenance-free lifespan (up to 25 years), minimizing downtime and costs. Ideal for marine applications and industrial water piping.



Ballast Water Treatment

Prevent invasive species with proper ballast water treatment (BWT). Traditional piping struggles with seawater & chemicals, leads to leaks & downtime. We offer BWT-ready, corrosion-resistant solutions and prefabricated skids by OEMs for fast on/offshore integration.



Water Engine Cooling

Plastic pipes prevent corrosion & erosion for reliable freshwater & seawater cooling. HEAT-FIT fire retardant jackets enable cooling in critical areas (machinery spaces, A/B pump rooms, accommodation, control & open decks) meeting fire regulations.



4 Floating Offshore Wind

Floating offshore wind farms can benefit from easy-to-install piping solutions with automation capabilities, enabling autonomous operations. Our solutions for offshore energy include lightweight, corrosion- and maintenance-free plastic piping systems with a long service life for safety and efficiency at sea.

Leading GF Polymer Piping Systems

HEAT-FIT
Ultimate fire protection



Fire retardant system to bring lightweight, corrosion-free thermoplastic piping systems in essential applications onboard

COOL-FIT 2.0
Pre-insulated system



Pre-insulated, corrosion-free piping system for chilled water, ideal for diverse buildings and applications

COOL-FIT 4.0
Pre-insulated system



Pre-insulated, corrosion-free piping system for commercial and industrial refrigeration setups

ecoFit I Industry
PE piping system



Polyethylene piping system for industrial use in water, wastewater, and chemical applications

ELGEF Plus I Electrofusion PE piping system



The reliable, modular PE system provides corrosion-free solutions for water and gas applications

ABS system



Energy-efficient system with low thermal conductivity, ideal for use at low temperatures

Hycleen Automation System



Intelligent valves and cloud-based, automated control for hydraulic balancing and flushing

PVC-C system



Cemented system for applications in the temperature range of 0°C to 80°C

INSTAFLEX PB Polybutene system



PB system for building applications, including cold and hot water, cooling systems, and compressed air lines

JRG Sanipex MT



Multilayer pipes and fittings with flared clamp connections are ideal for water, heating, cooling, and compressed air

Marine Grade™ CPVC Piping System



CPVC system for white, black, and grey water applications requiring enhanced fire performance, without needing USCG listing

PROGEF Plus PP-H High Purity



Specified PP-H production and packaging, certified leach-out results, and LABS compliance ensure top quality and safety

PVC-U system



Cemented system with excellent properties in the temperature range of 0°C to 60°C

SeaCor® CPVC system



CPVC system for marine water and vent applications, meeting FTP smoke, toxicity, and flammability standards

SeaDrain® White Marine Drainage



UV-resistant, paint-free plastic drainage system for black and grey water applications in marine passenger vessels

Valves and Actuation



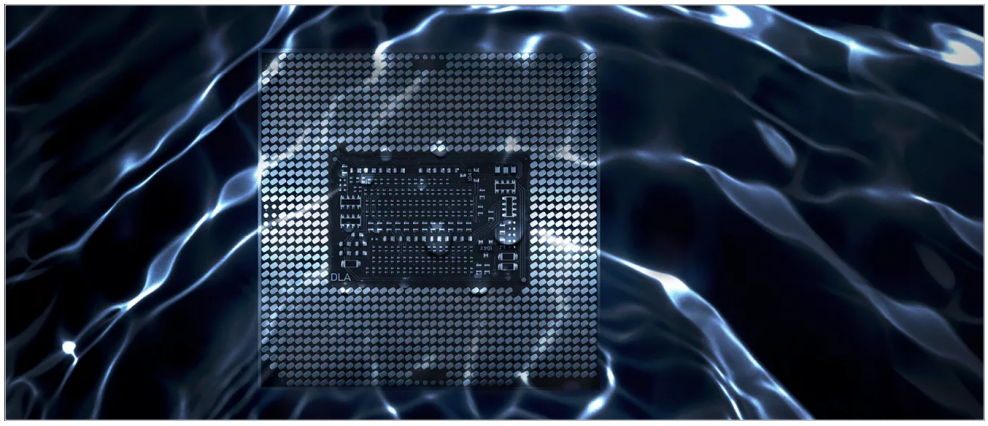
A wide range of valve types, with modular pneumatic and electric actuators and control units for automated industrial processes

Measurement and Control



Precision solutions for monitoring flow, pressure, temperature, and complete liquid analysis for optimal process control

12 Microelectronics



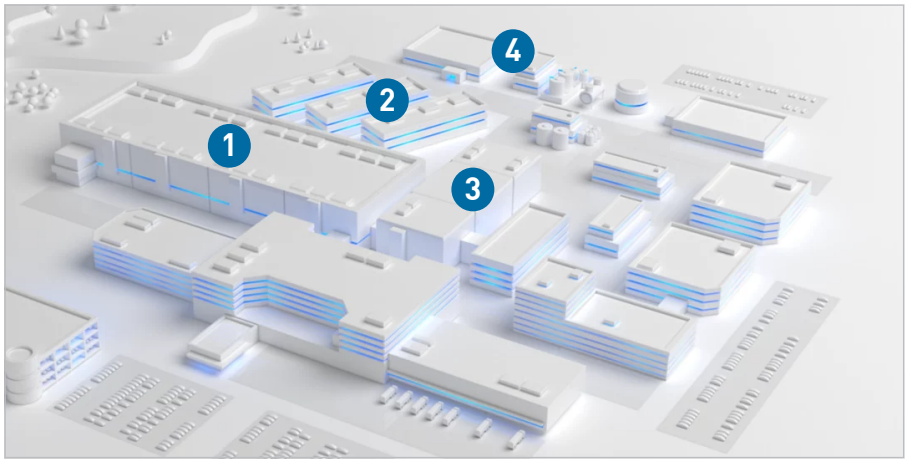


For over 30 years, GF Industry & Infrastructure Flow Solutions has been a trusted partner in the semiconductor industry, supporting the creation of sustainably managed fabrication factories. Our comprehensive solutions help the industry manufacture advanced technologies while prioritizing sustainable water resource management, carbon footprint reduction, and environmental impact minimization. We specialize in mission-critical fluid handling solutions, offering a complete range of products including plastic pipes, fittings, valves, actuation, automation, measurement and control systems, and comprehensive services. The industry-leading offsite fabrication capabilities, combined with our domain expertise and rapid delivery, ensure we meet the demanding specifications of large-scale, tech-driven projects.

Main GF Industry & Infrastructure Flow Solutions Benefits

+ **Ultra Integration Partner:** We provide mission-critical fluid handling solutions for the microelectronics industry, offering product reliability, engineering support, pre-fabrication, and global training to ensure project success.
+ **Ultra System Expertise:** With over 30 years of experience, we support the semiconductor industry in building sustainable factories, helping reduce carbon footprints and manage water resources efficiently.
+ **Ultra Connected Solutions:** Our fluid handling solutions meet the purity requirements of semiconductor facilities, supporting rapid development while maintaining high-quality standards and digitalization.
+ **Ultra-Fast Response:** We ensure on-time delivery with skilled project managers, advanced welding technology, and global pre-fabrication capabilities, meeting tight deadlines with high-quality, reliable solutions.

Applications for Microelectronics



1 Semiconductors

Ensuring pure water and compliance for optimal semiconductor manufacturing.

Our systems safely convey ultrapure water, the lifeblood of the fab, used in cleaning wafers and process cooling water, necessary for cooling heat-intensive equipment. With waste neutralization systems to carry away spent chemicals, industrial and scrubber water, the factory stays in compliance with environmental regulations. House vacuum and chemical mechanical planarization are other common applications where customers rely on our non-corrosive plastic solutions.

2 Photovoltaics

Optimizing PV Manufacturing with Advanced Piping Solutions.

GF Industry & Infrastructure Flow Solutions provides cutting-edge plastic piping systems crucial for photovoltaic manufacturing. Our solutions ensure the safe and efficient transport of critical fluids throughout the PV production process, from handling chemicals and water in module fabrication to managing cooling and cleaning fluids.

Designed to withstand harsh environments, our non-corrosive systems help maintain operational efficiency and compliance with industry standards. Whether for energy storage, PV cells, or system modules, our advanced piping solutions support every stage of the photovoltaic industry chain.

3 Substrate LED TFT

Supporting innovation with ultra pure water and advanced fluid handling solutions.

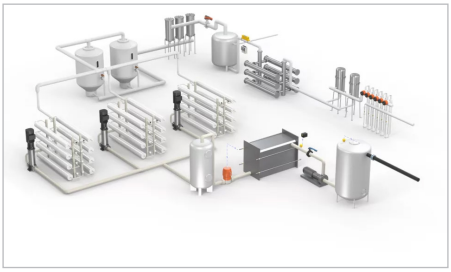
GF Industry & Infrastructure Flow Solutions offers advanced plastic piping solutions essential for the efficient and precise operations in substrate, LED, and TFT manufacturing. Our high-quality, corrosion-resistant piping systems are designed to handle the critical fluids and chemicals involved in these processes, from the delivery of ultrapure water and chemical solutions to the removal of waste. Our solutions ensure seamless fluid transport and process stability, which are crucial for maintaining the quality and consistency of substrates and electronic components.

4 Process

Project support at every step of the process to achieve construction excellence.

GF Industry & Infrastructure Flow Solutions is the perfect partner to integrate into your project from design through to commissioning. Our mission-critical fluid handling solutions for microelectronics plants and our specialized solutions such as design support, offsite prefabrication, and training programs ensure we are always ready when you are. With short project and operation lead times for semiconductor plants, our highly skilled project managers, engineering services, state-of-the-art welding technology, and advanced stock management can ensure we meet your tight deadlines on time, every time. Our global offsite prefabrication and customization network can support your needs, providing quality and operational excellence you can repeatedly trust.

Example Applications for Microelectronics



Ultrapure water & hot ultrapure water

Ultrapure and hot ultrapure water are essential to the production of microelectronic products. GF Industry & Infrastructure Flow Solutions provides pipes, fittings, valves and supporting components that are designed and manufactured to the most stringent industry specifications to ensure the quality of water being delivered to the manufacturing tools meet even the most difficult quality requirements.



Specialty waste & dedicated waste water treatment

The manufacture of microelectronics products can often produce waste products from highly corrosive to thermally challenging. Our portfolio of products are designed from a wide range of materials, extensive test library, laboratory test facilities and highly experienced staff to enable the best engineering and product selection for your specific needs. State of the art jointing technologies supported by worldwide engineering, material test facilities, training and support organizations ensures quality installations and longterm reliability of systems.



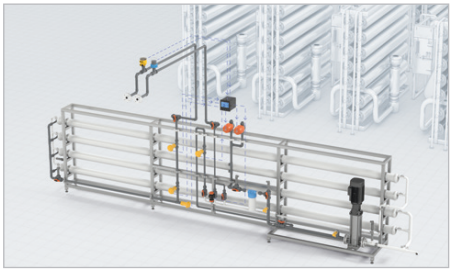
Process cooling water

Process cooling water is used extensively throughout microelectronics production due to the need to remove heat from manufacturing tools. Thermoplastic systems provide an excellent alternative to metal systems in the speed of installation, cost to install and operate, and the ease of completing system expansions. State of the art jointing technologies supported by worldwide engineering, training and support organizations ensures quality installations and long-term reliability of systems.



General waste neutralization

Waste Neutralization Systems are commonly found in every microelectronics facility and often are required to handle a wide range of operating parameters. GF Industry & Infrastructure Flow Solutions portfolio of products, extensive test library, laboratory test facilities and highly experienced staff enable the best engineering and product selection for your specifi c needs. State of the art jointing technologies supported by worldwide engineering, training and support organizations ensures quality installations and long-term reliability of systems.



Reverse osmosis

Reverse Osmosis technology covers several filtration techniques all based on selective membranes porosities. Based on selective porosity of a semi permeable membrane, impurities will be removed from a pressurized liquid. Due to the fact that it needs no chemicals, energy consumption is low and handling is easy.



Media filtration

Media fi ltration is still very much in use in water treatment processes. In the multi-level fi ltration processes, anthracite or stones, as well as sand, are used to remove particles up to 10-15 µm from fl uids. Due to the need for several operation modes, application-oriented system solutions help to achieve these processes efficiently.



Ion exchanger

Demineralization units (deionization, reverse osmosis, distillation techniques) secure the production of pure high quality process water in the industrial environment. Water purifi cation, separation and decontamination of aqueous and other ion-containing fl uids characterize applications in that water treatment area. In this context, ion exchangers can absorb unwanted ions in the water, thanks to selective synthetic resin beads, and release them during a regeneration process. The compact construction of ion exchange plants requires fl exible piping solutions and components. GF Industry & Infrastructure Flow Solutions provides complete solutions of high-quality piping systems warranting a maximum of fl exibility while ensuring an entirely safe plant operation with a maximum uptime.



Deionized water

Completely controlled processes in industrial or laboratory applications with highest purity and quality standards in manufacturing require process water of specified qualities at diff erent levels such as deionized water or less demanding UPW water. For initial industrial water treatment and for guaranteeing a consistently specified water quality throughout the entire process chain, physical water properties, parameters and concentrations have to be precisely controlled and reliably maintained. Deionization systems use a two-stage process of ion exchange resins to aff ect the removal of all cationic and anionic ions. GF Industry & Infrastructure Flow Solutions provides high-quality systems for these demanding binding and fi lter processes, meeting all relevant industry standards. In several applications, solutions from GF Industry & Infrastructure Flow Solutions assure the processing of water in a way that it maintains the given specifications.

Leading GF Polymer Piping Systems

CONTAIN-IT Plus



Dual protection for hazardous fluids with a chemical-resistant inner pipe and containment layer

COOL-FIT 2.0
Pre-insulated system



Pre-insulated, corrosion-free piping system for chilled water, ideal for diverse buildings and applications

COOL-FIT 4.0
Pre-insulated system



Pre-insulated, corrosion-free piping system for commercial and industrial refrigeration setups

ecoFit I Industry
PE piping system



Polyethylene piping system for industrial use in water, wastewater, and chemical applications

Fuseal® PP Special Waste Piping System



Reliable electrofusion piping system for special waste drainage, interchangeable with mechanical joint fittings

PROGEF Plus
PP-H High Purity



Specified PP-H production and packaging, certified leach-out results, and LABS compliance ensure top quality and safety

PVC-C system



Cemented system for applications in the temperature range of 0°C to 80°C

PVC-U system



Cemented system with excellent properties in the temperature range of 0°C to 60°C

SYGEF Standard
PVDF system



Reliable PVDF system with exceptional chemical and temperature resistance

SYGEF Plus
PVDF-HP High Purity



System with high mechanical and chemical resistance for high purity applications

SYGEF Ultra
High-purity PEEK



Next generation non-fluorinated high purity system for (H) UPW applications exceeding SEMI F57++ standards.

SYGEF ECTFE



Ideal for highly concentrated media under high pressure and temparatures

ELGEF Plus I Electrofusion PE piping system



The reliable, modular PE system provides corrosion-free solutions for water and gas applications

Fuseal 25/50™ PVDF Special Waste Piping System



PVDF piping system, designed for return air plenums and aggressive chemicals, offering thermal stability and low flame spread

Fuseal Squared™
Double Containment PP Special Waste Piping System



PP double containment system, perfect for special waste systems requiring secondary containment.

Valves and Actuation



A wide range of valve types, with modular pneumatic and electric actuators and control units for automated industrial processes

Measurement and Control



Precision solutions for monitoring flow, pressure, temperature, and complete liquid analysis for optimal process control

PROGEF Standard
PP system

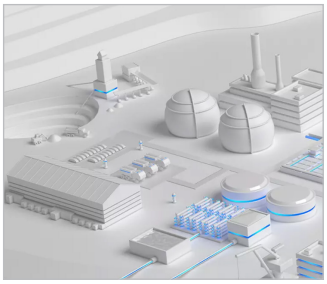


Unmatched chemical resistance and durability ensure reliable, cost-effective, high-performance solutions trusted industry-wide

13 Mining



From mobile phones to electric cars, mining provides essential materials for our daily lives like nickel, copper, lithium and others. Modern-day mining requires innovative, sustainable and more automated solutions to cope with the energy intensity from extraction to ore benefication to mineral processing while meeting environmental regulations. Plastic piping systems have been used for decades in mining applications to convey water for transporting slurries or hazardous liquids, such as sulphuric acid, sodium cyanide, hydrogen chloride, sodium hydroxide, carboxymethyl and other chemicals. With the focus on sustainability within the mining industry, GF Industry & Infrastructure Flow Solutions provides long-lasting, reliable and corrosion free piping solutions consisting of pipes, fittings, valves, tools, jointing, as well as measurement and control instrumentation for a variety of mining applications.

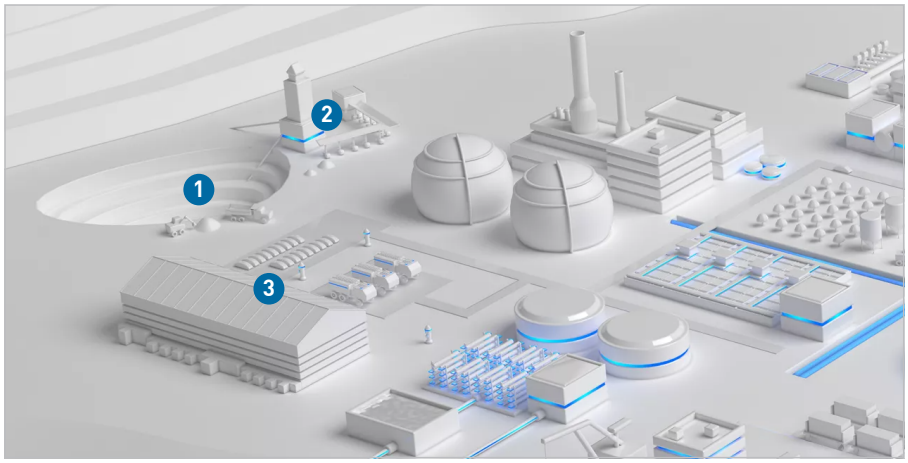


Main GF Industry & Infrastructure Flow Solutions Benefits



+ **Corrosion-Free & Low Maintenance:** GF's plastic piping systems resist corrosion, ensuring stable flow rates and reducing maintenance needs for over 25 years.
+ **Excellent Chemical Resistance:** Designed for mining's harsh environments, GF piping withstands a wide range of chemicals, ideal for sewage, acids, and abrasive compounds.
+ **Automated Solutions for Chemical Processes:** GF offers valves, sensors, and controllers for precise chemical process management, enhancing safety, efficiency, and product quality in mining.
+ **Enhanced Operational and Environmental Safety:** Our advanced jointing and testing technologies support safe, leak-free installation, minimizing accidents and downtime.
+ **Customized Solutions and Engineering Support:** GF provides digital libraries, engineering support, training, and on-site services to streamline project execution worldwide.

Segments for Mining









1 Extraction

Piping systems play a crucial role in mining extraction, ensuring the efficient transport of water, slurries and other fluids. Engineers must balance reliability, availability, capital costs, efficiency, and environmental responsibilities when designing complex pipelines. GF Industry & Infrastructure Flow Solutions' solutions are used for decades in mining as they are long lasting, maintenance free, non-corrosive and flexible.

2 Ore Benefication

Benefication is a separation process of valuable parts of the natural ore from the waste material. It involves various physical or chemical methods, such as gravity separation, flotation, or magnetic separation, to upgrade the ore. By doing so, it reduces costs related to handling, transportation, and extraction, ultimately maximizing the value of the extracted minerals. GF Industry & Infrastructure Flow Solutions' solutions are a good fit for many related processes and applications, due to their abrasive resistance, their durability and reliability as well as their non-corrosiveness.

3 Mineral Processing

Mineral processing ensures that the extracted material is more concentrated and suitable for further extractive metallurgy procedures. The aggressive environment of mining sites presents a particular challenge for piping systems. Depending on the application, different materials for pipes, fittings and valves combined with the right instrumentation are suitable to transport sulphuric acid, sodium cyanide, hydrogenchloride, sodium hydroxide, carboxymethyl cellulose and other hazardous liquids and other hazardous liquids. GF Industry & Infrastructure Flow Solutions' solutions are the right fit due to their excellent chemical resistance, reliability, durability and temperature resistance up to 90°C.

Example Applications for Mining

Extraction



Dewatering

The process of removing groundwater from mines is crucial for a safer working environment for miners. Excess water can weaken mine structures, cause collapses, and create hazardous conditions.

Dust Suppression

During mining operations, controlling and minimizing airborne dust particles is key. Dust can arise from activities like drilling, blasting, crushing, and material handling. It is crucial to protect the miners' health and the environment alike.

Safety Shower and Eyewash

Safety features like safety showers and eyewash stations are crucial in a mining environment. They ensure on-the-spot rinsing and decontamination when workors encounter hazardous chemicals or materials, thus minimizing injury risks.

Ore Beneficiation



Grinding

The process of reducing large ore particles into smaller sizes using mechanical forces, such as crushing and milling, is used to enhance mineral liberation and subsequent extraction. Water is added to a rotating cylindrical mill to grind the ore to form a slurry. GF solutions are used for transport of process water and slurry.

Flotation and Thickening

Piping systems are crucial for delivering the slurry to the flotation cells and for transporting the froth concentrate to further processing stages. The design of these systems must consider the abrasive nature of the slurry, the corrosive potential of chemicals, and the need for efficient flow management.

Salars

In salars, lithium is usually found dissolved in brine pools beneath the salt crust and is extracted through a process of evaporation and chemical treatment. Efficient piping systems are essential for managing the flow of brine, ensuring consistent supply, and minimizing the environmental impact of the operations. GF solutions are robust to withstand the harsh saline conditions and prevent leaks, which could lead to soil and water contamination.

Classification

The rotation of slurry inside a cyclone causes centrifugal force to move particles outwards. Larger mass particles migrate downward on the walls of the cyclone and discharged as underflow. Finer particles and water migrate upwards and discharge as overflow. GF solutions are used for transport of ore feed, overflow and underflow.

Tailings Disposal

Piping systems ensure the efficient and controlled movement of waste material like tailings slurry to designated containment facilities like ponds or dams, which is essential for maintaining environmental safety and operational efficiency.

Mineral Processing



Ion exchange

Ion exchangers can absorb unwanted ions in the water, thanks to selective synthetic resin beads, and release them during a regeneration process. The compact construction of ion exchange plants requires flexible piping solutions and components. GF Industry & Infrastructure Flow Solutions provides complete solutions of high-quality piping systems warranting a maximum of flexibility while ensuring an entirely safe plant operation with a maximum uptime.

Reverse osmosis

Reverse Osmosis technology covers several filtration techniques all based on selective membranes porosities. Based on selective porosity of a semi permeable membrane, impurities will be removed from a pressurized liquid. Due to the fact that it needs no chemicals, energy consumption is low and handling is easy.

Dosing / Dilution

Chemical dosing and dilution in drinking water applications are crucial for ensuring water safety and quality. Proper dosing adds precise amounts of chemicals, such as disinfectants and coagulants, to eliminate pathogens and remove impurities. Dilution ensures these chemicals are evenly distributed, preventing overdosing or underdosing, which could compromise water quality and safety.

Adsorption

Adsorption is a process where a solid is used to remove a soluble substance from an aqueous solution. GF product applications: safe transport of Sodium Cyanide (NaCN) in double contained pipe work (CONTAIN-IT and CONTAIN-IT Plus exclusive to GF).

Leaching

Leaching involves extraction of a soluble constituent from a solid by solvent. Bacterial Leaching uses naturally-occurring bacteria to harmlessly oxidize ore that is high in sulfides, thus making processing of the ore much easier and more cost effective.

Solvent Extraction / Electro Winning

Mass transfer operation based upon chemical difference. Feed solution containing solute to be extracted and feed solvent as a solute extractor. GF products are used in chemical processing and transport the liquid. Copper sulfate in solution coming from SX is electrochemically deposited in plates. This raffinate is extremely corrosive to metals.

Evaporation / Crystallization

The evaporation/crystallization process in mining is a method used to extract valuable minerals from a solution by evaporating the solvent and forming crystals of the solute. In lithium extraction, the concentrated brine is processed through a series of chemical treatments or ion exchange processes to extract lithium. GF solutions are ideal to tackle these related process steps due to their chemical resistance of our piping systems as well as our Process Automation portfolio.

Elution

Elution in mining, particularly in gold processing, is a critical step where valuable metals are separated from activated carbon. Acid washing removes the target metal from the adsorbent by adjusting pH and temperature. The efficiency of the elution process can significantly impact the overall efficiency and cost-effectiveness of the mining operation.

Process Cooling

Water absorbs heat from the process stream by flowing through heat exchangers or jackets surrounding equipment. Chilled water systems by GF Industry & Infrastructure Flow Solutions can be incorporated for even more effective cooling. Water cooling offers better heat transfer compared to air cooling.

Leading GF Polymer Piping Systems

Valves and Actuation



A wide range of valve types, with modular pneumatic and electric actuators and control units for automated industrial processes

Measurement and Control



Precision solutions for monitoring flow, pressure, temperature, and complete liquid analysis for optimal process control

ELGEF Plus I Electrofusion PE piping system



The reliable, modular PE system provides corrosion-free solutions for water and gas applications

ecoFit I Industry PE piping system



Polyethylene piping system for industrial use in water, wastewater, and chemical applications

PVC-C system



Cemented system for applications in the temperature range of 0°C to 80°C

PVC-U system



Cemented system with excellent properties in the temperature range of 0°C to 60°C

COOL-FIT 4.0
Pre-insulated system



Pre-insulated, corrosion-free piping system for commercial and industrial refrigeration setups

iJoint I Compression fitting



Compression fittings for easy and secure connection of PE pipes in applications such as drinking water supply, irrigation, and mining

PROGEF Standard PP system



Unmatched chemical resistance and durability ensure reliable, cost-effective, high-performance solutions trusted industry-wide

PROGEF Natural PP system



Transparent, pigment-free PP system with a high surface finish and exceptional chemical resistance meets purity standards for various applications

PROGEF Plus PP-H High Purity



Specified PP-H production and packaging, certified leach-out results, and LABS compliance ensure top quality and safety

CONTAIN-IT Plus



Dual protection for hazardous fluids with a chemical-resistant inner pipe and containment layer

SYGEF Standard PVDF system



Reliable PVDF system with exceptional chemical and temperature resistance

SYGEF Plus PVDF-HP High Purity



System with high mechanical and chemical resistance for high purity applications

SYGEF ECTFE

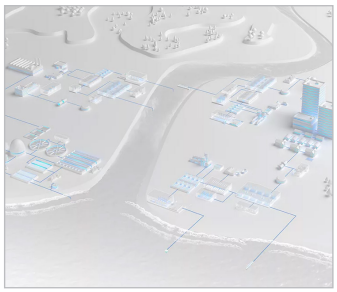


Ideal for highly concentrated media under high pressure and temparatures

14 Water Industry



The water treatment market faces several critical issues, with increasing urbanization and global warming resulting in one of the biggest concerns, namely water scarcity. Also, regulations on water discharge are getting stricter, commodity prices are rising, and infrastructure is aging in the developed world. Furthermore, providers are under pressure to keep up with digitization, aiming to have a competitive advantage in the industry of the future. Our comprehensive product portfolio includes state-of-the-art and interoperable valve and measurement solutions for Process Automation, as well as pipes, fittings, and jointing technology, offering holistic solutions across the whole water cycle.

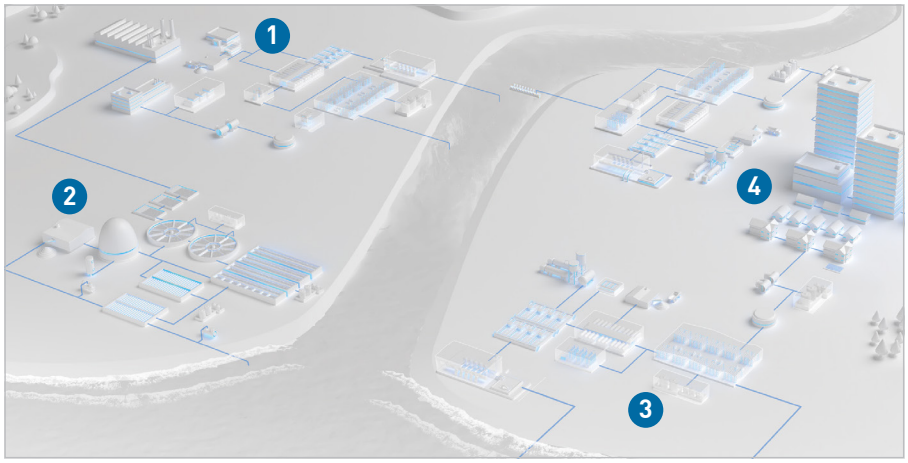


Main GF Industry & Infrastructure Flow Solutions Benefits

+ **Increased Longevity:** Thermoplastic piping resists corrosion, providing long-lasting durability with minimal maintenance and fewer replacements, even in harsh environments.
+ **One Partner:** GF's all-in-one portfolio includes valves, pipes, controls, and fittings, ensuring compatibility, simplifying procurement, and streamlining project management.
+ **Boosted Efficiency:** Lightweight thermoplastic pipes allow faster installation, reduce friction losses for improved water flow, and require less maintenance, cutting overall costs.
+ **Sustainable Contribution:** Long-lasting, lightweight design reduces waste, energy use, and carbon footprint, supporting environmental sustainability in water transport systems.



Segments for Water Industries



1 Industrial Water Treatment

High water purity is a critical requirement and an absolute necessity for production processes, feed boilers, and cooling systems in today's industry. Applications such as deionization, electrodialysis, and new membrane-based solutions avoid contamination, scale formation, and corrosion. At GF Industry & Infrastructure Flow Solutions, we offer a wide range of products, automation options, and comprehensive solutions for all applications, from chemical dosing systems and media filtration to ion exchangers.

2 Wastewater Treatment

Wastewater treatment plants are rapidly becoming water resource factories. This commands new advanced treatments and process intensifications, such as membrane and physicochemical treatments. This also places the automated sewage handling on the critical path for operators to lighten the burden on their shoulders, an area where GF Industry & Infrastructure Flow Solutions gladly helps. Membrane technology, chemical dosing systems, and polymer preparation are applications that require efficient water conveyance systems. GF Industry & Infrastructure Flow Solutions products are designed for maximum uptime reliability and maintenance simplicity with our Process Automation solutions and a minimum of energy consumption during operation.

3 Desalination

Wherever groundwater is difficult or even impossible to reach, other ways must be found to make water available in the right quantity and quality. GF Industry & Infrastructure Flow Solutions technology helps to reliably desalinate seawater or brackish water and use it as drinking water or for industrial use. Here, the corrosion-free characteristic of thermoplastic piping systems is essential to expand the lifetime of the system. The leading technology for desalination plants is reverse osmosis, a filtration process that is used for the purification of water. Solutions for Process Automation from GF Industry & Infrastructure Flow Solutions such as valves, actuators, measurement, and control help to ensure the failsafe operation of desalination plants.

4 Drinking water

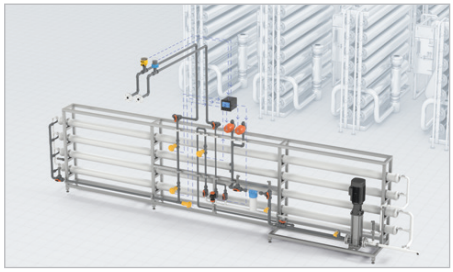
Drinking water will increasingly need to be produced closer to where it's used, which requires decentralization and distributed treatments. In this new realm, reliability and Process Automation are essential to reduce operation and maintenance burdens. GF Industry & Infrastructure Flow Solutions has a proven track record in helping with this. With the high-quality system solutions of GF Industry & Infrastructure Flow Solutions - offering pipes, fittings, automation, and instrumentation from one source – the optimal compatibility of all components is warranted.

Example Applications



Ion exchange

Demineralization units like deionization help to ensure the production of pure, high-quality process water in industrial settings. Ion exchangers use synthetic resin beads to absorb unwanted ions and release them during regeneration. GF provides flexible, high-quality piping solutions that help to ensure safe plant operation and maximum uptime.



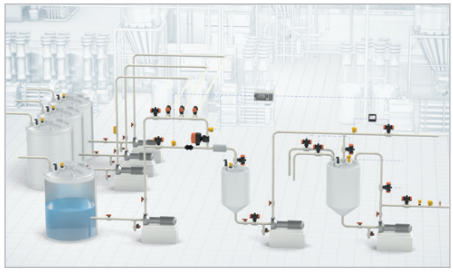
Reverse osmosis

Reverse Osmosis technology filters contaminated water through a high-pressure semi-permeable membrane, removing nearly all pollutants like minerals, bacteria, and particles. It requires no chemicals, has low energy consumption, and is easy to handle. GF Industry & Infrastructure Flow Solutions provides high-quality components for piping and monitoring water quality.



Deionized Water

Manufacturing processes require high-purity process water, such as deionized or UPW water. Ensuring consistent quality involves precise control of water properties and concentrations. Deionization uses ion exchange resins to remove all ions. GF Industry & Infrastructure Flow Solutions offers high-quality solutions for these processes, meeting industry standards and maintaining specified water quality.



Dosing / Dilution

Diluting chemicals with precision involves specialized workflows, especially for aggressive substances. We dose concentrated chemicals in-line or via static mixers to ensure accurate dilution. Custom plastic systems can be designed using pressure control valves, flow meters, and instrumentation.



Mixing / Batching Control

GF Industry & Infrastructure Flow Solutions has a comprehensive line of products that comply with the respective health, safety, and wastewater regulations. Our measurement and control technology ensures precisely controlled batch processes. The product range includes materials and technology specially designed for numerous process applications.



Chemical Distribution

Transporting chemicals of the highest quality, in different concentrations, and with exact dosing is mandatory. Choosing the appropriate piping system, including automation, offers many advantages, such as increased productivity, decreased production and maintenance costs, and improved product quality.



Neutralization

In nearly every water treatment process, pH adjustment is essential for meeting treatment requirements, whether for wastewater, or drinking water. Proper measurements and control are crucial. Our solutions offer high process reliability and cost optimization, ensuring efficiency in this cost-intensive area.



Filling of tanks

Tanks are required to store liquid media in manufacturing and processing plants. We offer fast, reliable, safe tools for filling and emptying tanks. Our range comprises a broad spectrum of piping systems, including measurement and control technology, automatic and manual valves, and an extensive array of valves for demanding applications.



Media filtration

In the multi-level filtration processes, anthracite or stones, as well as sand, are used to remove particles up to 10-15 µm from fluids. Due to the need for several operation modes, the process requires cleaned piping systems, numerous valves and bypass actuators, and adapted measurement and control technology.

Leading GF Polymer Piping Systems

Valves and Actuation



A wide range of valve types, with modular pneumatic and electric actuators and control units for automated industrial processes

Measurement and Control



Precision solutions for monitoring flow, pressure, temperature, and complete liquid analysis for optimal process control

ELGEF Plus I Electrofusion PE piping system



The reliable, modular PE system provides corrosion-free solutions for water and gas applications

ecoFit I Industry PE piping system



Polyethylene piping system for industrial use in water, wastewater, and chemical applications

PVC-C system



Cemented system for applications in the temperature range of 0°C to 80°C

PVC-U system



Cemented system with excellent properties in the temperature range of 0°C to 60°C

ABS system



Energy-efficient system with low thermal conductivity, ideal for use at low temperatures

iJoint I Compression fitting



Compression fittings for easy and secure connection of PE pipes in applications such as drinking water supply, irrigation, and mining

PROGEF Standard PP system



Unmatched chemical resistance and durability ensure reliable, cost-effective, high-performance solutions trusted industry-wide

PROGEF Natural PP system



Transparent, pigment-free PP system with a high surface finish and exceptional chemical resistance meets purity standards for various applications

PROGEF Plus PP-H High Purity



Specified PP-H production and packaging, certified leach-out results, and LABS compliance ensure top quality and safety

CONTAIN-IT Plus



Dual protection for hazardous fluids with a chemical-resistant inner pipe and containment layer

SYGEF Standard PVDF system



Reliable PVDF system with exceptional chemical and temperature resistance

SYGEF Plus PVDF-HP High Purity



System with high mechanical and chemical resistance for high purity applications

SYGEF ECTFE



Ideal for highly concentrated media under high pressure and temparatures

COOL-FIT 2.0

Pre-insulated system



Pre-insulated, corrosion-free piping system for chilled water

COOL-FIT 4.0

Pre-insulated system



Pre-insulated, corrosion-free piping system for commercial and industrial refrigeration setups

Materials and Piping Systems

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Introduction to Polymer Materials

1.1 Plastics in general

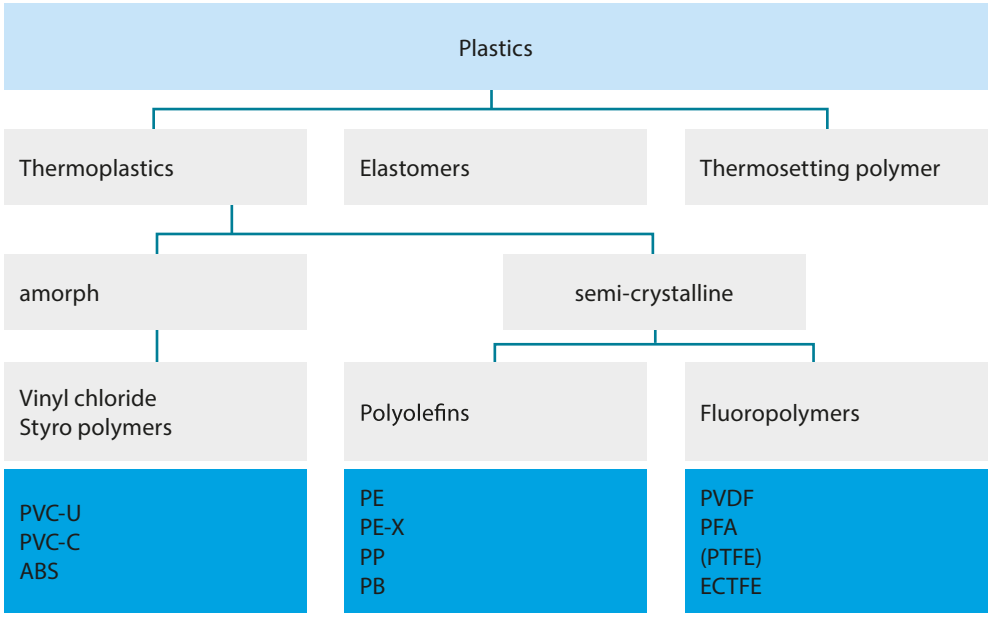
1.1.1 History

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.

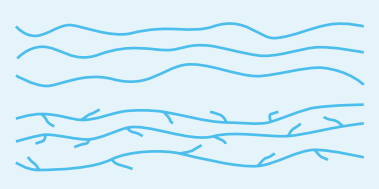
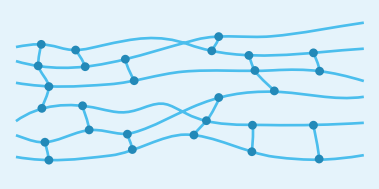
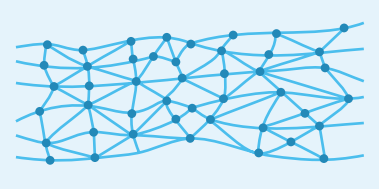
1.1.2 Structure and properties

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 fittings. For example, thermosetting polymer are used as insulation foams or in glass-fibre reinforced liners.



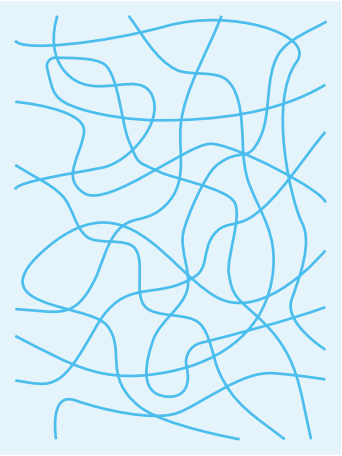
Materials for piping systems – Overview

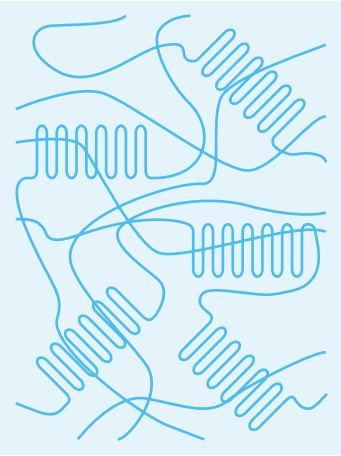
Main group		Property
Thermoplastics e.g. PE, PVC		• Linear or branched • Meltable • Soluble, swellable • Plastic mouldable
Elastomer e.g. NBR, EPDM		• Poorly linked • Not meltable • Not soluble, not swellable • Not plastically mouldable
Thermosetting plastics e.g. PUR, Epoxy		• Strongly linked • Not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

Plastics – Main groups

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

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.

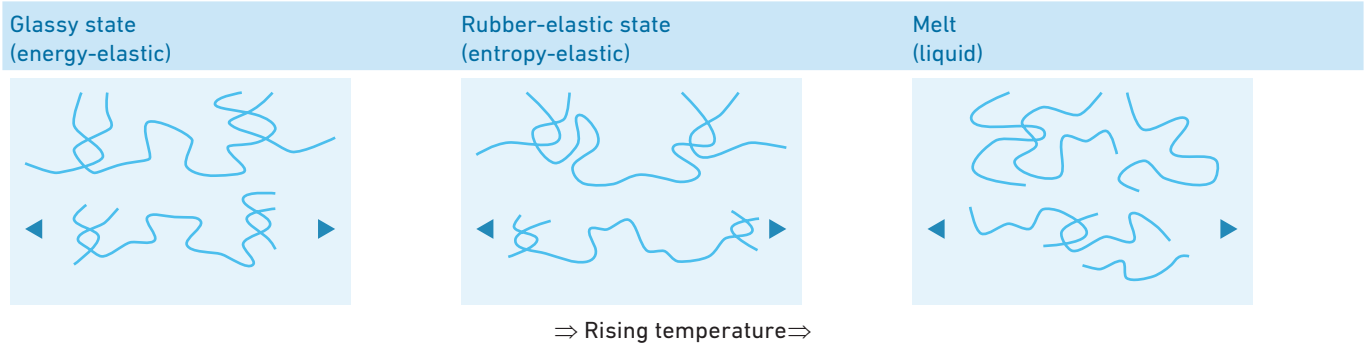


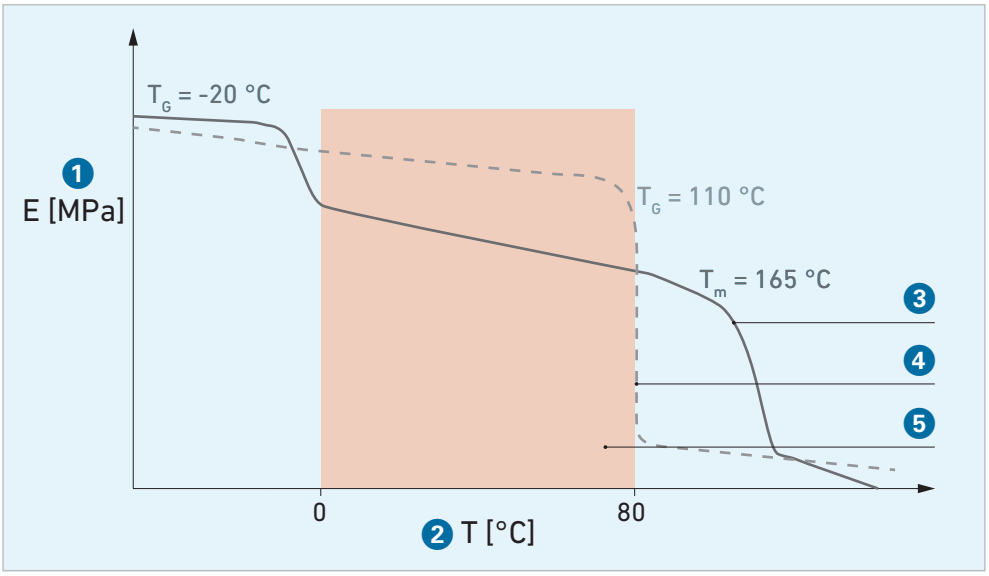


Subdivision of the Thermoplastics

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.





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:

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

Properties and advantages of plastics

1.1.5 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 Industry & Infrastructure Flow Solutions 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 Industry & Infrastructure Flow Solutions 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[1], Plastics Europe has quantified how energy consumption and greenhouse gas emissions affect plastic products by replacing them with other materials.

[1] Pilz, H., Brandt, B., Fehringer, R. (2010): The impact of plastics on energy consumption and greenhouse gas emissions in Europe. Denkstatt GmbH on behalf of PlasticsEurope, Brussels, Belgium.

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.

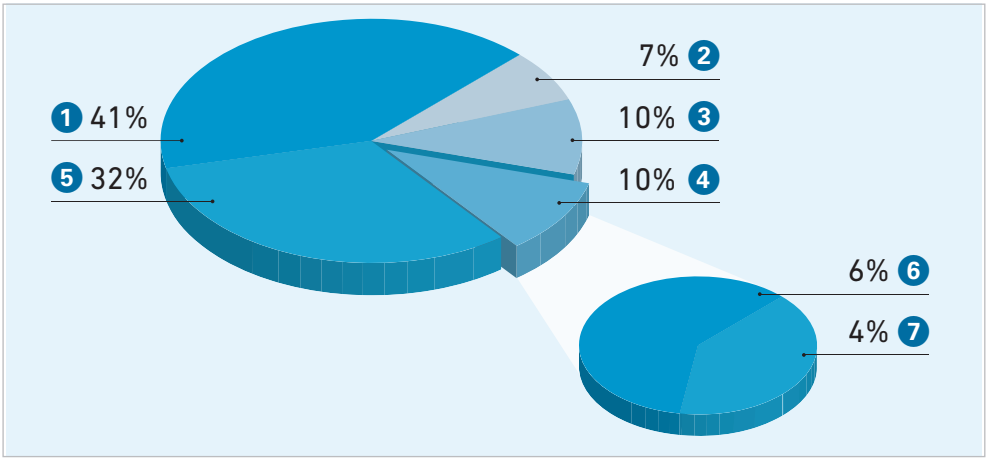
1.2 Manufacturing and processing methods

1.2.1 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.

1.2.2 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

Manufacturing of plastics

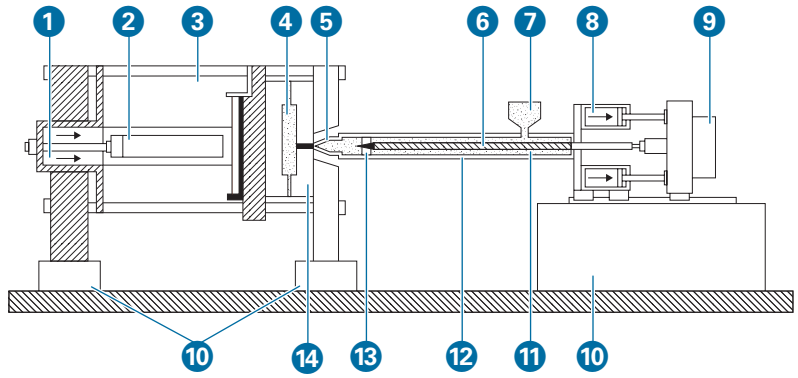
Polymerisation	Polycondensation	Polyaddition
Polymerisation is the most widely used process in the synthesis of plastics. Polymerisation refers to the attachment of monomers to macromolecule chains without elimination of foreign substances. When using e.g. polymerisation, polyethylene, polybutene, polypropylene, 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.

1.2.3 Processing

GF Industry & Infrastructure Flow Solutions 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

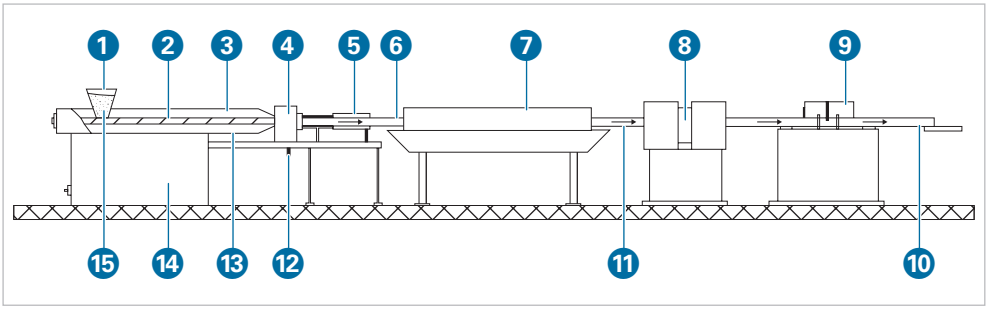
Extrusion

An extrusion machine integrates the following process steps:

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

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.



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

Material Selection

1.3 Chemical Resistance

1.3.1 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 Industry & Infrastructure Flow Solutions 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.

i GF Industry & Infrastructure Flow Solutions' 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 Industry & Infrastructure Flow Solutions.

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 Industry & Infrastructure Flow Solutions refers to the General Terms and Conditions of Sale. Subject to change without notice.

1.3.2 General information regarding chemical resistance

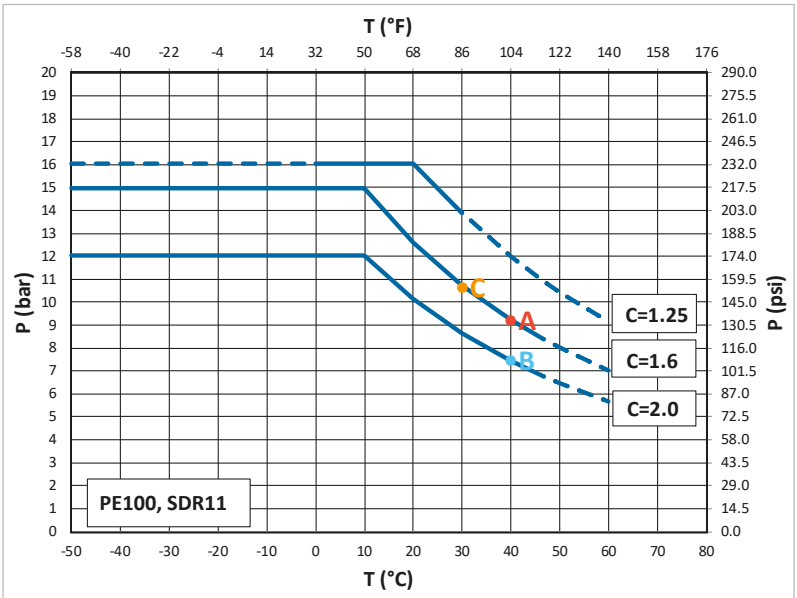
De-rating factor

The pressure-temperature diagrams of GF Industry & Infrastructure Flow Solutions 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

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 Tangit DTX, a special processing technique is required. Please refer to the relevant chapter in these Planning Fundamentals.

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, please refer to the “Jointing Technology” section in these Planning Fundamentals.

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.

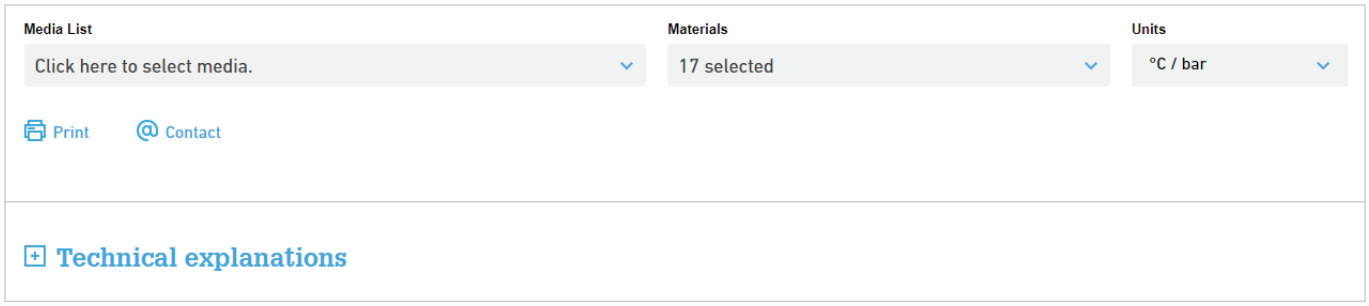
1.4 Chemical Resistance Tool ChemRes Plus

How to find the right material for aggressive media

Not every pipe material is suitable for transporting aggressive liquids and gases. The use of incorrect materials can lead to problems. With ChemRes Plus, you can find the right materials quickly and easily.

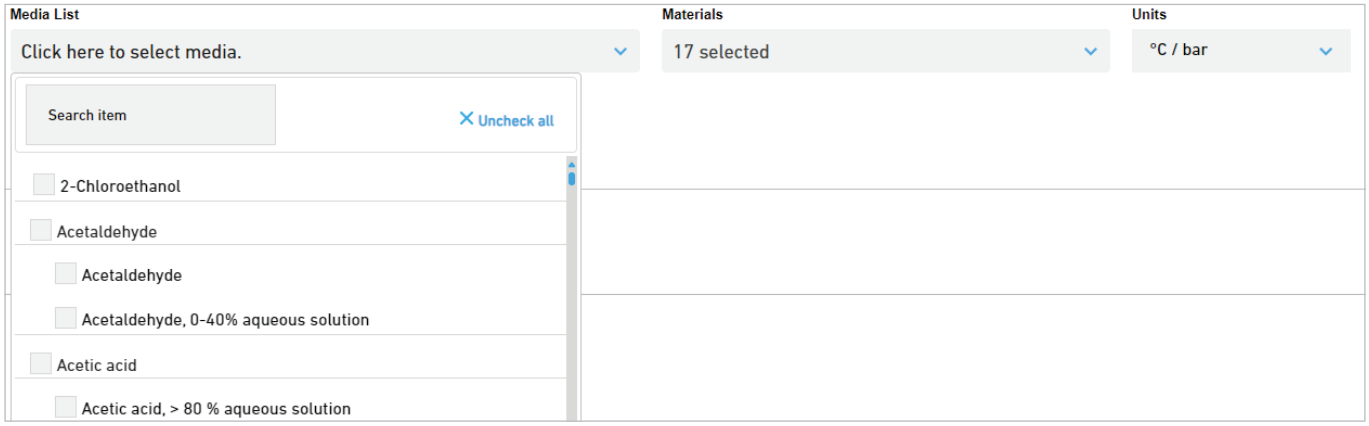
Direct link to ChemRes PLUS:
https://www.gfps.com/com/en/downloads-tools/online-tools/chemical-resistance.html

How to use ChemRes PLUS

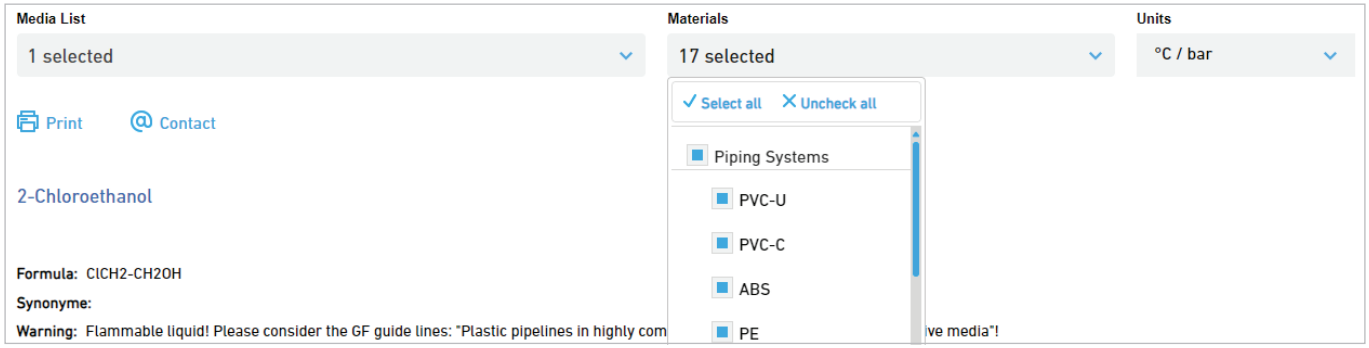


In order to locate a specific medium, click on the grey bar of the **Media List** and enter the corresponding name (e.g. sodium hypochlorite).

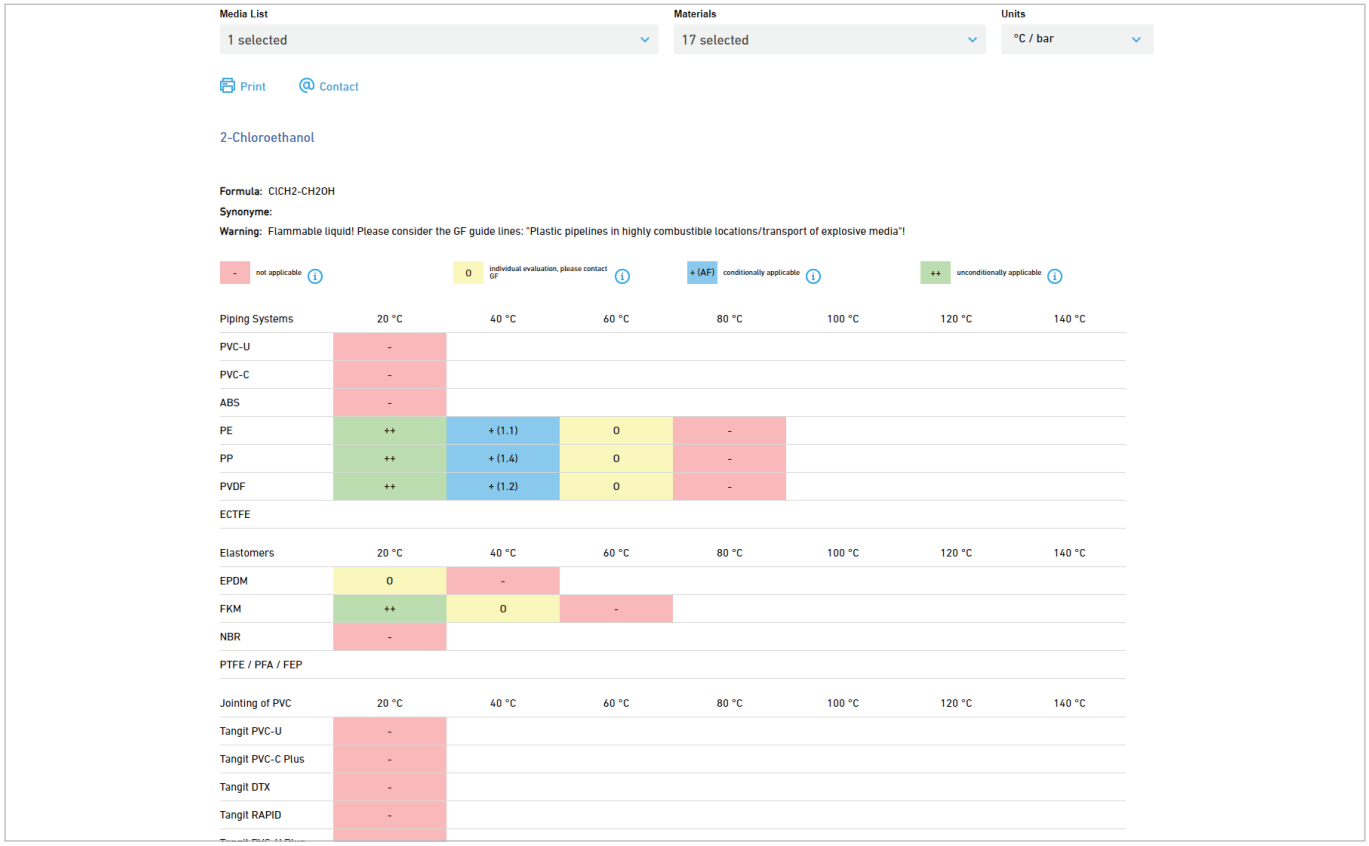
Synonyms can also be entered as an alternative, e.g. chlorine bleach.



The materials suitable for the medium are then displayed in **Materials** and can be selected as a single item or in groups. The groups **Piping Systems** and **Jointing of PVC** are pre-selected.



The **resistance profiles** of the selected materials are now displayed and can be compared.



Classification

Here's what the results mean:

Symbol	Meaning	Description
++	Recommended	Fully recommended, no influence on material properties.
+ (AF)	Recommended with restrictions	Recommended together with the specified reduction factor. Influence on material properties, e.g. by penetration or swelling, is possible, but no chemical attack.
0	Consultation with GF Industry & Infrastructure Flow Solutions	Restricted recommendation. From this temperature, recommendations are not generally given, only on the basis of an individual assessment. Please contact GF Industry & Infrastructure Flow Solutions directly.
-	Not suitable	Not suitable. Incompatibility of material and medium.

The listed ratings are valid for conditions listed and assumed to be for continual exposure to medium at temperature listed and for use in a pressure piping system. However, while a negative or conditional rating may be noted, a suitable application of a particular material/medium combination may be given under different process conditions (e.g. drainage systems, temporary exposure, briefly exceeding maximum temperature, etc.). Please contact GF for more information.

1.5 Material properties

The following properties describe the material.

UV and weather resistance



Describes the resistance to the effects of UV radiation, rain, wind and temperature fluctuations. Plastics with high UV and weather resistance are more durable and are suitable for outdoor applications because they are less susceptible to discoloration, cracking or material degradation.

Chemical resistance



A material's ability to withstand degradation or damage when exposed to chemicals, such as acids, bases, solvents, or corrosive agents. Plastics with high chemical resistance maintain their integrity and performance in harsh environments, making them suitable for applications in chemical processing, healthcare, and industrial settings.

Abrasion resistance



Refers to a plastic material's ability to withstand wear caused by friction or contact with rough surfaces. Plastics with high abrasion resistance are more durable and less prone to wear, making them ideal for applications involving frequent contact and high stress.

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



Refers to how a plastic material reacts when exposed to flames or high temperatures, including its flammability, smoke production, and potential to release toxic gases. Understanding a plastic's combustion behavior is crucial for safety in applications where fire resistance is important, as materials with high flame resistance can slow fire spread and reduce harmful emissions.

Electrical properties



Properties such as dielectric strength, conductivity and insulation resistance determine a plastic's ability to conduct or resist electricity, making them critical for applications such as insulation, connectors and shielding.

Physiological properties



Relate to the safety and compatibility of a material with biological systems, including toxicity and biocompatibility. These properties are of crucial importance for applications such as medical devices and food packaging, where plastics come into direct contact with humans or animals.

Recycling



Plastics recycling is divided into mechanical and advanced methods. Mechanical recycling involves sorting, cleaning, and melting plastics, but each cycle lowers material quality. Advanced techniques, like chemical recycling, can produce high-quality materials, though they require high energy and are not yet widely available. Ideally, materials should be mechanically recycled before advanced treatments or incineration for energy recovery.

ABS - Acrylonitrile-butadiene-styrene

1.1 Reference values

Property	Value[1]	Units	Test standard
Density	0.925	g/cm³	EN ISO 1183-1
Yield stress[2]	20	N/mm²	EN ISO 527-1
Tensile modulus[2]	450	N/mm²	EN ISO 527-1
Charpy notched impact strength[2]	20	kJ/m²	EN ISO 179-1/1eA
Charpy notched impact strength at -40 °C (-40 °F)	≥ 10	kJ/m²	EN ISO 179-1/1eA
Heat distortion temperature HDT A 1.80 MPa	≥ 74 ≥ 165	°C °F	EN ISO 75-2
Vicat-heat distortion temperature B/50N	≥ 94 ≥ 201	°C °F	ISO 306
Thermal conductivity[2]	0.19	W/m K	ASTM E1530
Water absorption[2]	≤ 0.45	%	EN ISO 62
Color	similar 7'001		RAL
Limiting oxygen index (LOI)	19	%	ISO 4589-1

[1] Typical characteristics measured at the material should not be used for calculations.
[2] At 23 °C (73.4 °F)

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 Industry & Infrastructure Flow Solutions 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 Industry & Infrastructure Flow Solutions or contact an authorized GF Industry & Infrastructure Flow Solutions 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 x 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 Industry & Infrastructure Flow Solutions 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 Industry & Infrastructure Flow Solutions representative.

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.

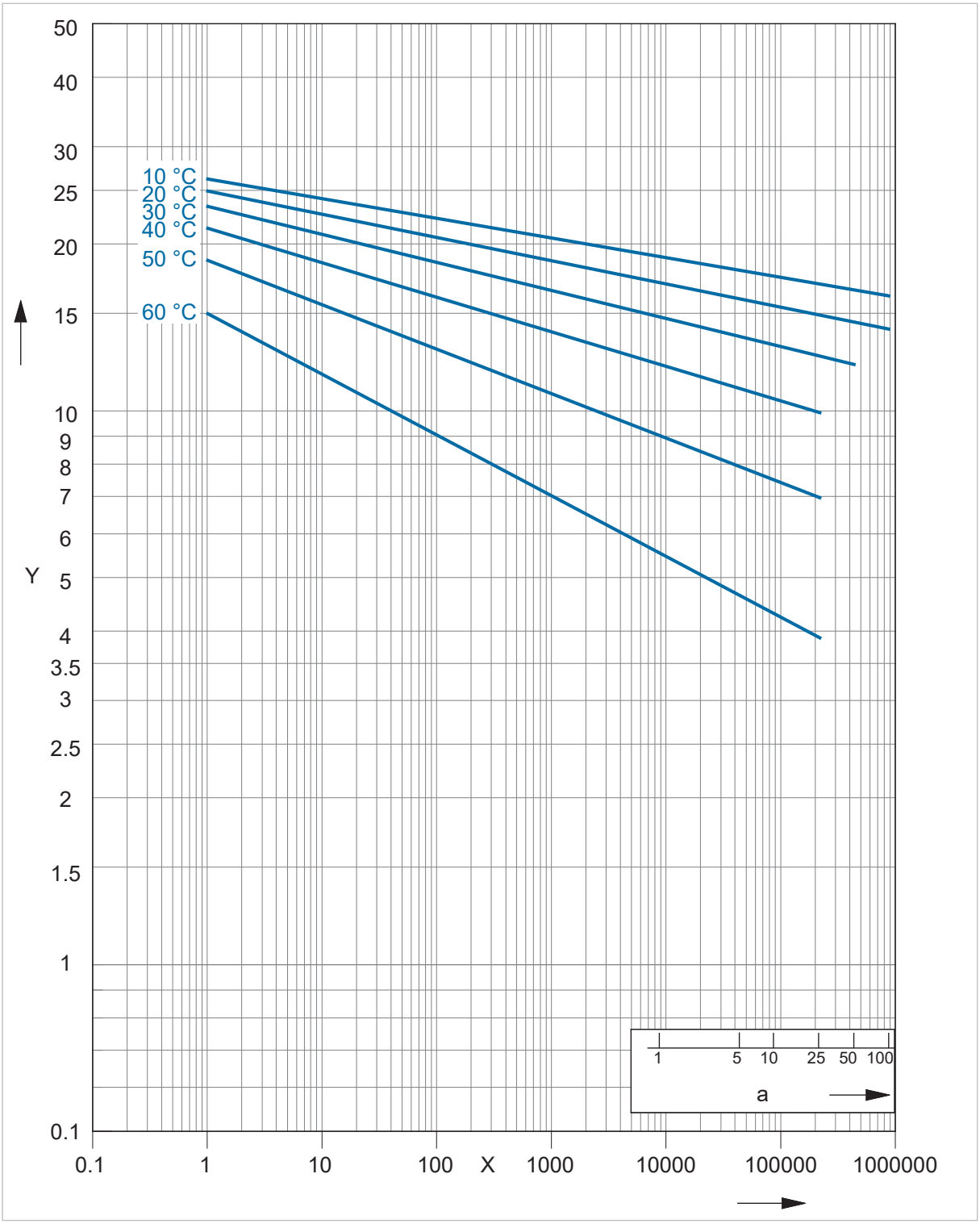
The long-term behavior was calculated by using the extrapolation method according to EN ISO 9080. With the following equation (4-parameter model), which was derived from that diagram, stress, temperature or time can be calculated for the temperature range of
+10 °C to +60 °C.

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

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

1.3 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.

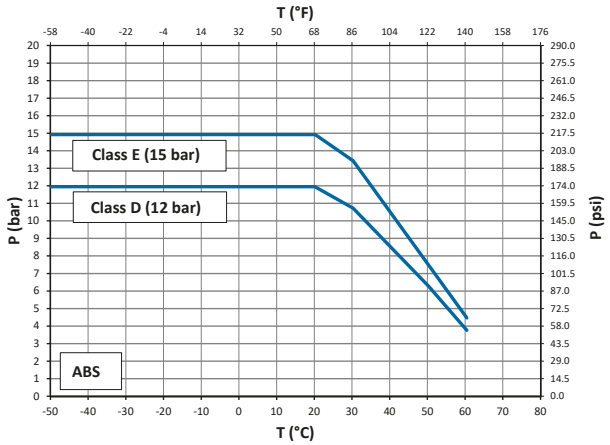
The design factor of 2.1 for British systems and 1.8 for metric systems recommended by GF Industry & Infrastructure Flow Solutions has been incorporated.

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

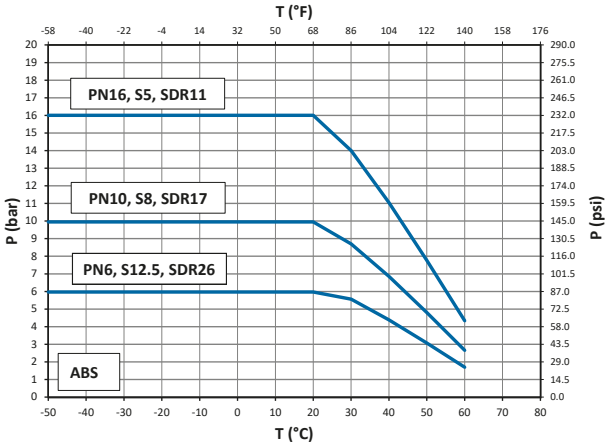
⚠ Please take into account the pressure-temperature diagrams for valves and special fittings. Because of the construction and/or sealing material used, differences are possible when compared to pipe and fittings. More information is available in the Planning Fundamentals of the relevant types of valves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

British systems



Metric systems



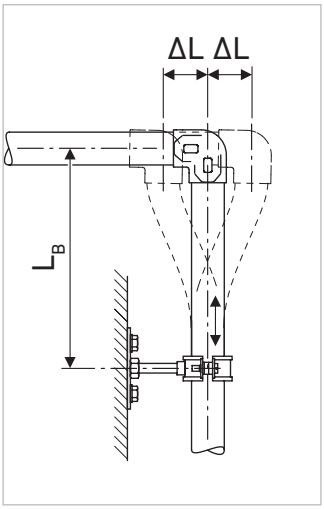
P Permissible pressure (bar, psi)
T Temperature (°C, °F)

⚠ 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.

1.4 Flexible sections of ABS piping systems

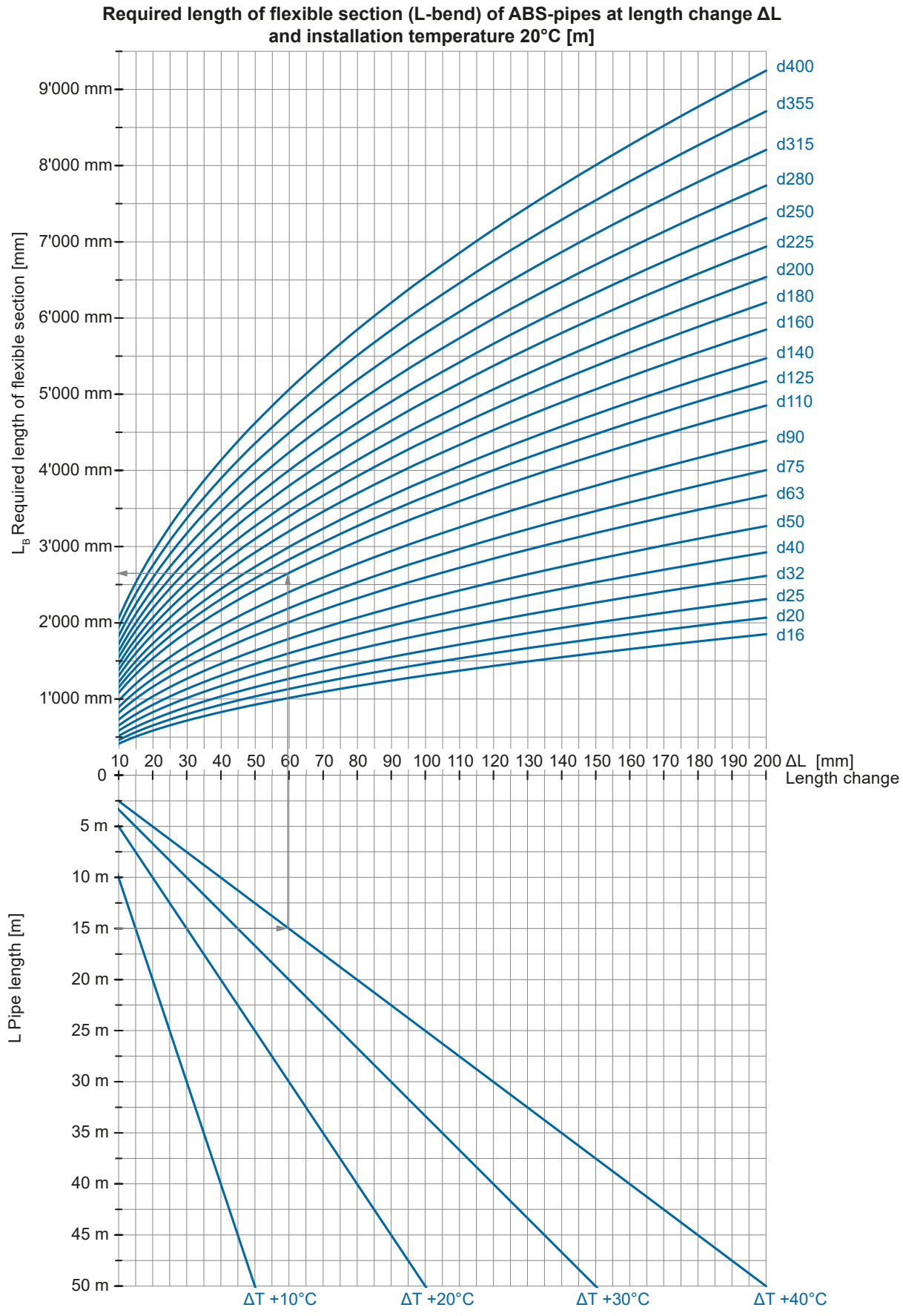
Properties of ABS

Symbol	Designation	Value	Unit
K	Proportionality factor for flexible sections	32.7	-
ΔL	Length change	-	mm/inch
d	Outer pipe diameter	-	mm
L_B	Required length of flexible section (L-bend)	-	mm/inch



$L_B = K * (d * \Delta L)^{\wedge 0.5}$

Flexible sections diagram - Outer pipe diameter d16 - d400



Required length of flexible section L_B at length change ΔL, [mm]

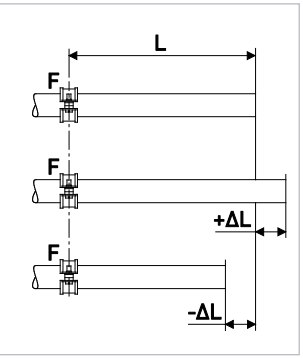
	Outer Pipe Diameter d (mm)																				
ΔL	16	20	25	32	40	50	63	75	90	110	125	140	160	180	200	225	250	280	315	355	400
(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)
15	505	565	635	715	800	895	1'000	1'100	1'200	1'350	1'400	1'500	1'600	1'700	1'800	1'900	2'000	2'100	2'250	2'400	2'550
30	715	800	895	1'000	1'150	1'250	1'400	1'550	1'700	1'900	2'000	2'100	2'250	2'400	2'550	2'700	2'850	3'000	3'200	3'350	3'600
45	875	980	1'100	1'250	1'400	1'550	1'750	1'900	2'100	2'300	2'450	2'600	2'750	2'950	3'100	3'300	3'450	3'650	3'900	4'150	4'400
60	1'000	1'150	1'250	1'450	1'600	1'800	2'000	2'200	2'400	2'650	2'850	3'000	3'200	3'400	3'600	3'800	4'000	4'250	4'500	4'750	5'050
75	1'150	1'250	1'400	1'600	1'800	2'000	2'250	2'450	2'700	2'950	3'150	3'350	3'600	3'800	4'000	4'250	4'500	4'750	5'050	5'350	5'650
90	1'250	1'400	1'550	1'750	1'950	2'200	2'450	2'700	2'950	3'250	3'450	3'650	3'900	4'150	4'400	4'650	4'900	5'200	5'500	5'850	6'200
105	1'350	1'500	1'700	1'900	2'100	2'350	2'650	2'900	3'200	3'500	3'750	3'950	4'250	4'500	4'750	5'050	5'300	5'600	5'950	6'300	6'700
120	1'450	1'600	1'800	2'050	2'250	2'550	2'850	3'100	3'400	3'750	4'000	4'250	4'550	4'800	5'050	5'350	5'650	6'000	6'350	6'750	7'150
135	1'500	1'700	1'900	2'150	2'400	2'700	3'000	3'300	3'600	4'000	4'250	4'500	4'800	5'100	5'350	5'700	6'000	6'350	6'750	7'150	7'600
150	1'600	1'800	2'000	2'250	2'550	2'850	3'200	3'450	3'800	4'200	4'500	4'750	5'050	5'350	5'650	6'000	6'350	6'700	7'100	7'550	8'000
165	1'700	1'900	2'100	2'400	2'650	2'950	3'350	3'650	4'000	4'400	4'700	4'950	5'300	5'650	5'950	6'300	6'650	7'050	7'450	7'900	8'400
180	1'750	1'950	2'200	2'500	2'750	3'100	3'500	3'800	4'150	4'600	4'900	5'200	5'550	5'900	6'200	6'600	6'950	7'350	7'800	8'250	8'750
195	1'850	2'050	2'300	2'600	2'900	3'250	3'600	3'950	4'350	4'800	5'100	5'400	5'800	6'150	6'450	6'850	7'200	7'650	8'100	8'600	9'150
210	1'900	2'100	2'350	2'700	3'000	3'350	3'750	4'100	4'500	4'950	5'300	5'600	6'000	6'350	6'700	7'100	7'500	7'950	8'400	8'950	9'500
225	1'950	2'200	2'450	2'750	3'100	3'450	3'900	4'250	4'650	5'150	5'500	5'800	6'200	6'600	6'950	7'350	7'750	8'200	8'700	9'250	9'800
240	2'050	2'250	2'550	2'850	3'200	3'600	4'000	4'400	4'800	5'300	5'650	6'000	6'400	6'800	7'150	7'600	8'000	8'500	9'000	9'550	10'150
255	2'100	2'350	2'600	2'950	3'300	3'700	4'150	4'500	4'950	5'500	5'850	6'200	6'600	7'000	7'400	7'850	8'250	8'750	9'250	9'850	10'450
270	2'150	2'400	2'700	3'050	3'400	3'800	4'250	4'650	5'100	5'650	6'000	6'350	6'800	7'200	7'600	8'050	8'500	9'000	9'550	10'100	10'750
285	2'200	2'450	2'750	3'100	3'500	3'900	4'400	4'800	5'250	5'800	6'150	6'550	7'000	7'400	7'800	8'300	8'750	9'250	9'800	10'400	11'050
300	2'250	2'550	2'850	3'200	3'600	4'000	4'500	4'900	5'350	5'950	6'350	6'700	7'150	7'600	8'000	8'500	8'950	9'500	10'050	10'650	11'350

Required length of flexible section L_B at length change ΔL, [inch]

	Outer Pipe Diameter d (mm)																				
ΔL	16	20	25	32	40	50	63	75	90	110	125	140	160	180	200	225	250	280	315	355	400
(inch)	(inch)	(inch)	(inch)	(inch)	(inch)	(inch)	(inch)	(inch)	(inch)	(inch)	(inch)	(inch)	(inch)	(inch)	(inch)	(inch)	(inch)	(inch)	(inch)	(inch)	(inch)
0.5	16.9	18.9	21.1	23.9	26.7	29.9	33.5	36.6	40.0	44.3	47.2	50.0	53.4	56.6	59.7	63.3	66.7	70.6	74.9	79.5	84.4
1.0	23.9	26.7	29.9	33.8	37.8	42.2	47.4	51.7	56.6	62.6	66.7	70.6	75.5	80.1	84.4	89.6	94.4	99.9	106	112	119
1.5	29.2	32.7	36.6	41.4	46.2	51.7	58.0	63.3	69.4	76.7	81.8	86.5	92.5	98.1	103	110	116	122	130	138	146
2.0	33.8	37.8	42.2	47.8	53.4	59.7	67.0	73.1	80.1	88.6	94.4	99.9	107	113	119	127	133	141	150	159	169
2.5	37.8	42.2	47.2	53.4	59.7	66.7	74.9	81.8	89.6	99.0	106	112	119	127	133	142	149	158	168	178	189
3.0	41.4	46.2	51.7	58.5	65.4	73.1	82.1	89.6	98.1	108	116	122	131	139	146	155	164	173	184	195	207
3.5	44.7	50.0	55.8	63.2	70.6	79.0	88.7	96.7	106	117	125	132	141	150	158	168	177	187	198	210	223
4.0	47.8	53.4	59.7	67.5	75.5	84.4	94.8	103	113	125	133	141	151	160	169	179	189	200	212	225	239
4.5	50.7	56.6	63.3	71.6	80.1	89.6	101	110	120	133	142	150	160	170	179	190	200	212	225	239	253
5.0	53.4	59.7	66.7	75.5	84.4	94.4	106	116	127	140	149	158	169	179	189	200	211	223	237	252	267
6.0	61.1	68.3	76.4	86.4	96.6	108	121	132	145	160	171	181	193	205	216	229	242	256	271	288	305
7.0	68.2	76.3	85.3	96.5	108	121	135	148	162	179	191	202	216	229	241	256	270	285	303	321	341
8.0	74.9	83.8	93.7	106	118	132	149	162	178	196	209	222	237	251	265	281	296	313	332	353	375
9.0	81.2	90.8	102	115	128	144	161	176	193	213	227	240	257	272	287	305	321	340	360	383	406
10.0	87.2	97.5	109	123	138	154	173	189	207	229	244	258	276	292	308	327	345	365	387	411	436
11.0	92.9	104	116	131	147	164	184	201	220	244	260	275	294	312	328	348	367	389	412	437	464
12.0	98.3	110	123	139	155	174	195	213	233	258	275	291	311	330	348	369	389	411	436	463	491
13.0	103	116	129	146	164	183	205	224	245	271	289	306	327	347	366	388	409	433	459	487	517
14.0	108	121	136	153	172	192	215	235	257	284	303	321	343	364	384	407	429	454	481	511	542
15.0	113	127	142	160	179	200	225	245	269	297	317	335	358	380	400	425	448	474	503	534	566

1.5 Length changes of ABS

Properties of ABS			
Symbol	Designation	Value	Unit
T_{min}	Temperature min.	-50 / -58	°C / °F
T_{max}	Temperature max.	+60 / +140	°C / °F
ΔT	Temperature difference	-	°C / °F
α_{min}	Linear thermal expansion coefficient @20°C/68°F	0.1	mm/m K
α_{max}	Linear thermal expansion coefficient @max. temperature	0.1	mm/m K
ΔL	Length change	-	mm
L	Pipe length	-	m/inch
F	Fix point	-	-



$\Delta L = L \cdot \Delta T \cdot \alpha$

Thermal length change ΔL (mm) between 20°C and any end temperature

Pipe length L	End temperature (°C)											
	-50	-40	-30	-20	-10	0	10	20	30	40	50	60
(m)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)
1	-7.0	-6.0	-5.0	-4.0	-3.0	-2.0	-1.0	0.0	1.0	2.0	3.0	4.0
2	-7.0	-5.0	-3.0	-1.0	1.0	3.0	5.0	7.0	9.0	11	13	15
3	-7.0	-4.0	-1.0	2.0	5.0	8.0	11	14	17	20	23	26
4	-7.0	-3.0	1.0	5.0	9.0	13	17	21	25	29	33	37
5	-7.0	-2.0	3.0	8.0	13	18	23	28	33	38	43	48
6	-7.0	-1.0	5.0	11	17	23	29	35	41	47	53	59
7	-7.0	0.0	7.0	14	21	28	35	42	49	56	63	70
8	-7.0	1.0	9.0	17	25	33	41	49	57	65	73	81
9	-7.0	2.0	11	20	29	38	47	56	65	74	83	92
10	-7.0	3.0	13	23	33	43	53	63	73	83	93	103
12	-7.0	5.0	17	29	41	53	65	77	89	101	113	125
14	-7.0	7.0	21	35	49	63	77	91	105	119	133	147
16	-7.0	9.0	25	41	57	73	89	105	121	137	153	169
18	-7.0	11	29	47	65	83	101	119	137	155	173	191
20	-7.0	13	33	53	73	93	113	133	153	173	193	213
30	-7.0	23	53	83	113	143	173	203	233	263	293	323
40	-7.0	33	73	113	153	193	233	273	313	353	393	433
50	-7.0	43	93	143	193	243	293	343	393	443	493	543

Thermal length change ΔL (inch) between 68°F and any end temperature

Pipe length L	End temperature (°F)											
	-58	-40	-22	-4	14	32	50	68	86	104	122	140
(ft)	(inch)	(inch)	(inch)	(inch)	(inch)	(inch)	(inch)	(inch)	(inch)	(inch)	(inch)	(inch)
3	-0.25	-0.22	-0.18	-0.14	-0.11	-0.07	-0.04	0.00	0.04	0.07	0.11	0.14
6	-0.25	-0.18	-0.11	-0.04	0.04	0.11	0.18	0.25	0.32	0.40	0.47	0.54
10	-0.28	-0.16	-0.04	0.08	0.20	0.32	0.44	0.56	0.68	0.80	0.92	1.04
15	-0.32	-0.14	0.05	0.23	0.41	0.59	0.77	0.95	1.13	1.31	1.49	1.67
20	-0.34	-0.10	0.14	0.38	0.62	0.86	1.10	1.34	1.58	1.82	2.06	2.30
25	-0.35	-0.05	0.25	0.55	0.85	1.15	1.45	1.75	2.05	2.35	2.65	2.95
30	-0.36	0.00	0.36	0.72	1.08	1.44	1.80	2.16	2.52	2.88	3.24	3.60
35	-0.37	0.05	0.47	0.89	1.31	1.73	2.15	2.57	2.99	3.41	3.83	4.25
40	-0.37	0.11	0.59	1.07	1.55	2.03	2.51	2.99	3.47	3.95	4.43	4.91
45	-0.38	0.16	0.70	1.24	1.78	2.32	2.86	3.40	3.94	4.48	5.02	5.56
50	-0.35	0.25	0.85	1.45	2.05	2.65	3.25	3.85	4.45	5.05	5.65	6.25
60	-0.36	0.36	1.08	1.80	2.52	3.24	3.96	4.68	5.40	6.12	6.84	7.56
70	-0.37	0.47	1.31	2.15	2.99	3.83	4.67	5.51	6.35	7.19	8.03	8.87
80	-0.37	0.59	1.55	2.51	3.47	4.43	5.39	6.35	7.31	8.27	9.23	10.2
90	-0.38	0.70	1.78	2.86	3.94	5.02	6.10	7.18	8.26	9.34	10.4	11.5
100	-0.28	0.92	2.12	3.32	4.52	5.72	6.92	8.12	9.32	10.5	11.7	12.9
125	-0.26	1.24	2.74	4.24	5.74	7.24	8.74	10.2	11.7	13.2	14.7	16.2
150	-0.25	1.55	3.35	5.15	6.95	8.75	10.5	12.3	14.1	15.9	17.7	19.5

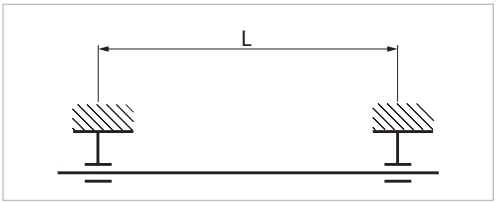
Thermal length change ΔL (mm/m) between any start temperature and any end temperature

Start temperature (°C)	End-Temperatur (°C)											
	-50	-40	-30	-20	-10	0	10	20	30	40	50	60
	(mm/m)	(mm/m)	(mm/m)	(mm/m)	(mm/m)	(mm/m)	(mm/m)	(mm/m)	(mm/m)	(mm/m)	(mm/m)	(mm/m)
-50	0.00	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00	11.00
-40	-1.00	0.00	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00
-30	-2.00	-1.00	0.00	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00
-20	-3.00	-2.00	-1.00	0.00	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00
-10	-4.00	-3.00	-2.00	-1.00	0.00	1.00	2.00	3.00	4.00	5.00	6.00	7.00
0	-5.00	-4.00	-3.00	-2.00	-1.00	0.00	1.00	2.00	3.00	4.00	5.00	6.00
10	-6.00	-5.00	-4.00	-3.00	-2.00	-1.00	0.00	1.00	2.00	3.00	4.00	5.00
20	-7.00	-6.00	-5.00	-4.00	-3.00	-2.00	-1.00	0.00	1.00	2.00	3.00	4.00
30	-8.00	-7.00	-6.00	-5.00	-4.00	-3.00	-2.00	-1.00	0.00	1.00	2.00	3.00
40	-9.00	-8.00	-7.00	-6.00	-5.00	-4.00	-3.00	-2.00	-1.00	0.00	1.00	2.00
50	-10.00	-9.00	-8.00	-7.00	-6.00	-5.00	-4.00	-3.00	-2.00	-1.00	0.00	1.00
60	-11.00	-10.00	-9.00	-8.00	-7.00	-6.00	-5.00	-4.00	-3.00	-2.00	-1.00	0.00

Thermal length change ΔL (inch/ft) between any start temperature and any end temperature

Start temperature (°F)	End temperature (°F)											
	-58	-40	-22	-4	14	32	50	68	86	104	122	140
	(inch/ft)	(inch/ft)	(inch/ft)	(inch/ft)	(inch/ft)	(inch/ft)	(inch/ft)	(inch/ft)	(inch/ft)	(inch/ft)	(inch/ft)	(inch/ft)
-58	0.000	0.012	0.024	0.036	0.048	0.060	0.072	0.084	0.096	0.108	0.120	0.132
-40	-0.012	0.000	0.012	0.024	0.036	0.048	0.060	0.072	0.084	0.096	0.108	0.120
-22	-0.024	-0.012	0.000	0.012	0.024	0.036	0.048	0.060	0.072	0.084	0.096	0.108
-4	-0.036	-0.024	-0.012	0.000	0.012	0.024	0.036	0.048	0.060	0.072	0.084	0.096
14	-0.048	-0.036	-0.024	-0.012	0.000	0.012	0.024	0.036	0.048	0.060	0.072	0.084
32	-0.060	-0.048	-0.036	-0.024	-0.012	0.000	0.012	0.024	0.036	0.048	0.060	0.072
50	-0.072	-0.060	-0.048	-0.036	-0.024	-0.012	0.000	0.012	0.024	0.036	0.048	0.060
68	-0.084	-0.072	-0.060	-0.048	-0.036	-0.024	-0.012	0.000	0.012	0.024	0.036	0.048
86	-0.096	-0.084	-0.072	-0.060	-0.048	-0.036	-0.024	-0.012	0.000	0.012	0.024	0.036
104	-0.108	-0.096	-0.084	-0.072	-0.060	-0.048	-0.036	-0.024	-0.012	0.000	0.012	0.024
122	-0.120	-0.108	-0.096	-0.084	-0.072	-0.060	-0.048	-0.036	-0.024	-0.012	0.000	0.012
140	-0.132	-0.120	-0.108	-0.096	-0.084	-0.072	-0.060	-0.048	-0.036	-0.024	-0.012	0.000

1.6 Pipe support spacing for ABS pipes



Liquids with a density of 1 g/cm³

d (mm)	DN (Inch)	Pipe support 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	1'000	900	850	750	650
40	1¼	1'100	1'000	950	850	750
50	1½	1'150	1'100	1'000	900	800
63	2	1'300	1'200	1'100	1'000	850
75	2½	1'500	1'350	1'200	1'100	950
90	3	1'600	1'450	1'350	1'200	1'050
110	4	1'800	1'650	1'550	1'350	1'200
140	5	2'050	1'800	1'700	1'400	1'250
160	6	2'200	1'850	1'750	1'450	1'300
200	7	2'300	2'050	1'850	1'550	1'350
225	8	2'400	2'200	1'900	1'600	1'450
250	9	2'500	2'300	2'000	1'650	1'500
280	10	2'650	2'400	2'100	1'700	1'600
315	12	2'800	2'500	2'200	1'800	1'650

For other SDR / PN values or classes, multiply the values given in the table by the following factor:

- SDR11 and PN16: Factor 1.08
- Class B: Factor 0.90
- Class D: Factor 1.05
- Class E: Factor 1.09

The pipe support 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 Pipe support 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 pipe support 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

1.7 Pressure test with water or a similar incompressible test medium for ABS

Pressure drop

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

Material	Pressure drop (bar/h)
ABS	0.6

*According to DVS 2210-1ff

Determining the test pressure

The permissible test pressure is calculated according to the following formula:

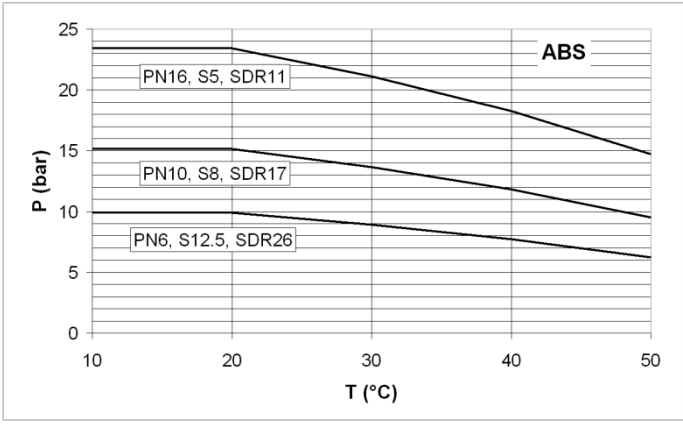
$$P_{p(zul)} = \frac{1}{SDR} \cdot \frac{20 \cdot \sigma_{v(T,\,100\,h)}}{S_p \cdot A_G}$$

$\sigma_{v(T,\,100\,h)}$ 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

In general, the weakest link in the system (in terms of PN rating) determines the maximum test pressure.
If valves are installed in the system, the maximum test pressure shall not exceed the nominal pressure (PN) of the valves.
At test temperatures above 20 °C, the maximum test pressure shall be limited according to the valve-specific pressure-temperature diagrams.

Material	S_p Minimum safety factor DVS 2210-1 Suppl.2
ABS	1.6

Test pressure diagram for ABS



P Permissible test pressure (bar)
T Pipe wall temperature (°C)

1.8 Relevant standards for pipes 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

1.9 ABS System by GF

The outstanding characteristics of ABS allow its application in a wide temperature range. 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 (145 psi)
Temperature range	-50 °C to +60 °C (-58 °F to +140 °F)
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
Fire performance	Class E according to EN 13501-1[2)]

1) For additional information about standards, approvals and guidelines, see www.gfps.com
2) Tested according to EN ISO 11925-2

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			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

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

Products	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		■	■	■	■	■	■	■	■	■	■	■			
Fittings	PN9-15			■	■	■	■	■	■	■	■	■	■			
Ball valves	PN16		■	■	■	■	■	■	■	■	■	■				
Butterfly valves	PN10												■	■	■	■
Check valves	PN6-16		■	■	■	■	■	■	■	■	■	■				
Diaphragm valves	PN6-16			■	■	■	■	■	■	■	■	■				
Flanges	PN10-16			■	■	■	■	■	■	■	■	■	■	■	■	
Gaskets and pipe clips			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
Automation	-		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	

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

PVC-U - Polyvinyl chloride, unplasticized

1.1 Reference values

Property	Value[1]	Units	Test standard
Density	1.38	g/cm³	EN ISO 1183-1
Yield stress[2]	≥ 54	N/mm²	EN ISO 527-1
Tensile e-modulus[2]	≥ 2'700	N/mm²	EN ISO 527-1
Charpy notched impact strength[2]	≥ 8	kJ/m²	EN ISO 179-1/1eA
Charpy notched impact strength at 0 °C (32 °F)	≥ 3	kJ/m²	EN ISO 179-1/1eA
Vicat-heat distortion temperature B/50N	≥ 76 ≥ 169	°C °F	ISO 306
Thermal conductivity[2]	0.15	W/m K	EN 12664
Water absorption[2]	≤ 0.1	%	EN ISO 62
Color	7'011		RAL
Limiting oxygen index (LOI)	42	%	ISO 4589-1

[1] Typical characteristics measured at the material should not be used for calculations.
[2] At 23 °C (73.4 °F)

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 Industry & Infrastructure Flow Solutions. 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 Industry & Infrastructure Flow Solutions 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 inertness 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
- The IR PVC-U system can be welded with infrared machines

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 Industry & Infrastructure Flow Solutions 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 Industry & Infrastructure Flow Solutions or contact the responsible GF Industry & Infrastructure Flow Solutions 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 Industry & Infrastructure Flow Solutions 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 Industry & Infrastructure Flow Solutions for use with drinking water and food. All PVC-U product offered by GF Industry & Infrastructure Flow Solutions 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 Industry & Infrastructure Flow Solutions representative.

1.2 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.

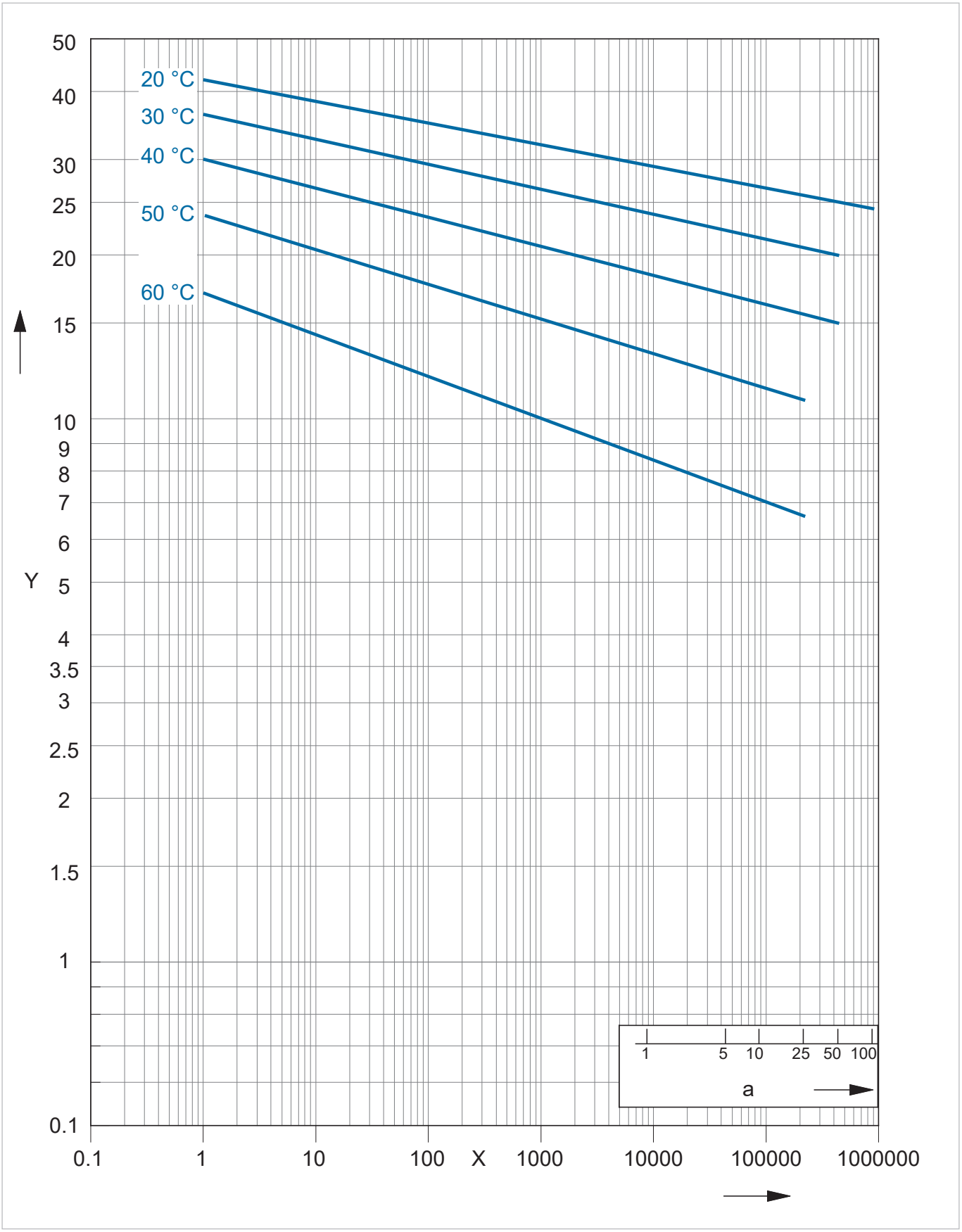
The long-term behavior was calculated by using the extrapolation method according to EN ISO 9080. With the following equation (4-parameter model), which was derived from the diagram, stress, temperature or time can be calculated for the temperature range of
+20 °C to +60 °C.

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

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

1.3 Pressure-temperature diagram for PVC-U

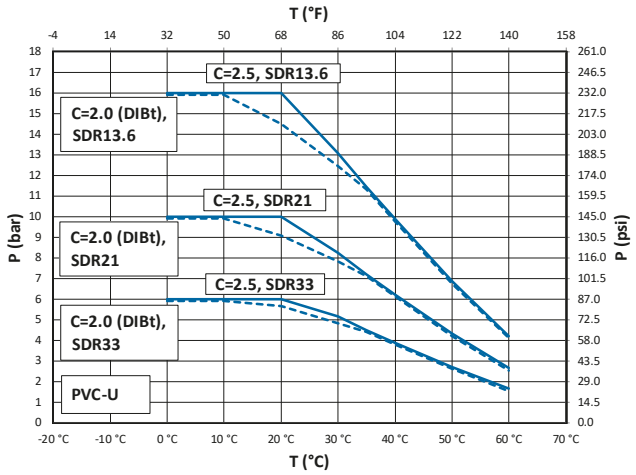
The following pressure-temperature diagrams for PVC-U pipe and fittings are valid for a service life of 25 years. The design factor of 2.5 recommended by GF Industry & Infrastructure Flow Solutions has been incorporated. They can be used for water or media resembling water, in other words, media that 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 Industry & Infrastructure Flow Solutions 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.

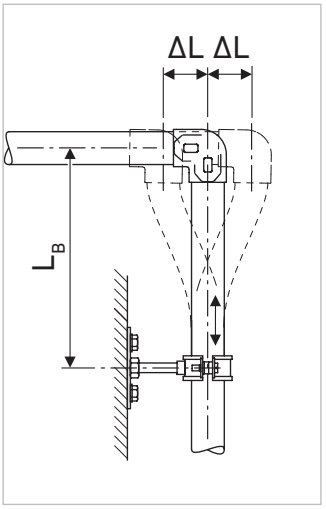
GF Industry & Infrastructure Flow Solutions therefore recommends that pipe equal or greater than d315 should be operated at a maximum operating pressure (+20 °C) of 6 bar. Please observe the special information for this dimension range in the cementing instructions for PVC-U.

1.4 Flexible sections of PVC-U piping systems

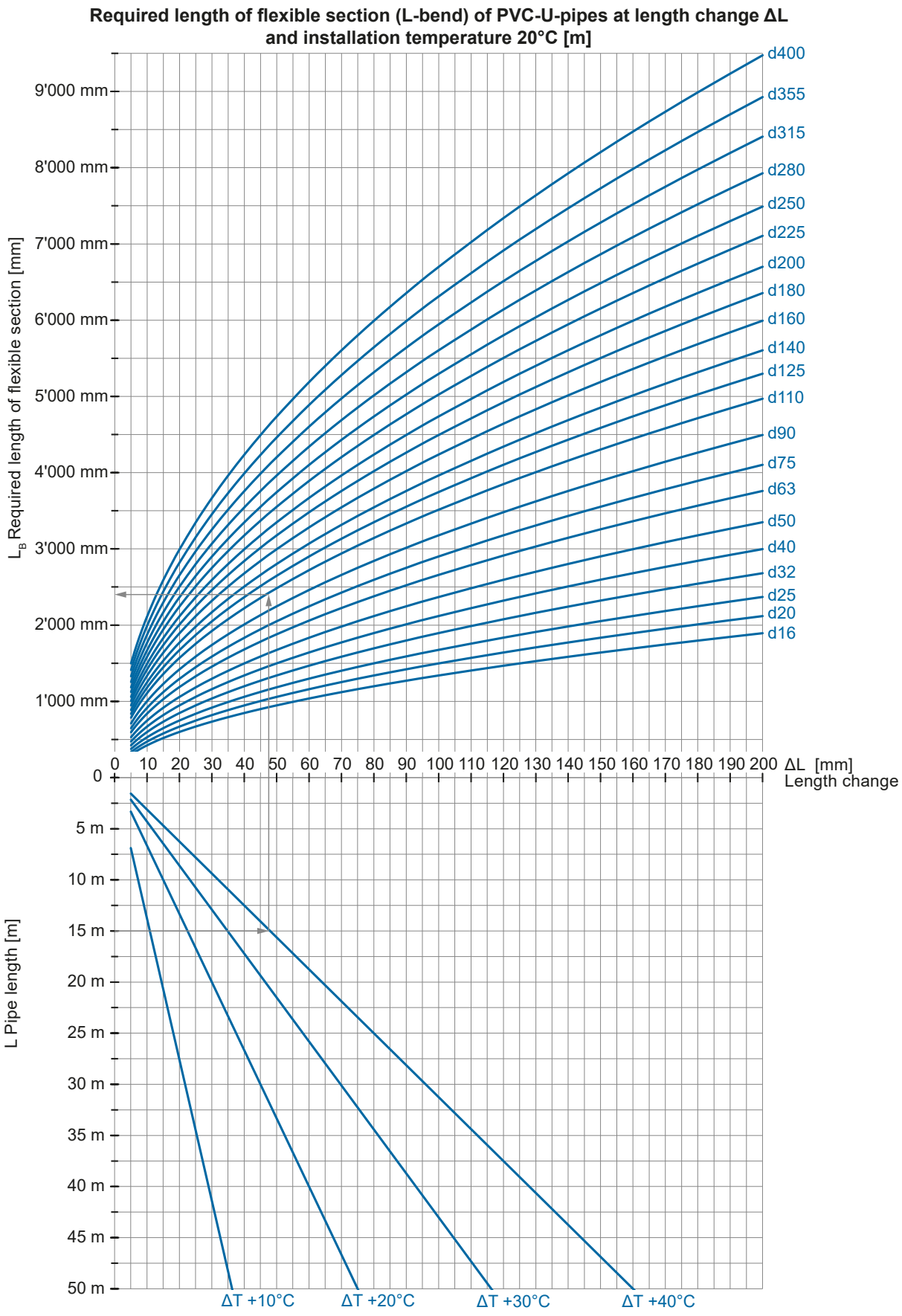
Properties of PVC-U

Symbol	Designation	Value	Unit
K	Proportionality factor for flexible sections	33.5	-
ΔL	Length change	-	mm/inch
d	Outer pipe diameter	-	mm
L_B	Required length of flexible section (L-bend)	-	mm/inch

$L_B = K * (d * \Delta L)^{\wedge 0.5}$



Flexible sections diagram - Outer pipe diameter d16 - d400



Required length of flexible section L_B at length change ΔL, [mm]

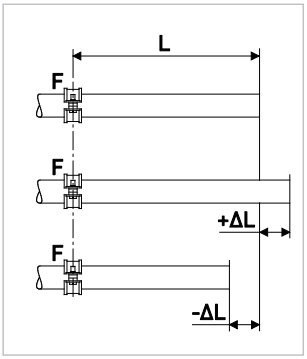
	Outer Pipe Diameter d (mm)																				
ΔL	16	20	25	32	40	50	63	75	90	110	125	140	160	180	200	225	250	280	315	355	400
(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)
15	520	580	650	735	820	915	1'050	1'100	1'250	1'350	1'450	1'550	1'650	1'750	1'850	1'950	2'050	2'150	2'300	2'450	2'600
30	735	820	915	1'050	1'150	1'300	1'450	1'600	1'750	1'900	2'050	2'150	2'300	2'450	2'600	2'750	2'900	3'050	3'250	3'450	3'650
45	900	1'000	1'100	1'250	1'400	1'600	1'800	1'950	2'150	2'350	2'500	2'650	2'850	3'000	3'200	3'350	3'550	3'750	4'000	4'250	4'500
60	1'050	1'150	1'300	1'450	1'650	1'850	2'050	2'250	2'450	2'700	2'900	3'050	3'300	3'500	3'650	3'900	4'100	4'350	4'600	4'900	5'200
75	1'150	1'300	1'450	1'650	1'850	2'050	2'300	2'500	2'750	3'050	3'250	3'450	3'650	3'900	4'100	4'350	4'600	4'850	5'150	5'450	5'800
90	1'250	1'400	1'600	1'800	2'000	2'250	2'500	2'750	3'000	3'350	3'550	3'750	4'000	4'250	4'500	4'750	5'050	5'300	5'650	6'000	6'350
105	1'350	1'550	1'700	1'950	2'150	2'450	2'700	2'950	3'250	3'600	3'850	4'050	4'350	4'600	4'850	5'150	5'450	5'750	6'100	6'450	6'850
120	1'450	1'650	1'850	2'100	2'300	2'600	2'900	3'200	3'500	3'850	4'100	4'350	4'650	4'900	5'200	5'500	5'800	6'150	6'500	6'900	7'350
135	1'550	1'750	1'950	2'200	2'450	2'750	3'100	3'350	3'700	4'100	4'350	4'600	4'900	5'200	5'500	5'850	6'150	6'500	6'900	7'350	7'800
150	1'650	1'850	2'050	2'300	2'600	2'900	3'250	3'550	3'900	4'300	4'600	4'850	5'200	5'500	5'800	6'150	6'500	6'850	7'300	7'750	8'200
165	1'700	1'900	2'150	2'450	2'700	3'050	3'400	3'750	4'100	4'500	4'800	5'100	5'450	5'750	6'100	6'450	6'800	7'200	7'650	8'100	8'600
180	1'800	2'000	2'250	2'550	2'850	3'200	3'550	3'900	4'250	4'700	5'050	5'300	5'700	6'050	6'350	6'750	7'100	7'500	8'000	8'450	9'000
195	1'850	2'100	2'350	2'650	2'950	3'300	3'700	4'050	4'450	4'900	5'250	5'550	5'900	6'300	6'600	7'000	7'400	7'850	8'300	8'800	9'350
210	1'950	2'150	2'450	2'750	3'050	3'450	3'850	4'200	4'600	5'100	5'450	5'750	6'150	6'500	6'850	7'300	7'700	8'100	8'600	9'150	9'700
225	2'000	2'250	2'500	2'850	3'200	3'550	4'000	4'350	4'750	5'250	5'600	5'950	6'350	6'750	7'100	7'550	7'950	8'400	8'900	9'450	10'050
240	2'100	2'300	2'600	2'950	3'300	3'650	4'100	4'500	4'900	5'450	5'800	6'150	6'550	6'950	7'350	7'800	8'200	8'700	9'200	9'800	10'400
255	2'150	2'400	2'650	3'050	3'400	3'800	4'250	4'650	5'100	5'600	6'000	6'350	6'750	7'200	7'550	8'000	8'450	8'950	9'500	10'100	10'700
270	2'200	2'450	2'750	3'100	3'500	3'900	4'350	4'750	5'200	5'750	6'150	6'500	6'950	7'400	7'800	8'250	8'700	9'200	9'750	10'350	11'000
285	2'250	2'550	2'850	3'200	3'600	4'000	4'500	4'900	5'350	5'950	6'300	6'700	7'150	7'600	8'000	8'500	8'950	9'450	10'050	10'650	11'300
300	2'300	2'600	2'900	3'300	3'650	4'100	4'600	5'050	5'500	6'100	6'500	6'850	7'350	7'800	8'200	8'700	9'150	9'700	10'300	10'950	11'600

Required length of flexible section L_B at length change ΔL, [inch]

	Outer Pipe Diameter d (mm)																				
ΔL	16	20	25	32	40	50	63	75	90	110	125	140	160	180	200	225	250	280	315	355	400
(inch)	(inch)	(inch)	(inch)	(inch)	(inch)	(inch)	(inch)	(inch)	(inch)	(inch)	(inch)	(inch)	(inch)	(inch)	(inch)	(inch)	(inch)	(inch)	(inch)	(inch)	(inch)
0.5	17.3	19.3	21.6	24.5	27.4	30.6	34.3	37.5	41.0	45.4	48.4	51.2	54.7	58.0	61.2	64.9	68.4	72.4	76.8	81.5	86.5
1.0	24.5	27.4	30.6	34.6	38.7	43.2	48.5	53.0	58.0	64.1	68.4	72.4	77.4	82.1	86.5	91.7	96.7	102	109	115	122
1.5	30.0	33.5	37.5	42.4	47.4	53.0	59.5	64.9	71.1	78.6	83.8	88.6	94.8	101	106	112	118	125	133	141	150
2.0	34.6	38.7	43.2	48.9	54.7	61.2	68.7	74.9	82.1	90.7	96.7	102	109	116	122	130	137	145	154	163	173
2.5	38.7	43.2	48.4	54.7	61.2	68.4	76.8	83.8	91.7	101	108	114	122	130	137	145	153	162	172	182	193
3.0	42.4	47.4	53.0	59.9	67.0	74.9	84.1	91.7	101	111	118	125	134	142	150	159	168	177	188	200	212
3.5	45.8	51.2	57.2	64.7	72.4	80.9	90.8	99.1	109	120	128	135	145	154	162	172	181	191	203	216	229
4.0	48.9	54.7	61.2	69.2	77.4	86.5	97.1	106	116	128	137	145	155	164	173	183	193	205	217	230	245
4.5	51.9	58.0	64.9	73.4	82.1	91.7	103	112	123	136	145	154	164	174	183	195	205	217	230	244	259
5.0	54.7	61.2	68.4	77.4	86.5	96.7	109	118	130	143	153	162	173	183	193	205	216	229	243	258	274
6.0	62.6	70.0	78.2	88.5	99.0	111	124	136	148	164	175	185	198	210	221	235	247	262	278	295	313
7.0	69.9	78.2	87.4	98.9	111	124	139	151	166	183	195	207	221	235	247	262	276	292	310	329	350
8.0	76.8	85.8	96.0	109	121	136	152	166	182	201	215	227	243	257	271	288	303	321	341	362	384
9.0	83.2	93.0	104	118	132	147	165	180	197	218	233	246	263	279	294	312	329	348	369	392	416
10.0	89.3	99.9	112	126	141	158	177	193	212	234	250	264	282	300	316	335	353	374	396	421	447
11.0	95.1	106	119	135	150	168	189	206	226	249	266	281	301	319	336	357	376	398	422	448	476
12.0	101	113	126	142	159	178	200	218	239	264	281	298	318	338	356	378	398	421	447	474	503
13.0	106	119	133	150	168	187	210	230	251	278	296	314	335	356	375	398	419	443	470	499	530
14.0	111	124	139	157	176	196	221	241	264	291	311	329	351	373	393	417	439	465	493	523	556
15.0	116	130	145	164	183	205	230	251	275	304	324	343	367	389	410	435	459	485	515	547	580

1.5 Length changes of PVC-U

Properties of PVC-U			
Symbol	Designation	Value	Unit
T_{min}	Temperature min.	0 / +32	°C / °F
T_{max}	Temperature max.	+60 / +140	°C / °F
ΔT	Temperature difference	-	°C / °F
α_{min}	Linear thermal expansion coefficient @20°C/68°F	0.07	mm/m K
α_{max}	Linear thermal expansion coefficient @max. temperature	0.08	mm/m K
ΔL	Length change	-	mm
L	Pipe length	-	m/inch
F	Fix point	-	-



Thermal length change ΔL (mm) between 20°C and any end temperature

Pipe length L	End temperature (°C)						
	0	10	20	30	40	50	60
(m)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)
1	-1.4	-0.7	0.0	0.7	1.5	2.3	3.2
2	-2.7	-1.4	0.0	1.5	3.0	4.7	6.4
3	-4.1	-2.1	0.0	2.2	4.5	7.0	9.6
4	-5.4	-2.8	0.0	2.9	6.0	9.3	13
5	-6.8	-3.4	0.0	3.6	7.5	12	16
6	-8.1	-4.1	0.0	4.4	9.0	14	19
7	-9.5	-4.8	0.0	5.1	11	16	22
8	-11	-5.5	0.0	5.8	12	19	26
9	-12	-6.2	0.0	6.5	14	21	29
10	-14	-6.9	0.0	7.3	15	23	32
12	-16	-8.3	0.0	8.7	18	28	38
14	-19	-9.6	0.0	10	21	33	45
16	-22	-11	0.0	12	24	37	51
18	-24	-12	0.0	13	27	42	58
20	-27	-14	0.0	15	30	47	64
30	-41	-21	0.0	22	45	70	96
40	-54	-28	0.0	29	60	93	128
50	-68	-34	0.0	36	75	116	160

Thermal length change ΔL (inch) between 68°F and any end temperature

Pipe length L	End temperature (°F)						
	32	50	68	86	104	122	140
(ft)	(inch)	(inch)	(inch)	(inch)	(inch)	(inch)	(inch)
3	-0.05	-0.02	0.00	0.03	0.05	0.08	0.12
6	-0.10	-0.05	0.00	0.05	0.11	0.17	0.23
10	-0.16	-0.08	0.00	0.09	0.18	0.28	0.38
15	-0.24	-0.12	0.00	0.13	0.27	0.42	0.58
20	-0.32	-0.17	0.00	0.17	0.36	0.56	0.77
25	-0.41	-0.21	0.00	0.22	0.45	0.70	0.96
30	-0.49	-0.25	0.00	0.26	0.54	0.84	1.15
35	-0.57	-0.29	0.00	0.30	0.63	0.98	1.34
40	-0.65	-0.33	0.00	0.35	0.72	1.12	1.54
45	-0.73	-0.37	0.00	0.39	0.81	1.26	1.73
50	-0.81	-0.41	0.00	0.44	0.90	1.40	1.92
60	-0.97	-0.50	0.00	0.52	1.08	1.67	2.30
70	-1.13	-0.58	0.00	0.61	1.26	1.95	2.69
80	-1.30	-0.66	0.00	0.70	1.44	2.23	3.07
90	-1.46	-0.74	0.00	0.78	1.62	2.51	3.46
100	-1.62	-0.83	0.00	0.87	1.80	2.79	3.84
125	-2.03	-1.03	0.00	1.09	2.25	3.49	4.80
150	-2.43	-1.24	0.00	1.31	2.70	4.19	5.76

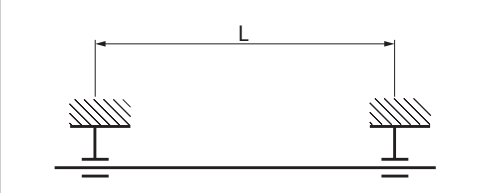
Thermal length change ΔL (mm/m) between any start temperature and any end temperature

Start temperature (°C)	End temperature (°C) 0 (mm/m)	10 (mm/m)	20 (mm/m)	30 (mm/m)	40 (mm/m)	50 (mm/m)	60 (mm/m)
0	0.00	0.66	1.35	2.08	2.85	3.68	4.55
10	-0.66	0.00	0.69	1.41	2.19	3.01	3.89
20	-1.35	-0.69	0.00	0.73	1.50	2.33	3.20
30	-2.08	-1.41	-0.73	0.00	0.78	1.60	2.48
40	-2.85	-2.19	-1.50	-0.78	0.00	0.83	1.70
50	-3.68	-3.01	-2.33	-1.60	-0.83	0.00	0.88
60	-4.55	-3.89	-3.20	-2.48	-1.70	-0.88	0.00

Thermal length change ΔL (inch/ft) between any start temperature and any end temperature

Start temperature (°F)	End temperature (°F) 32 (inch/ft)	50 (inch/ft)	68 (inch/ft)	86 (inch/ft)	104 (inch/ft)	122 (inch/ft)	140 (inch/ft)
32	0.000	0.008	0.016	0.025	0.034	0.044	0.055
50	-0.008	0.000	0.008	0.017	0.026	0.036	0.047
68	-0.016	-0.008	0.000	0.009	0.018	0.028	0.038
86	-0.025	-0.017	-0.009	0.000	0.009	0.019	0.030
104	-0.034	-0.026	-0.018	-0.009	0.000	0.010	0.020
122	-0.044	-0.036	-0.028	-0.019	-0.010	0.000	0.011
140	-0.055	-0.047	-0.038	-0.030	-0.020	-0.011	0.000

1.6 Pipe support spacing for PVC-U pipes



PVC-U pipe for liquids with a density of 1 g/cm³

d (mm)	DN (Inch)	Pipe support 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	1'100	1'050	1'000	900	700
25	¾	1'200	1'150	1'050	950	750
32	1	1'350	1'300	1'250	1'100	900
40	1¼	1'450	1'400	1'350	1'250	1'000
50	1½	1'600	1'550	1'500	1'400	1'150
63	2	1'800	1'750	1'700	1'550	1'300
75	2½	2'000	1'900	1'850	1'700	1'450
90	3	2'200	2'100	2'000	1'850	1'550
110	4	2'400	2'300	2'250	2'050	1'750
125		2'550	2'450	2'400	2'200	1'850
140	5	2'700	2'600	2'500	2'300	1'950
160	6	2'900	2'800	2'700	2'500	2'100
180		3'100	2'950	2'850	2'650	2'200
200		3'250	3'150	3'000	2'800	2'350
225	8	3'450	3'300	3'200	2'950	2'500
250		3'650	3'500	3'350	3'100	2'600
280	10	3'750	3'700	3'550	3'300	2'750
315	12	4'100	3'900	3'750	3'500	2'950
355	14	4'300	4'200	4'000	3'700	3'100
400	16	4'600	4'450	4'250	3'950	3'300

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 support 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 Pipe support 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 pipe support 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	1.42 for SDR21, S8 and PN10 1.30 for SDR13.6, S6.3 and PN16 1.20 for SDR11, S5 and PN20

1.7 Pressure test with water or a similar incompressible test medium for PVC-U

Pressure drop

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

Material	Pressure drop (bar/h)
PVC-U	0.5

*According to DVS 2210-1ff

Determining the test pressure

The permissible test pressure is calculated according to the following formula:

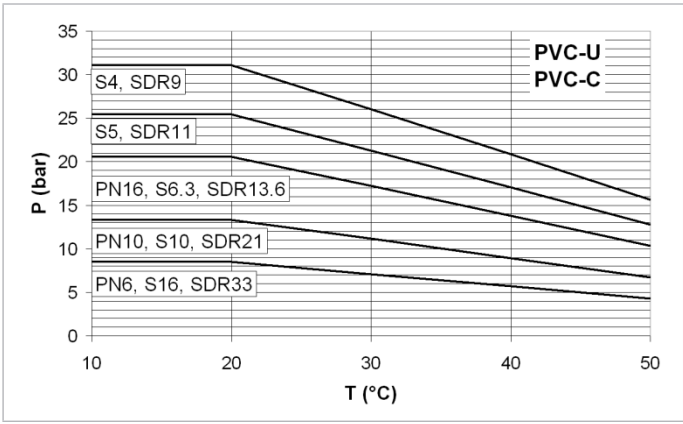
$$P_{p(zul)} = \frac{1}{SDR} \cdot \frac{20 \cdot \sigma_{v(T,\,100\,h)}}{S_p \cdot A_G}$$

$\sigma_{v(T,\,100\,h)}$ 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

In general, the weakest link in the system (in terms of PN rating) determines the maximum test pressure.
If valves are installed in the system, the maximum test pressure shall not exceed the nominal pressure (PN) of the valves.
At test temperatures above 20 °C, the maximum test pressure shall be limited according to the valve-specific pressure-temperature diagrams.

Material	S_p Minimum safety factor DVS 2210-1 Suppl.2
PVC-U	2.5

Test pressure diagram for PVC-U



P Permissible test pressure (bar)
T Pipe wall temperature (°C)

1.8 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

1.9 PVC-U System by GF

The piping system made of PVC-U material can be used for operating temperatures in the range of 0 °C to +60 °C (32 °F to +140 °F). 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 (232 psi)
Temperature range	0 °C to +60 °C (32 °F to +140 °F)
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
Fire performance	Class B s1 d0 according to EN 13501-1[2)]

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

2) Tested according to EN13823 and EN ISO 11925-2

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																										
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			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

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

Products	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															
Fittings	PN9-15															
Ball valves	PN16															
Butterfly valves	PN10															
Check valves	PN6-16															
Diaphragm valves	PN6-16															
Flanges	PN10-16															
Gaskets and pipe clips			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
Automation	-		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	

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

1.10 IR PVC-U System by GF

The piping system made of PVC-U material can be used for operating temperatures in the range of 0 °C to +60 °C (32 °F to +140 °F). 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. For a number of damanding applications DTX cement is needed to create a sutible joint. The IR PVC-U System creates an alternative to cemented PVC-U, while improving on quality control and tracablity through the use of IR welding mashines.

The IR PVC-U system is used in the most challanging applications in the chemical industry, in water treatment processes, for drinking water applications and food applications.



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
- First infrared welded PVC-U system

Most important market segments

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

Technical data

Nominal pressure	Up to 16 bar (232 psi)
Temperature range	0 °C to +60 °C (32 °F to +140 °F)
Jointing technology	Infrared Welding
Standards and guidelines[1)]	ISO, EN, 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
Fire performance	Class B s1 d0 according to EN 13501-1[2)]

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

2) Tested according to EN13823 and EN ISO 11925-2

IR PVC-U product overview

The following table uses metric units of measure.

Products	PN (bar)	d (mm)	20	25	32	40	50	63
		DN (mm)	15	20	25	32	40	50
Pipes	PN6-16							
Fittings	PN6-16							
Ball valves	PN6-16							
Butterfly Valves	PN6-16							
Check valves	PN6-16							
Diaphragm valves	PN6-16							
Flanges	PN6-16							
Gaskets and pipe clips			✓	✓	✓	✓	✓	✓
Automation			✓	✓	✓	✓	✓	✓

IR PVC-U System

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

PVC-C Polyvinyl chloride, chlorinated

1.1 Reference values

Property	Value[1]	Units	Test standard
Density	1.5	g/cm³	EN ISO 1183-1
Yield stress[2]	≥ 53	N/mm²	EN ISO 527-1
Tensile e-modulus[2]	≥ 2'700	N/mm²	EN ISO 527-1
Charpy notched impact strength[2]	≥ 8	kJ/m²	EN ISO 179-1/1eA
Charpy notched impact strength at 0 °C (32 °F)	≥ 4	kJ/m²	EN ISO 179-1/1eA
Heat distortion temperature HDT A 1.80 MPa	≥ 102 ≥ 215	°C °F	EN ISO 75-2
Vicat-heat distortion temperature B/50N	≥ 103 ≥ 217	°C °F	ISO 306
Thermal conductivity[2]	0.15	W/m K	EN 12664
Water absorption[2]	0.1	%	EN ISO 62
Color	7'038		RAL
Limiting oxygen index (LOI)	60	%	ISO 4589-1

[1] Typical characteristics measured at the material should not be used for calculations.
[2] At 23 °C (73.4 °F)

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 Industry & Infrastructure Flow Solutions 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 Industry & Infrastructure Flow Solutions or contact the responsible GF Industry & Infrastructure Flow Solutions 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 Industry & Infrastructure Flow Solutions 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.

1.2 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

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

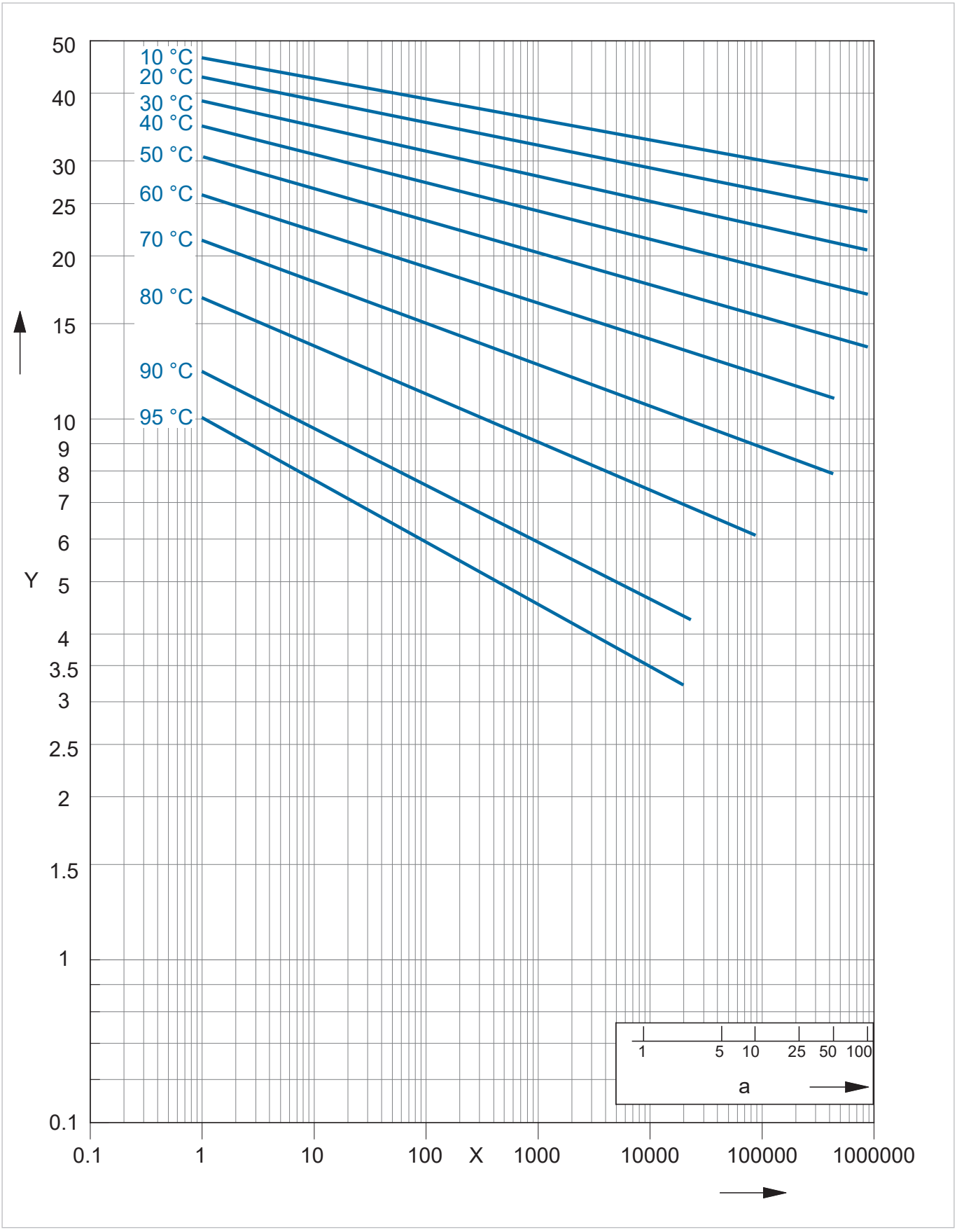
Fittings material in the temperature range of 10 °C to 90 °C

$$\log t = -121.699 - 25985 \cdot \frac{\log \sigma}{T} + 47143.18 \cdot \frac{1}{T} + 63.03511 \cdot \log \sigma$$

t Time to failure (h)
T Medium temperature (K)
σ Hoop stress (MPa) (1 MPa = 1 N/mm²)

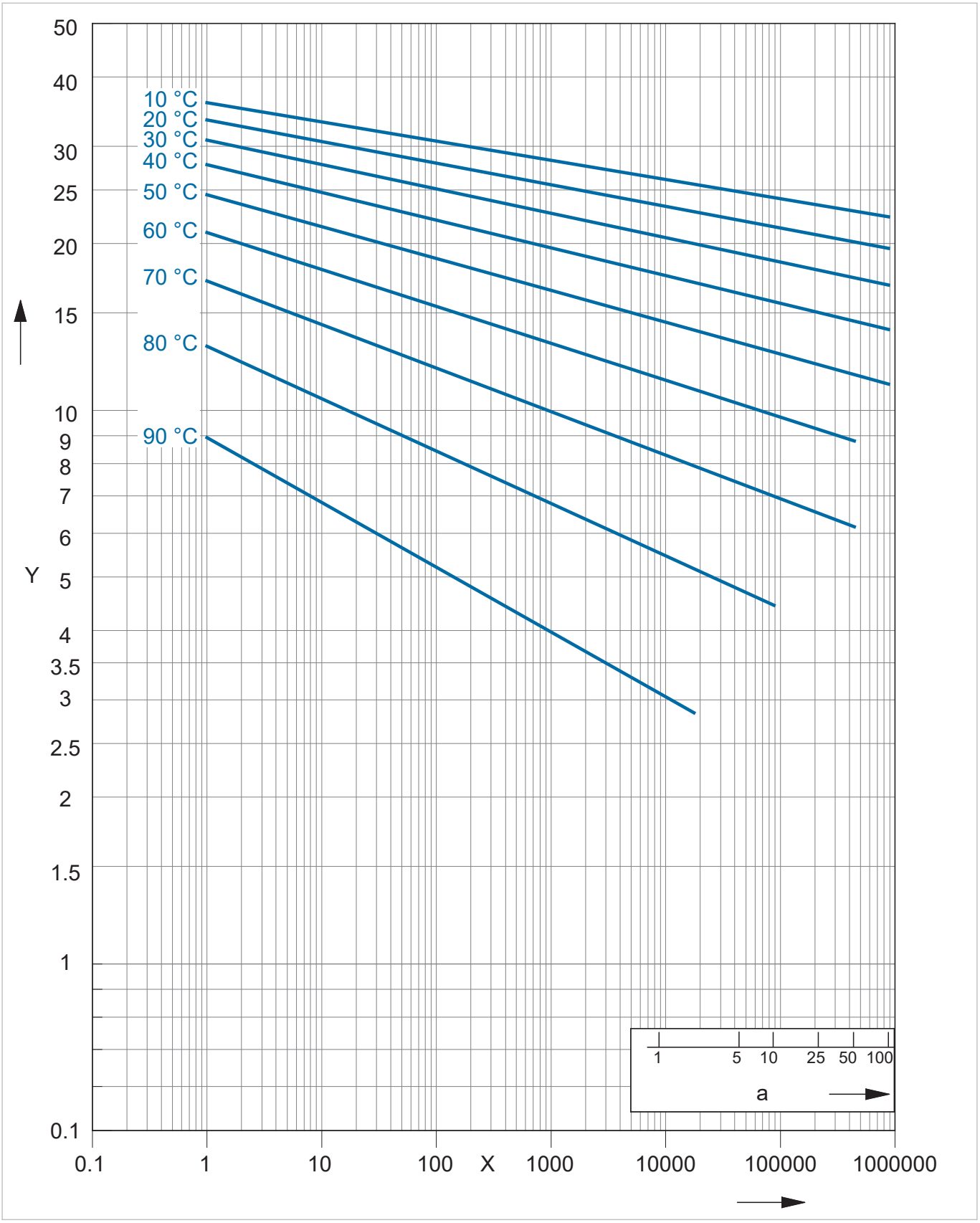
The pressure-temperature diagram that we provide for pipe and fittings made of PVC-C is derived from the long-term behavior, including the design factor, for a service life of 25 years.

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/mm²)
X Time to failure (h)
a Years

1.3 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 Industry & Infrastructure Flow Solutions (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.

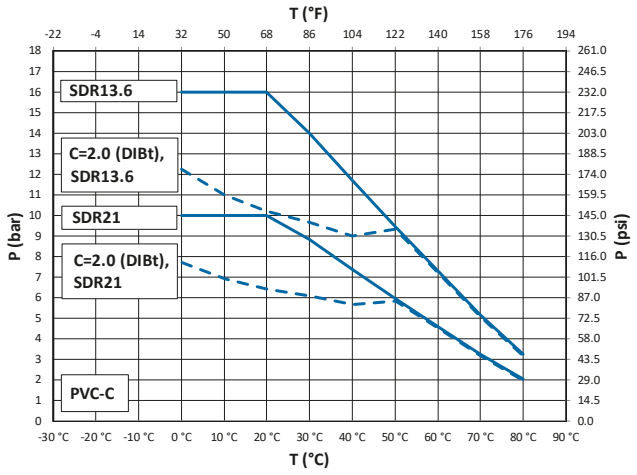
For chemical applications or piping systems that require approval by the building authorities according to DIBt, the dashed curves shown apply taking into account the toughness factors A1 according to DVS 2205-1.

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 Industry & Infrastructure Flow Solutions representative for advice on applications beyond GF Industry & Infrastructure Flow Solutions' specifications.

PVC-C, SDR13.6 and SDR21



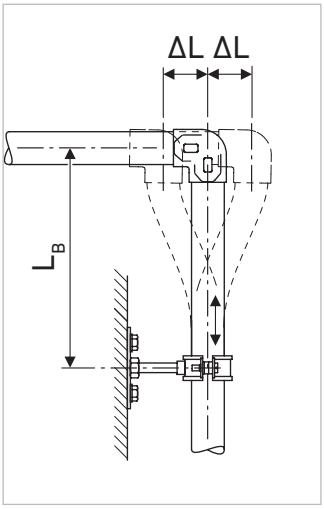
P Permissible pressure (bar, psi)
T Temperature (°C, °F)

⚠ 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.

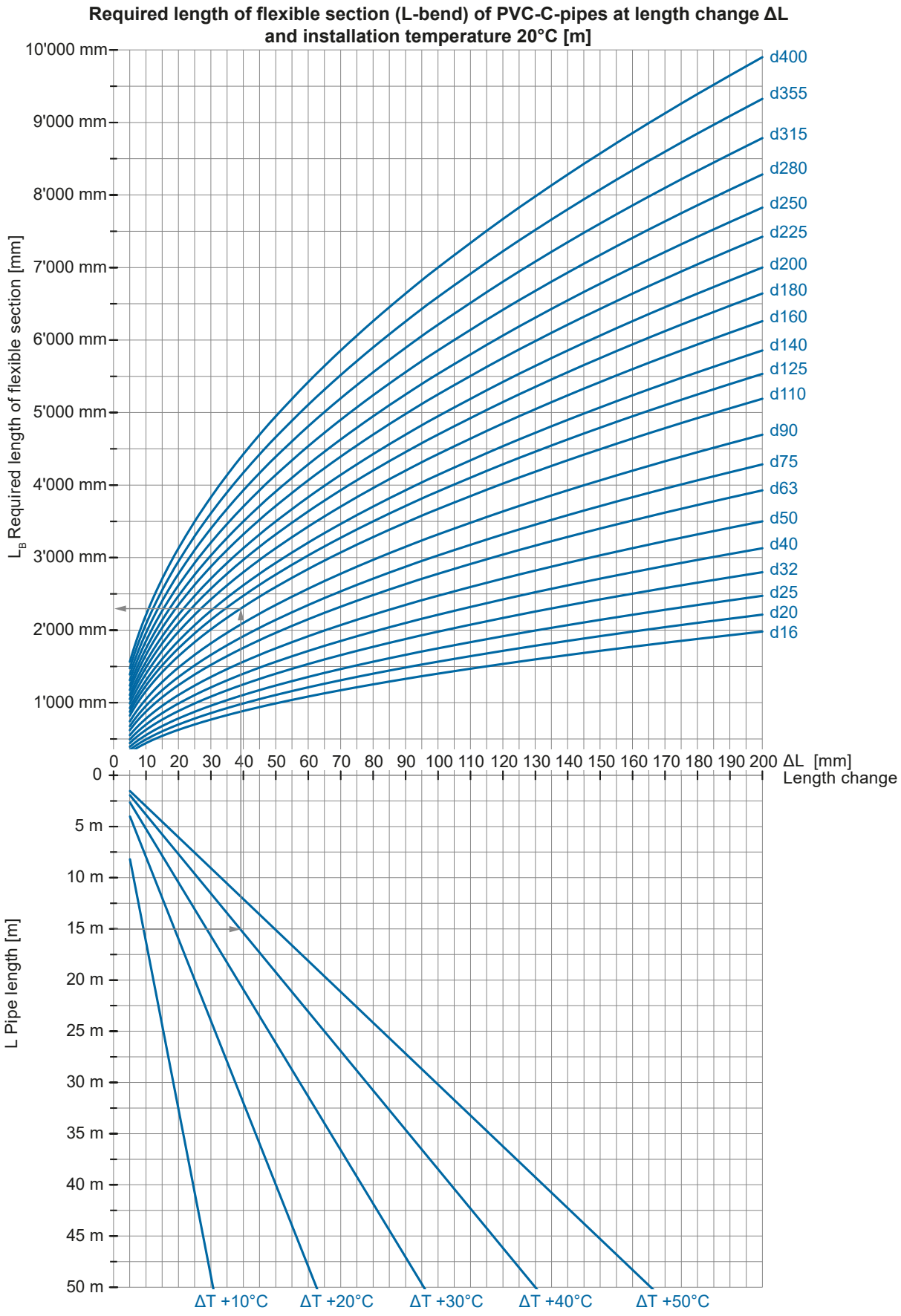
1.4 Flexible sections of PVC-C piping systems

Properties of PVC-C			
Symbol	Designation	Value	Unit
K	Proportionality factor for flexible sections	35	-
ΔL	Length change	-	mm/inch
d	Outer pipe diameter	-	mm
L_B	Required length of flexible section (L-bend)	-	mm/inch

$L_B = K * (d * \Delta L)^{\wedge 0.5}$



Flexible sections diagram - Outer pipe diameter d16 - d400



Required length of flexible section L_B at length change ΔL, [mm]

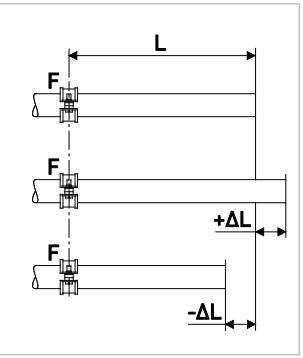
	Outer Pipe Diameter d (mm)																				
ΔL	16	20	25	32	40	50	63	75	90	110	125	140	160	180	200	225	250	280	315	355	400
(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)
15	540	605	680	765	855	960	1'100	1'150	1'300	1'400	1'500	1'600	1'700	1'800	1'900	2'050	2'150	2'250	2'400	2'550	2'700
30	765	855	960	1'100	1'200	1'350	1'500	1'650	1'800	2'000	2'150	2'250	2'400	2'550	2'700	2'900	3'050	3'200	3'400	3'600	3'850
45	940	1'050	1'150	1'350	1'500	1'650	1'850	2'050	2'250	2'450	2'650	2'800	2'950	3'150	3'300	3'500	3'700	3'950	4'150	4'400	4'700
60	1'100	1'200	1'350	1'550	1'700	1'900	2'150	2'350	2'550	2'850	3'050	3'200	3'450	3'650	3'850	4'050	4'300	4'550	4'800	5'100	5'400
75	1'200	1'350	1'500	1'700	1'900	2'150	2'400	2'650	2'900	3'200	3'400	3'600	3'850	4'050	4'300	4'550	4'800	5'050	5'400	5'700	6'050
90	1'350	1'500	1'650	1'900	2'100	2'350	2'650	2'900	3'150	3'500	3'700	3'950	4'200	4'450	4'700	5'000	5'250	5'550	5'900	6'250	6'650
105	1'450	1'600	1'800	2'050	2'250	2'550	2'850	3'100	3'400	3'750	4'000	4'250	4'550	4'800	5'050	5'400	5'650	6'000	6'350	6'750	7'150
120	1'550	1'700	1'900	2'150	2'400	2'700	3'050	3'300	3'650	4'000	4'300	4'550	4'850	5'150	5'400	5'750	6'050	6'400	6'800	7'200	7'650
135	1'650	1'800	2'050	2'300	2'550	2'900	3'250	3'500	3'850	4'250	4'550	4'800	5'150	5'450	5'750	6'100	6'450	6'800	7'200	7'650	8'150
150	1'700	1'900	2'150	2'400	2'700	3'050	3'400	3'700	4'050	4'500	4'800	5'050	5'400	5'750	6'050	6'450	6'800	7'150	7'600	8'100	8'550
165	1'800	2'000	2'250	2'550	2'850	3'200	3'550	3'900	4'250	4'700	5'050	5'300	5'700	6'050	6'350	6'750	7'100	7'500	8'000	8'450	9'000
180	1'900	2'100	2'350	2'650	2'950	3'300	3'750	4'050	4'450	4'900	5'250	5'550	5'950	6'300	6'650	7'050	7'400	7'850	8'350	8'850	9'400
195	1'950	2'200	2'450	2'750	3'100	3'450	3'900	4'250	4'650	5'150	5'450	5'800	6'200	6'550	6'900	7'350	7'750	8'200	8'650	9'200	9'750
210	2'050	2'250	2'550	2'850	3'200	3'600	4'050	4'400	4'800	5'300	5'650	6'000	6'400	6'800	7'150	7'600	8'000	8'500	9'000	9'550	10'150
225	2'100	2'350	2'650	2'950	3'300	3'700	4'150	4'550	5'000	5'500	5'850	6'200	6'650	7'050	7'400	7'900	8'300	8'800	9'300	9'900	10'500
240	2'150	2'400	2'700	3'050	3'450	3'850	4'300	4'700	5'150	5'700	6'050	6'400	6'850	7'250	7'650	8'150	8'550	9'050	9'600	10'200	10'850
255	2'250	2'500	2'800	3'150	3'550	3'950	4'450	4'850	5'300	5'850	6'250	6'600	7'050	7'500	7'900	8'400	8'850	9'350	9'900	10'550	11'200
270	2'300	2'550	2'900	3'250	3'650	4'050	4'550	5'000	5'450	6'050	6'450	6'800	7'250	7'700	8'150	8'650	9'100	9'600	10'200	10'850	11'500
285	2'350	2'650	2'950	3'350	3'750	4'200	4'700	5'100	5'600	6'200	6'600	7'000	7'450	7'950	8'350	8'850	9'350	9'900	10'500	11'150	11'800
300	2'400	2'700	3'050	3'450	3'850	4'300	4'800	5'250	5'750	6'350	6'800	7'150	7'650	8'150	8'550	9'100	9'600	10'150	10'750	11'400	12'100

Required length of flexible section L_B at length change ΔL, [inch]

	Outer Pipe Diameter d (mm)																				
ΔL	16	20	25	32	40	50	63	75	90	110	125	140	160	180	200	225	250	280	315	355	400
(inch)	(inch)	(inch)	(inch)	(inch)	(inch)	(inch)	(inch)	(inch)	(inch)	(inch)	(inch)	(inch)	(inch)	(inch)	(inch)	(inch)	(inch)	(inch)	(inch)	(inch)	(inch)
0.5	18.1	20.2	22.6	25.6	28.6	32.0	35.9	39.1	42.9	47.4	50.5	53.5	57.2	60.6	63.9	67.8	71.4	75.6	80.2	85.1	90.4
1.0	25.6	28.6	32.0	36.1	40.4	45.2	50.7	55.3	60.6	67.0	71.4	75.6	80.8	85.7	90.4	95.9	101	107	113	120	128
1.5	31.3	35.0	39.1	44.3	49.5	55.3	62.1	67.8	74.2	82.1	87.5	92.6	99.0	105	111	117	124	131	139	147	157
2.0	36.1	40.4	45.2	51.1	57.2	63.9	71.7	78.3	85.7	94.8	101	107	114	121	128	136	143	151	160	170	181
2.5	40.4	45.2	50.5	57.2	63.9	71.4	80.2	87.5	95.9	106	113	120	128	136	143	152	160	169	179	190	202
3.0	44.3	49.5	55.3	62.6	70.0	78.3	87.8	95.9	105	116	124	131	140	148	157	166	175	185	196	209	221
3.5	47.8	53.5	59.8	67.6	75.6	84.5	94.9	104	113	125	134	141	151	160	169	179	189	200	212	225	239
4.0	51.1	57.2	63.9	72.3	80.8	90.4	101	111	121	134	143	151	162	171	181	192	202	214	227	241	256
4.5	54.2	60.6	67.8	76.7	85.7	95.9	108	117	129	142	152	160	171	182	192	203	214	227	241	255	271
5.0	57.2	63.9	71.4	80.8	90.4	101	113	124	136	150	160	169	181	192	202	214	226	239	254	269	286
6.0	65.4	73.1	81.7	92.5	103	116	130	142	155	171	183	193	207	219	231	245	258	274	290	308	327
7.0	73.0	81.7	91.3	103	115	129	145	158	173	192	204	216	231	245	258	274	289	306	324	344	365
8.0	80.2	89.7	100	113	127	142	159	174	190	210	224	237	254	269	284	301	317	336	356	378	401
9.0	86.9	97.2	109	123	137	154	173	188	206	228	243	257	275	292	307	326	344	364	386	410	435
10.0	93.3	104	117	132	148	165	185	202	221	245	261	276	295	313	330	350	369	390	414	440	467
11.0	99.4	111	124	141	157	176	197	215	236	261	278	294	314	333	351	373	393	416	441	468	497
12.0	105	118	132	149	166	186	209	228	250	276	294	311	333	353	372	395	416	440	467	496	526
13.0	111	124	138	157	175	196	220	240	263	290	310	328	350	372	392	415	438	463	491	522	554
14.0	116	130	145	164	184	205	230	251	275	304	325	343	367	389	410	435	459	486	515	547	581
15.0	121	136	152	171	192	214	241	263	288	318	339	359	383	407	429	455	479	507	538	571	606

1.5 Length changes of PVC-C

Properties of PVC-C			
Symbol	Designation	Value	Unit
T_{min}	Temperature min.	0 / +32	°C / °F
T_{max}	Temperature max.	+80 / +176	°C / °F
ΔT	Temperature difference	-	°C / °F
α_{min}	Linear thermal expansion coefficient @20°C/68°F	0.06	mm/m K
α_{max}	Linear thermal expansion coefficient @max. temperature	0.07	mm/m K
ΔL	Length change	-	mm
L	Pipe length	-	m/inch
F	Fix point	-	-



$\Delta L = L \cdot \Delta T \cdot \alpha$

Thermal length change ΔL (mm) between 20°C and any end temperature

Pipe length L	End temperature (°C)								
	0	10	20	30	40	50	60	70	80
(m)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)
1	-1.2	-0.6	0.0	0.6	1.3	1.9	2.6	3.3	4.1
2	-2.4	-1.2	0.0	1.2	2.5	3.8	5.2	6.6	8.1
3	-3.5	-1.8	0.0	1.8	3.8	5.7	7.8	9.9	12
4	-4.7	-2.4	0.0	2.5	5.0	7.7	10	13	16
5	-5.9	-3.0	0.0	3.1	6.3	9.6	13	17	20
6	-7.1	-3.6	0.0	3.7	7.5	11	16	20	24
7	-8.2	-4.2	0.0	4.3	8.8	13	18	23	28
8	-9.4	-4.8	0.0	4.9	10	15	21	27	32
9	-11	-5.3	0.0	5.5	11	17	23	30	36
10	-12	-5.9	0.0	6.1	13	19	26	33	41
12	-14	-7.1	0.0	7.4	15	23	31	40	49
14	-16	-8.3	0.0	8.6	18	27	36	46	57
16	-19	-9.5	0.0	9.8	20	31	42	53	65
18	-21	-11	0.0	11	23	34	47	60	73
20	-24	-12	0.0	12	25	38	52	66	81
30	-35	-18	0.0	18	38	57	78	99	122
40	-47	-24	0.0	25	50	77	104	133	162
50	-59	-30	0.0	31	63	96	130	166	203

Thermal length change ΔL (inch) between 68°F and any end temperature

Pipe length L	End temperature (°F)								
	32	50	68	86	104	122	140	158	176
(ft)	(inch)	(inch)	(inch)	(inch)	(inch)	(inch)	(inch)	(inch)	(inch)
3	-0.04	-0.02	0.00	0.02	0.05	0.07	0.09	0.12	0.15
6	-0.08	-0.04	0.00	0.04	0.09	0.14	0.19	0.24	0.29
10	-0.14	-0.07	0.00	0.07	0.15	0.23	0.31	0.40	0.49
15	-0.21	-0.11	0.00	0.11	0.23	0.34	0.47	0.60	0.73
20	-0.28	-0.14	0.00	0.15	0.30	0.46	0.62	0.80	0.97
25	-0.35	-0.18	0.00	0.18	0.38	0.57	0.78	0.99	1.22
30	-0.42	-0.21	0.00	0.22	0.45	0.69	0.94	1.19	1.46
35	-0.49	-0.25	0.00	0.26	0.53	0.80	1.09	1.39	1.70
40	-0.56	-0.29	0.00	0.29	0.60	0.92	1.25	1.59	1.94
45	-0.63	-0.32	0.00	0.33	0.68	1.03	1.40	1.79	2.19
50	-0.71	-0.36	0.00	0.37	0.75	1.15	1.56	1.99	2.43
60	-0.85	-0.43	0.00	0.44	0.90	1.38	1.87	2.39	2.92
70	-0.99	-0.50	0.00	0.51	1.05	1.61	2.18	2.78	3.40
80	-1.13	-0.57	0.00	0.59	1.20	1.84	2.50	3.18	3.89
90	-1.27	-0.64	0.00	0.66	1.35	2.07	2.81	3.58	4.37
100	-1.41	-0.71	0.00	0.74	1.50	2.30	3.12	3.98	4.86
125	-1.76	-0.89	0.00	0.92	1.88	2.87	3.90	4.97	6.08
150	-2.12	-1.07	0.00	1.10	2.25	3.44	4.68	5.96	7.29

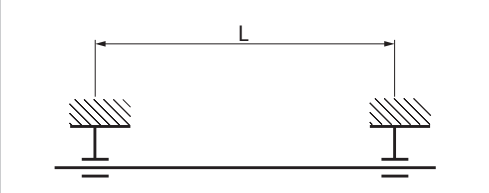
Thermal length change ΔL (mm/m) between any start temperature and any end temperature

Start temperature (°C)	End temperature (°C) 0 (mm/m)	10 (mm/m)	20 (mm/m)	30 (mm/m)	40 (mm/m)	50 (mm/m)	60 (mm/m)	70 (mm/m)	80 (mm/m)
0	0.00	0.58	1.18	1.79	2.43	3.09	3.78	4.49	5.23
10	-0.58	0.00	0.59	1.21	1.84	2.51	3.19	3.91	4.64
20	-1.18	-0.59	0.00	0.61	1.25	1.91	2.60	3.31	4.05
30	-1.79	-1.21	-0.61	0.00	0.64	1.30	1.99	2.70	3.44
40	-2.43	-1.84	-1.25	-0.64	0.00	0.66	1.35	2.06	2.80
50	-3.09	-2.51	-1.91	-1.30	-0.66	0.00	0.69	1.40	2.14
60	-3.78	-3.19	-2.60	-1.99	-1.35	-0.69	0.00	0.71	1.45
70	-4.49	-3.91	-3.31	-2.70	-2.06	-1.40	-0.71	0.00	0.74
80	-5.23	-4.64	-4.05	-3.44	-2.80	-2.14	-1.45	-0.74	0.00

Thermal length change ΔL (inch/ft) between any start temperature and any end temperature

Start temperature (°F)	End temperature (°F) 32 (inch/ft)	50 (inch/ft)	68 (inch/ft)	86 (inch/ft)	104 (inch/ft)	122 (inch/ft)	140 (inch/ft)	158 (inch/ft)	176 (inch/ft)
32	0.000	0.007	0.014	0.021	0.029	0.037	0.045	0.054	0.063
50	-0.007	0.000	0.007	0.014	0.022	0.030	0.038	0.047	0.056
68	-0.014	-0.007	0.000	0.007	0.015	0.023	0.031	0.040	0.049
86	-0.021	-0.014	-0.007	0.000	0.008	0.016	0.024	0.032	0.041
104	-0.029	-0.022	-0.015	-0.008	0.000	0.008	0.016	0.025	0.034
122	-0.037	-0.030	-0.023	-0.016	-0.008	0.000	0.008	0.017	0.026
140	-0.045	-0.038	-0.031	-0.024	-0.016	-0.008	0.000	0.009	0.017
158	-0.054	-0.047	-0.040	-0.032	-0.025	-0.017	-0.009	0.000	0.009
176	-0.063	-0.056	-0.049	-0.041	-0.034	-0.026	-0.017	-0.009	0.000

1.6 Pipe support spacing for PVC-C pipes



PVC-C pipe for liquids with a density of 1 g/cm³

d (mm)	Pipe support spacing L for pipe SDR21 / S10 / PN10 (mm)							
	≤ 20 °C	30 °C	40 °C	50 °C	60 °C	70 °C	80 °C	90 °C
16	1'000	950	900	850	750	675	600	500
20	1'150	1'100	1'025	950	875	775	700	600
25	1'200	1'150	1'100	1'000	900	800	700	600
32	1'350	1'250	1'200	1'100	1'000	900	800	700
40	1'500	1'400	1'300	1'250	1'150	1'050	900	800
50	1'650	1'600	1'500	1'400	1'300	1'200	1'100	900
63	1'850	1'750	1'650	1'600	1'500	1'350	1'250	1050
75	2'050	1'950	1'850	1'750	1'650	1'500	1'350	1200
90	2'250	2'100	2'000	1'900	1'800	1'650	1'500	1300
110	2'500	2'350	2'200	2'100	1'950	1'800	1'650	1450
125	2'650	2'500	2'350	2'250	2'100	1'950	1'750	1550
140	2'800	2'650	2'500	2'350	2'200	2'050	1'850	1650
160	3'000	2'850	2'700	2'550	2'400	2'200	2'000	1750
180	3'150	3'000	2'850	2'700	2'500	2'300	2'100	1850
200	3'350	3'150	3'000	2'850	2'650	2'450	2'200	1950
225	3'550	3'350	3'200	3'000	2'800	2'600	2'350	2100
250	3'750	3'550	3'350	3'150	3'000	2'750	2'500	2200
280	3'950	3'750	3'550	3'350	3'150	2'900	2'650	2350
315	4'200	4'000	3'750	3'550	3'350	3'050	2'800	2450
355	4'450	4'250	4'000	3'800	3'550	3'250	2'950	2650
400	4'750	4'500	4'250	4'000	3'750	3'450	3'150	2800

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 support 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 Pipe support 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 pipe support 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	1.42 for SDR21, S8 and PN10 1.30 for SDR13.6, S6.3 and PN16 1.20 for SDR11, S5 and PN20

1.7 Pressure test with water or a similar incompressible test medium for PVC-C

Pressure drop

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

Material	Pressure drop (bar/h)
PVC-C	0.5

*According to DVS 2210-1ff

Determining the test pressure

The permissible test pressure is calculated according to the following formula:

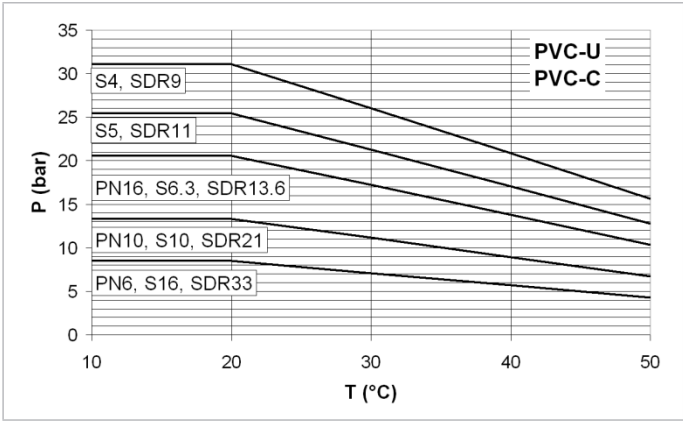
$$P_{p(zul)} = \frac{1}{SDR} \cdot \frac{20 \cdot \sigma_{v(T,\,100\,h)}}{S_p \cdot A_G}$$

$\sigma_{v(T,\,100\,h)}$ 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

In general, the weakest link in the system (in terms of PN rating) determines the maximum test pressure.
If valves are installed in the system, the maximum test pressure shall not exceed the nominal pressure (PN) of the valves.
At test temperatures above 20 °C, the maximum test pressure shall be limited according to the valve-specific pressure-temperature diagrams.

Material	S_p Minimum safety factor DVS 2210-1 Suppl.2
PVC-C	2.5

Test pressure diagram for PVC-C



P Permissible test pressure (bar)
T Pipe wall temperature (°C)

1.8 Relevant standards and guidelines for pipes 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

1.9 PVC-C System by GF

PVC-C piping systems, having an operational temperature range from 0 °C to 80 °C (32 °F to 176 °F), 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 (232 psi)
Temperature range	0 °C to 80 °C (32 °F to 176 °F)
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
Fire performance	- [2)]

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

2) Not yet been EN 13823 tested but will receive a B s1 d0 classification once completed.

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	PN6-16																										
Gaskets and pipe clips			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Automation			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

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

PVDF - Polyvinylidenefluoride

1.1 Reference values

Property	Value[1]	Units	Test standard
Density	1.78	g/cm³	EN ISO 1183-1
Yield stress[2]	≥ 48	N/mm²	EN ISO 527-1
Tensile e-modulus[2]	≥ 1'800	N/mm²	EN ISO 527-1
Charpy notched impact strength[2]	≥ 8	kJ/m²	EN ISO 179-1/1eA
Charpy notched impact strength at 0 °C (32 °F)	≥ 7	kJ/m²	EN ISO 179-1/1eA
Heat distortion temperature HDT A 1.80 MPa	≥ 104 ≥ 219	°C °F	EN ISO 75-2
Crystallite melting point	≥ 168 ≥ 334	°C °F	ISO 11357-3
Thermal conductivity[2]	0.19	W/m K	EN 12664
Water absorption[2] / 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.
[2] At 23 °C (73.4 °F)

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 Industry & Infrastructure Flow Solutions 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 Industry & Infrastructure Flow Solutions 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 Industry & Infrastructure Flow Solutions or contact the responsible GF Industry & Infrastructure Flow Solutions 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 Industry & Infrastructure Flow Solutions 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 Industry & Infrastructure Flow Solutions 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 F40 are done regularly for quality control.

1.2 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)

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

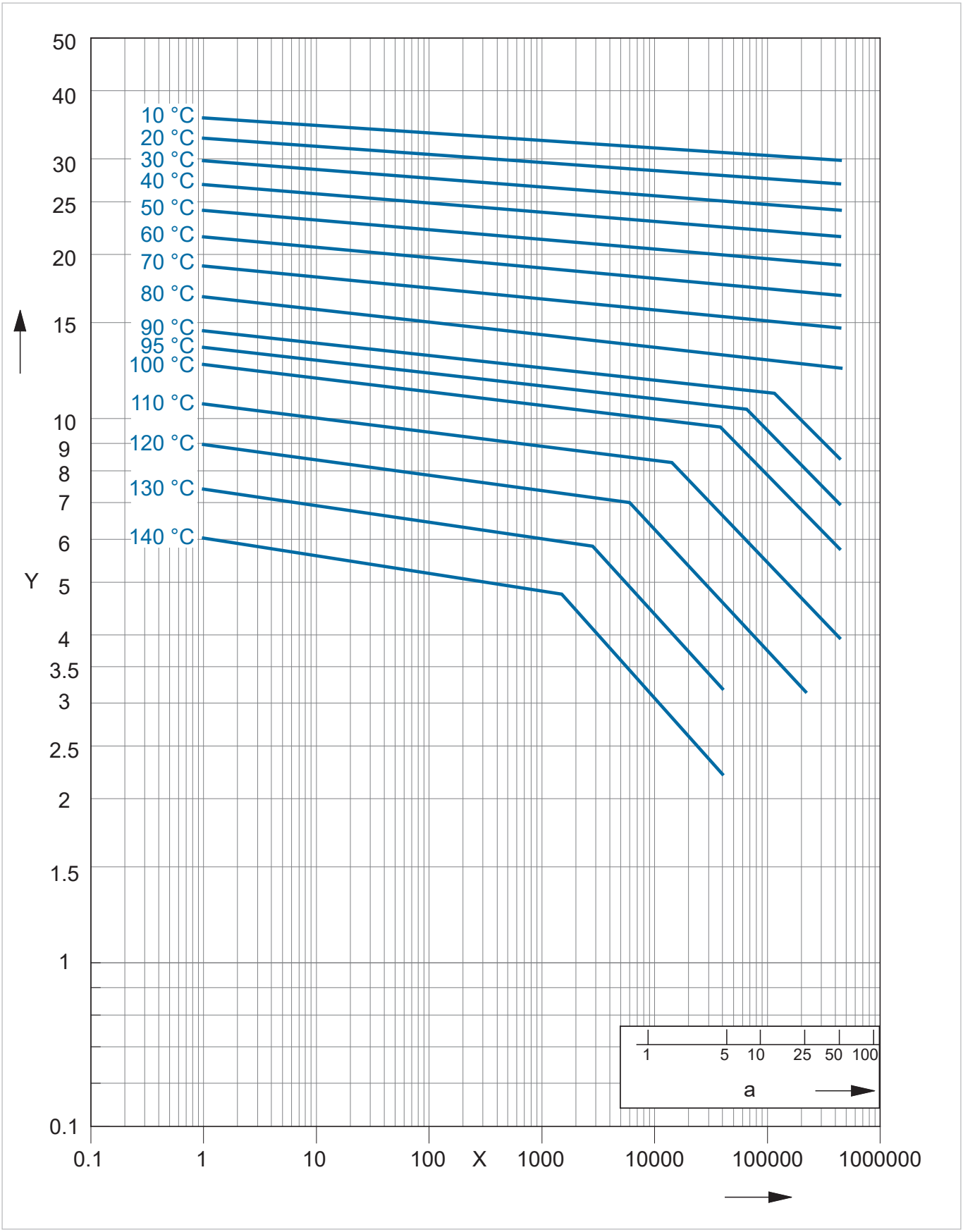
Second branch (right-hand portion of the curves as shown in the following long-term behavior)

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

t Time to failure (h)
T Medium temperature (K)
σ Hoop stress (MPa) (1 MPa = 1 N/mm²)

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/mm²)
X Time to failure (h)
a Years

1.3 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 Industry & Infrastructure Flow Solutions 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.

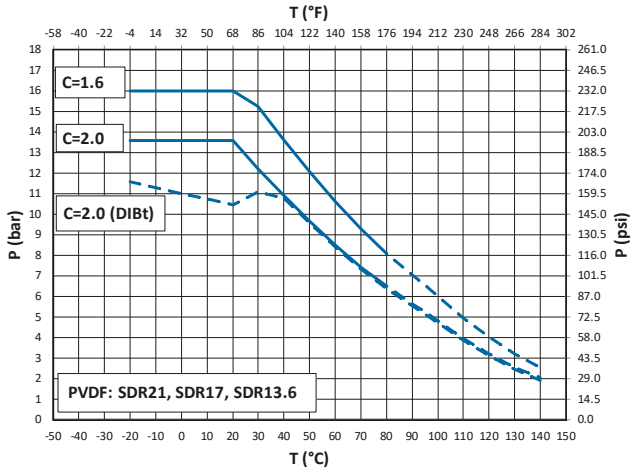
For chemical applications or piping systems that require approval by the building authorities, the dashed curves apply, taking into account the toughness factors A1 in accordance with DVS 2205-1.

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).

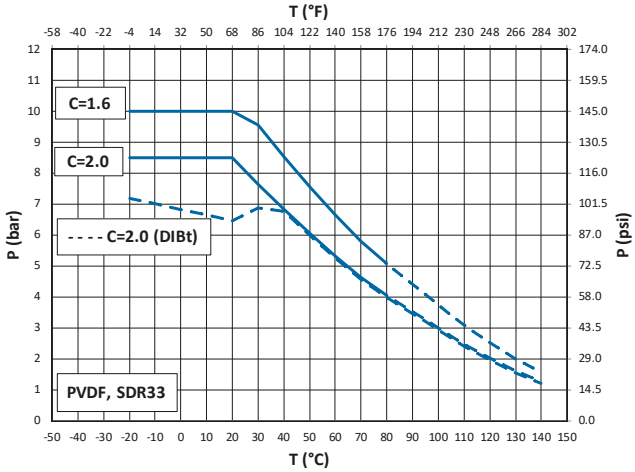
⚠ Please take into account the pressure-temperature diagrams for valves and special fittings. Because of the construction and/or sealing material used, differences are possible when compared to pipe and fittings. More information is available in the Planning Fundamentals of the relevant types of valves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

i In case of operating in the temperature range shown in dotted lines, contact your authorized GF Industry & Infrastructure Flow Solutions representative.

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.

i These diagrams can only be used for applications with liquids!

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 Years		

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 years

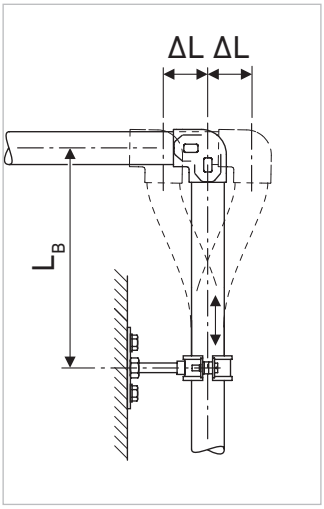
This calculated service life is higher than the specified operating life; i.e. the dimensions of this application are sufficient.

1.4 Flexible sections of PVDF piping systems

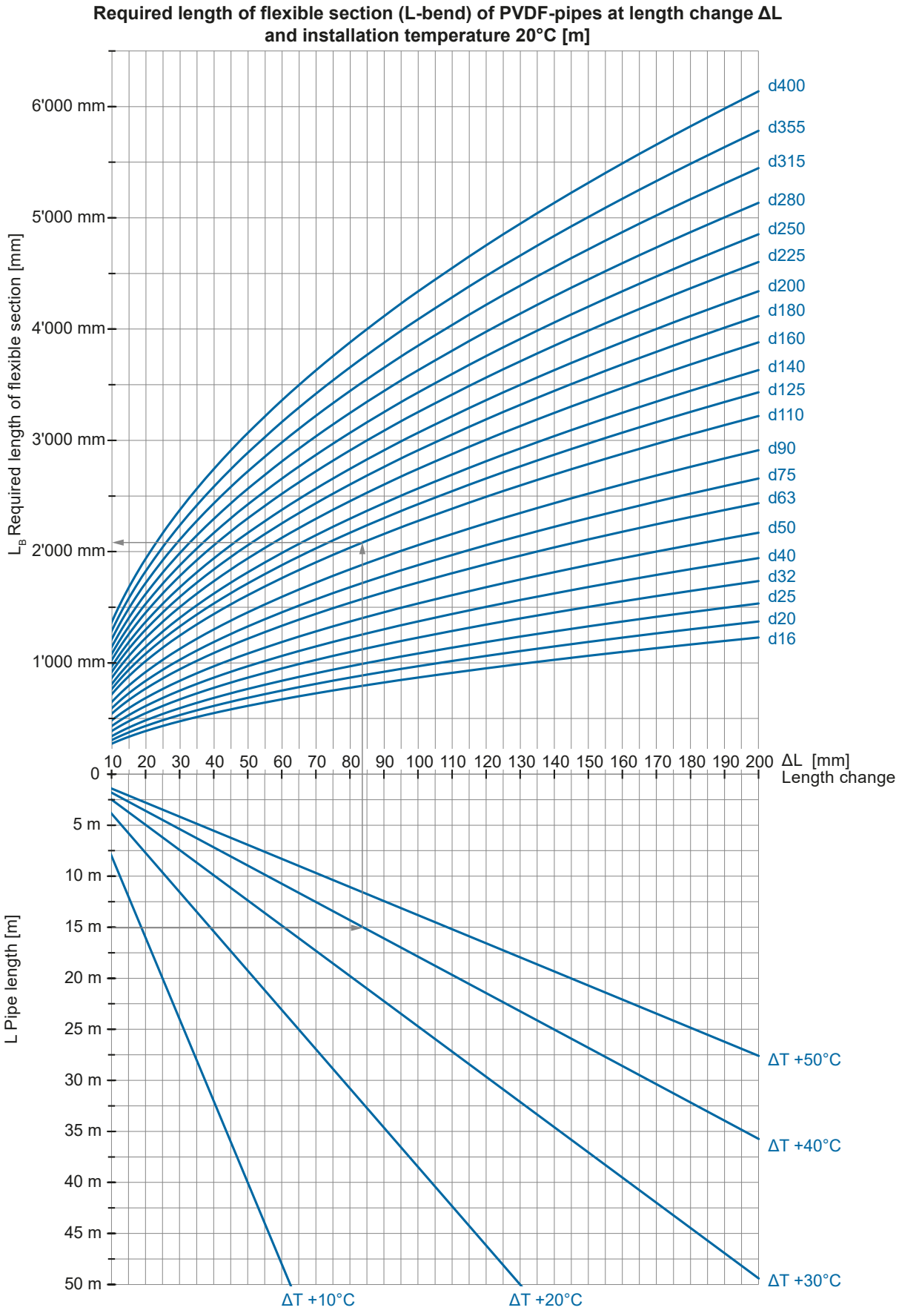
Properties of PVDF

Symbol	Designation	Value	Unit
K	Proportionality factor for flexible sections	21.7	-
ΔL	Length change	-	mm/inch
d	Outer pipe diameter	-	mm
L_B	Required length of flexible section (L-bend)	-	mm/inch

$L_B = K * (d * \Delta L)^{\wedge 0.5}$



Flexible sections diagram - Outer pipe diameter d16 - d400



Required length of flexible section L_B at length change ΔL, [mm]

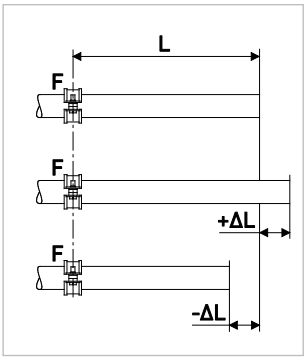
ΔL	Outer Pipe Diameter d (mm)																				
	16	20	25	32	40	50	63	75	90	110	125	140	160	180	200	225	250	280	315	355	400
(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)
15	335	375	420	475	530	595	665	730	795	880	940	995	1'050	1'150	1'200	1'250	1'350	1'400	1'500	1'600	1'700
30	475	530	595	670	750	840	945	1'050	1'150	1'250	1'350	1'400	1'500	1'600	1'700	1'800	1'900	2'000	2'100	2'250	2'400
45	580	650	730	825	920	1'050	1'150	1'250	1'400	1'550	1'650	1'700	1'850	1'950	2'050	2'200	2'300	2'450	2'600	2'750	2'900
60	670	750	840	950	1'050	1'200	1'350	1'450	1'600	1'750	1'900	2'000	2'150	2'250	2'400	2'500	2'650	2'800	3'000	3'150	3'350
75	750	840	940	1'050	1'200	1'350	1'500	1'650	1'800	1'950	2'100	2'200	2'400	2'500	2'650	2'800	2'950	3'150	3'350	3'550	3'750
90	825	920	1'050	1'150	1'300	1'450	1'650	1'800	1'950	2'150	2'300	2'450	2'600	2'750	2'900	3'100	3'250	3'450	3'650	3'900	4'100
105	890	995	1'100	1'250	1'400	1'550	1'750	1'950	2'100	2'350	2'500	2'650	2'800	3'000	3'150	3'350	3'500	3'700	3'950	4'200	4'450
120	950	1'050	1'200	1'350	1'500	1'700	1'900	2'050	2'250	2'500	2'650	2'800	3'000	3'200	3'350	3'550	3'750	4'000	4'200	4'500	4'750
135	1'000	1'150	1'250	1'450	1'600	1'800	2'000	2'200	2'400	2'650	2'800	3'000	3'200	3'400	3'550	3'800	4'000	4'200	4'450	4'750	5'050
150	1'050	1'200	1'350	1'500	1'700	1'900	2'100	2'300	2'500	2'800	2'950	3'150	3'350	3'550	3'750	4'000	4'200	4'450	4'700	5'000	5'300
165	1'100	1'250	1'400	1'600	1'750	1'950	2'200	2'400	2'650	2'900	3'100	3'300	3'550	3'750	3'950	4'200	4'400	4'650	4'950	5'250	5'550
180	1'150	1'300	1'450	1'650	1'850	2'050	2'300	2'500	2'750	3'050	3'250	3'450	3'700	3'900	4'100	4'350	4'600	4'850	5'150	5'500	5'800
195	1'200	1'350	1'500	1'700	1'900	2'150	2'400	2'600	2'850	3'200	3'400	3'600	3'850	4'050	4'300	4'550	4'800	5'050	5'400	5'700	6'050
210	1'250	1'400	1'550	1'800	2'000	2'200	2'500	2'700	3'000	3'300	3'500	3'700	4'000	4'200	4'450	4'700	4'950	5'250	5'600	5'900	6'300
225	1'300	1'450	1'650	1'850	2'050	2'300	2'600	2'800	3'100	3'400	3'650	3'850	4'100	4'350	4'600	4'900	5'150	5'450	5'800	6'150	6'500
240	1'350	1'500	1'700	1'900	2'150	2'400	2'650	2'900	3'200	3'550	3'750	4'000	4'250	4'500	4'750	5'050	5'300	5'650	5'950	6'350	6'700
255	1'400	1'550	1'750	1'950	2'200	2'450	2'750	3'000	3'300	3'650	3'850	4'100	4'400	4'650	4'900	5'200	5'500	5'800	6'150	6'550	6'950
270	1'450	1'600	1'800	2'000	2'250	2'500	2'850	3'100	3'400	3'750	4'000	4'200	4'500	4'800	5'050	5'350	5'650	5'950	6'350	6'700	7'150
285	1'450	1'650	1'850	2'050	2'300	2'600	2'900	3'150	3'500	3'850	4'100	4'350	4'650	4'900	5'200	5'500	5'800	6'150	6'500	6'900	7'350
300	1'500	1'700	1'900	2'150	2'400	2'650	3'000	3'250	3'550	3'950	4'200	4'450	4'750	5'050	5'300	5'650	5'950	6'300	6'650	7'100	7'500

Required length of flexible section L_B at length change ΔL, [inch]

ΔL	Outer Pipe Diameter d (mm)																				
	16	20	25	32	40	50	63	75	90	110	125	140	160	180	200	225	250	280	315	355	400
(inch)	(inch)	(inch)	(inch)	(inch)	(inch)	(inch)	(inch)	(inch)	(inch)	(inch)	(inch)	(inch)	(inch)	(inch)	(inch)	(inch)	(inch)	(inch)	(inch)	(inch)	(inch)
0.5	11.2	12.5	14.0	15.8	17.7	19.8	22.2	24.3	26.6	29.4	31.3	33.1	35.4	37.6	39.6	42.0	44.3	46.9	49.7	52.8	56.0
1.0	15.8	17.7	19.8	22.4	25.1	28.0	31.4	34.3	37.6	41.6	44.3	46.9	50.1	53.2	56.0	59.4	62.6	66.3	70.3	74.6	79.2
1.5	19.4	21.7	24.3	27.4	30.7	34.3	38.5	42.0	46.0	50.9	54.3	57.4	61.4	65.1	68.6	72.8	76.7	81.2	86.1	91.4	97.0
2.0	22.4	25.1	28.0	31.7	35.4	39.6	44.5	48.5	53.2	58.8	62.6	66.3	70.9	75.2	79.2	84.0	88.6	93.8	99.4	106	112
2.5	25.1	28.0	31.3	35.4	39.6	44.3	49.7	54.3	59.4	65.7	70.0	74.1	79.2	84.0	88.6	94.0	99.0	105	111	118	125
3.0	27.4	30.7	34.3	38.8	43.4	48.5	54.5	59.4	65.1	72.0	76.7	81.2	86.8	92.1	97.0	103	109	115	122	129	137
3.5	29.6	33.1	37.1	41.9	46.9	52.4	58.8	64.2	70.3	77.7	82.9	87.7	93.8	99.4	105	111	117	124	132	140	148
4.0	31.7	35.4	39.6	44.8	50.1	56.0	62.9	68.6	75.2	83.1	88.6	93.8	100	106	112	119	125	133	141	149	158
4.5	33.6	37.6	42.0	47.5	53.2	59.4	66.7	72.8	79.7	88.1	94.0	99.4	106	113	119	126	133	141	149	158	168
5.0	35.4	39.6	44.3	50.1	56.0	62.6	70.3	76.7	84.0	92.9	99.0	105	112	119	125	133	140	148	157	167	177
6.0	40.5	45.3	50.7	57.3	64.1	71.7	80.5	87.8	96.2	106	113	120	128	136	143	152	160	170	180	191	203
7.0	45.3	50.6	56.6	64.0	71.6	80.1	89.9	98.1	107	119	127	134	143	152	160	170	179	189	201	213	226
8.0	49.7	55.6	62.2	70.3	78.6	87.9	98.7	108	118	130	139	147	157	167	176	186	197	208	221	234	249
9.0	53.9	60.3	67.4	76.2	85.2	95.3	107	117	128	141	151	159	170	181	191	202	213	226	239	254	270
10.0	57.9	64.7	72.3	81.8	91.5	102	115	125	137	152	162	171	183	194	205	217	229	242	257	273	289
11.0	61.6	68.9	77.0	87.2	97.4	109	122	133	146	162	172	182	195	207	218	231	244	258	273	290	308
12.0	65.2	72.9	81.5	92.2	103	115	129	141	155	171	182	193	206	219	231	245	258	273	289	307	326
13.0	68.7	76.8	85.8	97.1	109	121	136	149	163	180	192	203	217	230	243	258	271	287	305	323	343
14.0	72.0	80.5	90.0	102	114	127	143	156	171	189	201	213	228	241	254	270	285	301	319	339	360
15.0	75.2	84.0	94.0	106	119	133	149	163	178	197	210	222	238	252	266	282	297	314	334	354	376

Length changes of PVDF

Properties of PVDF			
Symbol	Designation	Value	Unit
T_{min}	Temperature min.	-20 / -4	°C / °F
T_{max}	Temperature max.	+140 / +284	°C / °F
ΔT	Temperature difference	-	°C / °F
α_{min}	Linear thermal expansion coefficient @20°C/68°F	0.12	mm/m K
α_{max}	Linear thermal expansion coefficient @max. temperature	0.18	mm/m K
ΔL	Length change	-	mm
L	Pipe length	-	m/inch
F	Fix point	-	-



$\Delta L = L \cdot \Delta T \cdot \alpha$

Thermal length change ΔL (mm) between 20°C and any end temperature

Pipe length L	End temperature (°C)																
	-20	-10	0	10	20	30	40	50	60	70	80	90	100	110	120	130	140
(m)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)
1	-4.4	-3.4	-2.3	-1.2	0.0	1.3	2.6	4.1	5.6	7.3	9.0	11	13	15	17	19	22
2	-8.8	-6.8	-4.6	-2.4	0.0	2.5	5.2	8.1	11	15	18	22	26	30	34	39	43
3	-13	-10	-6.9	-3.5	0.0	3.8	7.8	12	17	22	27	33	38	45	51	58	65
4	-18	-14	-9.2	-4.7	0.0	5.0	10	16	22	29	36	43	51	59	68	77	86
5	-22	-17	-12	-5.9	0.0	6.3	13	20	28	36	45	54	64	74	85	96	108
6	-26	-20	-14	-7.1	0.0	7.5	16	24	34	44	54	65	77	89	102	116	130
7	-31	-24	-16	-8.2	0.0	8.8	18	28	39	51	63	76	90	104	119	135	151
8	-35	-27	-18	-9.4	0.0	10	21	32	45	58	72	87	102	119	136	154	173
9	-40	-30	-21	-11	0.0	11	23	36	50	65	81	98	115	134	153	173	194
10	-44	-34	-23	-12	0.0	13	26	41	56	73	90	109	128	149	170	193	216
12	-53	-41	-28	-14	0.0	15	31	49	67	87	108	130	154	178	204	231	259
14	-62	-47	-32	-16	0.0	18	36	57	78	102	126	152	179	208	238	270	302
16	-70	-54	-37	-19	0.0	20	42	65	90	116	144	174	205	238	272	308	346
18	-79	-61	-41	-21	0.0	23	47	73	101	131	162	195	230	267	306	347	389
20	-88	-68	-46	-24	0.0	25	52	81	112	145	180	217	256	297	340	385	432
30	-132	-101	-69	-35	0.0	38	78	122	168	218	270	326	384	446	510	578	648
40	-176	-135	-92	-47	0.0	50	104	162	224	290	360	434	512	594	680	770	864
50	-220	-169	-115	-59	0.0	63	130	203	280	363	450	543	640	743	850	963	1080

Thermal length change ΔL (inch) between 68°F and any end temperature

Pipe length L	End temperature (°F)																
	-4	14	32	50	68	86	104	122	140	158	176	194	212	230	248	266	284
(ft)	(inch)	(inch)	(inch)	(inch)	(inch)	(inch)	(inch)	(inch)	(inch)	(inch)	(inch)	(inch)	(inch)	(inch)	(inch)	(inch)	(inch)
3	-0.16	-0.12	-0.08	-0.04	0.00	0.05	0.09	0.15	0.20	0.26	0.32	0.39	0.46	0.53	0.61	0.69	0.78
6	-0.32	-0.24	-0.17	-0.08	0.00	0.09	0.19	0.29	0.40	0.52	0.65	0.78	0.92	1.07	1.22	1.39	1.56
10	-0.53	-0.41	-0.28	-0.14	0.00	0.15	0.31	0.49	0.67	0.87	1.08	1.30	1.54	1.78	2.04	2.31	2.59
15	-0.79	-0.61	-0.41	-0.21	0.00	0.23	0.47	0.73	1.01	1.31	1.62	1.95	2.30	2.67	3.06	3.47	3.89
20	-1.06	-0.81	-0.55	-0.28	0.00	0.30	0.62	0.97	1.34	1.74	2.16	2.60	3.07	3.56	4.08	4.62	5.18
25	-1.32	-1.01	-0.69	-0.35	0.00	0.38	0.78	1.22	1.68	2.18	2.70	3.26	3.84	4.46	5.10	5.78	6.48
30	-1.58	-1.22	-0.83	-0.42	0.00	0.45	0.94	1.46	2.02	2.61	3.24	3.91	4.61	5.35	6.12	6.93	7.78
35	-1.85	-1.42	-0.97	-0.49	0.00	0.53	1.09	1.70	2.35	3.05	3.78	4.56	5.38	6.24	7.14	8.09	9.07
40	-2.11	-1.62	-1.10	-0.56	0.00	0.60	1.25	1.94	2.69	3.48	4.32	5.21	6.14	7.13	8.16	9.24	10.4
45	-2.38	-1.82	-1.24	-0.63	0.00	0.68	1.40	2.19	3.02	3.92	4.86	5.86	6.91	8.02	9.18	10.4	11.7
50	-2.64	-2.03	-1.38	-0.71	0.00	0.75	1.56	2.43	3.36	4.35	5.40	6.51	7.68	8.91	10.2	11.6	13.0
60	-3.17	-2.43	-1.66	-0.85	0.00	0.90	1.87	2.92	4.03	5.22	6.48	7.81	9.22	10.7	12.2	13.9	15.6
70	-3.70	-2.84	-1.93	-0.99	0.00	1.05	2.18	3.40	4.70	6.09	7.56	9.11	10.8	12.5	14.3	16.2	18.1
80	-4.22	-3.24	-2.21	-1.13	0.00	1.20	2.50	3.89	5.38	6.96	8.64	10.4	12.3	14.3	16.3	18.5	20.7
90	-4.75	-3.65	-2.48	-1.27	0.00	1.35	2.81	4.37	6.05	7.83	9.72	11.7	13.8	16.0	18.4	20.8	23.3
100	-5.28	-4.05	-2.76	-1.41	0.00	1.50	3.12	4.86	6.72	8.70	10.8	13.0	15.4	17.8	20.4	23.1	25.9
125	-6.60	-5.06	-3.45	-1.76	0.00	1.88	3.90	6.08	8.40	10.9	13.5	16.3	19.2	22.3	25.5	28.9	32.4
150	-7.92	-6.08	-4.14	-2.12	0.00	2.25	4.68	7.29	10.1	13.1	16.2	19.5	23.0	26.7	30.6	34.7	38.9

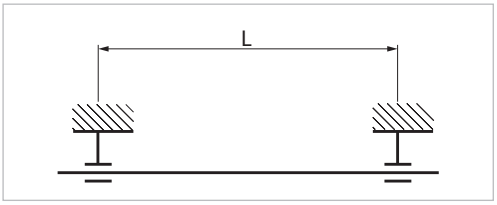
Thermal length change ΔL (mm/m) between any start temperature and any end temperature

Start temperature (°C)	End temperature (°C)																
	-20	-10	0	10	20	30	40	50	60	70	80	90	100	110	120	130	140
	(mm/m)	(mm/m)	(mm/m)	(mm/m)	(mm/m)	(mm/m)	(mm/m)	(mm/m)	(mm/m)	(mm/m)	(mm/m)	(mm/m)	(mm/m)	(mm/m)	(mm/m)	(mm/m)	(mm/m)
-20	0.00	1.03	2.10	3.23	4.40	5.65	7.00	8.45	10.00	11.65	13.40	15.25	17.20	19.25	21.40	23.65	26.00
-10	-1.03	0.00	1.08	2.20	3.38	4.63	5.98	7.43	8.98	10.63	12.38	14.23	16.18	18.23	20.38	22.63	24.98
0	-2.10	-1.08	0.00	1.13	2.30	3.55	4.90	6.35	7.90	9.55	11.30	13.15	15.10	17.15	19.30	21.55	23.90
10	-3.23	-2.20	-1.13	0.00	1.18	2.43	3.78	5.23	6.78	8.43	10.18	12.03	13.98	16.03	18.18	20.43	22.78
20	-4.40	-3.38	-2.30	-1.18	0.00	1.25	2.60	4.05	5.60	7.25	9.00	10.85	12.80	14.85	17.00	19.25	21.60
30	-5.65	-4.63	-3.55	-2.43	-1.25	0.00	1.35	2.80	4.35	6.00	7.75	9.60	11.55	13.60	15.75	18.00	20.35
40	-7.00	-5.98	-4.90	-3.78	-2.60	-1.35	0.00	1.45	3.00	4.65	6.40	8.25	10.20	12.25	14.40	16.65	19.00
50	-8.45	-7.43	-6.35	-5.23	-4.05	-2.80	-1.45	0.00	1.55	3.20	4.95	6.80	8.75	10.80	12.95	15.20	17.55
60	-10.00	-8.98	-7.90	-6.78	-5.60	-4.35	-3.00	-1.55	0.00	1.65	3.40	5.25	7.20	9.25	11.40	13.65	16.00
70	-11.65	-10.63	-9.55	-8.43	-7.25	-6.00	-4.65	-3.20	-1.65	0.00	1.75	3.60	5.55	7.60	9.75	12.00	14.35
80	-13.40	-12.38	-11.30	-10.18	-9.00	-7.75	-6.40	-4.95	-3.40	-1.75	0.00	1.85	3.80	5.85	8.00	10.25	12.60
90	-15.25	-14.23	-13.15	-12.03	-10.85	-9.60	-8.25	-6.80	-5.25	-3.60	-1.85	0.00	1.95	4.00	6.15	8.40	10.75
100	-17.20	-16.18	-15.10	-13.98	-12.80	-11.55	-10.20	-8.75	-7.20	-5.55	-3.80	-1.95	0.00	2.05	4.20	6.45	8.80
110	-19.25	-18.23	-17.15	-16.03	-14.85	-13.60	-12.25	-10.80	-9.25	-7.60	-5.85	-4.00	-2.05	0.00	2.15	4.40	6.75
120	-21.40	-20.38	-19.30	-18.18	-17.00	-15.75	-14.40	-12.95	-11.40	-9.75	-8.00	-6.15	-4.20	-2.15	0.00	2.25	4.60
130	-23.65	-22.63	-21.55	-20.43	-19.25	-18.00	-16.65	-15.20	-13.65	-12.00	-10.25	-8.40	-6.45	-4.40	-2.25	0.00	2.35
140	-26.00	-24.98	-23.90	-22.78	-21.60	-20.35	-19.00	-17.55	-16.00	-14.35	-12.60	-10.75	-8.80	-6.75	-4.60	-2.35	0.00

Thermal length change ΔL (inch/ft) between any start temperature and any end temperature

Start temperature (°F)	End temperature (°F)																
	-4	14	32	50	68	86	104	122	140	158	176	194	212	230	248	266	284
	(inch/ft)	(inch/ft)	(inch/ft)	(inch/ft)	(inch/ft)	(inch/ft)	(inch/ft)	(inch/ft)	(inch/ft)	(inch/ft)	(inch/ft)	(inch/ft)	(inch/ft)	(inch/ft)	(inch/ft)	(inch/ft)	(inch/ft)
-4	0.000	0.012	0.025	0.039	0.053	0.068	0.084	0.101	0.120	0.140	0.161	0.183	0.206	0.231	0.257	0.284	0.312
14	-0.012	0.000	0.013	0.026	0.041	0.056	0.072	0.089	0.108	0.128	0.149	0.171	0.194	0.219	0.245	0.272	0.300
32	-0.025	-0.013	0.000	0.014	0.028	0.043	0.059	0.076	0.095	0.115	0.136	0.158	0.181	0.206	0.232	0.259	0.287
50	-0.039	-0.026	-0.014	0.000	0.014	0.029	0.045	0.063	0.081	0.101	0.122	0.144	0.168	0.192	0.218	0.245	0.273
68	-0.053	-0.041	-0.028	-0.014	0.000	0.015	0.031	0.049	0.067	0.087	0.108	0.130	0.154	0.178	0.204	0.231	0.259
86	-0.068	-0.056	-0.043	-0.029	-0.015	0.000	0.016	0.034	0.052	0.072	0.093	0.115	0.139	0.163	0.189	0.216	0.244
104	-0.084	-0.072	-0.059	-0.045	-0.031	-0.016	0.000	0.017	0.036	0.056	0.077	0.099	0.122	0.147	0.173	0.200	0.228
122	-0.101	-0.089	-0.076	-0.063	-0.049	-0.034	-0.017	0.000	0.019	0.038	0.059	0.082	0.105	0.130	0.155	0.182	0.211
140	-0.120	-0.108	-0.095	-0.081	-0.067	-0.052	-0.036	-0.019	0.000	0.020	0.041	0.063	0.086	0.111	0.137	0.164	0.192
158	-0.140	-0.128	-0.115	-0.101	-0.087	-0.072	-0.056	-0.038	-0.020	0.000	0.021	0.043	0.067	0.091	0.117	0.144	0.172
176	-0.161	-0.149	-0.136	-0.122	-0.108	-0.093	-0.077	-0.059	-0.041	-0.021	0.000	0.022	0.046	0.070	0.096	0.123	0.151
194	-0.183	-0.171	-0.158	-0.144	-0.130	-0.115	-0.099	-0.082	-0.063	-0.043	-0.022	0.000	0.023	0.048	0.074	0.101	0.129
212	-0.206	-0.194	-0.181	-0.168	-0.154	-0.139	-0.122	-0.105	-0.086	-0.067	-0.046	-0.023	0.000	0.025	0.050	0.077	0.106
230	-0.231	-0.219	-0.206	-0.192	-0.178	-0.163	-0.147	-0.130	-0.111	-0.091	-0.070	-0.048	-0.025	0.000	0.026	0.053	0.081
248	-0.257	-0.245	-0.232	-0.218	-0.204	-0.189	-0.173	-0.155	-0.137	-0.117	-0.096	-0.074	-0.050	-0.026	0.000	0.027	0.055
266	-0.284	-0.272	-0.259	-0.245	-0.231	-0.216	-0.200	-0.182	-0.164	-0.144	-0.123	-0.101	-0.077	-0.053	-0.027	0.000	0.028
284	-0.312	-0.300	-0.287	-0.273	-0.259	-0.244	-0.228	-0.211	-0.192	-0.172	-0.151	-0.129	-0.106	-0.081	-0.055	-0.028	0.000

1.5 Pipe support spacing for PVDF pipes



Liquids with a density of 1 g/cm³

d (mm)	Pipe support 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	1'100	1'050	1'000	950	900	850	800	700	600	500
40	1'200	1'150	1'100	1'050	1'000	950	900	750	650	550
50	1'400	1'350	1'300	1'200	1'150	1'100	1'000	900	750	600

d (mm)	Pipe support 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	1'400	1'350	1'300	1'250	1'200	1'150	1'100	950	800	650
75	1'500	1'450	1'400	1'350	1'300	1'250	1'200	1'050	850	700
90	1'600	1'550	1'500	1'450	1'400	1'350	1'300	1'100	950	850
110	1'800	1'750	1'700	1'650	1'550	1'500	1'450	1'250	1'100	950
125	1'900	1'850	1'800	1'700	1'650	1'600	1'500	1'350	1'200	1'000
140	2'000	1'950	1'900	1'800	1'750	1'700	1'600	1'450	1'250	1'050
160	2'150	2'100	2'050	1'950	1'850	1'800	1'700	1'550	1'350	1'150
180	2'300	2'200	2'150	2'050	1'950	1'900	1'800	1'600	1'400	1'200
200	2'400	2'350	2'250	2'150	2'100	2'000	1'900	1'700	1'500	1'300
225	2'550	2'500	2'400	2'300	2'200	2'100	2'000	1'800	1'600	1'400
250	2'650	2'600	2'500	2'400	2'300	2'200	2'100	1'900	1'700	1'500
280	2'850	2'750	2'650	2'550	2'450	2'350	2'250	2'000	1'800	1'600
315	3'000	2'950	2'850	2'750	2'600	2'500	2'400	2'150	1'900	1'650
355	3'200	3'100	3'000	2'850	2'750	2'650	2'500	2'250	2'000	1'750
400	3'400	3'300	3'200	3'050	2'950	2'800	2'650	2'400	2'100	1'800

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 support 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 Pipe support 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 pipe support 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	1.48 for SDR33 and PN10 1.36 for SDR21 and PN16

1.6 Pressure test with water or a similar incompressible test medium for PVDF

Pressure drop

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

Material	Pressure drop (bar/h)
PVDF	0.8

*According to DVS 2210-1ff

Determining the test pressure

The permissible test pressure is calculated according to the following formula:

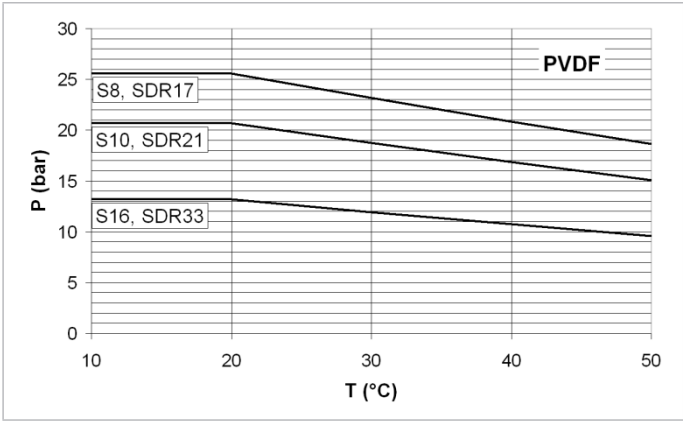
$$P_{p(zul)} = \frac{1}{SDR} \cdot \frac{20 \cdot \sigma_{v(T,\,100\,h)}}{S_p \cdot A_G}$$

$\sigma_{v(T,\,100\,h)}$ 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

In general, the weakest link in the system (in terms of PN rating) determines the maximum test pressure.
If valves are installed in the system, the maximum test pressure shall not exceed the nominal pressure (PN) of the valves.
At test temperatures above 20 °C, the maximum test pressure shall be limited according to the valve-specific pressure-temperature diagrams.

Material	S_p Minimum safety factor DVS 2210-1 Suppl.2
PVDF	1.4

Test pressure diagram for PVDF



P Permissible test pressure (bar)
T Pipe wall temperature (°C)

1.7 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

1.8 SYGEF Standard and SYGEF Plus Systems by GF

SYGEF Standard and SYGEF 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 of -20 °C to +140 °C (-4 °F to +284 °F). 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 (232 psi)
Temperature range	-20 °C to +140 °C (-4 °F to +284 °F)
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
Fire performance	Class B s1 d0 according to EN 13501-1[2)]

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

2) Tested according to EN13823 and EN ISO 11925-2

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																				
	10	33																				
Socket fusion fittings	16																					
Butt fusion fittings[1] IR and BCF-compatible	16	21																				
	10	33																				
Ball valves	16																					
	10																					
Diaphragm valves	16			On request																		
	10																					
Butterfly valves	10																					
Check valves	16																					
	10																					
Pressure regulating valves	10																					
Ventilating and bleed valves	16																					
Flanges																						
Gaskets																						
Pipe Clips																						
Automation																						
IR-welding machine																						
BCF-welding machine																						
Butt fusion machine[1]																						
Socket fusion machine																						

SYGEF Standard

SYGEF Plus

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

PEEK - Polyetheretherketone

1.1 Reference values

Property	Value[1]	Units	Test standard
Density	1.30	g/cm³	EN ISO 1183-1
Yield stress[2]	≥ 94	N/mm²	EN ISO 527-1
Tensile modulus[2]	≥ 3'700	N/mm²	EN ISO 527-1
Charpy notched impact strength[2]	≥ 8	kJ/m²	EN ISO 179-1/1eA
Heat distortion temperature HDT A 1.80 MPa	≥ 157 ≥ 315	°C °F	EN ISO 75
Melting point	≥ 340 ≥ 644	°C °F	ASTM D3418
Thermal conductivity[2]	0.19	Btu-in./h-ft2-°F	ASTM E1530
Water absorption[2] / 24 h	≤ 0.1	%	ASTM D570
Color	Natural		
Limiting oxygen index (LOI)	≥ 36.8	%	ASTM D2863

[1] Typical characteristics measured at the material should not be used for calculations.
[2] At 23 °C (73.4 °F)

General

Polyetheretherketone (PEEK) is a high-performance semi-crystalline thermoplastic belonging to the polyaryletherketone (PAEK) family. Its molecular structure results in an exceptional combination of mechanical strength, low creep, thermal stability and excellent hydrolysis resistance, making it one of the most advanced engineering polymers for demanding industrial applications.

PEEK maintains its excellent mechanical properties at continuous operating temperatures even up to 250 °C, while exhibiting a very low thermal expansion and high dimensional stability.

For high-purity applications, PEEK offers an exceptionally low extractables profile regarding TOC and ionic contamination as the material can be processed and used without additives. These properties make it particularly suitable for ultrapure water (UPW) and hot ultrapure water (HUPW) systems used in semiconductor manufacturing, where the highest purity standards must be maintained even at elevated temperatures and pressures.

Advantages of PEEK

- Additive-free, unpigmented material for maximum purity
- Suitable for hot ultrapure water applications
- Outstanding leachout performance and very fast rinse-up in (H)UPW
- Exceptional combination of mechanical strength, stiffness and ductility, also at elevated temperatures
- High dimensional stability and low thermal expansion
- Excellent long-term pressure performance
- Secure jointing by infrared welding
- Excellent flame retardant properties

UV and weather resistance



PEEK exhibits a good resistance to ultraviolet radiation and weathering. For high-purity semiconductor applications, however, SYGEF Ultra PEEK systems are intended for indoor installation and should be protected from unnecessary environmental exposure during storage and installation. Contact the responsible GF Industry & Infrastructure Flow Solutions representative for more detailed information.

Chemical resistance



Though PEEK offers a good resistance to a wide range of chemicals, SYGEF Ultra PEEK is primarily intended for use with ultrapure water. For detailed information on the use of chemicals for sanitization contact the responsible GF Industry & Infrastructure Flow Solutions representative.

Abrasion resistance



PEEK offers excellent wear and abrasion resistance combined with high mechanical strength and stiffness. These properties contribute to the long service life of components exposed to dynamic loading or flowing media.

Application limits



The application limits depend on operating temperature, pressure, media and expected service life. PEEK as a polymer can be used up to 250°C. The SYGEF Ultra PEEK piping system is specifically designed for Hot Ultra Pure Water applications with continuous operating temperatures up to 140 °C. Pressure-temperature ratings are provided in the corresponding pressure-temperature diagrams.

Combustion behavior



PEEK exhibits excellent intrinsic flame resistance and belongs to the highest-performing thermoplastics regarding fire behaviour. It has a high limiting oxygen index (LOI) and is inherently self-extinguishing without the use of flame-retardant additives. If exposed to a fire from other materials burning, decomposition products of PEEK depend on the fire conditions. Please consider that fire fighting methods have to be adapted to the burnig material. For PEEK, powder, foam, water, water spray and CO2 can be used as extinguishing media. Please refer to the safety data sheets for appropriate fire fighting measures.

Electrical properties



Like most unmodified thermoplastics, PEEK is electrically non-conductive and therefore not susceptible to electrochemical corrosion. However, electrostatic charging may occur under certain operating conditions. Appropriate precautions should be taken where electrostatic discharge could present a hazard. Various methods are available to prevent the occurrence of electrostatic charges. GF Industry & Infrastructure Flow Solutions representatives can provide support in selecting the right one. The specific volume resistance is greater than 1.6 $x10^{17}$ Ωcm and the surface resistivity is >1.9$x10^{17}$ Ω.

High-purity properties



SYGEF Ultra PEEK is manufactured from unpigmented, additive-free PEEK to achieve the highest purity. The material is characterized by extremely low extractables.

These properties make SYGEF Ultra PEEK particularly suitable for Hot Ultra Pure Water (HUPW) systems in semiconductor manufacturing, where the highest purity standards are required. In addition, products made of PEEK exhibit a very smooth surface. Leach-out tests according to SEMI F40 are done regularly for quality control.

1.2 Pressure-temperature diagram for PEEK

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

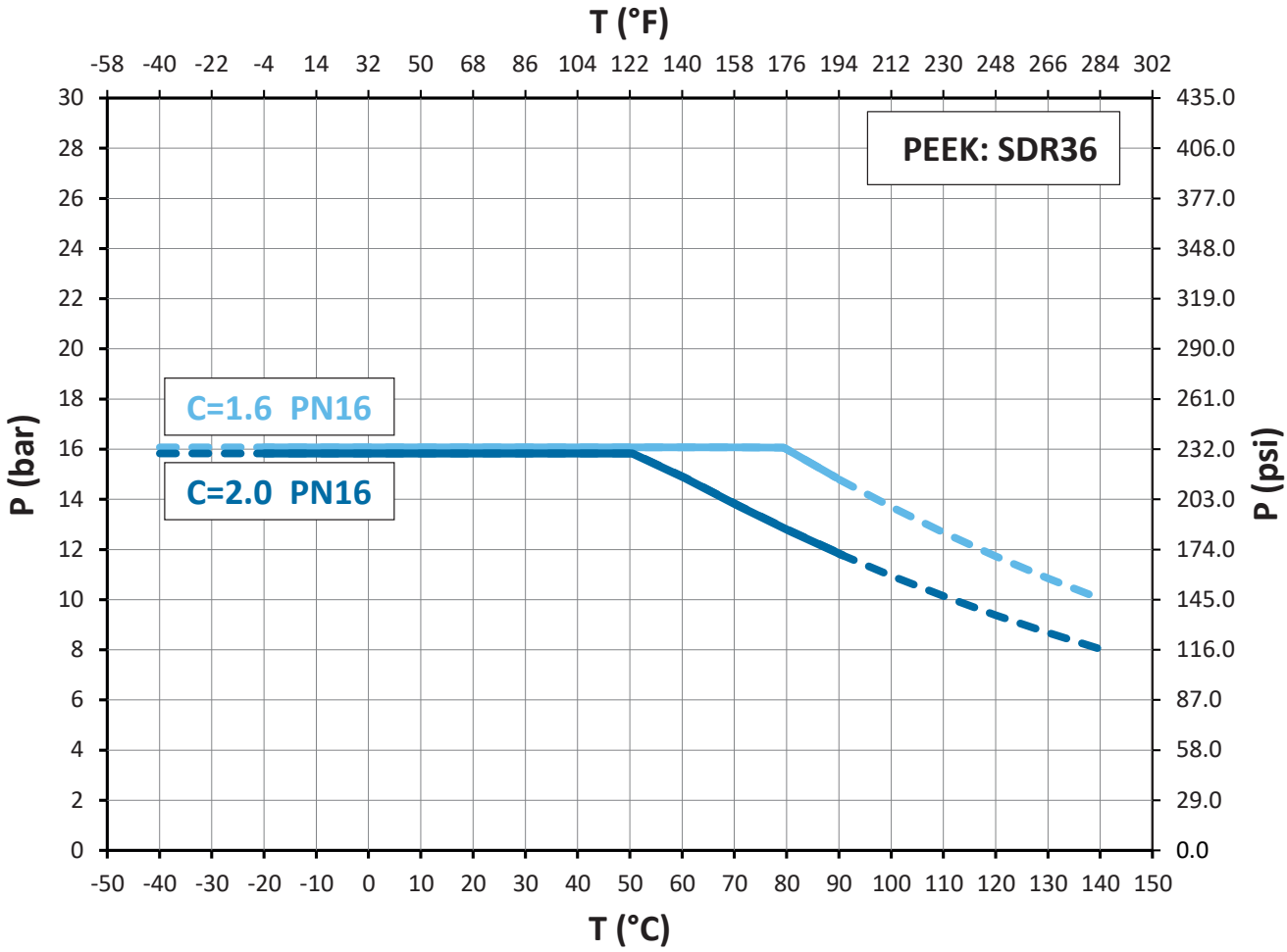
The design factor of 2.0 recommended by GF Industry & Infrastructure Flow Solutions has been incorporated. The pressure-temperature curves are valid for water or media resembling water, in other words, media that have no reduction factor for chemical resistance.

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.

i In case of operating in the temperature range shown in dotted lines, contact your authorized GF Industry & Infrastructure Flow Solutions representative.

PEEK, SDR36



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.

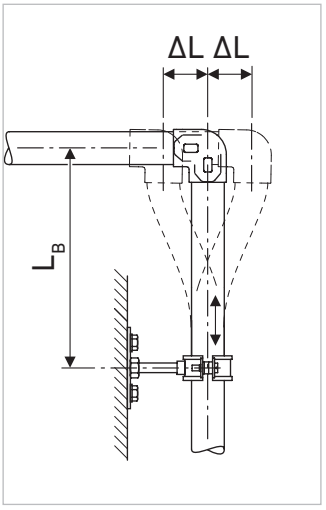
i These diagrams can only be used for applications with liquids!

1.3 Flexible sections of PEEK piping systems

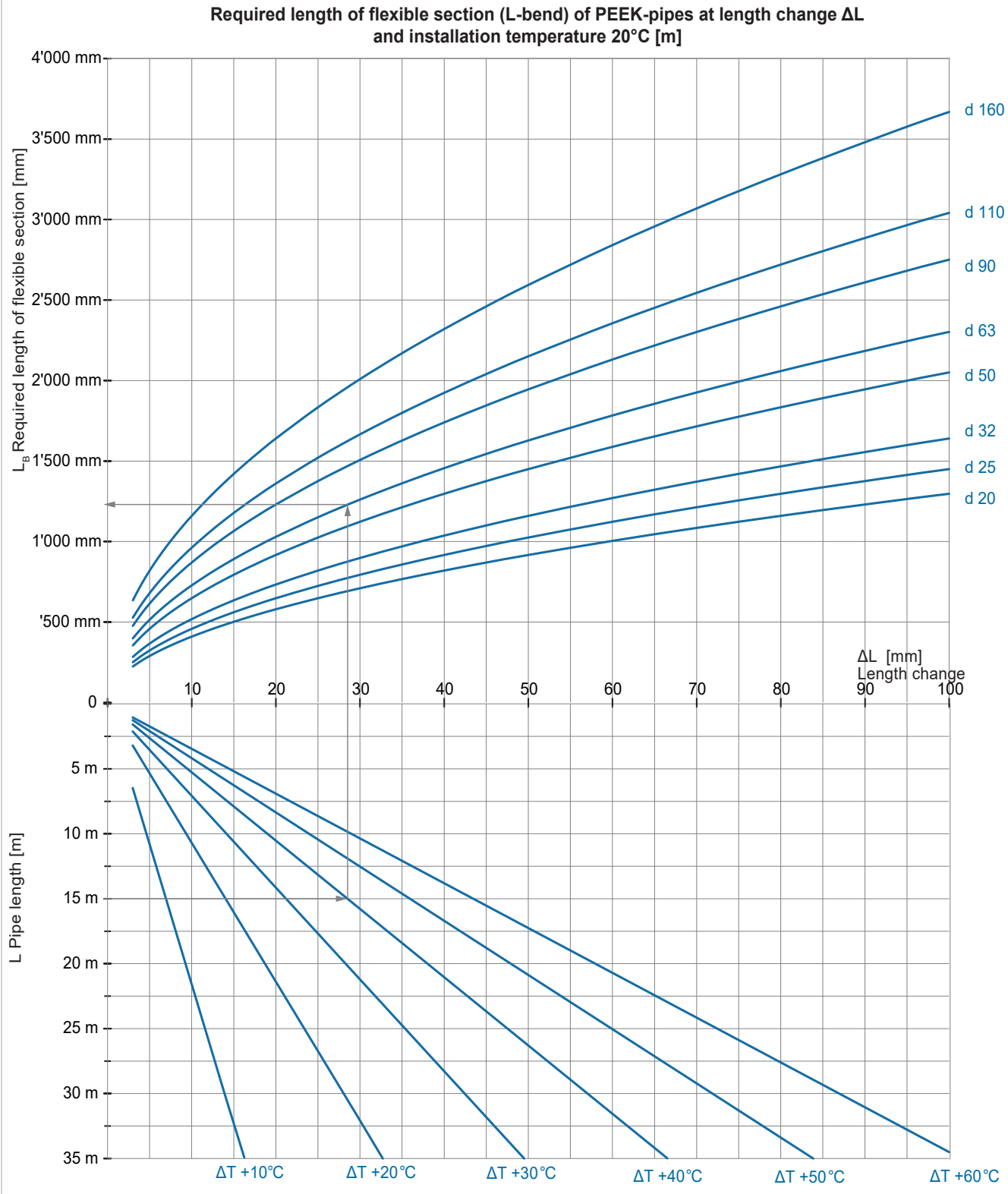
Properties of PEEK

Symbol	Designation	Value	Unit
K	Proportionality factor for flexible sections	29	-
ΔL	Length change	-	mm/inch
d	Outer pipe diameter	-	mm
L_B	Required length of flexible section (L-bend)	-	mm/inch

$L_B = K * (d * \Delta L)^{\wedge 0.5}$



Flexible sections diagram - Outer pipe diameter d20 - d160



Required length of flexible section L_B at length change ΔL, [mm]

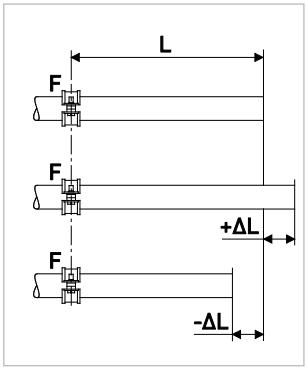
ΔL (mm)	Outer Pipe Diameter d (mm)							
	20 (mm)	25 (mm)	32 (mm)	50 (mm)	63 (mm)	90 (mm)	110 (mm)	160 (mm)
15	500	560	635	795	890	1050	1200	1400
30	710	795	900	1100	1250	1500	1650	2000
45	870	975	1100	1400	1550	1850	2050	2450
60	1000	1100	1250	1600	1800	2150	2350	2850
75	1100	1250	1400	1800	2000	2400	2650	3200
90	1250	1400	1550	1950	2200	2600	2900	3500
105	1350	1500	1700	2100	2350	2800	3100	3750
120	1400	1600	1800	2250	2500	3000	3350	4000
135	1500	1700	1900	2400	2650	3200	3550	4250
150	1600	1800	2000	2500	2800	3350	3750	4500
165	1650	1850	2100	2650	2950	3550	3900	4700
180	1750	1950	2200	2750	3100	3700	4100	4900
195	1800	2000	2300	2850	3200	3850	4250	5100
210	1900	2100	2400	2950	3350	4000	4400	5300
225	1950	2200	2450	3100	3450	4150	4550	5500
240	2000	2250	2550	3200	3550	4250	4700	5700
255	2050	2300	2600	3250	3700	4400	4850	5850
270	2150	2400	2700	3350	3800	4500	5000	6050
285	2200	2450	2750	3450	3900	4650	5150	6200
300	2250	2500	2850	3550	4000	4750	5250	6350

Required length of flexible section L_B at length change ΔL, [inch]

ΔL (inch)	Outer Pipe Diameter d (mm)							
	20 (inch)	25 (inch)	32 (inch)	50 (inch)	63 (inch)	90 (inch)	110 (inch)	160 (inch)
0.5	16.7	18.7	21.2	26.5	29.7	35.5	39.3	47.4
1.0	23.7	26.5	30.0	37.4	42.0	50.2	55.5	67.0
1.5	29.0	32.4	36.7	45.9	51.5	61.5	68.0	82.0
2.0	33.5	37.4	42.4	52.9	59.4	71.0	78.5	94.7
2.5	37.4	41.9	47.4	59.2	66.4	79.4	87.8	106
3.0	41.0	45.9	51.9	64.8	72.8	87.0	96.2	116
3.5	44.3	49.5	56.0	70.0	78.6	94.0	104	125
4.0	47.4	52.9	59.9	74.9	84.0	100	111	134
4.5	50.2	56.2	63.5	79.4	89.1	107	118	142
5.0	52.9	59.2	67.0	83.7	94.0	112	124	150
6.0	60.6	67.7	76.6	95.8	108	129	142	171
7.0	67.7	75.7	85.6	107	120	144	159	191
8.0	74.3	83.1	94.0	117	132	158	174	210
9.0	80.5	90.1	102	127	143	171	189	228
10.0	86.5	96.7	109	137	153	183	203	245
11.0	92.1	103	116	146	163	195	216	260
12.0	97.5	109	123	154	173	207	229	276
13.0	103	115	130	162	182	218	241	290
14.0	108	120	136	170	191	228	252	304
15.0	112	126	142	178	199	238	263	318

1.4 Length changes of PEEK

Properties of PEEK			
Symbol	Designation	Value	Unit
T_{min}	Temperature min.	-40 / -40	°C / °F
T_{max}	Temperature max.	+140 / +284	°C / °F
ΔT	Temperature difference	-	°C / °F
α_{min}	Linear thermal expansion coefficient @20°C/68°F	0.04	mm/m K
α_{max}	Linear thermal expansion coefficient @max. temperature	0.048	mm/m K
ΔL	Length change	-	mm
L	Pipe length	-	m/inch
F	Fix point	-	-



$\Delta L = L \cdot \Delta T \cdot \alpha$

Thermal length change ΔL (mm) between 20°C and any end temperature

Pipe length L	End temperature (°C)																		
	-40	-30	-20	-10	0	10	20	30	40	50	60	70	80	90	100	110	120	130	140
(m)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)
1	-2.6	-2.2	-1.8	-1.3	-0.9	-0.5	0.0	0.5	0.9	1.4	1.9	2.4	2.9	3.4	3.9	4.5	5.0	5.5	6.1
2	-5.2	-4.4	-3.5	-2.7	-1.8	-0.9	0.0	0.9	1.9	2.8	3.8	4.8	5.8	6.8	7.9	8.9	10.0	11.0	12.1
3	-7.8	-6.5	-5.3	-4.0	-2.7	-1.4	0.0	1.4	2.8	4.2	5.7	7.2	8.7	10.2	11.8	13.4	15.0	16.6	18.2
4	-10.3	-8.7	-7.1	-5.3	-3.6	-1.8	0.0	1.9	3.7	5.7	7.6	9.6	11.6	13.6	15.7	17.8	19.9	22.1	24.3
5	-12.9	-10.9	-8.8	-6.7	-4.5	-2.3	0.0	2.3	4.7	7.1	9.5	12.0	14.5	17.0	19.6	22.3	24.9	27.6	30.4
6	-15.5	-13.1	-10.6	-8.0	-5.4	-2.7	0.0	2.8	5.6	8.5	11.4	14.4	17.4	20.4	23.6	26.7	29.9	33.1	36.4
7	-18.1	-15.3	-12.3	-9.4	-6.3	-3.2	0.0	3.2	6.5	9.9	13.3	16.8	20.3	23.9	27.5	31.2	34.9	38.7	42.5
8	-20.7	-17.4	-14.1	-10.7	-7.2	-3.6	0.0	3.7	7.5	11.3	15.2	19.2	23.2	27.3	31.4	35.6	39.9	44.2	48.6
9	-23.3	-19.6	-15.9	-12.0	-8.1	-4.1	0.0	4.2	8.4	12.7	17.1	21.6	26.1	30.7	35.3	40.1	44.9	49.7	54.6
10	-25.9	-21.8	-17.6	-13.4	-9.0	-4.6	0.0	4.6	9.4	14.1	19.0	24.0	29.0	34.1	39.3	44.5	49.8	55.2	60.7
12	-31.0	-26.2	-21.2	-16.0	-10.8	-5.5	0.0	5.6	11.2	17.0	22.8	28.8	34.8	40.9	47.1	53.4	59.8	66.3	72.9
14	-36.2	-30.5	-24.7	-18.7	-12.6	-6.4	0.0	6.5	13.1	19.8	26.6	33.5	40.6	47.7	55.0	62.3	69.8	77.3	85.0
16	-41.4	-34.9	-28.2	-21.4	-14.4	-7.3	0.0	7.4	15.0	22.6	30.4	38.3	46.4	54.5	62.8	71.2	79.7	88.4	97.2
18	-46.5	-39.2	-31.7	-24.1	-16.2	-8.2	0.0	8.3	16.8	25.5	34.2	43.1	52.2	61.3	70.7	80.1	89.7	99.4	109.3
20	-51.7	-43.6	-35.3	-26.7	-18.0	-9.1	0.0	9.3	18.7	28.3	38.0	47.9	58.0	68.2	78.5	89.0	99.7	110.5	121.4
30	-77.6	-65.4	-52.9	-40.1	-27.0	-13.7	0.0	13.9	28.1	42.4	57.0	71.9	86.9	102.2	117.8	133.5	149.5	165.7	182.2
40	-103.4	-87.2	-70.5	-53.5	-36.0	-18.2	0.0	18.6	37.4	56.6	76.1	95.8	115.9	136.3	157.0	178.0	199.3	221.0	242.9
50	-129.3	-109.0	-88.1	-66.8	-45.0	-22.8	0.0	23.2	46.8	70.7	95.1	119.8	144.9	170.4	196.3	222.5	249.2	276.2	303.6

Thermal length change ΔL (inch) between 68°F and any end temperature

Pipe length L	End temperature (°F)																		
	-40	-22	-4	14	32	50	68	86	104	122	140	158	176	194	212	230	248	266	284
(ft)	(inch)	(inch)	(inch)	(inch)	(inch)	(inch)	(inch)	(inch)	(inch)	(inch)	(inch)	(inch)	(inch)	(inch)	(inch)	(inch)	(inch)	(inch)	(inch)
3	-0.09	-0.08	-0.06	-0.05	-0.03	-0.02	0.00	0.02	0.03	0.05	0.07	0.09	0.10	0.12	0.14	0.16	0.18	0.20	0.22
6	-0.19	-0.16	-0.13	-0.10	-0.06	-0.03	0.00	0.03	0.07	0.10	0.14	0.17	0.21	0.25	0.28	0.32	0.36	0.40	0.44
10	-0.31	-0.26	-0.21	-0.16	-0.11	-0.05	0.00	0.06	0.11	0.17	0.23	0.29	0.35	0.41	0.47	0.53	0.60	0.66	0.73
15	-0.47	-0.39	-0.32	-0.24	-0.16	-0.08	0.00	0.08	0.17	0.25	0.34	0.43	0.52	0.61	0.71	0.80	0.90	0.99	1.09
20	-0.62	-0.52	-0.42	-0.32	-0.22	-0.11	0.00	0.11	0.22	0.34	0.46	0.58	0.70	0.82	0.94	1.07	1.20	1.33	1.46
25	-0.78	-0.65	-0.53	-0.40	-0.27	-0.14	0.00	0.14	0.28	0.42	0.57	0.72	0.87	1.02	1.18	1.34	1.50	1.66	1.82
30	-0.93	-0.78	-0.63	-0.48	-0.32	-0.16	0.00	0.17	0.34	0.51	0.68	0.86	1.04	1.23	1.41	1.60	1.79	1.99	2.19
35	-1.09	-0.92	-0.74	-0.56	-0.38	-0.19	0.00	0.19	0.39	0.59	0.80	1.01	1.22	1.43	1.65	1.87	2.09	2.32	2.55
40	-1.24	-1.05	-0.85	-0.64	-0.43	-0.22	0.00	0.22	0.45	0.68	0.91	1.15	1.39	1.64	1.88	2.14	2.39	2.65	2.91
45	-1.40	-1.18	-0.95	-0.72	-0.49	-0.25	0.00	0.25	0.51	0.76	1.03	1.29	1.56	1.84	2.12	2.40	2.69	2.98	3.28
50	-1.55	-1.31	-1.06	-0.80	-0.54	-0.27	0.00	0.28	0.56	0.85	1.14	1.44	1.74	2.04	2.36	2.67	2.99	3.31	3.64
60	-1.86	-1.57	-1.27	-0.96	-0.65	-0.33	0.00	0.33	0.67	1.02	1.37	1.73	2.09	2.45	2.83	3.20	3.59	3.98	4.37
70	-2.17	-1.83	-1.48	-1.12	-0.76	-0.38	0.00	0.39	0.79	1.19	1.60	2.01	2.43	2.86	3.30	3.74	4.19	4.64	5.10
80	-2.48	-2.09	-1.69	-1.28	-0.86	-0.44	0.00	0.45	0.90	1.36	1.83	2.30	2.78	3.27	3.77	4.27	4.78	5.30	5.83
90	-2.79	-2.35	-1.90	-1.44	-0.97	-0.49	0.00	0.50	1.01	1.53	2.05	2.59	3.13	3.68	4.24	4.81	5.38	5.97	6.56
100	-3.10	-2.62	-2.12	-1.60	-1.08	-0.55	0.00	0.56	1.12	1.70	2.28	2.88	3.48	4.09	4.71	5.34	5.98	6.63	7.29
125	-3.88	-3.27	-2.64	-2.00	-1.35	-0.68	0.00	0.70	1.40	2.12	2.85	3.59	4.35	5.11	5.89	6.68	7.48	8.29	9.11
150	-4.65	-3.92	-3.17	-2.41	-1.62	-0.82	0.00	0.83	1.68	2.55	3.42	4.31	5.22	6.13	7.07	8.01	8.97	9.94	10.9

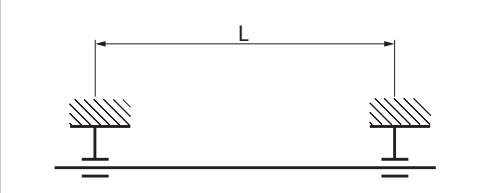
Thermal length change ΔL (mm/m) between any start temperature and any end temperature

Start temperature (°C)	End temperature (°C)																		
	-40	-30	-20	-10	0	10	20	30	40	50	60	70	80	90	100	110	120	130	140
	(mm/m)	(mm/m)	(mm/m)	(mm/m)	(mm/m)	(mm/m)	(mm/m)	(mm/m)	(mm/m)	(mm/m)	(mm/m)	(mm/m)	(mm/m)	(mm/m)	(mm/m)	(mm/m)	(mm/m)	(mm/m)	(mm/m)
-40	0.00	0.41	0.82	1.25	1.69	2.13	2.59	3.05	3.52	4.00	4.49	4.98	5.48	5.99	6.51	7.04	7.57	8.11	8.66
-30	-0.41	0.00	0.42	0.84	1.28	1.72	2.18	2.64	3.11	3.59	4.08	4.58	5.08	5.59	6.10	6.63	7.16	7.70	8.25
-20	-0.82	-0.42	0.00	0.43	0.86	1.31	1.76	2.23	2.70	3.18	3.66	4.16	4.66	5.17	5.69	6.21	6.75	7.29	7.83
-10	-1.25	-0.84	-0.43	0.00	0.44	0.88	1.34	1.80	2.27	2.75	3.24	3.73	4.23	4.74	5.26	5.79	6.32	6.86	7.41
0	-1.69	-1.28	-0.86	-0.44	0.00	0.45	0.90	1.36	1.84	2.32	2.80	3.30	3.80	4.31	4.83	5.35	5.88	6.42	6.97
10	-2.13	-1.72	-1.31	-0.88	-0.45	0.00	0.46	0.92	1.39	1.87	2.36	2.85	3.35	3.86	4.38	4.91	5.44	5.98	6.53
20	-2.59	-2.18	-1.76	-1.34	-0.90	-0.46	0.00	0.46	0.94	1.41	1.90	2.40	2.90	3.41	3.93	4.45	4.98	5.52	6.07
30	-3.05	-2.64	-2.23	-1.80	-1.36	-0.92	-0.46	0.00	0.47	0.95	1.44	1.93	2.43	2.94	3.46	3.99	4.52	5.06	5.61
40	-3.52	-3.11	-2.70	-2.27	-1.84	-1.39	-0.94	-0.47	0.00	0.48	0.97	1.46	1.96	2.47	2.99	3.52	4.05	4.59	5.14
50	-4.00	-3.59	-3.18	-2.75	-2.32	-1.87	-1.41	-0.95	-0.48	0.00	0.49	0.98	1.48	1.99	2.51	3.04	3.57	4.11	4.66
60	-4.49	-4.08	-3.66	-3.24	-2.80	-2.36	-1.90	-1.44	-0.97	-0.49	0.00	0.49	1.00	1.51	2.02	2.55	3.08	3.62	4.17
70	-4.98	-4.58	-4.16	-3.73	-3.30	-2.85	-2.40	-1.93	-1.46	-0.98	-0.49	0.00	0.50	1.01	1.53	2.05	2.59	3.13	3.68
80	-5.48	-5.08	-4.66	-4.23	-3.80	-3.35	-2.90	-2.43	-1.96	-1.48	-1.00	-0.50	0.00	0.51	1.03	1.55	2.09	2.63	3.17
90	-5.99	-5.59	-5.17	-4.74	-4.31	-3.86	-3.41	-2.94	-2.47	-1.99	-1.51	-1.01	-0.51	0.00	0.52	1.04	1.58	2.12	2.66
100	-6.51	-6.10	-5.69	-5.26	-4.83	-4.38	-3.93	-3.46	-2.99	-2.51	-2.02	-1.53	-1.03	-0.52	0.00	0.53	1.06	1.60	2.15
110	-7.04	-6.63	-6.21	-5.79	-5.35	-4.91	-4.45	-3.99	-3.52	-3.04	-2.55	-2.05	-1.55	-1.04	-0.53	0.00	0.53	1.07	1.62
120	-7.57	-7.16	-6.75	-6.32	-5.88	-5.44	-4.98	-4.52	-4.05	-3.57	-3.08	-2.59	-2.09	-1.58	-1.06	-0.53	0.00	0.54	1.09
130	-8.11	-7.70	-7.29	-6.86	-6.42	-5.98	-5.52	-5.06	-4.59	-4.11	-3.62	-3.13	-2.63	-2.12	-1.60	-1.07	-0.54	0.00	0.55
140	-8.66	-8.25	-7.83	-7.41	-6.97	-6.53	-6.07	-5.61	-5.14	-4.66	-4.17	-3.68	-3.17	-2.66	-2.15	-1.62	-1.09	-0.55	0.00

Thermal length change ΔL (inch/ft) between any start temperature and any end temperature

Start temperature (°F)	End temperature (°F)																		
	-40	-22	-4	14	32	50	68	86	104	122	140	158	176	194	212	230	248	266	284
	(inch/ft)	(inch/ft)	(inch/ft)	(inch/ft)	(inch/ft)	(inch/ft)	(inch/ft)	(inch/ft)	(inch/ft)	(inch/ft)	(inch/ft)	(inch/ft)	(inch/ft)	(inch/ft)	(inch/ft)	(inch/ft)	(inch/ft)	(inch/ft)	(inch/ft)
-40	0.000	0.005	0.010	0.015	0.020	0.026	0.031	0.037	0.042	0.048	0.054	0.060	0.066	0.072	0.078	0.084	0.091	0.097	0.104
-22	-0.005	0.000	0.005	0.010	0.015	0.021	0.026	0.032	0.037	0.043	0.049	0.055	0.061	0.067	0.073	0.080	0.086	0.092	0.099
-4	-0.010	-0.005	0.000	0.005	0.010	0.016	0.021	0.027	0.032	0.038	0.044	0.050	0.056	0.062	0.068	0.075	0.081	0.087	0.094
14	-0.015	-0.010	-0.005	0.000	0.005	0.011	0.016	0.022	0.027	0.033	0.039	0.045	0.051	0.057	0.063	0.069	0.076	0.082	0.089
32	-0.020	-0.015	-0.010	-0.005	0.000	0.005	0.011	0.016	0.022	0.028	0.034	0.040	0.046	0.052	0.058	0.064	0.071	0.077	0.084
50	-0.026	-0.021	-0.016	-0.011	-0.005	0.000	0.005	0.011	0.017	0.022	0.028	0.034	0.040	0.046	0.053	0.059	0.065	0.072	0.078
68	-0.031	-0.026	-0.021	-0.016	-0.011	-0.005	0.000	0.006	0.011	0.017	0.023	0.029	0.035	0.041	0.047	0.053	0.060	0.066	0.073
86	-0.037	-0.032	-0.027	-0.022	-0.016	-0.011	-0.006	0.000	0.006	0.011	0.017	0.023	0.029	0.035	0.042	0.048	0.054	0.061	0.067
104	-0.042	-0.037	-0.032	-0.027	-0.022	-0.017	-0.011	-0.006	0.000	0.006	0.012	0.018	0.024	0.030	0.036	0.042	0.049	0.055	0.062
122	-0.048	-0.043	-0.038	-0.033	-0.028	-0.022	-0.017	-0.011	-0.006	0.000	0.006	0.012	0.018	0.024	0.030	0.036	0.043	0.049	0.056
140	-0.054	-0.049	-0.044	-0.039	-0.034	-0.028	-0.023	-0.017	-0.012	-0.006	0.000	0.006	0.012	0.018	0.024	0.031	0.037	0.043	0.050
158	-0.060	-0.055	-0.050	-0.045	-0.040	-0.034	-0.029	-0.023	-0.018	-0.012	-0.006	0.000	0.006	0.012	0.018	0.025	0.031	0.038	0.044
176	-0.066	-0.061	-0.056	-0.051	-0.046	-0.040	-0.035	-0.029	-0.024	-0.018	-0.012	-0.006	0.000	0.006	0.012	0.019	0.025	0.032	0.038
194	-0.072	-0.067	-0.062	-0.057	-0.052	-0.046	-0.041	-0.035	-0.030	-0.024	-0.018	-0.012	-0.006	0.000	0.006	0.013	0.019	0.025	0.032
212	-0.078	-0.073	-0.068	-0.063	-0.058	-0.053	-0.047	-0.042	-0.036	-0.030	-0.024	-0.018	-0.012	-0.006	0.000	0.006	0.013	0.019	0.026
230	-0.084	-0.080	-0.075	-0.069	-0.064	-0.059	-0.053	-0.048	-0.042	-0.036	-0.031	-0.025	-0.019	-0.013	-0.006	0.000	0.006	0.013	0.019
248	-0.091	-0.086	-0.081	-0.076	-0.071	-0.065	-0.060	-0.054	-0.049	-0.043	-0.037	-0.031	-0.025	-0.019	-0.013	-0.006	0.000	0.006	0.013
266	-0.097	-0.092	-0.087	-0.082	-0.077	-0.072	-0.066	-0.061	-0.055	-0.049	-0.043	-0.038	-0.032	-0.025	-0.019	-0.013	-0.006	0.000	0.007
284	-0.104	-0.099	-0.094	-0.089	-0.084	-0.078	-0.073	-0.067	-0.062	-0.056	-0.050	-0.044	-0.038	-0.032	-0.026	-0.019	-0.013	-0.007	0.000

1.5 Pipe support spacing for PEEK pipes



Liquids with a density of 1 g/cm³

d (mm)	Pipe support spacings L in mm for pipe PN16 / SDR36 (mm)												
	≤ 20 °C	30 °C	40 °C	50 °C	60 °C	70 °C	80 °C	90 °C	100 °C	110 °C	120 °C	130 °C	140 °C
20	1'400	1'350	1'350	1'300	1'300	1'300	1'250	1'200	1'200	1'150	1'100	1'000	900
25	1'500	1'450	1'450	1'400	1'400	1'400	1'350	1'300	1'300	1'250	1'200	1'100	1'000
32	1'600	1'600	1'550	1'550	1'500	1'500	1'450	1'450	1'400	1'350	1'300	1'250	1'100
50	1'950	1'900	1'900	1'850	1'800	1'800	1'750	1'700	1'650	1'650	1'600	1'500	1'350
63	2'100	2'050	2'000	2'000	1'950	1'900	1'900	1'850	1'800	1'750	1'700	1'600	1'500
90	2'300	2'250	2'250	2'200	2'150	2'150	2'100	2'050	2'000	1'950	1'900	1'800	1'650
110	2'550	2'500	2'500	2'450	2'400	2'350	2'300	2'250	2'200	2'150	2'100	1'950	1'800
160	3'100	3'050	3'000	2'950	2'900	2'850	2'800	2'750	2'650	2'600	2'550	2'400	2'200

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 Pipe support 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 pipe support spacing
1.00	Water	1.00
1.25	Other media	0.96
1.50		0.92
1.75		0.88
2.00		0.84

1.6 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 Industry & Infrastructure Flow Solutions. 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 Industry & Infrastructure Flow Solutions are dimensioned for these upper limits.

Pipe outer diameter d (mm)	Nominal diameter DN (mm)	No. of bolts	For SYGEF Ultra metric systems, with PP-Steel flanges (Nm)	
			O-ring, unlubed	SYGEF Ultra gasket unlubed
d20	DN15	4	13	
d25	DN20	4	13	14
d32	DN 25	4	13	16
d40	DN 32	4	20	20
d50	DN 40	4	20	26
d63	DN 50	4	26	34
d75	DN 65	4	33	38
d90	DN 80	8	20	45
d110, 125	DN 100	8	26	30
d140	DN 125	8	33	
d160	DN 150	8	39	49

1.7 Pressure and leak test

1.7.1 Introduction to pressure testing

Overview of the different testing methods

Testing method	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 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 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 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!

1.7.2 Pressure test with water or a similar incompressible test medium for PEEK

Pressure drop

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

Material	Pressure drop (bar/h)
PEEK	0.8

*According to DVS 2210-1ff

Determining the test pressure

The permissible test pressure is calculated according to the following formula:

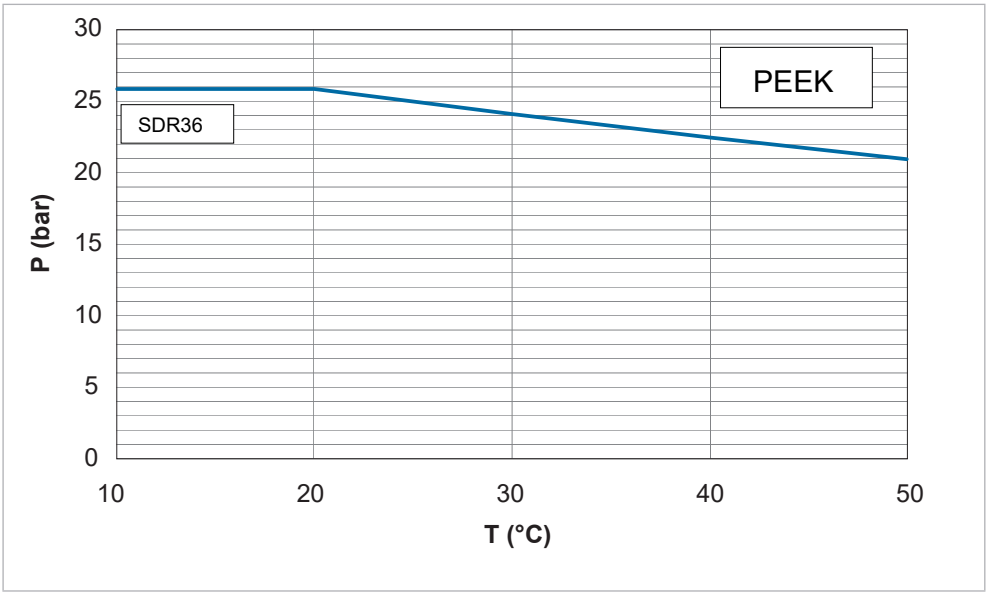
$$P_{p(zul)} = \frac{1}{SDR} \cdot \frac{20 \cdot \sigma_{v(T,\,100\,h)}}{S_p \cdot A_G}$$

$\sigma_{v(T,\,100\,h)}$	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

⚠ In general, the weakest link in the system (in terms of PN rating) determines the maximum test pressure. If valves are installed in the system, the maximum test pressure shall not exceed the nominal pressure (PN) of the valves. At test temperatures above 20 °C, the maximum test pressure shall be limited according to the valve-specific pressure-temperature diagrams.

Material	S_p Minimum safety factor DVS 2210-1 Suppl.2
PEEK	1.4

Test pressure diagram for PEEK



P Permissible test pressure (bar)
T Pipe wall temperature (°C)

1.7.3 Pressure test with water or a similar incompressible test medium

Overview

The 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 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 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")	≤ $P_{p\,(perm)}$	≤ 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
PEEK	0.5
ECTFE	0.9
PA-U*	0.8

*According to DVS 2210-1ff

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.

1.7.4 Filling the pipeline

Before starting with the 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.

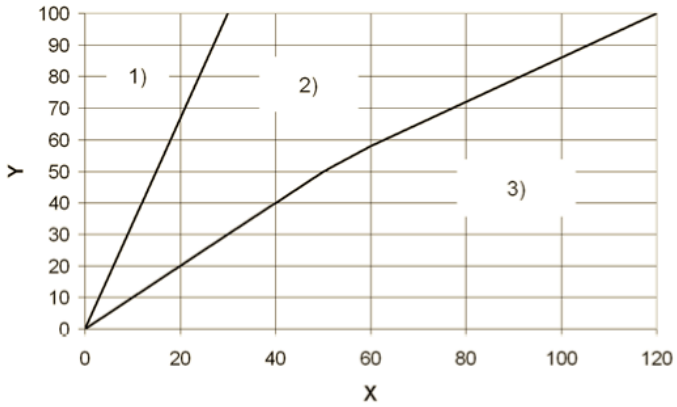
Reference values for the filling volume are given in the table below.

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

If the piping system contains valves, the maximum allowable test pressure is limited to the nominal pressure of the valves.

For the pressure test of valves in open position, the same instructions apply as for the piping system (max. 1.5 x PN, or max. PN + 5 bar), but the test pressure in closed valve position must not exceed max. 1.1 x PN.

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
PEEK	1.3
ECTFE	1.6

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

1.7.5 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 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 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.

1.8 Relevant standards and guidelines for pipe and fittings made of PEEK

Standard	Name
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 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
PEEK standards and guidelines based on	
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
DVS 2205 Supplement 4	Calculation of tanks and apparatus made of thermoplastics - Characteristic values of the PVDF pipe
DVS 2207-15	Fusioning of thermoplastics - Heated tool fusion of pipe, piping system components and sheets made of PVDF

1.9 SYGEF Ultra System by GF

SYGEF Ultra System overview



The outstanding physical and mechanical properties of the SYGEF Ultra PEEK piping system ensure reliable long-term performance for ultra hot ultrapure water (UHPW) applications.

SYGEF Ultra combines high mechanical strength, outstanding material purity and a wide operating temperature range from –40 °C to +140 °C (–40 °F to +284 °F).

Technical data

Nominal pressure	Up to 16 bar (232 psi)
Temperature range	-40 °C to +140 °C (-40 °F to +284 °F)
Jointing technology	Infrared (IR) fusion
Standards and guidelines[1)]	ISO, EN, ASTM, BS, JIS, CE, RoHS, DIN, DVS, SEMI
Fire performance	Class B s1 d0 according to EN 13501-1[2)]

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

2) Tested according to EN13823 and EN ISO 11925-2

Essential system properties

- PEEK high-performance, non-PFAS material [1)]
- Wide temperature range
- High mechanical strength and dimensional stability
- Extremely smooth inner surface
- Highest purity levels, exceeding SEMI F57++
- PN16 rating for long-term operational safety

System and design advantages

- Up to 80% faster rinse-up to specification (TOC, F) [2)]
- Up to 50% wider pipe spans enabling optimized rack design
- Up to 70% reduced thermal expansion
- Elimination of expansion loops depending on layout
- Up to 20% reduction of total piping components

[1)] More information on the PFAS definition at www.gfps.com/sygef-ultra

[2)] Performance comparisons were conducted between SYGEF Ultra (PEEK) and PVDF-HP systems

Important market segments

- Microelectronics

SYGEF Ultra product overview

The following table uses metric units of measure.

Products	PN (bar)	SDR)	d (mm) / DN (mm)	20 / 12	25 / 20	32 / 25	40 / 32	50 / 40	63 / 50	75 / 65	90 / 80	110 / 100	125 / 100	140 / 125	160 / 150
Pipes	16	36		■	■	■		■	■		■	■			■
Fittings	16	36		■	■	■		■	■		■	■			■
Unions	16	36		■	■	■		■	■						
Flange connections	16	36		■	■	■		■	■		■	■			■
Diaphragm valves	16	36		■	■	■		■	■		■	■			
Gaskets	16	36		■	■	■		■	■		■	■			■
Pipe clips	16	36		■	■	■		■	■		■	■			■
Automation	16	36		■	■	■		■	■		■	■			
IR-welding machine	16	36		■	■	■		■	■		■	■			■

■ SYGEF Ultra



Pipes



Fittings



Jointing technology



Automation



Valves

ECTFE - Ethylen-Chlorotrifluoroethylene

1.1 Reference values

Property	Value[1]	Units	Test standard
Density	1.68	g/cm³	EN ISO 1183-1 ASTM D792
Yield stress[2]	≥ 30	N/mm²	EN ISO 527-1
Tensile e-modulus[2]	≥ 1'600	N/mm²	EN ISO 527-1
Charpy notched impact strength[2]	no break	kJ/m²	EN ISO 179-1/1eA
Charpy notched impact strength at 0 °C (32 °F)	≥ 6	kJ/m²	EN ISO 179-1/1eA
Heat distortion temperature HDT A 1.80 MPa	≥ 65 ≥ 149	°C °F	ASTM D648
Crystallite melting point	≥ 240 ≥ 464	°C °F	ISO 11357-3 DSC / ASTM D3418
Thermal conductivity[2]	0.20	W/m K	ASTM C177
Water absorption[2] / 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.
[2] At 23 °C (73.4 °F)

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 Industry & Infrastructure Flow Solutions 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 Industry & Infrastructure Flow Solutions or contact the responsible GF Industry & Infrastructure Flow Solutions representative.

Abrasion resistance

For the use of ECTFE in abrasive applications please contact your GF Industry & Infrastructure Flow Solutions 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 Industry & Infrastructure Flow Solutions 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.

1.2 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 -20 °C to +80 °C (-4 °F to +176 °F), 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 -20 °C to +80 °C (-4 °F to +176 °F).

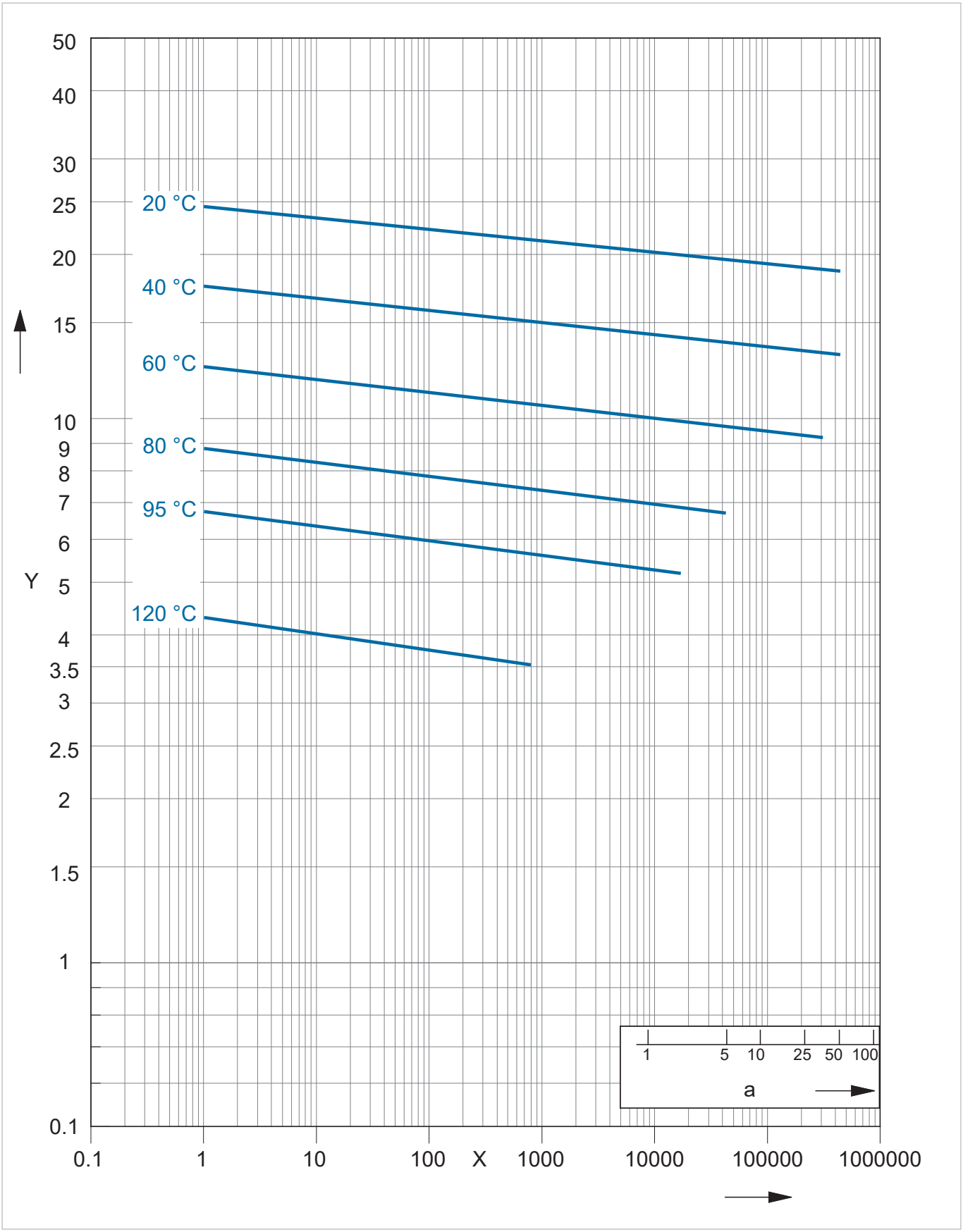
First branch (left-hand portion of the curves as shown in the following long-term behavior)

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

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



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

1.3 Pressure-temperature diagram for ECTFE

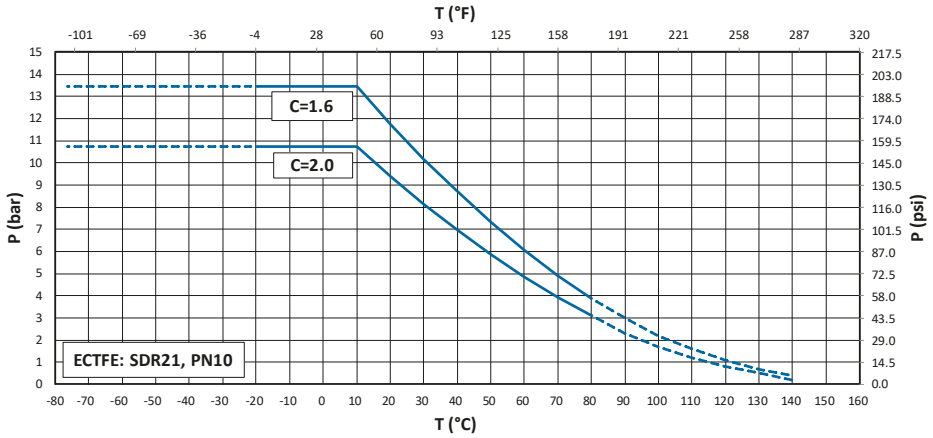
The pressure-temperature diagram that we provide for pipe and fittings made of ECTFE is derived from the long-term behavior, including the design factor, for a service life of 25 years.

The design factor of 2.0 (or 1.6) recommended by GF Industry & Infrastructure Flow Solutions 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.

i In case of operating in the temperature range shown in dotted lines, contact your authorized GF Industry & Infrastructure Flow Solutions representative.

ECTFE, SDR21



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

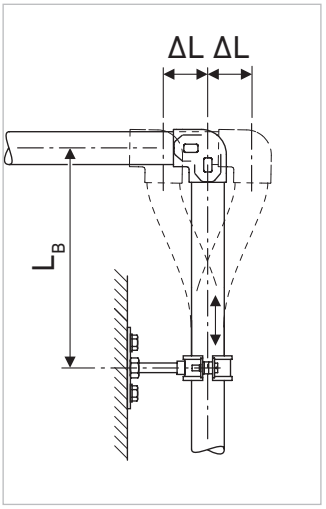
⚠ For any additional project support like engineering, design and installation or chemical resistance please contact gss@georgfischer.com

1.4 Flexible sections of ECTFE piping systems

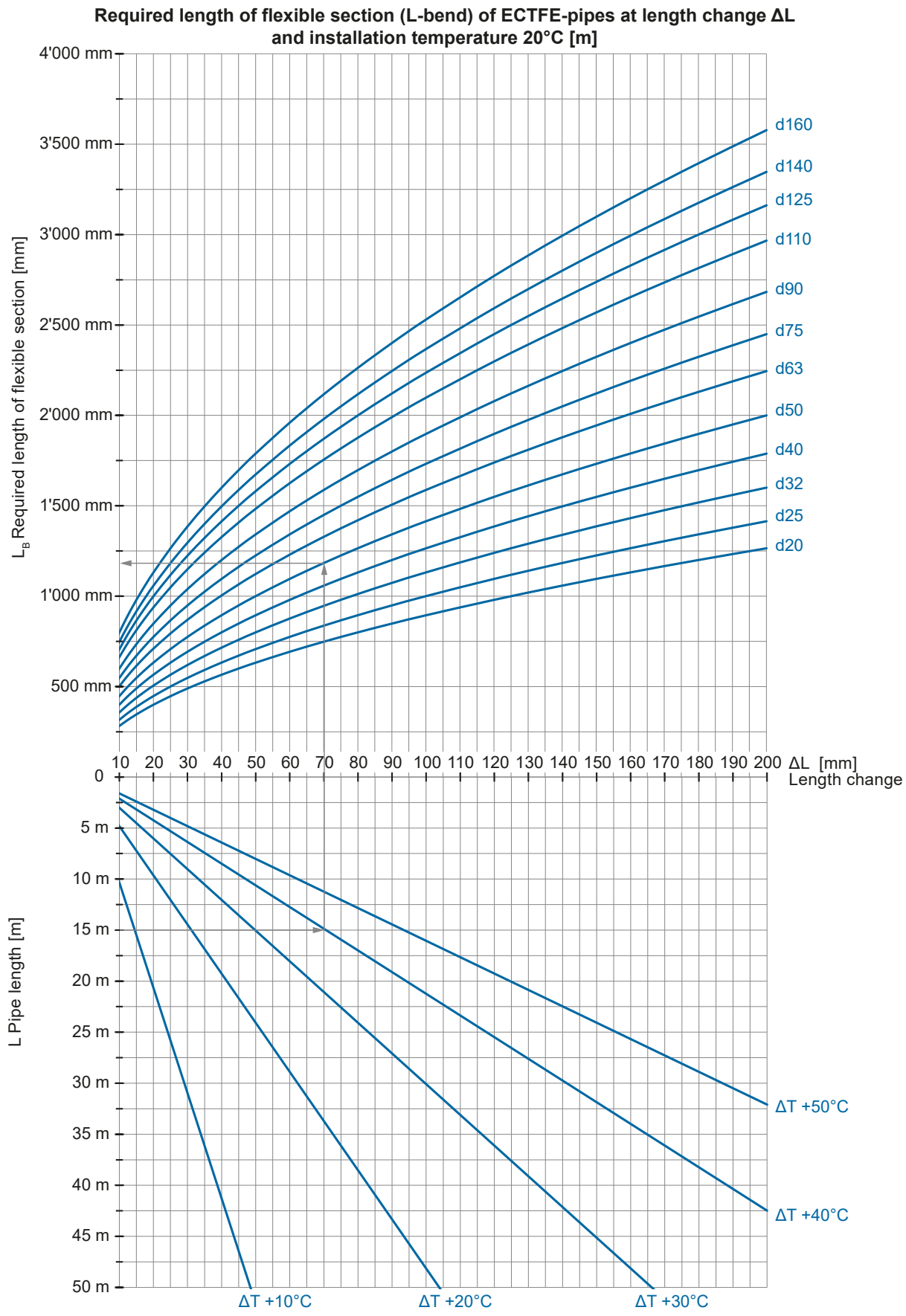
Properties of ECTFE

Symbol	Designation	Value	Unit
K	Proportionality factor for flexible sections	20	-
ΔL	Length change	-	mm/inch
d	Outer pipe diameter	-	mm
L_B	Required length of flexible section (L-bend)	-	mm/inch

$L_B = K * (d * \Delta L)^{\wedge 0.5}$



Flexible sections diagram - Outer pipe diameter d20 - d160



Required length of flexible section L_B at length change ΔL, [mm]

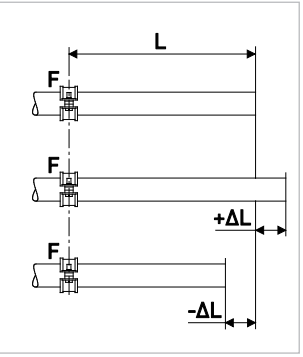
ΔL (mm)	Outer Pipe Diameter d (mm)											
	20 (mm)	25 (mm)	32 (mm)	40 (mm)	50 (mm)	63 (mm)	75 (mm)	90 (mm)	110 (mm)	125 (mm)	140 (mm)	160 (mm)
15	345	385	440	490	550	615	670	735	810	865	915	980
30	490	550	620	695	775	870	950	1'050	1'150	1'200	1'300	1'400
45	600	670	760	850	950	1'050	1'150	1'250	1'400	1'500	1'600	1'700
60	695	775	875	980	1'100	1'250	1'350	1'450	1'600	1'750	1'850	1'950
75	775	865	980	1'100	1'200	1'350	1'500	1'650	1'800	1'950	2'050	2'200
90	850	950	1'050	1'200	1'350	1'500	1'650	1'800	2'000	2'100	2'250	2'400
105	915	1'000	1'150	1'300	1'450	1'650	1'750	1'950	2'150	2'300	2'400	2'600
120	980	1'100	1'250	1'400	1'550	1'750	1'900	2'100	2'300	2'450	2'600	2'750
135	1'050	1'150	1'300	1'450	1'650	1'850	2'000	2'200	2'450	2'600	2'750	2'950
150	1'100	1'200	1'400	1'550	1'750	1'950	2'100	2'300	2'550	2'750	2'900	3'100
165	1'150	1'300	1'450	1'600	1'800	2'050	2'200	2'450	2'700	2'850	3'050	3'250
180	1'200	1'350	1'500	1'700	1'900	2'150	2'300	2'550	2'800	3'000	3'150	3'400
195	1'250	1'400	1'600	1'750	1'950	2'200	2'400	2'650	2'950	3'100	3'300	3'550
210	1'300	1'450	1'650	1'850	2'050	2'300	2'500	2'750	3'050	3'250	3'450	3'650
225	1'350	1'500	1'700	1'900	2'100	2'400	2'600	2'850	3'150	3'350	3'550	3'800
240	1'400	1'550	1'750	1'950	2'200	2'450	2'700	2'950	3'250	3'450	3'650	3'900
255	1'450	1'600	1'800	2'000	2'250	2'550	2'750	3'050	3'350	3'550	3'800	4'050
270	1'450	1'650	1'850	2'100	2'300	2'600	2'850	3'100	3'450	3'650	3'900	4'150
285	1'500	1'700	1'900	2'150	2'400	2'700	2'900	3'200	3'550	3'750	4'000	4'250
300	1'550	1'750	1'950	2'200	2'450	2'750	3'000	3'300	3'650	3'850	4'100	4'400

Required length of flexible section L_B at length change ΔL, [inch]

ΔL (inch)	Outer Pipe Diameter d (mm)											
	20 (inch)	25 (inch)	32 (inch)	40 (inch)	50 (inch)	63 (inch)	75 (inch)	90 (inch)	110 (inch)	125 (inch)	140 (inch)	160 (inch)
0.5	11.5	12.9	14.6	16.3	18.3	20.5	22.4	24.5	27.1	28.9	30.6	32.7
1.0	16.3	18.3	20.7	23.1	25.8	29.0	31.6	34.6	38.3	40.8	43.2	46.2
1.5	20.0	22.4	25.3	28.3	31.6	35.5	38.7	42.4	46.9	50.0	52.9	56.6
2.0	23.1	25.8	29.2	32.7	36.5	41.0	44.7	49.0	54.2	57.7	61.1	65.3
2.5	25.8	28.9	32.7	36.5	40.8	45.8	50.0	54.8	60.6	64.5	68.3	73.0
3.0	28.3	31.6	35.8	40.0	44.7	50.2	54.8	60.0	66.3	70.7	74.8	80.0
3.5	30.6	34.2	38.6	43.2	48.3	54.2	59.2	64.8	71.6	76.4	80.8	86.4
4.0	32.7	36.5	41.3	46.2	51.6	58.0	63.2	69.3	76.6	81.6	86.4	92.4
4.5	34.6	38.7	43.8	49.0	54.8	61.5	67.1	73.5	81.2	86.6	91.7	98.0
5.0	36.5	40.8	46.2	51.6	57.7	64.8	70.7	77.5	85.6	91.3	96.6	103
6.0	41.8	46.7	52.8	59.1	66.1	74.1	80.9	88.6	98.0	104	111	118
7.0	46.7	52.2	59.0	66.0	73.8	82.8	90.4	99.0	109	117	123	132
8.0	51.2	57.3	64.8	72.5	81.0	90.9	99.2	109	120	128	136	145
9.0	55.5	62.1	70.3	78.6	87.8	98.6	108	118	130	139	147	157
10.0	59.6	66.7	75.4	84.3	94.3	106	115	126	140	149	158	169
11.0	63.5	71.0	80.3	89.8	100	113	123	135	149	159	168	180
12.0	67.2	75.1	85.0	95.1	106	119	130	143	158	168	178	190
13.0	70.8	79.1	89.5	100	112	126	137	150	166	177	187	200
14.0	74.2	82.9	93.8	105	117	132	144	157	174	185	196	210
15.0	77.5	86.6	98.0	110	122	137	150	164	182	194	205	219

1.5 Length changes of ECTFE

Properties of ECTFE			
Symbol	Designation	Value	Unit
T_{min}	Temperature min.	-40 / -40	°C / °F
T_{max}	Temperature max.	+140 / +284	°C / °F
ΔT	Temperature difference	-	°C / °F
α_{min}	Linear thermal expansion coefficient @20°C/68°F	0.09	mm/m K
α_{max}	Linear thermal expansion coefficient @max. temperature	0.18	mm/m K
ΔL	Length change	-	mm
L	Pipe length	-	m/inch
F	Fix point	-	-



$\Delta L = L \cdot \Delta T \cdot \alpha$

Thermal length change ΔL (mm) between 20°C and any end temperature

Pipe length L	End temperature (°C)																		
	-40	-30	-20	-10	0	10	20	30	40	50	60	70	80	90	100	110	120	130	140
(m)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)
1	-4.2	-3.6	-3.0	-2.4	-1.7	-0.9	0.0	1.0	2.1	3.3	4.7	6.2	7.9	9.7	12	14	16	18	21
2	-8.3	-7.3	-6.1	-4.8	-3.3	-1.7	0.0	1.9	4.2	6.6	9.4	12	16	19	23	27	32	37	42
3	-12	-11	-9.1	-7.2	-5.0	-2.6	0.0	2.9	6.2	10.0	14	19	24	29	35	41	48	55	62
4	-17	-15	-12	-9.6	-6.6	-3.5	0.0	3.9	8.3	13	19	25	32	39	47	55	64	73	83
5	-21	-18	-15	-12	-8.3	-4.3	0.0	4.8	10	17	24	31	39	48	58	69	80	91	104
6	-25	-22	-18	-14	-10.0	-5.2	0.0	5.8	12	20	28	37	47	58	70	82	96	110	125
7	-29	-25	-21	-17	-12	-6.1	0.0	6.8	15	23	33	44	55	68	81	96	111	128	145
8	-33	-29	-24	-19	-13	-6.9	0.0	7.8	17	27	38	50	63	78	93	110	127	146	166
9	-37	-33	-27	-21	-15	-7.8	0.0	8.7	19	30	42	56	71	87	105	123	143	164	187
10	-42	-36	-30	-24	-17	-8.7	0.0	9.7	21	33	47	62	79	97	116	137	159	183	208
12	-50	-44	-37	-29	-20	-10	0.0	12	25	40	56	75	95	116	140	164	191	219	249
14	-58	-51	-43	-33	-23	-12	0.0	14	29	47	66	87	110	136	163	192	223	256	291
16	-66	-58	-49	-38	-27	-14	0.0	16	33	53	75	100	126	155	186	219	255	292	332
18	-75	-65	-55	-43	-30	-16	0.0	17	37	60	85	112	142	174	209	247	287	329	374
20	-83	-73	-61	-48	-33	-17	0.0	19	42	66	94	125	158	194	233	274	318	366	415
30	-125	-109	-91	-72	-50	-26	0.0	29	62	100	141	187	237	291	349	411	478	548	623
40	-166	-145	-122	-96	-66	-35	0.0	39	83	133	188	249	316	388	465	548	637	731	831
50	-208	-182	-152	-119	-83	-43	0.0	48	104	166	235	312	395	485	582	685	796	914	1038

Thermal length change ΔL (inch) between 68°F and any end temperature

Pipe length L	End temperature (°F)																		
	-40	-22	-4	14	32	50	68	86	104	122	140	158	176	194	212	230	248	266	284
(ft)	(inch)	(inch)	(inch)	(inch)	(inch)	(inch)	(inch)	(inch)	(inch)	(inch)	(inch)	(inch)	(inch)	(inch)	(inch)	(inch)	(inch)	(inch)	(inch)
3	-0.15	-0.13	-0.11	-0.09	-0.06	-0.03	0.00	0.03	0.07	0.12	0.17	0.22	0.28	0.35	0.42	0.49	0.57	0.66	0.75
6	-0.30	-0.26	-0.22	-0.17	-0.12	-0.06	0.00	0.07	0.15	0.24	0.34	0.45	0.57	0.70	0.84	0.99	1.15	1.32	1.50
10	-0.50	-0.44	-0.37	-0.29	-0.20	-0.10	0.00	0.12	0.25	0.40	0.56	0.75	0.95	1.16	1.40	1.64	1.91	2.19	2.49
15	-0.75	-0.65	-0.55	-0.43	-0.30	-0.16	0.00	0.17	0.37	0.60	0.85	1.12	1.42	1.74	2.09	2.47	2.87	3.29	3.74
20	-1.00	-0.87	-0.73	-0.57	-0.40	-0.21	0.00	0.23	0.50	0.80	1.13	1.50	1.89	2.33	2.79	3.29	3.82	4.39	4.98
25	-1.25	-1.09	-0.91	-0.72	-0.50	-0.26	0.00	0.29	0.62	1.00	1.41	1.87	2.37	2.91	3.49	4.11	4.78	5.48	6.23
30	-1.50	-1.31	-1.10	-0.86	-0.60	-0.31	0.00	0.35	0.75	1.20	1.69	2.24	2.84	3.49	4.19	4.93	5.73	6.58	7.48
35	-1.74	-1.53	-1.28	-1.00	-0.70	-0.36	0.00	0.41	0.87	1.40	1.98	2.62	3.31	4.07	4.88	5.76	6.69	7.68	8.72
40	-1.99	-1.74	-1.46	-1.15	-0.80	-0.42	0.00	0.47	1.00	1.60	2.26	2.99	3.79	4.65	5.58	6.58	7.64	8.77	9.97
45	-2.24	-1.96	-1.64	-1.29	-0.90	-0.47	0.00	0.52	1.12	1.79	2.54	3.36	4.26	5.23	6.28	7.40	8.60	9.87	11.2
50	-2.49	-2.18	-1.83	-1.43	-1.00	-0.52	0.00	0.58	1.25	1.99	2.82	3.74	4.74	5.82	6.98	8.22	9.55	11.0	12.5
60	-2.99	-2.62	-2.19	-1.72	-1.20	-0.62	0.00	0.70	1.50	2.39	3.39	4.49	5.68	6.98	8.37	9.87	11.5	13.2	15.0
70	-3.49	-3.05	-2.56	-2.01	-1.40	-0.73	0.00	0.81	1.74	2.79	3.95	5.23	6.63	8.14	9.77	11.5	13.4	15.4	17.4
80	-3.99	-3.49	-2.92	-2.29	-1.60	-0.83	0.00	0.93	1.99	3.19	4.52	5.98	7.58	9.30	11.2	13.2	15.3	17.5	19.9
90	-4.49	-3.93	-3.29	-2.58	-1.79	-0.93	0.00	1.05	2.24	3.59	5.08	6.73	8.52	10.5	12.6	14.8	17.2	19.7	22.4
100	-4.98	-4.36	-3.66	-2.87	-1.99	-1.04	0.00	1.16	2.49	3.99	5.65	7.48	9.47	11.6	14.0	16.4	19.1	21.9	24.9
125	-6.23	-5.45	-4.57	-3.58	-2.49	-1.30	0.00	1.45	3.12	4.98	7.06	9.35	11.8	14.5	17.4	20.6	23.9	27.4	31.2
150	-7.48	-6.54	-5.48	-4.30	-2.99	-1.56	0.00	1.74	3.74	5.98	8.47	11.2	14.2	17.4	20.9	24.7	28.7	32.9	37.4

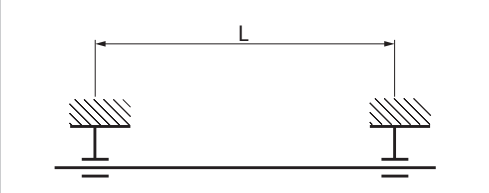
Thermal length change ΔL (mm/m) between any start temperature and any end temperature

Start temperature (°C)	End temperature (°C)																		
	-40	-30	-20	-10	0	10	20	30	40	50	60	70	80	90	100	110	120	130	140
	(mm/m)	(mm/m)	(mm/m)	(mm/m)	(mm/m)	(mm/m)	(mm/m)	(mm/m)	(mm/m)	(mm/m)	(mm/m)	(mm/m)	(mm/m)	(mm/m)	(mm/m)	(mm/m)	(mm/m)	(mm/m)	(mm/m)
-40	0.00	0.52	1.11	1.77	2.49	3.29	4.15	5.12	6.23	7.48	8.86	10.38	12.05	13.85	15.78	17.86	20.08	22.43	24.92
-30	-0.52	0.00	0.59	1.25	1.97	2.77	3.63	4.60	5.71	6.96	8.34	9.87	11.53	13.33	15.27	17.34	19.56	21.91	24.40
-20	-1.11	-0.59	0.00	0.66	1.38	2.18	3.05	4.02	5.12	6.37	7.75	9.28	10.94	12.74	14.68	16.75	18.97	21.32	23.82
-10	-1.77	-1.25	-0.66	0.00	0.73	1.52	2.39	3.36	4.47	5.71	7.10	8.62	10.28	12.08	14.02	16.10	18.31	20.67	23.16
0	-2.49	-1.97	-1.38	-0.73	0.00	0.80	1.66	2.63	3.74	4.98	6.37	7.89	9.55	11.35	13.29	15.37	17.58	19.94	22.43
10	-3.29	-2.77	-2.18	-1.52	-0.80	0.00	0.87	1.83	2.94	4.19	5.57	7.10	8.76	10.56	12.50	14.57	16.79	19.14	21.63
20	-4.15	-3.63	-3.05	-2.39	-1.66	-0.87	0.00	0.97	2.08	3.32	4.71	6.23	7.89	9.69	11.63	13.71	15.92	18.28	20.77
30	-5.12	-4.60	-4.02	-3.36	-2.63	-1.83	-0.97	0.00	1.11	2.35	3.74	5.26	6.92	8.72	10.66	12.74	14.95	17.31	19.80
40	-6.23	-5.71	-5.12	-4.47	-3.74	-2.94	-2.08	-1.11	0.00	1.25	2.63	4.15	5.82	7.62	9.55	11.63	13.85	16.20	18.69
50	-7.48	-6.96	-6.37	-5.71	-4.98	-4.19	-3.32	-2.35	-1.25	0.00	1.38	2.91	4.57	6.37	8.31	10.38	12.60	14.95	17.45
60	-8.86	-8.34	-7.75	-7.10	-6.37	-5.57	-4.71	-3.74	-2.63	-1.38	0.00	1.52	3.18	4.98	6.92	9.00	11.22	13.57	16.06
70	-10.38	-9.87	-9.28	-8.62	-7.89	-7.10	-6.23	-5.26	-4.15	-2.91	-1.52	0.00	1.66	3.46	5.40	7.48	9.69	12.05	14.54
80	-12.05	-11.53	-10.94	-10.28	-9.55	-8.76	-7.89	-6.92	-5.82	-4.57	-3.18	-1.66	0.00	1.80	3.74	5.82	8.03	10.38	12.88
90	-13.85	-13.33	-12.74	-12.08	-11.35	-10.56	-9.69	-8.72	-7.62	-6.37	-4.98	-3.46	-1.80	0.00	1.94	4.02	6.23	8.58	11.08
100	-15.78	-15.27	-14.68	-14.02	-13.29	-12.50	-11.63	-10.66	-9.55	-8.31	-6.92	-5.40	-3.74	-1.94	0.00	2.08	4.29	6.65	9.14
110	-17.86	-17.34	-16.75	-16.10	-15.37	-14.57	-13.71	-12.74	-11.63	-10.38	-9.00	-7.48	-5.82	-4.02	-2.08	0.00	2.22	4.57	7.06
120	-20.08	-19.56	-18.97	-18.31	-17.58	-16.79	-15.92	-14.95	-13.85	-12.60	-11.22	-9.69	-8.03	-6.23	-4.29	-2.22	0.00	2.35	4.85
130	-22.43	-21.91	-21.32	-20.67	-19.94	-19.14	-18.28	-17.31	-16.20	-14.95	-13.57	-12.05	-10.38	-8.58	-6.65	-4.57	-2.35	0.00	2.49
140	-24.92	-24.40	-23.82	-23.16	-22.43	-21.63	-20.77	-19.80	-18.69	-17.45	-16.06	-14.54	-12.88	-11.08	-9.14	-7.06	-4.85	-2.49	0.00

Thermal length change ΔL (inch/ft) between any start temperature and any end temperature

Start temperature (°F)	End temperature (°F)																		
	-40	-22	-4	14	32	50	68	86	104	122	140	158	176	194	212	230	248	266	284
	(inch/ft)	(inch/ft)	(inch/ft)	(inch/ft)	(inch/ft)	(inch/ft)	(inch/ft)	(inch/ft)	(inch/ft)	(inch/ft)	(inch/ft)	(inch/ft)	(inch/ft)	(inch/ft)	(inch/ft)	(inch/ft)	(inch/ft)	(inch/ft)	(inch/ft)
-40	0.000	0.006	0.013	0.021	0.030	0.039	0.050	0.061	0.075	0.090	0.106	0.125	0.145	0.166	0.189	0.214	0.241	0.269	0.299
-22	-0.006	0.000	0.007	0.015	0.024	0.033	0.044	0.055	0.069	0.083	0.100	0.118	0.138	0.160	0.183	0.208	0.235	0.263	0.293
-4	-0.013	-0.007	0.000	0.008	0.017	0.026	0.037	0.048	0.061	0.076	0.093	0.111	0.131	0.153	0.176	0.201	0.228	0.256	0.286
14	-0.021	-0.015	-0.008	0.000	0.009	0.018	0.029	0.040	0.054	0.069	0.085	0.103	0.123	0.145	0.168	0.193	0.220	0.248	0.278
32	-0.030	-0.024	-0.017	-0.009	0.000	0.010	0.020	0.032	0.045	0.060	0.076	0.095	0.115	0.136	0.160	0.184	0.211	0.239	0.269
50	-0.039	-0.033	-0.026	-0.018	-0.010	0.000	0.010	0.022	0.035	0.050	0.067	0.085	0.105	0.127	0.150	0.175	0.201	0.230	0.260
68	-0.050	-0.044	-0.037	-0.029	-0.020	-0.010	0.000	0.012	0.025	0.040	0.056	0.075	0.095	0.116	0.140	0.164	0.191	0.219	0.249
86	-0.061	-0.055	-0.048	-0.040	-0.032	-0.022	-0.012	0.000	0.013	0.028	0.045	0.063	0.083	0.105	0.128	0.153	0.179	0.208	0.238
104	-0.075	-0.069	-0.061	-0.054	-0.045	-0.035	-0.025	-0.013	0.000	0.015	0.032	0.050	0.070	0.091	0.115	0.140	0.166	0.194	0.224
122	-0.090	-0.083	-0.076	-0.069	-0.060	-0.050	-0.040	-0.028	-0.015	0.000	0.017	0.035	0.055	0.076	0.100	0.125	0.151	0.179	0.209
140	-0.106	-0.100	-0.093	-0.085	-0.076	-0.067	-0.056	-0.045	-0.032	-0.017	0.000	0.018	0.038	0.060	0.083	0.108	0.135	0.163	0.193
158	-0.125	-0.118	-0.111	-0.103	-0.095	-0.085	-0.075	-0.063	-0.050	-0.035	-0.018	0.000	0.020	0.042	0.065	0.090	0.116	0.145	0.174
176	-0.145	-0.138	-0.131	-0.123	-0.115	-0.105	-0.095	-0.083	-0.070	-0.055	-0.038	-0.020	0.000	0.022	0.045	0.070	0.096	0.125	0.155
194	-0.166	-0.160	-0.153	-0.145	-0.136	-0.127	-0.116	-0.105	-0.091	-0.076	-0.060	-0.042	-0.022	0.000	0.023	0.048	0.075	0.103	0.133
212	-0.189	-0.183	-0.176	-0.168	-0.160	-0.150	-0.140	-0.128	-0.115	-0.100	-0.083	-0.065	-0.045	-0.023	0.000	0.025	0.052	0.080	0.110
230	-0.214	-0.208	-0.201	-0.193	-0.184	-0.175	-0.164	-0.153	-0.140	-0.125	-0.108	-0.090	-0.070	-0.048	-0.025	0.000	0.027	0.055	0.085
248	-0.241	-0.235	-0.228	-0.220	-0.211	-0.201	-0.191	-0.179	-0.166	-0.151	-0.135	-0.116	-0.096	-0.075	-0.052	-0.027	0.000	0.028	0.058
266	-0.269	-0.263	-0.256	-0.248	-0.239	-0.230	-0.219	-0.208	-0.194	-0.179	-0.163	-0.145	-0.125	-0.103	-0.080	-0.055	-0.028	0.000	0.030
284	-0.299	-0.293	-0.286	-0.278	-0.269	-0.260	-0.249	-0.238	-0.224	-0.209	-0.193	-0.174	-0.155	-0.133	-0.110	-0.085	-0.058	-0.030	0.000

1.6 Pipe support spacing for ECTFE pipes



Liquids with a density of 1 g/cm³

d (mm)	Pipe support 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	1'050	950	850	750	700	650	600	550	500	500	450
50	1'250	1'100	1'000	900	800	750	700	650	600	550	500
63	1'400	1'200	1'100	1'000	900	850	750	700	650	600	550
75	1'550	1'350	1'200	1'100	1'000	950	850	800	750	700	650
90	1'700	1'500	1'350	1'250	1'150	1'050	950	900	850	800	700
110	1'850	1'650	1'550	1'450	1'300	1'200	1'100	1'000	950	900	800
140	2'050	1'750	1'600	1'450	1'300	1'250	1'150	1'050	950	900	850
160	2'250	1'950	1'750	1'600	1'450	1'350	1'250	1'150	1'050	1'000	900

Pipe support 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 Pipe support 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 pipe support 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

1.7 Pressure test with water or a similar incompressible test medium for ECTFE

Pressure drop

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

Material	Pressure drop (bar/h)
ECTFE	0.9

*According to DVS 2210-1ff

Determining the test pressure

The permissible test pressure is calculated according to the following formula:

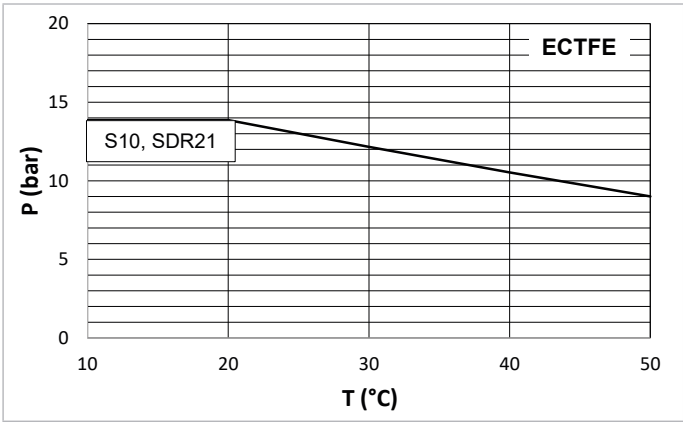
$$P_{p(zul)} = \frac{1}{SDR} \cdot \frac{20 \cdot \sigma_{v(T,\,100\,h)}}{S_p \cdot A_G}$$

$\sigma_{v(T,\,100\,h)}$ 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

In general, the weakest link in the system (in terms of PN rating) determines the maximum test pressure.
If valves are installed in the system, the maximum test pressure shall not exceed the nominal pressure (PN) of the valves.
At test temperatures above 20 °C, the maximum test pressure shall be limited according to the valve-specific pressure-temperature diagrams.

Material	S_p Minimum safety factor DVS 2210-1 Suppl.2
ECTFE	1.6

Test pressure diagram for ECTFE



P Permissible test pressure (bar)
T Pipe wall temperature (°C)

1.8 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 – Characteristic 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 - Above-ground pipe systems - Calculation example
DVS 2210-1 Supplement 2	Industrial piping made of thermoplastics - Design and execution - Above-ground pipe systems - Recommen-dations 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 installa¬tion of two-pipe systems

1.9 SYGEF ECTFE System by GF

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 (-104.8 °F to +284 °F)[1], on a welded system approach for the use of aggressive chemicals approved between -20 °C to +80 °C (-4 °F to +176 °F). 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.

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 (145 psi)
Temperature range	-20 °C to +80 °C (-4 °F to +176 °F)
Extended temperature range for uncritical media	-76 °C to +130 °C (140 °C)[1] -104.8 °F to 266 °F (284 °F)[1]
Jointing technology	Infrared (IR) fusion
	Mechanical joints
Standards and guidelines[2]	ISO, EN, DIN, ASTM, DVS
Fire performance	Class B s1 d0 according to EN 13501-1[3]

[1] on short term only

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

[3] Tested according to EN13823 and EN ISO 11925-2

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.)

PP - Polypropylene

1.1 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[2]	25	31	N/mm²	EN ISO 527-1
Tensile modulus[2]	900	1'300	N/mm²	EN ISO 527-1
Charpy notched impact strength[2]	20	50	kJ/ m²	EN ISO 179-1/1eA
Charpy notched impact strength at 0 °C (32 °F)	3.4	4.8	kJ/m²	EN ISO 179-1/1eA
Heat distortion temperature HDT B 0.45 MPa	75 167	95 203	°C °F	EN ISO 75-2
Water absorption[2]	0.1	0.1	%	EN ISO 62
Color	Neutral/ 7'032	7'032		RAL
Limiting oxygen index (LOI)	19	19	%	ISO 4589-1

[1] Typical characteristics measured at the material should not be used for calculations.
[2] At 23 °C (73.4 °F)

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 Industry & Infrastructure Flow Solutions 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 generally UV sensitive. For the non-pigmented PROGEF Natural system, extended exposure to direct sunlight must be avoided in any case. For indoor applications, PROGEF Natural needs to be protected when installed directly under light sources emitting UV radiation. For PROGEF Standard & PROGEF Plus, additional UV protection is beneficial for outdoor applications. For indoor applications, additional protection for these systems is not required. Contact the responsible GF Industry & Infrastructure Flow Solutions representative for information on 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 Industry & Infrastructure Flow Solutions or contact the responsible GF Industry & Infrastructure Flow Solutions 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 Industry & Infrastructure Flow Solutions are generally non-toxic and biologically inert. For details regarding existing approvals for applications with drinking water or foodstuffs, please contact the responsible GF Industry & Infrastructure Flow Solutions representative.

1.2 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

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

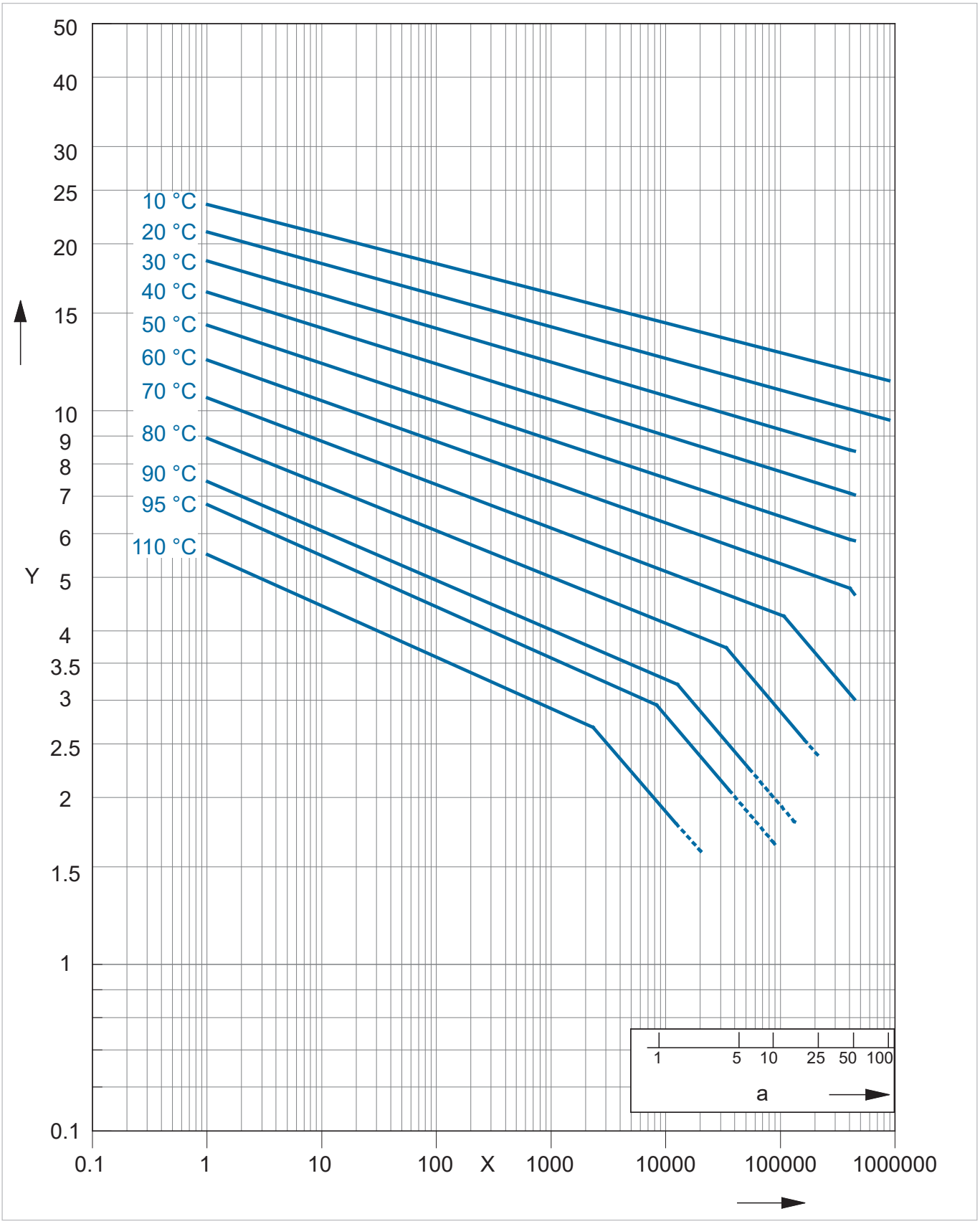
PP-R

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

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

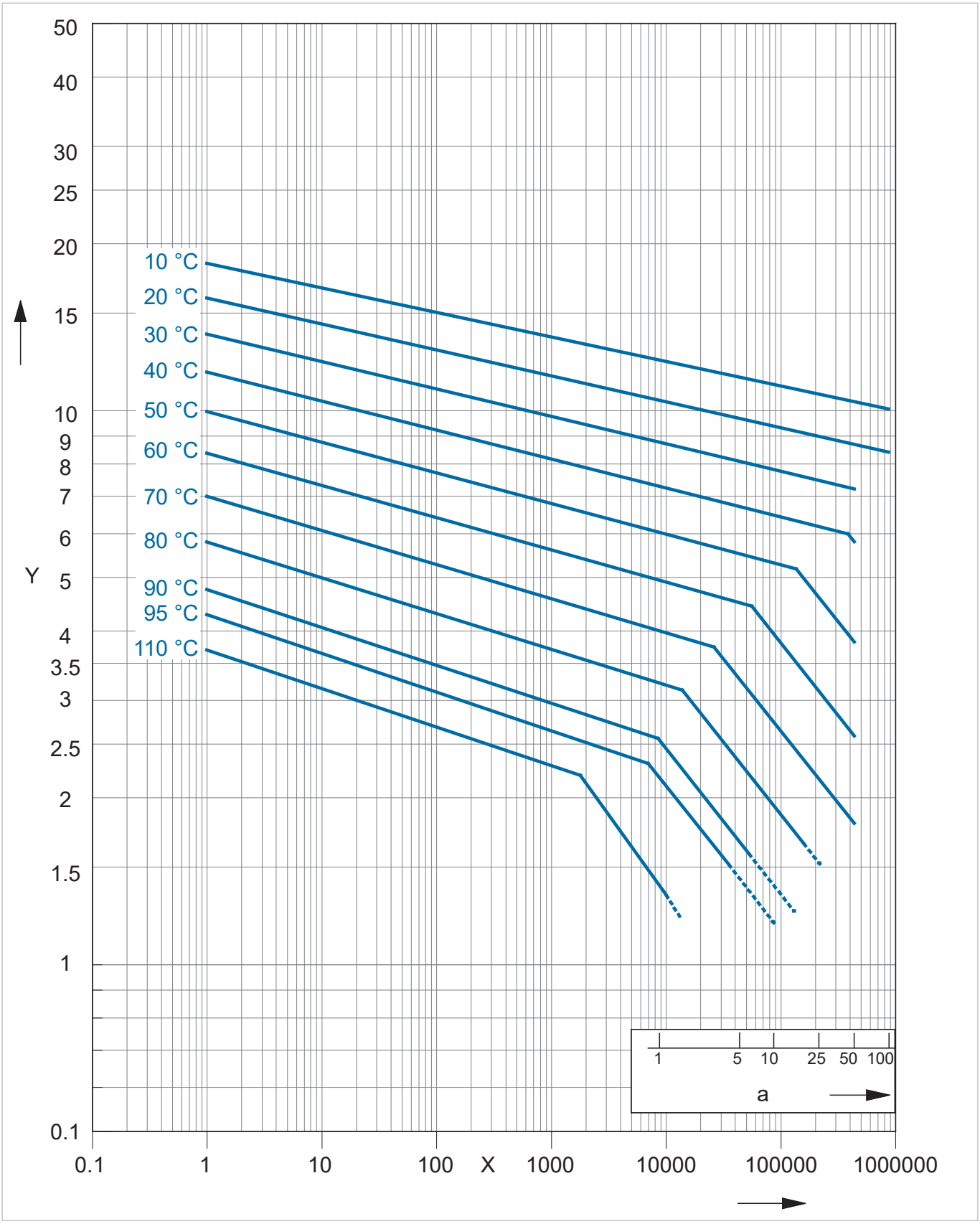
The pressure-temperature diagram that we provide for pipe and fittings made of PP-H and PP-R is derived from the long-term behavior, including the design factor, for a service life of 25 years.

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



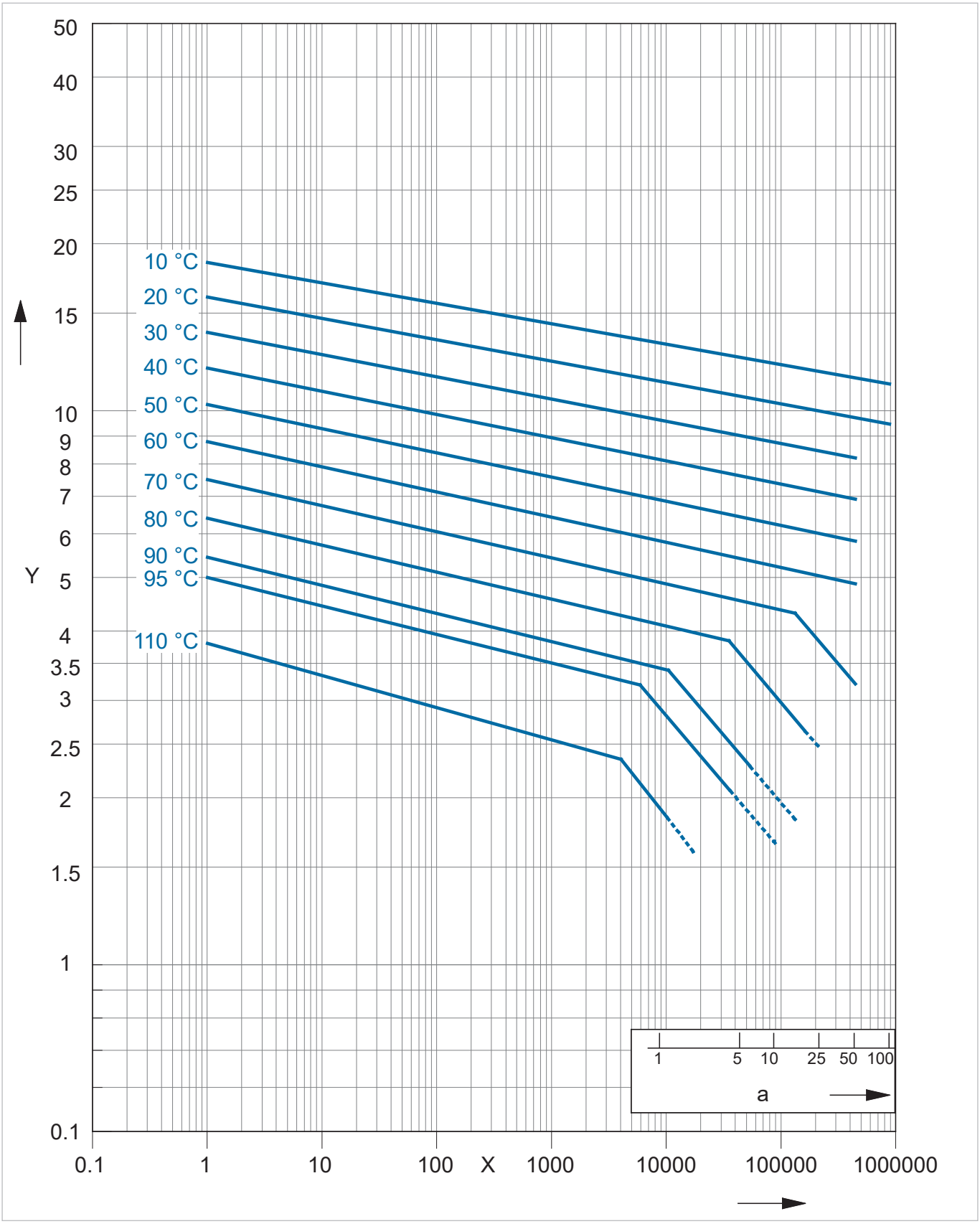
Y Hoop stress (MPa) (1 MPa = 1 N/mm²)
X Time to failure (h)
a Years

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



Y Hoop stress (MPa) (1 MPa = 1 N/mm²)
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

1.3 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.

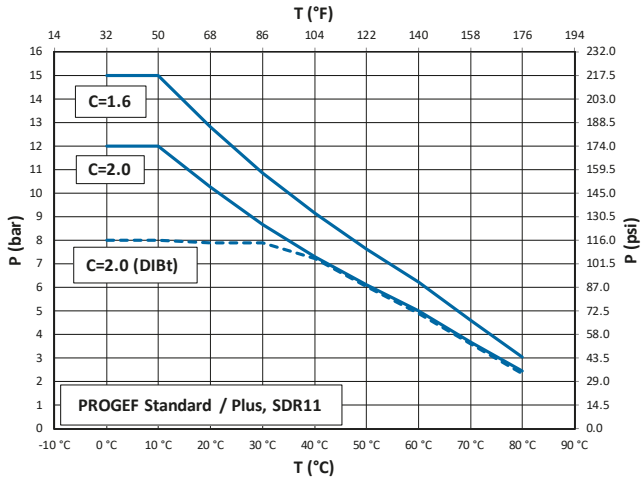
The long-term welding factor fs (or long-term joining factor) must be taken into account if relevant (e.g. stress check in longitudinal direction).

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

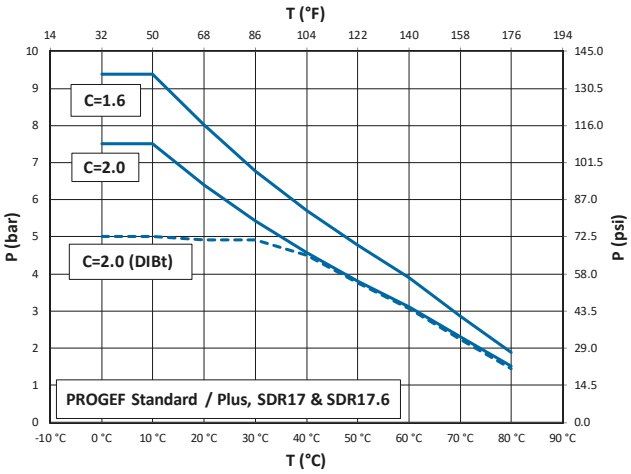
⚠ Please take into account the pressure-temperature diagrams for valves and special fittings. Because of the construction and/or sealing material used, differences are possible when compared to pipe and fittings. More information is available in the Planning Fundamentals of the relevant types of valves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

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

PP, SDR11



PP, SDR17, SDR17.6



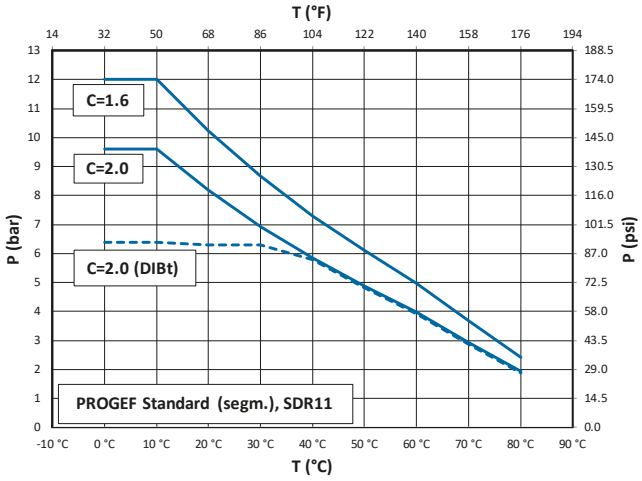
P Permissible pressure (bar, psi)
T Temperature (°C, °F)

⚠ 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.

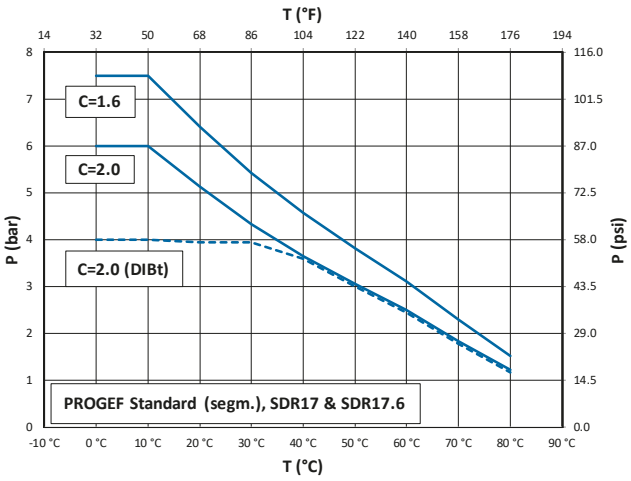
Pressure-temperature diagrams for PP segment-welded fittings

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.

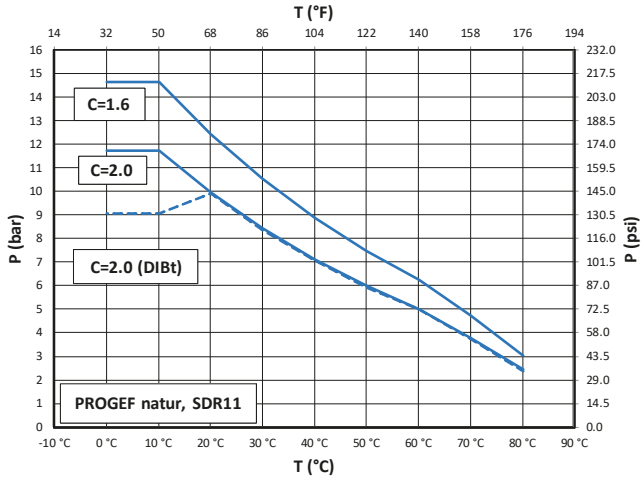
The long-term welding factor fs (or long-term joining factor) must be taken into account if relevant (e.g. stress check in longitudinal direction).

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

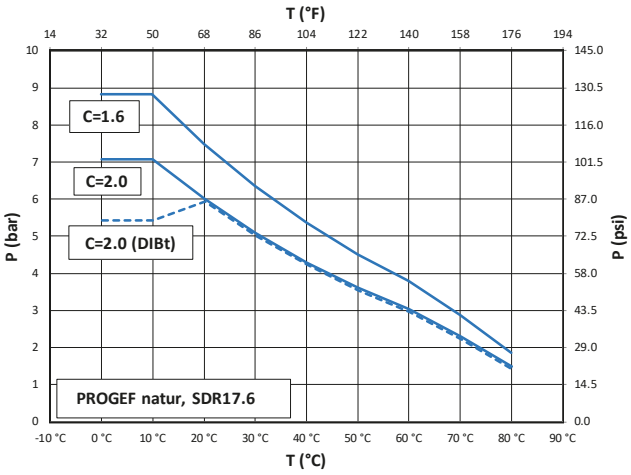
⚠ Please take into account the pressure-temperature diagrams for valves and special fittings. Because of the construction and/or sealing material used, differences are possible when compared to pipe and fittings. More information is available in the Planning Fundamentals of the relevant types of valves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

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

PROGEF Natural, SDR11



PROGEF Natural, SDR17.6



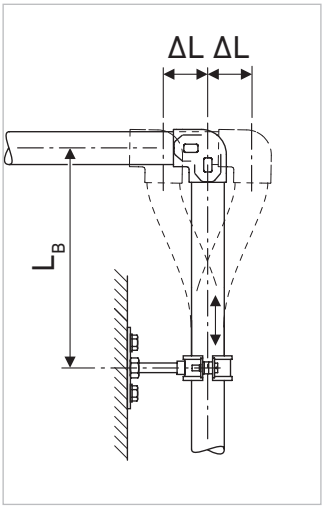
P Permissible pressure (bar, psi)
T Temperature (°C, °F)

⚠ 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.

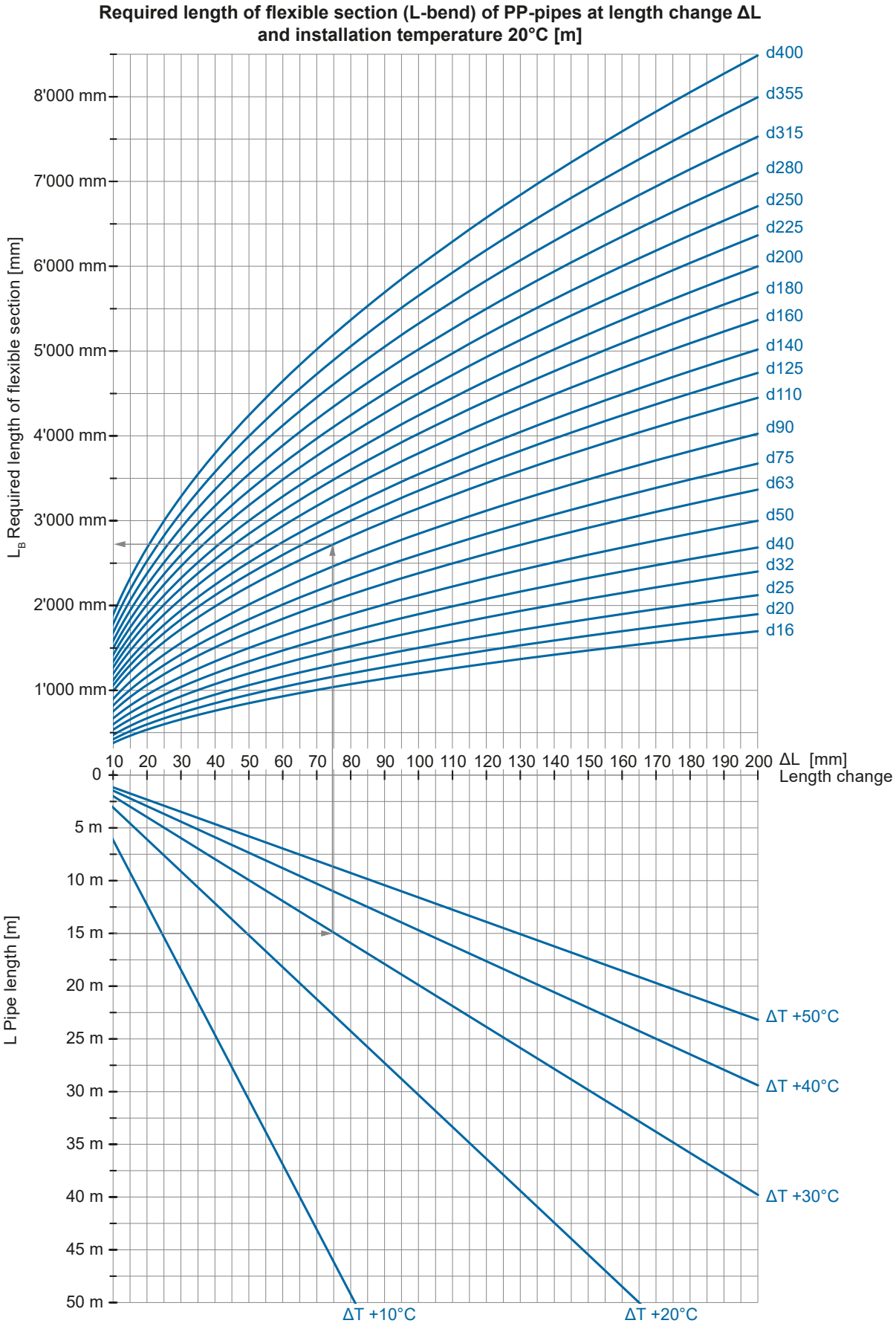
1.4 Flexible sections of PP piping systems

Properties of PP			
Symbol	Designation	Value	Unit
K	Proportionality factor for flexible sections	30	-
ΔL	Length change	-	mm/inch
d	Outer pipe diameter	-	mm
L_B	Required length of flexible section (L-bend)	-	mm/inch

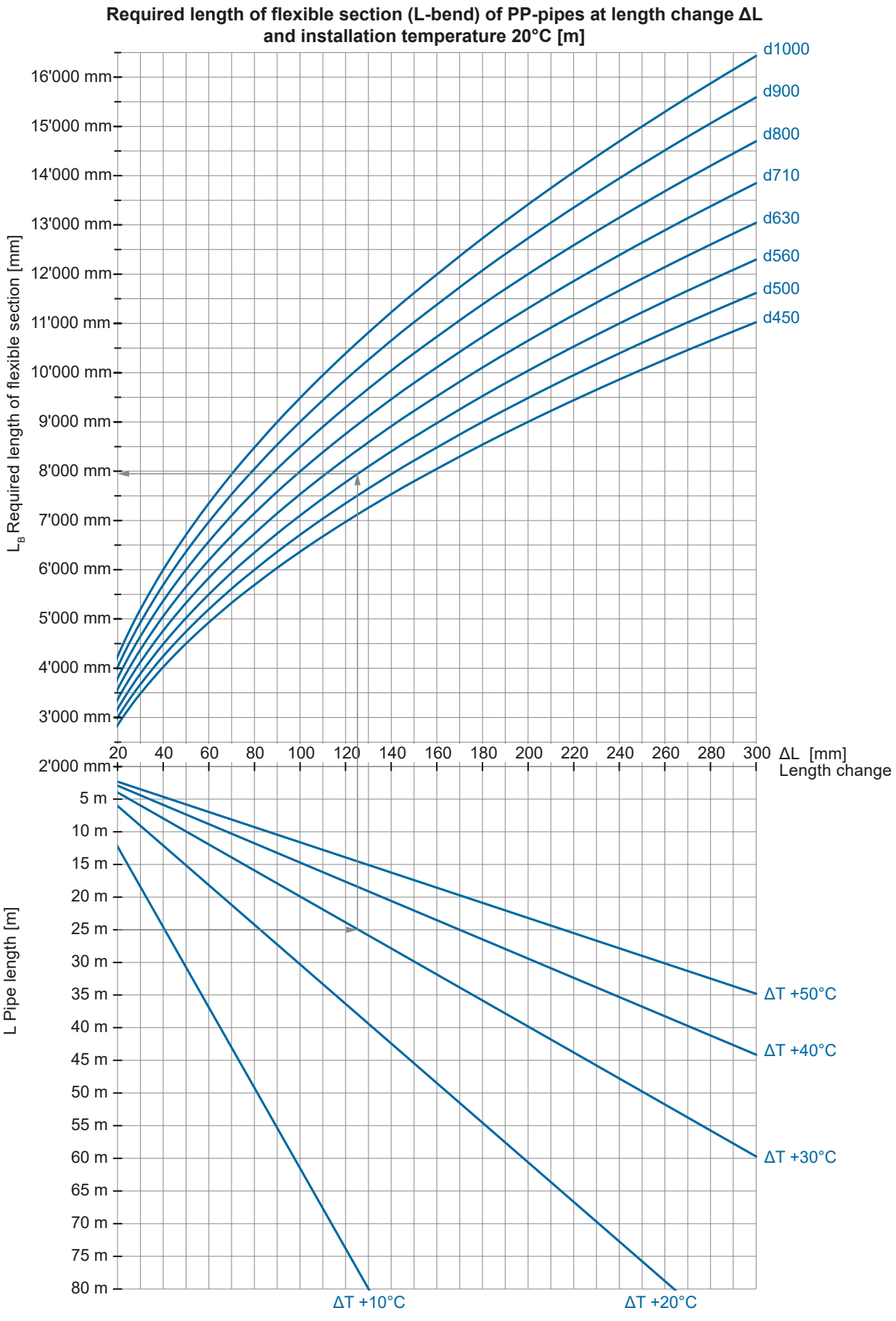
$L_B = K * (d * \Delta L)^{\wedge 0.5}$



Flexible sections diagram - Outer pipe diameter d16 - d400



Flexible sections diagram - Outer pipe diameter d450 - d1000



Required length of flexible section L_B at length change ΔL, [mm]

ΔL	Outer Pipe Diameter d (mm)																					
(mm)	16 (mm)	20 (mm)	25 (mm)	32 (mm)	40 (mm)	50 (mm)	63 (mm)	75 (mm)	90 (mm)	110 (mm)	125 (mm)	140 (mm)	160 (mm)	180 (mm)	200 (mm)	225 (mm)	250 (mm)	280 (mm)	315 (mm)	355 (mm)	400 (mm)
15	465	520	580	655	735	820	920	1'000	1'100	1'200	1'300	1'350	1'450	1'550	1'650	1'750	1'850	1'950	2'050	2'200	2'300
30	655	735	820	930	1'050	1'150	1'300	1'400	1'550	1'700	1'850	1'950	2'100	2'200	2'300	2'450	2'600	2'750	2'900	3'100	3'300
45	805	900	1'000	1'150	1'250	1'400	1'600	1'750	1'900	2'100	2'250	2'400	2'550	2'700	2'850	3'000	3'200	3'350	3'550	3'800	4'000
60	930	1'050	1'150	1'300	1'450	1'650	1'850	2'000	2'200	2'450	2'600	2'750	2'950	3'100	3'300	3'500	3'650	3'900	4'100	4'400	4'650
75	1'050	1'150	1'300	1'450	1'650	1'850	2'050	2'250	2'450	2'700	2'900	3'050	3'300	3'500	3'650	3'900	4'100	4'350	4'600	4'900	5'200
90	1'150	1'250	1'400	1'600	1'800	2'000	2'250	2'450	2'700	3'000	3'200	3'350	3'600	3'800	4'000	4'250	4'500	4'750	5'050	5'350	5'700
105	1'250	1'350	1'550	1'750	1'950	2'150	2'450	2'650	2'900	3'200	3'450	3'650	3'900	4'100	4'350	4'600	4'850	5'150	5'450	5'800	6'150
120	1'300	1'450	1'650	1'850	2'100	2'300	2'600	2'850	3'100	3'450	3'650	3'900	4'150	4'400	4'650	4'950	5'200	5'500	5'850	6'200	6'550
135	1'400	1'550	1'750	1'950	2'200	2'450	2'750	3'000	3'300	3'650	3'900	4'100	4'400	4'700	4'950	5'250	5'500	5'850	6'200	6'550	6'950
150	1'450	1'650	1'850	2'100	2'300	2'600	2'900	3'200	3'500	3'850	4'100	4'350	4'650	4'950	5'200	5'500	5'800	6'150	6'500	6'900	7'350
165	1'550	1'700	1'950	2'200	2'450	2'700	3'050	3'350	3'650	4'050	4'300	4'550	4'850	5'150	5'450	5'800	6'100	6'450	6'850	7'250	7'700
180	1'600	1'800	2'000	2'300	2'550	2'850	3'200	3'500	3'800	4'200	4'500	4'750	5'100	5'400	5'700	6'050	6'350	6'750	7'150	7'600	8'050
195	1'700	1'850	2'100	2'350	2'650	2'950	3'350	3'650	3'950	4'400	4'700	4'950	5'300	5'600	5'900	6'300	6'600	7'000	7'450	7'900	8'400
210	1'750	1'950	2'150	2'450	2'750	3'050	3'450	3'750	4'100	4'550	4'850	5'150	5'500	5'850	6'150	6'500	6'850	7'250	7'700	8'200	8'700
225	1'800	2'000	2'250	2'550	2'850	3'200	3'550	3'900	4'250	4'700	5'050	5'300	5'700	6'050	6'350	6'750	7'100	7'550	8'000	8'500	9'000
240	1'850	2'100	2'300	2'650	2'950	3'300	3'700	4'000	4'400	4'850	5'200	5'500	5'900	6'250	6'550	6'950	7'350	7'800	8'250	8'750	9'300
255	1'900	2'150	2'400	2'700	3'050	3'400	3'800	4'150	4'550	5'000	5'350	5'650	6'050	6'450	6'750	7'200	7'550	8'000	8'500	9'050	9'600
270	1'950	2'200	2'450	2'800	3'100	3'500	3'900	4'250	4'700	5'150	5'500	5'850	6'250	6'600	6'950	7'400	7'800	8'250	8'750	9'300	9'850
285	2'050	2'250	2'550	2'850	3'200	3'600	4'000	4'400	4'800	5'300	5'650	6'000	6'400	6'800	7'150	7'600	8'000	8'450	9'000	9'550	10'150
300	2'100	2'300	2'600	2'950	3'300	3'650	4'100	4'500	4'950	5'450	5'800	6'150	6'550	6'950	7'350	7'800	8'200	8'700	9'200	9'800	10'400

ΔL	Outer Pipe Diameter d (mm)							
(mm)	450 (mm)	500 (mm)	560 (mm)	630 (mm)	710 (mm)	800 (mm)	900 (mm)	1000 (mm)
15	2'450	2'600	2'750	2'900	3'100	3'300	3'500	3'650
30	3'500	3'650	3'900	4'100	4'400	4'650	4'950	5'200
45	4'250	4'500	4'750	5'050	5'350	5'700	6'050	6'350
60	4'950	5'200	5'500	5'850	6'200	6'550	6'950	7'350
75	5'500	5'800	6'150	6'500	6'900	7'350	7'800	8'200
90	6'050	6'350	6'750	7'150	7'600	8'050	8'550	9'000
105	6'500	6'850	7'250	7'700	8'200	8'700	9'200	9'700
120	6'950	7'350	7'800	8'250	8'750	9'300	9'850	10'400
135	7'400	7'800	8'250	8'750	9'300	9'850	10'450	11'000
150	7'800	8'200	8'700	9'200	9'800	10'400	11'000	11'600
165	8'150	8'600	9'100	9'650	10'250	10'900	11'550	12'200
180	8'550	9'000	9'500	10'100	10'700	11'400	12'050	12'750
195	8'900	9'350	9'900	10'500	11'150	11'850	12'550	13'250
210	9'200	9'700	10'300	10'900	11'600	12'300	13'050	13'750
225	9'550	10'050	10'650	11'300	12'000	12'750	13'500	14'250
240	9'850	10'400	11'000	11'650	12'400	13'150	13'950	14'700
255	10'150	10'700	11'350	12'000	12'750	13'550	14'350	15'150
270	10'450	11'000	11'650	12'350	13'150	13'950	14'800	15'600
285	10'750	11'300	12'000	12'700	13'500	14'300	15'200	16'000
300	11'000	11'600	12'300	13'050	13'850	14'700	15'600	16'450

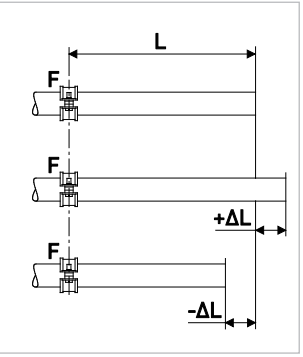
Required length of flexible section L_B at length change ΔL, [inch]

ΔL	Outer Pipe Diameter d (mm)																				
(inch)	16 (inch)	20 (inch)	25 (inch)	32 (inch)	40 (inch)	50 (inch)	63 (inch)	75 (inch)	90 (inch)	110 (inch)	125 (inch)	140 (inch)	160 (inch)	180 (inch)	200 (inch)	225 (inch)	250 (inch)	280 (inch)	315 (inch)	355 (inch)	400 (inch)
0.5	15.5	17.3	19.4	21.9	24.5	27.4	30.7	33.5	36.7	40.6	43.3	45.8	49.0	52.0	54.8	58.1	61.2	64.8	68.7	73.0	77.5
1.0	21.9	24.5	27.4	31.0	34.6	38.7	43.5	47.4	52.0	57.4	61.2	64.8	69.3	73.5	77.5	82.2	86.6	91.7	97.2	103	110
1.5	26.8	30.0	33.5	37.9	42.4	47.4	53.2	58.1	63.6	70.4	75.0	79.4	84.9	90.0	94.9	101	106	112	119	126	134
2.0	31.0	34.6	38.7	43.8	49.0	54.8	61.5	67.1	73.5	81.2	86.6	91.7	98.0	104	110	116	122	130	137	146	155
2.5	34.6	38.7	43.3	49.0	54.8	61.2	68.7	75.0	82.2	90.8	96.8	102	110	116	122	130	137	145	154	163	173
3.0	37.9	42.4	47.4	53.7	60.0	67.1	75.3	82.2	90.0	99.5	106	112	120	127	134	142	150	159	168	179	190
3.5	41.0	45.8	51.2	58.0	64.8	72.5	81.3	88.7	97.2	107	115	121	130	137	145	154	162	171	182	193	205
4.0	43.8	49.0	54.8	62.0	69.3	77.5	86.9	94.9	104	115	122	130	139	147	155	164	173	183	194	206	219
4.5	46.5	52.0	58.1	65.7	73.5	82.2	92.2	101	110	122	130	137	147	156	164	174	184	194	206	219	232
5.0	49.0	54.8	61.2	69.3	77.5	86.6	97.2	106	116	128	137	145	155	164	173	184	194	205	217	231	245
6.0	56.1	62.7	70.1	79.3	88.6	99.1	111	121	133	147	157	166	177	188	198	210	222	234	249	264	280
7.0	62.6	70.0	78.3	88.5	99.0	111	124	136	148	164	175	185	198	210	221	235	247	262	278	295	313
8.0	68.7	76.9	85.9	97.2	109	122	136	149	163	180	192	203	217	231	243	258	272	288	305	324	344
9.0	74.5	83.3	93.2	105	118	132	148	161	177	195	208	220	236	250	263	279	295	312	331	351	373
10.0	80.0	89.4	100	113	126	141	159	173	190	210	224	237	253	268	283	300	316	335	355	377	400
11.0	85.2	95.3	107	120	135	151	169	184	202	223	238	252	269	286	301	320	337	356	378	401	426
12.0	90.2	101	113	128	143	159	179	195	214	236	252	267	285	302	319	338	356	377	400	425	451
13.0	94.9	106	119	134	150	168	188	206	225	249	265	281	300	318	336	356	375	397	421	447	475
14.0	99.5	111	124	141	157	176	197	215	236	261	278	294	315	334	352	373	393	416	442	469	498
15.0	104	116	130	147	164	184	206	225	246	272	290	307	329	349	367	390	411	435	461	490	520

ΔL	Outer Pipe Diameter d (mm)							
(inch)	450 (inch)	500 (inch)	560 (inch)	630 (inch)	710 (inch)	800 (inch)	900 (inch)	1000 (inch)
0.5	82.2	86.6	91.7	97.2	103	110	116	122
1.0	116	122	130	137	146	155	164	173
1.5	142	150	159	168	179	190	201	212
2.0	164	173	183	194	206	219	232	245
2.5	184	194	205	217	231	245	260	274
3.0	201	212	224	238	253	268	285	300
3.5	217	229	242	257	273	290	307	324
4.0	232	245	259	275	292	310	329	346
4.5	246	260	275	292	310	329	349	367
5.0	260	274	290	307	326	346	367	387
6.0	297	313	332	352	373	396	420	443
7.0	332	350	370	393	417	443	470	495
8.0	365	384	407	431	458	486	516	543
9.0	395	417	441	468	496	527	559	589
10.0	424	447	473	502	533	566	600	632
11.0	452	476	504	535	568	602	639	674
12.0	478	504	533	566	601	638	676	713
13.0	503	531	562	596	632	671	712	751
14.0	528	556	589	624	663	704	746	787
15.0	551	581	615	652	692	735	779	822

1.5 Length changes of PP

Properties of PP			
Symbol	Designation	Value	Unit
T_{min}	Temperature min.	0 / +32	°C / °F
T_{max}	Temperature max.	+95 / +203	°C / °F
ΔT	Temperature difference	-	°C / °F
α_{min}	Linear thermal expansion coefficient @20°C/68°F	0.16	mm/m K
α_{max}	Linear thermal expansion coefficient @max. temperature	0.18	mm/m K
ΔL	Length change	-	mm
L	Pipe length	-	m/inch
F	Fix point	-	-



$\Delta L = L \cdot \Delta T \cdot \alpha$

Thermal length change ΔL (mm) between 20°C and any end temperature

Pipe length L	End temperature (°C)										
	0	10	20	30	40	50	60	70	80	90	95
(m)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)
1	-3.2	-1.6	0.0	1.6	3.3	5.0	6.8	8.6	11	12	13
2	-6.3	-3.2	0.0	3.3	6.6	10	14	17	21	25	27
3	-9.5	-4.8	0.0	4.9	9.9	15	20	26	32	37	40
4	-13	-6.4	0.0	6.5	13	20	27	35	42	50	54
5	-16	-7.9	0.0	8.1	17	25	34	43	53	62	67
6	-19	-9.5	0.0	9.8	20	30	41	52	63	75	80
7	-22	-11	0.0	11	23	35	48	60	74	87	94
8	-25	-13	0.0	13	26	40	54	69	84	99	107
9	-28	-14	0.0	15	30	45	61	78	95	112	121
10	-32	-16	0.0	16	33	50	68	86	105	124	134
12	-38	-19	0.0	20	40	60	82	104	126	149	161
14	-44	-22	0.0	23	46	70	95	121	147	174	188
16	-50	-25	0.0	26	53	80	109	138	168	199	215
18	-57	-29	0.0	29	59	90	122	155	189	224	241
20	-63	-32	0.0	33	66	101	136	173	210	249	268
30	-95	-48	0.0	49	99	151	204	259	315	373	402
40	-126	-64	0.0	65	132	201	272	345	420	497	536
50	-158	-79	0.0	81	165	251	340	431	525	621	670

Thermal length change ΔL (inch) between 68°F and any end temperature

Pipe length L	End temperature (°F)										
	32	50	68	86	104	122	140	158	176	194	203
(ft)	(inch)	(inch)	(inch)	(inch)	(inch)	(inch)	(inch)	(inch)	(inch)	(inch)	(inch)
3	-0.11	-0.06	0.00	0.06	0.12	0.18	0.24	0.31	0.38	0.45	0.48
6	-0.23	-0.11	0.00	0.12	0.24	0.36	0.49	0.62	0.76	0.89	0.97
10	-0.38	-0.19	0.00	0.20	0.40	0.60	0.82	1.04	1.26	1.49	1.61
15	-0.57	-0.29	0.00	0.29	0.59	0.90	1.22	1.55	1.89	2.24	2.41
20	-0.76	-0.38	0.00	0.39	0.79	1.21	1.63	2.07	2.52	2.98	3.22
25	-0.95	-0.48	0.00	0.49	0.99	1.51	2.04	2.59	3.15	3.73	4.02
30	-1.13	-0.57	0.00	0.59	1.19	1.81	2.45	3.11	3.78	4.47	4.83
35	-1.32	-0.67	0.00	0.68	1.39	2.11	2.86	3.62	4.41	5.22	5.63
40	-1.51	-0.76	0.00	0.78	1.58	2.41	3.26	4.14	5.04	5.96	6.44
45	-1.70	-0.86	0.00	0.88	1.78	2.71	3.67	4.66	5.67	6.71	7.24
50	-1.89	-0.95	0.00	0.98	1.98	3.02	4.08	5.18	6.30	7.46	8.04
60	-2.27	-1.14	0.00	1.17	2.38	3.62	4.90	6.21	7.56	8.95	9.65
70	-2.65	-1.33	0.00	1.37	2.77	4.22	5.71	7.25	8.82	10.4	11.3
80	-3.02	-1.52	0.00	1.56	3.17	4.82	6.53	8.28	10.1	11.9	12.9
90	-3.40	-1.71	0.00	1.76	3.56	5.43	7.34	9.32	11.3	13.4	14.5
100	-3.78	-1.91	0.00	1.95	3.96	6.03	8.16	10.4	12.6	14.9	16.1
125	-4.73	-2.38	0.00	2.44	4.95	7.54	10.2	12.9	15.8	18.6	20.1
150	-5.67	-2.86	0.00	2.93	5.94	9.05	12.2	15.5	18.9	22.4	24.1

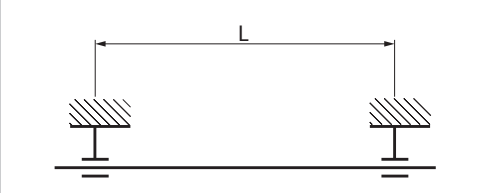
Thermal length change ΔL (mm/m) between any start temperature and any end temperature

Start temperature (°C)	End temperature (°C)										
	0	10	20	30	40	50	60	70	80	90	95
	(mm/m)	(mm/m)	(mm/m)	(mm/m)	(mm/m)	(mm/m)	(mm/m)	(mm/m)	(mm/m)	(mm/m)	(mm/m)
0	0.00	1.56	3.15	4.78	6.45	8.18	9.95	11.78	13.65	15.58	16.56
10	-1.56	0.00	1.59	3.21	4.89	6.61	8.39	10.21	12.09	14.01	14.99
20	-3.15	-1.59	0.00	1.63	3.30	5.03	6.80	8.63	10.50	12.43	13.41
30	-4.78	-3.21	-1.63	0.00	1.68	3.40	5.18	7.00	8.88	10.80	11.78
40	-6.45	-4.89	-3.30	-1.68	0.00	1.73	3.50	5.33	7.20	9.13	10.11
50	-8.18	-6.61	-5.03	-3.40	-1.73	0.00	1.78	3.60	5.48	7.40	8.38
60	-9.95	-8.39	-6.80	-5.18	-3.50	-1.78	0.00	1.83	3.70	5.63	6.61
70	-11.78	-10.21	-8.63	-7.00	-5.33	-3.60	-1.83	0.00	1.88	3.80	4.78
80	-13.65	-12.09	-10.50	-8.88	-7.20	-5.48	-3.70	-1.88	0.00	1.93	2.91
90	-15.58	-14.01	-12.43	-10.80	-9.13	-7.40	-5.63	-3.80	-1.93	0.00	0.98
95	-16.56	-14.99	-13.41	-11.78	-10.11	-8.38	-6.61	-4.78	-2.91	-0.98	0.00

Thermal length change ΔL (inch/ft) between any start temperature and any end temperature

Start temperature (°F)	End temperature (°F)										
	32	50	68	86	104	122	140	158	176	194	203
	(inch/ft)	(inch/ft)	(inch/ft)	(inch/ft)	(inch/ft)	(inch/ft)	(inch/ft)	(inch/ft)	(inch/ft)	(inch/ft)	(inch/ft)
32	0.000	0.019	0.038	0.057	0.077	0.098	0.119	0.141	0.164	0.187	0.199
50	-0.019	0.000	0.019	0.039	0.059	0.079	0.101	0.123	0.145	0.168	0.180
68	-0.038	-0.019	0.000	0.020	0.040	0.060	0.082	0.104	0.126	0.149	0.161
86	-0.057	-0.039	-0.020	0.000	0.020	0.041	0.062	0.084	0.107	0.130	0.141
104	-0.077	-0.059	-0.040	-0.020	0.000	0.021	0.042	0.064	0.086	0.110	0.121
122	-0.098	-0.079	-0.060	-0.041	-0.021	0.000	0.021	0.043	0.066	0.089	0.101
140	-0.119	-0.101	-0.082	-0.062	-0.042	-0.021	0.000	0.022	0.044	0.068	0.079
158	-0.141	-0.123	-0.104	-0.084	-0.064	-0.043	-0.022	0.000	0.023	0.046	0.057
176	-0.164	-0.145	-0.126	-0.107	-0.086	-0.066	-0.044	-0.023	0.000	0.023	0.035
194	-0.187	-0.168	-0.149	-0.130	-0.110	-0.089	-0.068	-0.046	-0.023	0.000	0.012
203	-0.199	-0.180	-0.161	-0.141	-0.121	-0.101	-0.079	-0.057	-0.035	-0.012	0.000

1.6 Pipe support spacing for PP pipes



PP-H pipe for liquids with a density of 1 g/cm³

d (mm)	Pipe support 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	1'100	1'075	1'050	1'000	950	925	875
50	1'250	1'225	1'200	1'150	1'100	1'050	1'000
63	1'450	1'425	1'400	1'350	1'300	1'250	1'200
75	1'550	1'500	1'450	1'400	1'350	1'300	1'250
90	1'650	1'600	1'550	1'500	1'450	1'400	1'350
110	1'850	1'800	1'750	1'700	1'600	1'500	1'400
125	2'000	1'950	1'900	1'800	1'700	1'600	1'500
140	2'100	2'050	2'000	1'900	1'800	1'700	1'600
160	2'250	2'200	2'100	2'000	1'900	1'800	1'700
180	2'350	2'300	2'200	2'100	2'000	1'900	1'800
200	2'500	2'400	2'300	2'200	2'100	2'000	1'900
225	2'650	2'550	2'450	2'350	2'250	2'150	2'000
250	2'800	2'700	2'600	2'500	2'400	2'300	2'150
280	2'950	2'850	2'750	2'650	2'550	2'450	2'300
315	3'150	3'050	2'950	2'850	2'700	2'600	2'450
355	3'350	3'250	3'150	3'000	2'850	2'750	2'600
400	3'550	3'450	3'350	3'200	3'050	2'900	2'750
450	3'800	3'700	3'600	3'450	3'300	3'100	2'950
500	4'100	4'000	3'850	3'700	3'500	3'350	3'150
560	4'400	4'300	4'200	4'000	3'800	3'600	3'400
630	4'800	4'700	4'500	4'300	4'100	3'900	3'700

For other SDRs, multiply the values given in the table by the following factor:

- SDR17 and SDR17.6: 0.91

The pipe support 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/cm³

If the liquid to be transported has a density not equal 1 g/cm³, then the Pipe support 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	Type of medium
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 for SDR11 1.47 for SDR17.6 and SDR17

PP-R pipe for liquids with a density of 1 g/cm³

d (mm)	Pipe support 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	1'100	1'075	1'050	1'025	975	925	900
75	1'150	1'150	1'100	1'050	1'000	975	950
90	1'250	1'200	1'150	1'150	1'100	1'050	1'000
110	1'400	1'350	1'300	1'300	1'200	1'125	1'050
125	1'500	1'450	1'450	1'350	1'300	1'200	1'150
140	1'600	1'550	1'500	1'450	1'350	1'275	1'200
160	1'700	1'650	1'600	1'500	1'450	1'350	1'300
180	1'750	1'750	1'650	1'600	1'500	1'425	1'350
200	1'900	1'800	1'750	1'650	1'600	1'500	1'450
225	2'000	1'900	1'850	1'750	1'700	1'600	1'500
250	2'100	2'050	1'950	1'900	1'800	1'700	1'600
280	2'950	2'850	2'750	2'650	2'550	2'450	2'300
315	2'350	2'300	2'200	2'150	2'050	1'950	1'850
355	2'500	2'425	2'350	2'250	2'125	2'050	1'950
400	2'650	2'575	2'500	2'400	2'275	2'175	2'050
450	2'850	2'775	2'700	2'575	2'475	2'325	2'200
500	3'075	3'000	2'875	2'775	2'625	2'500	2'350
560	3'300	3'225	3'150	3'000	2'850	2'700	2'550
630	3'600	3'525	3'375	3'225	3'075	2'925	2'775

For other SDRs, multiply the values given in the table by the following factor:

- SDR17 and SDR17.6: 0.91

The pipe support 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 Pipe support 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	Type of medium
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 for SDR11 1.47 for SDR17.6 and SDR17

1.7 Pressure test with water or a similar incompressible test medium for PP

Pressure drop

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

Material	Pressure drop (bar/h)
PP	0.8

*According to DVS 2210-1ff

Determining the test pressure

The permissible test pressure is calculated according to the following formula:

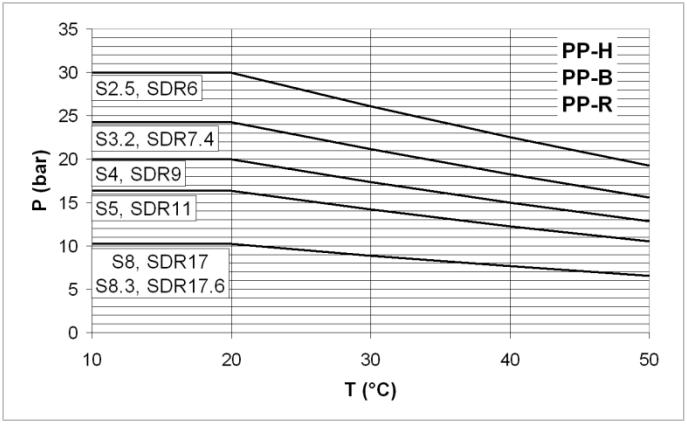
$$P_{p(zul)} = \frac{1}{SDR} \cdot \frac{20 \cdot \sigma_{v(T,\,100\,h)}}{S_p \cdot A_G}$$

$\sigma_{v(T,\,100\,h)}$ 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

In general, the weakest link in the system (in terms of PN rating) determines the maximum test pressure.
If valves are installed in the system, the maximum test pressure shall not exceed the nominal pressure (PN) of the valves.
At test temperatures above 20 °C, the maximum test pressure shall be limited according to the valve-specific pressure-temperature diagrams.

Material	S_p Minimum safety factor DVS 2210-1 Suppl.2
PP-H	1.8
PP-R	1.4

Test pressure diagram for PP



P Permissible test pressure (bar)
T Pipe wall temperature (°C)

1.8 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

1.9 PROGEF Standard, PROGEF Plus, and PROGEF Natural Systems by GF

PROGEF systems out of polypropylene show excellent physical properties and mechanical characteristics. The high-quality material allows applications in a very broad temperature range. 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 (145 psi)
Temperature range	0 °C to 80 °C (32 °F to 176 °F)
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
Fire performance	Class E according to EN 13501-1[2)]

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

2) Tested according to EN ISO 11925-2

PROGEF Standard, PROGEF Plus product overview

The following table uses metric units of measure.

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

PE - Polyethylene

1.1 Reference values

Property	PE 80-Value[1]	PE 4710-Value[1]	PE 100-Value[1]	Units	Test standard
Density	0.93	0.95	0.95	g/cm³	EN ISO 1183-1
Yield stress[2]	18	25	25	N/mm²	EN ISO 527-1
Tensile modulus[2]	700	900	900	N/mm²	EN ISO 527-1
Charpy notched impact strength[2]	110	83	83	kJ/m²	EN ISO 179-1/1eA
Charpy notched impact strength at -40 °C (-40 °F)	7	10	13	kJ/m²	EN ISO 179-1/1eA
Thermal conductivity[2]	0.43	0.38	0.38	W/m K	EN 12664
Water absorption[2]	0.01 - 0.04	0.01 - 0.04	0.01 - 0.04	%	EN ISO 62
Color	9'005	9'005	9'005	RAL	
Limiting oxygen index (LOI)	17.4	17.4	17.4	%	ISO 4589-1

[1] Typical characteristics measured at the material should not be used for calculations.
[2] At 23 °C (73.4 °F)

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
- 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 Industry & Infrastructure Flow Solutions or contact the responsible GF Industry & Infrastructure Flow Solutions 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 x 10^{16} Ωcm and the specific surface resistance is 10^{13} Ω. These figures have to be taken into account wherever there is a hazard of ignition or explosion.

Physiological properties



The black polyethylene materialsfrom GF Industry & Infrastructure Flow Solutions 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 Industry & Infrastructure Flow Solutions representative.

1.2 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

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

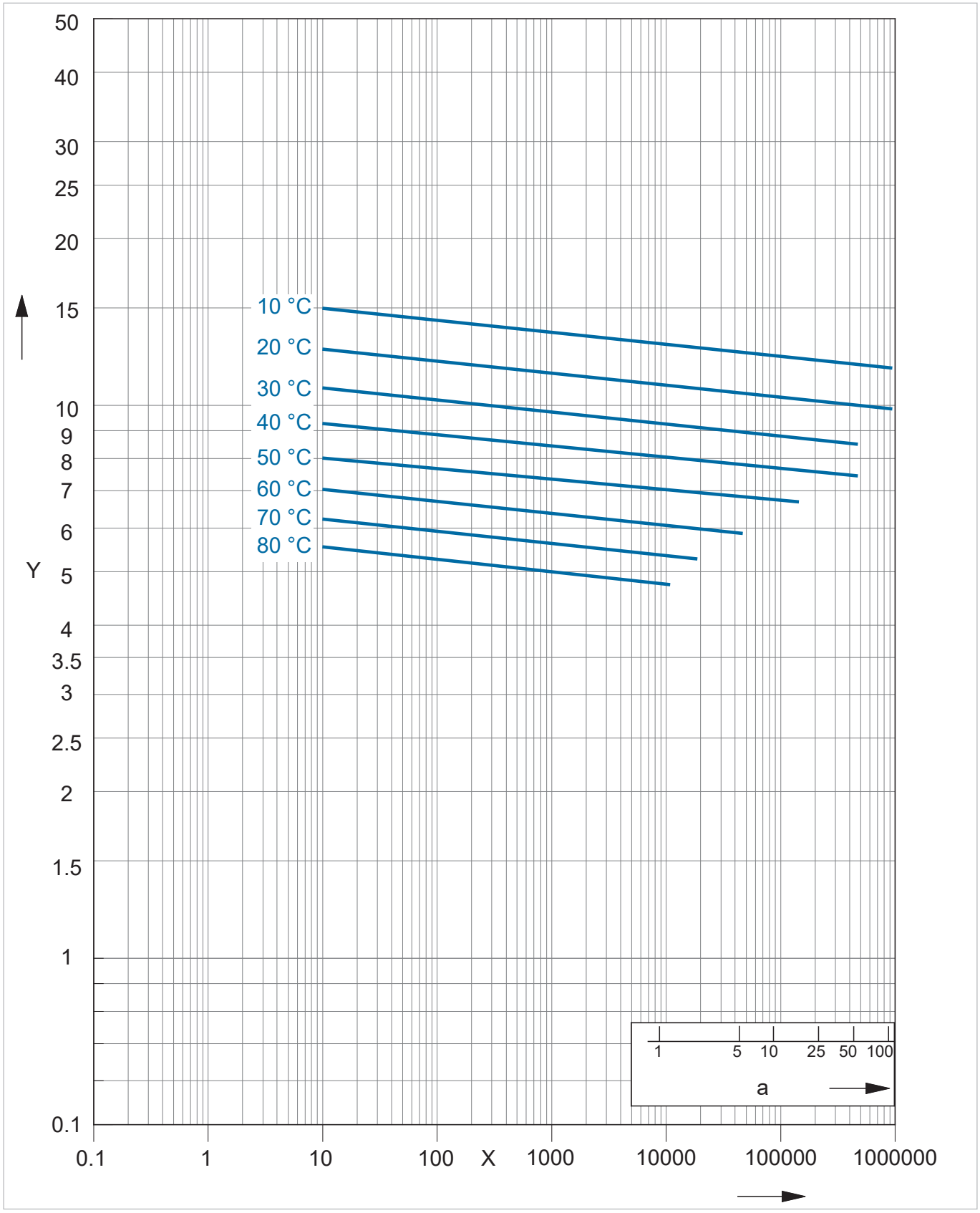
PE63

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

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

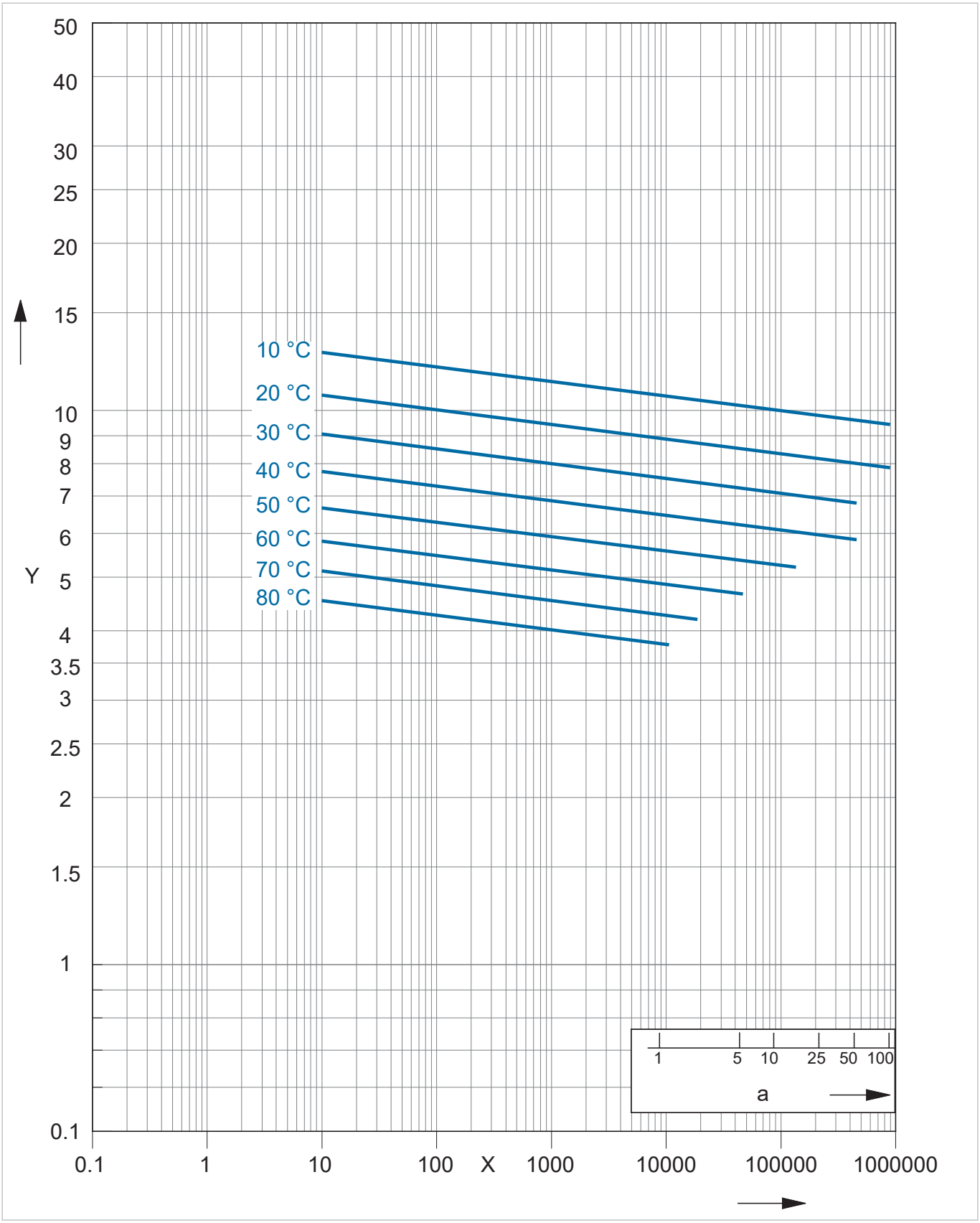
The pressure-temperature diagram that we provide for pipe and fittings made of PE80 and PE100 is derived from the long-term behavior, including the design factor, for a service life of 25 years.

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



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

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



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

1.3 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

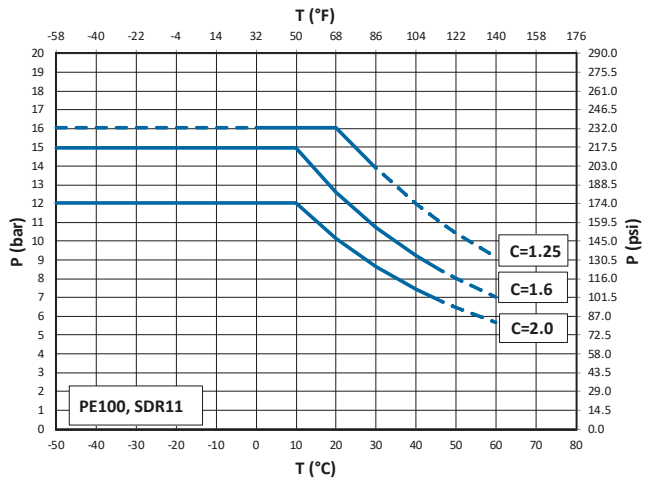
The long-term welding factor fs (or long-term joining factor) must be taken into account if relevant (e.g. stress check in longitudinal direction).

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

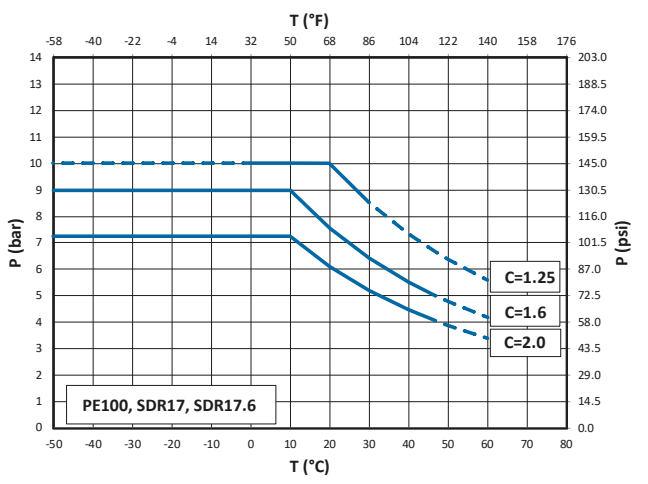
Please take into account the pressure-temperature diagrams for valves and special fittings. Because of the construction and/or sealing material used, differences are possible when compared to pipe and fittings. More information is available in the Planning Fundamentals of the relevant types of valves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

In case of operating in the temperature range shown in dotted lines, contact your authorized GF Industry & Infrastructure Flow Solutions 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.

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.

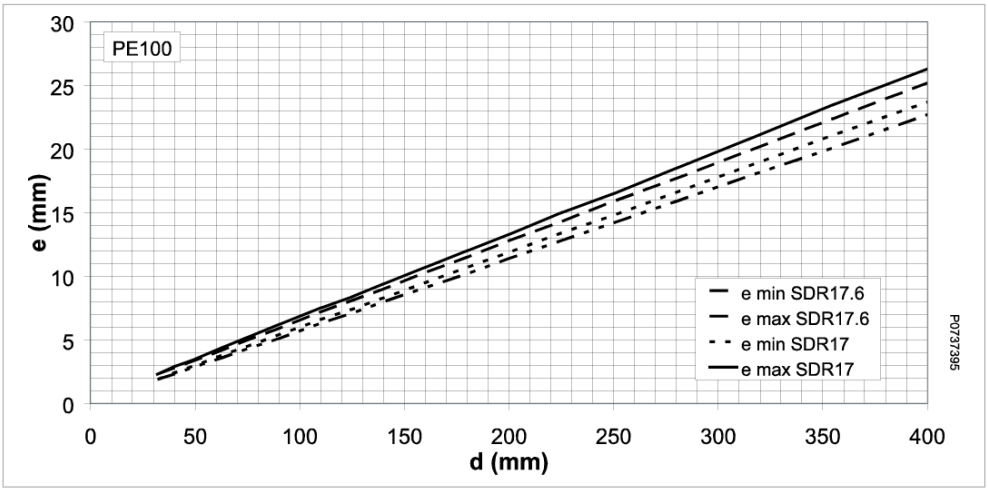
The actual nominal pressure in practice for SDR17 and SDR17.6 is:

- 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:

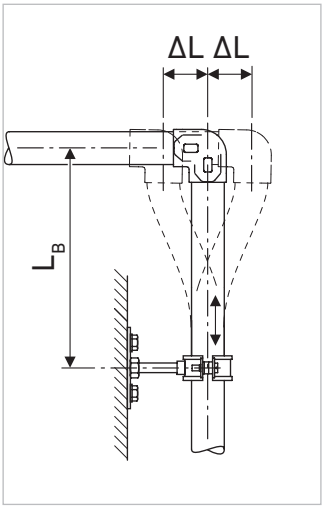


d Pipe outer diameter (mm)
e Wall thickness (mm)

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.

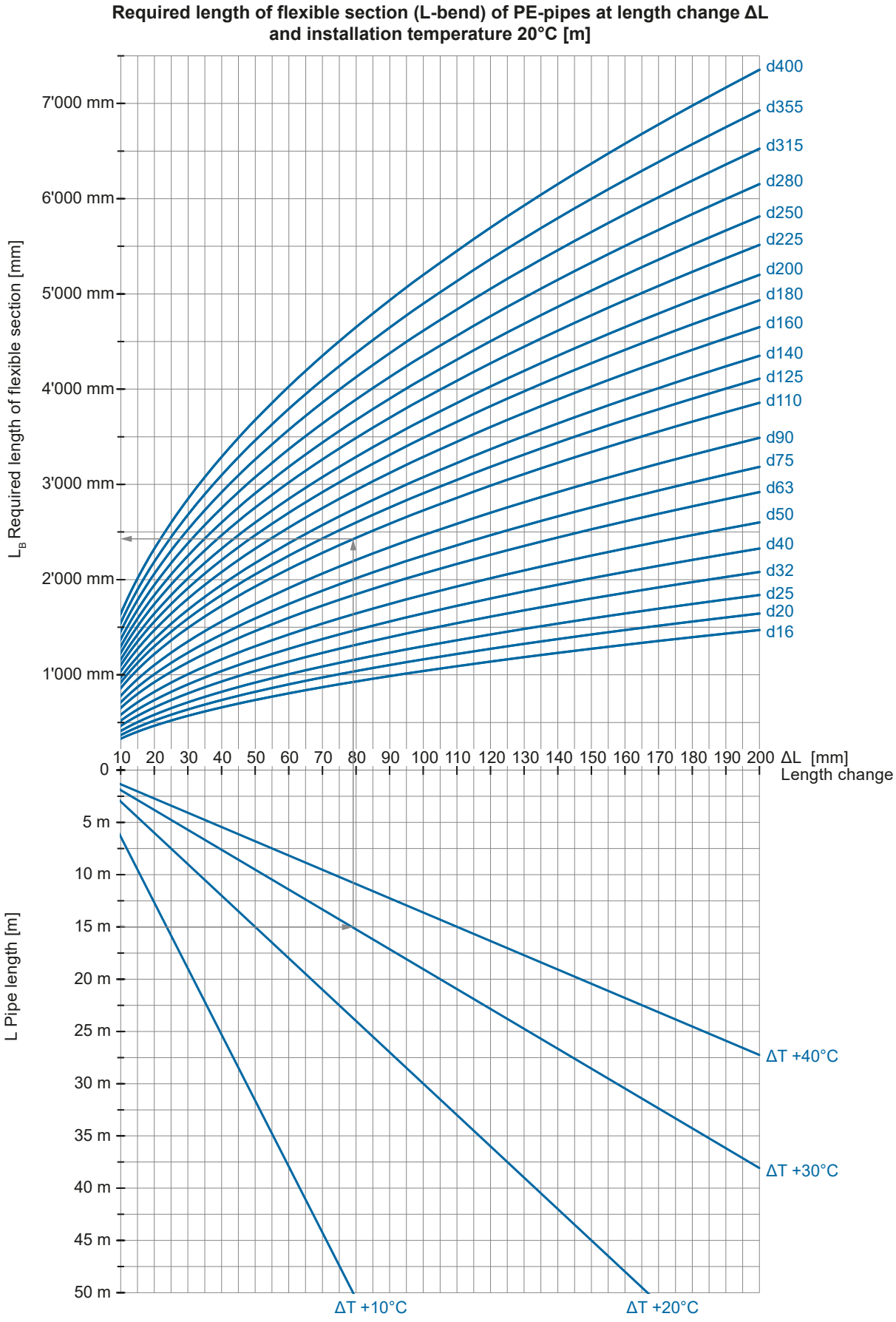
1.4 Flexible sections of PE (PE80, PE100) piping systems

Properties of PE			
Symbol	Designation	Value	Unit
K	Proportionality factor for flexible sections	26	-
ΔL	Length change	-	mm/inch
d	Outer pipe diameter	-	mm
L_B	Required length of flexible section (L-bend)	-	mm/inch

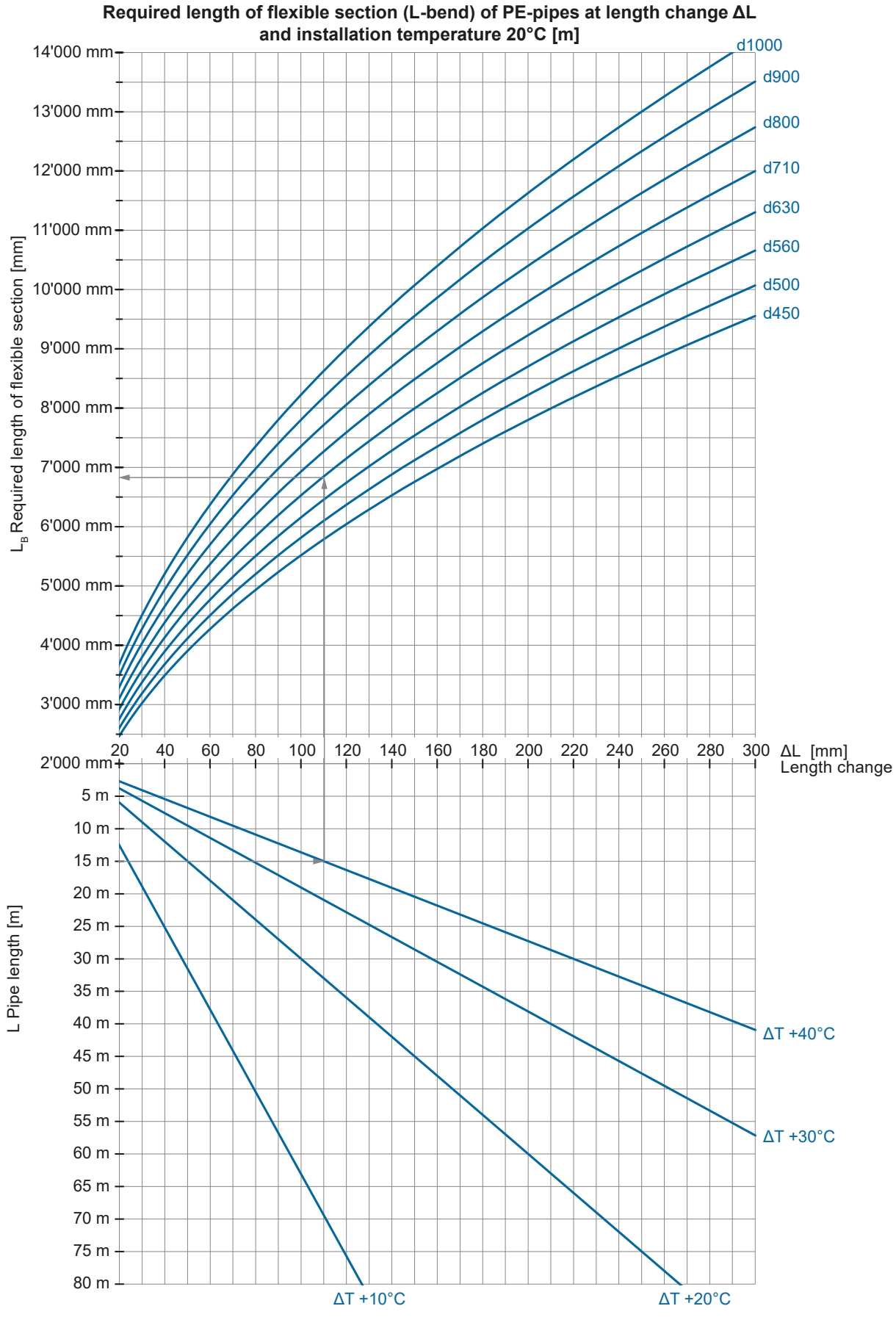


$L_B = K * (d * \Delta L)^{\wedge 0.5}$

Flexible sections diagram - Outer pipe diameter d16 - d400



Flexible sections diagram - Outer pipe diameter d450 - d1000



Required length of flexible section L_B at length change ΔL, [mm]

ΔL	Outer Pipe Diameter d (mm)																				
(mm)	16 (mm)	20 (mm)	25 (mm)	32 (mm)	40 (mm)	50 (mm)	63 (mm)	75 (mm)	90 (mm)	110 (mm)	125 (mm)	140 (mm)	160 (mm)	180 (mm)	200 (mm)	225 (mm)	250 (mm)	280 (mm)	315 (mm)	355 (mm)	400 (mm)
15	405	450	505	570	635	710	800	870	955	1'050	1'150	1'200	1'250	1'350	1'400	1'500	1'600	1'700	1'800	1'900	2'000
30	570	635	710	805	900	1'000	1'150	1'250	1'350	1'500	1'600	1'700	1'800	1'900	2'000	2'150	2'250	2'400	2'550	2'700	2'850
45	700	780	870	985	1'100	1'250	1'400	1'500	1'650	1'850	1'950	2'050	2'200	2'350	2'450	2'600	2'750	2'900	3'100	3'300	3'500
60	805	900	1'000	1'150	1'250	1'400	1'600	1'750	1'900	2'100	2'250	2'400	2'550	2'700	2'850	3'000	3'200	3'350	3'550	3'800	4'050
75	900	1'000	1'150	1'250	1'400	1'600	1'800	1'950	2'150	2'350	2'500	2'650	2'850	3'000	3'200	3'400	3'550	3'750	4'000	4'250	4'500
90	985	1'100	1'250	1'400	1'550	1'750	1'950	2'150	2'350	2'600	2'750	2'900	3'100	3'300	3'500	3'700	3'900	4'150	4'400	4'650	4'950
105	1'050	1'200	1'350	1'500	1'700	1'900	2'100	2'300	2'550	2'800	3'000	3'150	3'350	3'550	3'750	4'000	4'200	4'450	4'750	5'000	5'350
120	1'150	1'250	1'400	1'600	1'800	2'000	2'250	2'450	2'700	3'000	3'200	3'350	3'600	3'800	4'050	4'250	4'500	4'750	5'050	5'350	5'700
135	1'200	1'350	1'500	1'700	1'900	2'150	2'400	2'600	2'850	3'150	3'400	3'550	3'800	4'050	4'250	4'550	4'800	5'050	5'350	5'700	6'050
150	1'250	1'400	1'600	1'800	2'000	2'250	2'550	2'750	3'000	3'350	3'550	3'750	4'050	4'250	4'500	4'800	5'050	5'350	5'650	6'000	6'350
165	1'350	1'500	1'650	1'900	2'100	2'350	2'650	2'900	3'150	3'500	3'750	3'950	4'200	4'500	4'700	5'000	5'300	5'600	5'950	6'300	6'700
180	1'400	1'550	1'750	1'950	2'200	2'450	2'750	3'000	3'300	3'650	3'900	4'150	4'400	4'700	4'950	5'250	5'500	5'850	6'200	6'550	7'000
195	1'450	1'600	1'800	2'050	2'300	2'550	2'900	3'150	3'450	3'800	4'050	4'300	4'600	4'850	5'150	5'450	5'750	6'100	6'450	6'850	7'250
210	1'500	1'700	1'900	2'150	2'400	2'650	3'000	3'250	3'550	3'950	4'200	4'450	4'750	5'050	5'350	5'650	5'950	6'300	6'700	7'100	7'550
225	1'550	1'750	1'950	2'200	2'450	2'750	3'100	3'400	3'700	4'100	4'350	4'600	4'950	5'250	5'500	5'850	6'150	6'550	6'900	7'350	7'800
240	1'600	1'800	2'000	2'300	2'550	2'850	3'200	3'500	3'800	4'200	4'500	4'750	5'100	5'400	5'700	6'050	6'350	6'750	7'150	7'600	8'050
255	1'650	1'850	2'100	2'350	2'650	2'950	3'300	3'600	3'950	4'350	4'650	4'900	5'250	5'550	5'850	6'250	6'550	6'950	7'350	7'800	8'300
270	1'700	1'900	2'150	2'400	2'700	3'000	3'400	3'700	4'050	4'500	4'800	5'050	5'400	5'750	6'050	6'400	6'750	7'150	7'600	8'050	8'550
285	1'750	1'950	2'200	2'500	2'800	3'100	3'500	3'800	4'150	4'600	4'900	5'200	5'550	5'900	6'200	6'600	6'950	7'350	7'800	8'250	8'800
300	1'800	2'000	2'250	2'550	2'850	3'200	3'550	3'900	4'250	4'700	5'050	5'350	5'700	6'050	6'350	6'750	7'100	7'550	8'000	8'500	9'000

ΔL	Outer Pipe Diameter d (mm)							
(mm)	450 (mm)	500 (mm)	560 (mm)	630 (mm)	710 (mm)	800 (mm)	900 (mm)	1000 (mm)
15	2'150	2'250	2'400	2'550	2'700	2'850	3'000	3'200
30	3'000	3'200	3'350	3'550	3'800	4'050	4'250	4'500
45	3'700	3'900	4'150	4'400	4'650	4'950	5'250	5'500
60	4'250	4'500	4'750	5'050	5'350	5'700	6'050	6'350
75	4'800	5'050	5'350	5'650	6'000	6'350	6'750	7'100
90	5'250	5'500	5'850	6'200	6'550	7'000	7'400	7'800
105	5'650	5'950	6'300	6'700	7'100	7'550	8'000	8'400
120	6'050	6'350	6'750	7'150	7'600	8'050	8'550	9'000
135	6'400	6'750	7'150	7'600	8'050	8'550	9'050	9'550
150	6'750	7'100	7'550	8'000	8'500	9'000	9'550	10'050
165	7'100	7'450	7'900	8'400	8'900	9'450	10'000	10'550
180	7'400	7'800	8'250	8'750	9'300	9'850	10'450	11'050
195	7'700	8'100	8'600	9'100	9'650	10'250	10'900	11'500
210	8'000	8'400	8'900	9'450	10'050	10'650	11'300	11'900
225	8'250	8'700	9'250	9'800	10'400	11'050	11'700	12'350
240	8'550	9'000	9'550	10'100	10'750	11'400	12'100	12'750
255	8'800	9'300	9'850	10'400	11'050	11'750	12'450	13'150
270	9'050	9'550	10'100	10'700	11'400	12'100	12'800	13'500
285	9'300	9'800	10'400	11'000	11'700	12'400	13'150	13'900
300	9'550	10'050	10'650	11'300	12'000	12'750	13'500	14'250

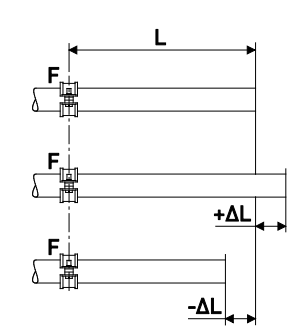
Required length of flexible section L_B at length change ΔL, [inch]

ΔL	Outer Pipe Diameter d (mm)																				
(inch)	16 (inch)	20 (inch)	25 (inch)	32 (inch)	40 (inch)	50 (inch)	63 (inch)	75 (inch)	90 (inch)	110 (inch)	125 (inch)	140 (inch)	160 (inch)	180 (inch)	200 (inch)	225 (inch)	250 (inch)	280 (inch)	315 (inch)	355 (inch)	400 (inch)
0.5	13.4	15.0	16.8	19.0	21.2	23.7	26.6	29.1	31.8	35.2	37.5	39.7	42.5	45.0	47.5	50.3	53.1	56.2	59.6	63.2	67.1
1.0	19.0	21.2	23.7	26.9	30.0	33.6	37.7	41.1	45.0	49.8	53.1	56.2	60.0	63.7	67.1	71.2	75.1	79.4	84.2	89.4	94.9
1.5	23.3	26.0	29.1	32.9	36.8	41.1	46.1	50.3	55.2	61.0	65.0	68.8	73.5	78.0	82.2	87.2	91.9	97.3	103	110	116
2.0	26.9	30.0	33.6	38.0	42.5	47.5	53.3	58.1	63.7	70.4	75.1	79.4	84.9	90.1	94.9	101	106	112	119	126	134
2.5	30.0	33.6	37.5	42.5	47.5	53.1	59.6	65.0	71.2	78.7	83.9	88.8	94.9	101	106	113	119	126	133	141	150
3.0	32.9	36.8	41.1	46.5	52.0	58.1	65.3	71.2	78.0	86.2	91.9	97.3	104	110	116	123	130	138	146	155	164
3.5	35.5	39.7	44.4	50.2	56.2	62.8	70.5	76.9	84.2	93.1	99.3	105	112	119	126	133	140	149	158	167	178
4.0	38.0	42.5	47.5	53.7	60.0	67.1	75.4	82.2	90.1	99.6	106	112	120	127	134	142	150	159	168	179	190
4.5	40.3	45.0	50.3	57.0	63.7	71.2	79.9	87.2	95.5	106	113	119	127	135	142	151	159	168	179	190	201
5.0	42.5	47.5	53.1	60.0	67.1	75.1	84.2	91.9	101	111	119	126	134	142	150	159	168	178	188	200	212
6.0	48.6	54.3	60.7	68.7	76.8	85.9	96.4	105	115	127	136	144	154	163	172	182	192	203	216	229	243
7.0	54.3	60.7	67.8	76.7	85.8	95.9	108	117	129	142	152	161	172	182	192	203	214	227	241	256	271
8.0	59.6	66.6	74.5	84.3	94.2	105	118	129	141	156	167	176	188	200	211	223	236	249	264	281	298
9.0	64.6	72.2	80.7	91.3	102	114	128	140	153	169	181	191	204	217	228	242	255	270	287	304	323
10.0	69.3	77.5	86.7	98.1	110	123	138	150	164	182	194	205	219	233	245	260	274	290	308	327	347
11.0	73.8	82.6	92.3	104	117	131	147	160	175	194	206	218	234	248	261	277	292	309	328	348	369
12.0	78.2	87.4	97.7	111	124	138	155	169	185	205	218	231	247	262	276	293	309	327	347	368	391
13.0	82.3	92.0	103	116	130	145	163	178	195	216	230	243	260	276	291	309	325	344	365	388	411
14.0	86.2	96.4	108	122	136	152	171	187	205	226	241	255	273	289	305	323	341	361	383	406	431
15.0	90.1	101	113	127	142	159	179	195	214	236	252	266	285	302	318	338	356	377	400	424	450

ΔL	Outer Pipe Diameter d (mm)							
(inch)	450 (inch)	500 (inch)	560 (inch)	630 (inch)	710 (inch)	800 (inch)	900 (inch)	1000 (inch)
0.5	71.2	75.1	79.4	84.2	89.4	94.9	101	106
1.0	101	106	112	119	126	134	142	150
1.5	123	130	138	146	155	164	174	184
2.0	142	150	159	168	179	190	201	212
2.5	159	168	178	188	200	212	225	237
3.0	174	184	195	206	219	233	247	260
3.5	188	199	210	223	237	251	266	281
4.0	201	212	225	238	253	269	285	300
4.5	214	225	238	253	268	285	302	318
5.0	225	237	251	266	283	300	318	336
6.0	258	272	287	305	324	344	364	384
7.0	288	303	321	340	361	384	407	429
8.0	316	333	352	374	397	421	447	471
9.0	343	361	382	405	430	457	484	511
10.0	368	388	410	435	462	490	520	548
11.0	392	413	437	463	492	522	554	584
12.0	414	437	462	490	521	553	586	618
13.0	436	460	487	516	548	582	617	650
14.0	457	482	510	541	575	610	647	682
15.0	478	503	533	565	600	637	675	712

1.5 Length changes of PE

Properties of PE			
Symbol	Designation	Value	Unit
T_{min}	Temperature min.	-50 / -58	°C / °F
T_{max}	Temperature max.	+60 / +140	°C / °F
ΔT	Temperature difference	-	°C / °F
α_{min}	Linear thermal expansion coefficient @20°C/68°F	0.15	mm/m K
α_{max}	Linear thermal expansion coefficient @max. temperature	0.20	mm/m K
ΔL	Length change	-	mm
L	Pipe length	-	m/inch
F	Fix point	-	-



$\Delta L = L \cdot \Delta T \cdot \alpha$

Thermal length change ΔL (mm) between 20°C and any end temperature

Pipe length L	End temperature (°C)											
	-50	-40	-30	-20	-10	0	10	20	30	40	50	60
(m)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)
1	-8.5	-7.5	-6.5	-5.3	-4.1	-2.8	-1.5	0.0	1.6	3.3	5.3	7.3
2	-17	-15	-13	-11	-8.3	-5.7	-2.9	0.0	3.2	6.7	11	15
3	-25	-23	-19	-16	-12	-8.5	-4.4	0.0	4.8	10	16	22
4	-34	-30	-26	-21	-17	-11	-5.8	0.0	6.3	13	21	29
5	-42	-38	-32	-27	-21	-14	-7.3	0.0	7.9	17	26	37
6	-51	-45	-39	-32	-25	-17	-8.8	0.0	9.5	20	32	44
7	-59	-53	-45	-37	-29	-20	-10	0.0	11	23	37	51
8	-68	-60	-52	-43	-33	-23	-12	0.0	13	27	42	59
9	-76	-68	-58	-48	-37	-26	-13	0.0	14	30	47	66
10	-85	-75	-65	-53	-41	-28	-15	0.0	16	33	53	73
12	-102	-90	-78	-64	-50	-34	-18	0.0	19	40	63	88
14	-118	-105	-90	-75	-58	-40	-20	0.0	22	47	74	103
16	-135	-120	-103	-85	-66	-45	-23	0.0	25	53	84	117
18	-152	-135	-116	-96	-74	-51	-26	0.0	29	60	95	132
20	-169	-150	-129	-107	-83	-57	-29	0.0	32	67	105	147
30	-254	-225	-194	-160	-124	-85	-44	0.0	48	100	158	220
40	-338	-300	-258	-213	-165	-113	-58	0.0	63	133	210	293
50	-423	-375	-323	-267	-206	-142	-73	0.0	79	167	263	367

Thermal length change ΔL (inch) between 68°F and any end temperature

Pipe length L	End temperature (°F)											
	-58	-40	-22	-4	14	32	50	68	86	104	122	140
(ft)	(inch)	(inch)	(inch)	(inch)	(inch)	(inch)	(inch)	(inch)	(inch)	(inch)	(inch)	(inch)
3	-0.30	-0.27	-0.23	-0.19	-0.15	-0.10	-0.05	0.00	0.06	0.12	0.19	0.26
6	-0.61	-0.54	-0.47	-0.38	-0.30	-0.20	-0.11	0.00	0.11	0.24	0.38	0.53
10	-1.02	-0.90	-0.78	-0.64	-0.50	-0.34	-0.18	0.00	0.19	0.40	0.63	0.88
15	-1.52	-1.35	-1.16	-0.96	-0.74	-0.51	-0.26	0.00	0.29	0.60	0.95	1.32
20	-2.03	-1.80	-1.55	-1.28	-0.99	-0.68	-0.35	0.00	0.38	0.80	1.26	1.76
25	-2.54	-2.25	-1.94	-1.60	-1.24	-0.85	-0.44	0.00	0.48	1.00	1.58	2.20
30	-3.05	-2.70	-2.33	-1.92	-1.49	-1.02	-0.53	0.00	0.57	1.20	1.89	2.64
35	-3.55	-3.15	-2.71	-2.24	-1.73	-1.19	-0.61	0.00	0.67	1.40	2.21	3.08
40	-4.06	-3.60	-3.10	-2.56	-1.98	-1.36	-0.70	0.00	0.76	1.60	2.52	3.52
45	-4.57	-4.05	-3.49	-2.88	-2.23	-1.53	-0.79	0.00	0.86	1.80	2.84	3.96
50	-5.08	-4.50	-3.88	-3.20	-2.48	-1.70	-0.88	0.00	0.95	2.00	3.15	4.40
60	-6.09	-5.40	-4.65	-3.84	-2.97	-2.04	-1.05	0.00	1.14	2.40	3.78	5.28
70	-7.11	-6.30	-5.43	-4.48	-3.47	-2.38	-1.23	0.00	1.33	2.80	4.41	6.16
80	-8.12	-7.20	-6.20	-5.12	-3.96	-2.72	-1.40	0.00	1.52	3.20	5.04	7.04
90	-9.14	-8.10	-6.98	-5.76	-4.46	-3.06	-1.58	0.00	1.71	3.60	5.67	7.92
100	-10.2	-9.00	-7.75	-6.40	-4.95	-3.40	-1.75	0.00	1.90	4.00	6.30	8.80
125	-12.7	-11.3	-9.69	-8.00	-6.19	-4.25	-2.19	0.00	2.38	5.00	7.88	11.0
150	-15.2	-13.5	-11.6	-9.60	-7.43	-5.10	-2.63	0.00	2.85	6.00	9.45	13.2

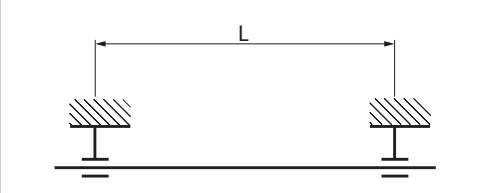
Thermal length change ΔL (mm/m) between any start temperature and any end temperature

Start temperature (°C)	End temperature (°C)											
	-50	-40	-30	-20	-10	0	10	20	30	40	50	60
	(mm/m)	(mm/m)	(mm/m)	(mm/m)	(mm/m)	(mm/m)	(mm/m)	(mm/m)	(mm/m)	(mm/m)	(mm/m)	(mm/m)
-50	0.00	0.96	2.00	3.13	4.33	5.63	7.00	8.46	10.04	11.79	13.71	15.79
-40	-0.96	0.00	1.04	2.17	3.38	4.67	6.04	7.50	9.08	10.83	12.75	14.83
-30	-2.00	-1.04	0.00	1.13	2.33	3.63	5.00	6.46	8.04	9.79	11.71	13.79
-20	-3.13	-2.17	-1.13	0.00	1.21	2.50	3.88	5.33	6.92	8.67	10.58	12.67
-10	-4.33	-3.38	-2.33	-1.21	0.00	1.29	2.67	4.13	5.71	7.46	9.38	11.46
0	-5.63	-4.67	-3.63	-2.50	-1.29	0.00	1.38	2.83	4.42	6.17	8.08	10.17
10	-7.00	-6.04	-5.00	-3.88	-2.67	-1.38	0.00	1.46	3.04	4.79	6.71	8.79
20	-8.46	-7.50	-6.46	-5.33	-4.13	-2.83	-1.46	0.00	1.58	3.33	5.25	7.33
30	-10.04	-9.08	-8.04	-6.92	-5.71	-4.42	-3.04	-1.58	0.00	1.75	3.67	5.75
40	-11.79	-10.83	-9.79	-8.67	-7.46	-6.17	-4.79	-3.33	-1.75	0.00	1.92	4.00
50	-13.71	-12.75	-11.71	-10.58	-9.38	-8.08	-6.71	-5.25	-3.67	-1.92	0.00	2.08
60	-15.79	-14.83	-13.79	-12.67	-11.46	-10.17	-8.79	-7.33	-5.75	-4.00	-2.08	0.00

Thermal length change ΔL (inch/ft) between any start temperature and any end temperature

Start temperature (°F)	End temperature (°F)											
	-58	-40	-22	-4	14	32	50	68	86	104	122	140
	(inch/ft)	(inch/ft)	(inch/ft)	(inch/ft)	(inch/ft)	(inch/ft)	(inch/ft)	(inch/ft)	(inch/ft)	(inch/ft)	(inch/ft)	(inch/ft)
-58	0.000	0.012	0.024	0.038	0.052	0.068	0.084	0.102	0.121	0.142	0.165	0.190
-40	-0.012	0.000	0.013	0.026	0.041	0.056	0.073	0.090	0.109	0.130	0.153	0.178
-22	-0.024	-0.013	0.000	0.014	0.028	0.044	0.060	0.078	0.097	0.118	0.141	0.166
-4	-0.038	-0.026	-0.014	0.000	0.015	0.030	0.047	0.064	0.083	0.104	0.127	0.152
14	-0.052	-0.041	-0.028	-0.015	0.000	0.016	0.032	0.050	0.069	0.090	0.113	0.138
32	-0.068	-0.056	-0.044	-0.030	-0.016	0.000	0.017	0.034	0.053	0.074	0.097	0.122
50	-0.084	-0.073	-0.060	-0.047	-0.032	-0.017	0.000	0.018	0.037	0.058	0.081	0.106
68	-0.102	-0.090	-0.078	-0.064	-0.050	-0.034	-0.018	0.000	0.019	0.040	0.063	0.088
86	-0.121	-0.109	-0.097	-0.083	-0.069	-0.053	-0.037	-0.019	0.000	0.021	0.044	0.069
104	-0.142	-0.130	-0.118	-0.104	-0.090	-0.074	-0.058	-0.040	-0.021	0.000	0.023	0.048
122	-0.165	-0.153	-0.141	-0.127	-0.113	-0.097	-0.081	-0.063	-0.044	-0.023	0.000	0.025
140	-0.190	-0.178	-0.166	-0.152	-0.138	-0.122	-0.106	-0.088	-0.069	-0.048	-0.025	0.000

1.6 Pipe support spacing for PE pipes



Liquids with a density of 1 g/cm³

d (mm)	Pipe support 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	1'050	1'000	900	850	750
63	1'200	1'150	1'050	1'000	900
75	1'350	1'300	1'200	1'100	1'000
90	1'500	1'450	1'350	1'250	1'150
110	1'650	1'600	1'500	1'450	1'300
125	1'750	1'700	1'600	1'550	1'400
140	1'900	1'850	1'750	1'650	1'500
160	2'050	1'950	1'850	1'750	1'600
180	2'150	2'050	1'950	1'850	1'750
200	2'300	2'200	2'100	2'000	1'900
225	2'450	2'350	2'250	2'150	2'050
250	2'600	2'500	2'400	2'300	2'100
280	2'750	2'650	2'550	2'400	2'200
315	2'900	2'800	2'700	2'550	2'350
355	3'100	3'000	2'900	2'750	2'550
400	3'300	3'150	3'050	2'900	2'700
450	3'550	3'400	3'300	3'100	2'900
500	3'900	3'650	3'500	3'350	3'100

For other SDR values, multiply the values by the following factors:

- SDR17 and SDR17.6: 0.91
- SDR7.4: 1.07

The pipe support 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 Pipe support 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 pipe support 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 for SDR11 1.21 for SDR7.4

1.7 Pressure test with water or a similar incompressible test medium for PE

Pressure drop

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

Material	Pressure drop (bar/h)
PE	1.2

*According to DVS 2210-1ff

Determining the test pressure

The permissible test pressure is calculated according to the following formula:

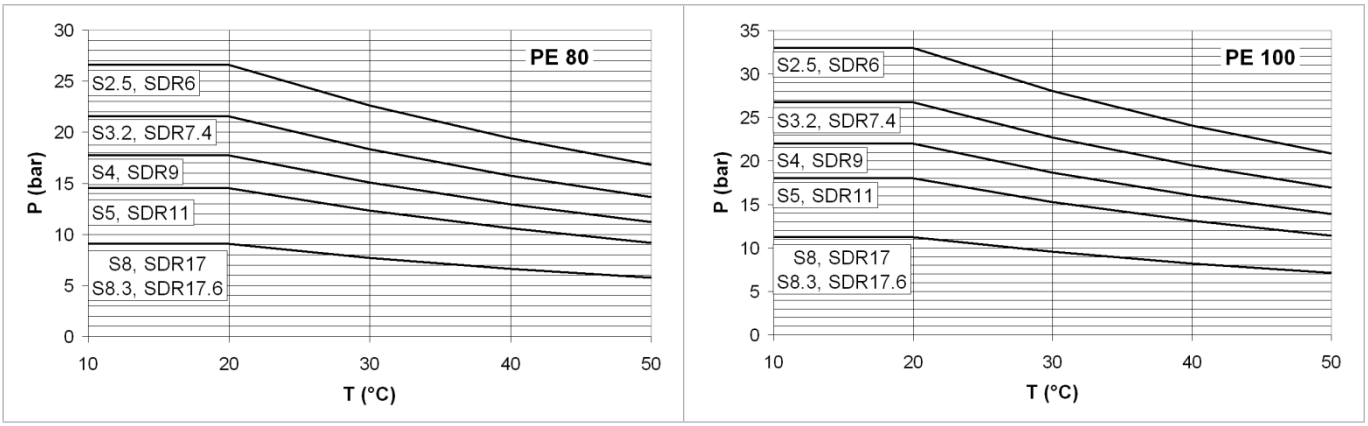
$$P_{p(zul)} = \frac{1}{SDR} \cdot \frac{20 \cdot \sigma_{v(T,\,100\,h)}}{S_p \cdot A_G}$$

$\sigma_{v(T,\,100\,h)}$ 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

In general, the weakest link in the system (in terms of PN rating) determines the maximum test pressure.
If valves are installed in the system, the maximum test pressure shall not exceed the nominal pressure (PN) of the valves.
At test temperatures above 20 °C, the maximum test pressure shall be limited according to the valve-specific pressure-temperature diagrams.

Material	S_p Minimum safety factor DVS 2210-1 Suppl.2
PE80, PE100	1.25

Test pressure diagram for PE



P Permissible test pressure (bar)
T Pipe wall temperature (°C)

1.8 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
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

Standard	Name
DVGW VP 302	Gas-Absperrarmaturen aus Polyethylen (PE 80 and PE 100) - Anforderungen and 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
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

1.9 ecoFIT System by GF

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 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
- Data Center
- Chemical process industry
- Energy
- Marine
- Cooling
- Microelectronics

Technical data

Nominal pressure	PN10 / PN16 (145 - 232 psi)
Temperature range	-50 °C to +60 °C (-58 °F to +140 °F)
Jointing technology	Socket fusion
	Butt fusion
	Infrared (IR) fusion
	Electrofusion[2]
Standards and guidelines[1]	ISO, EN, DVS
Approvals[1]	DIBt, FM, IIP, ABS, DNV, GL, RINA, NK
Fire performance	Class E according to EN 13501-1[3]
	UL94 HB[4]

1) For additional information about standards, guidelines and approvals, see www.gfps.com
2) See the ELGEF+ portfolio
3) Tested according to EN ISO 11925-2
4) ecoFIT PE100 has been tested according to UL94 and achieved UL94 HB

ecoFIT product overview

The following table uses metric units of measure.

Products	Material	SDR	PN (bar)	d (mm) / DN (mm)	20 / 15	25 / 20	32 / 25	40 / 32	50 / 40	63 / 50	75 / 65	90 / 80	110 / 100	125 / 100	140 / 125	160 / 150	180 / 150	200 / 200	225 / 200	250 / 250	280 / 250	315 / 300	355 / 350	400 / 400	450 / 450	450 / 500	500 / 500	560 / 500	630 / 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) / DN (mm)	20 / 15	25 / 20	32 / 25	40 / 32	50 / 40	63 / 50	75 / 65	90 / 80	110 / 100	125 / 100	140 / 125	160 / 150	180 / 150	200 / 200	225 / 200	250 / 250	280 / 250	315 / 300	355 / 350	400 / 400	450 / 450	450 / 500	500 / 500	560 / 500	630 / 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

1.10 Design-Flow®IPS HDPE System by GF

The Design-Flow® IPS HDPE piping system is based on PE4710, a high-performance polyethylene material that meets the highest requirements in industrial environments. It supports a wide range of applications, with excellent UV resistance, abrasion resistance, and impact strength. This system enables use across a broad temperature range. Valve bodies made of PVC-U or PP-H with PE end connections allow easy integration into the Design-Flow® IPS HDPE piping system. For maximum flexibility, the valves come with socket welding, butt welding spigots, or flanges.



Pipes



Fittings



Jointing technology

Essential system properties

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

Most important market segments

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

Technical data

Nominal pressure	Up to 16 bar (232 psi)
Temperature range	-50 °C to +60 °C (-58 °F to +140 °F)
Jointing technology	Socket fusion
	Butt fusion
	Infrared (IR) fusion
	Electrofusion
Standards and guidelines[1)]	AWWA C906, NSF/ANSI/CAN-61-G, ASTM D3261, ASTM D2513, FM 1613,
Approvals[1)]	FM CL335, ASTM F714, ASTM F1055
Fire performance	Class E according to EN 13501-1[2)]

1) For additional information about standards, guidelines and approvals, see www.gfps.com
2) Tested according to EN ISO 11925-2

HDPE product overview

The following table uses imperial units of measure.

IPS = Iron Pipe Size

DIPS = Ductile Iron Pipe Size

Products	Material	DR	PN (psi)	size (inch) ½"	¾"	1"	1 ¼"	1 ½"	2"	3"	4"	6"	8"	10"	12"	14"	16"	18"	20"	24"	26"	28"	30"	32"	34"	36"	48"	54"
IPS Butt Fusion Fittings	PE 4710	7	335						■	■	■	■	■	■	■	■	■	■	■	■								
		9	250						■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■				
		11	200						■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■			
		17	130						■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	
IPS Adapters	PE 4710	7	335						■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■		
		9	250						■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■		
		11	200						■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■		
		17	130						■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■		
IPS Butt Fusion Saddle Fittings (outlet size)	PE 4710	7	335						■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■		
		9	250						■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■		
		11	200						■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■		
		17	130						■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■		
IPS Electrofusion Fittings	PE 4710	7	335		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■								
IPS Electrofusion Saddles	PE 4710	11	200						■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■		
		17	130						■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■		
IPS Transition Fittings	PE 4710	7	335		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■								
		9	250		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■								
		11	200		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■								
		17	130		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■								
IPS Socket Fusion Fittings	PE 4710	7	335		■	■	■	■																				
DIPS Butt Fusion Fittings	PE 4710	7	335						■	■	■	■	■	■	■	■	■	■	■	■								
		9	250						■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■				
		11	200						■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■			
		17	130						■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■		
DIPS Adapters	PE 4710	7	335						■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■		
		9	250						■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■		
		11	200						■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■		
		17	130						■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■		
DIPS Electrofusion Fittings	PE 4710	7	335							■	■	■	■	■	■	■	■	■	■	■								
DIPS Electrofusion Saddles	PE 4710	11	200							■	■	■	■	■	■	■	■	■	■	■								
		17	130							■	■	■	■	■	■	■	■	■	■	■								

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

Design and Installation

of Plastic Piping Systems

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1 Pipeline Design

1.1 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.

1.1.1 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
PEEK	73
ECTFE	18

1.2 Range of applications for pipe and fittings

1.2.1 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 Industry & Infrastructure Flow Solutions.

1.3 Calculation of the allowable pressure/required wall thickness

1.3.1 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 Industry & Infrastructure Flow Solutions recommends the use of dimension and wall thickness, as well as SDR at all times.

1.3.2 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/mm²)
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/mm²

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

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 Industry & Infrastructure Flow Solutions representative for additional information.

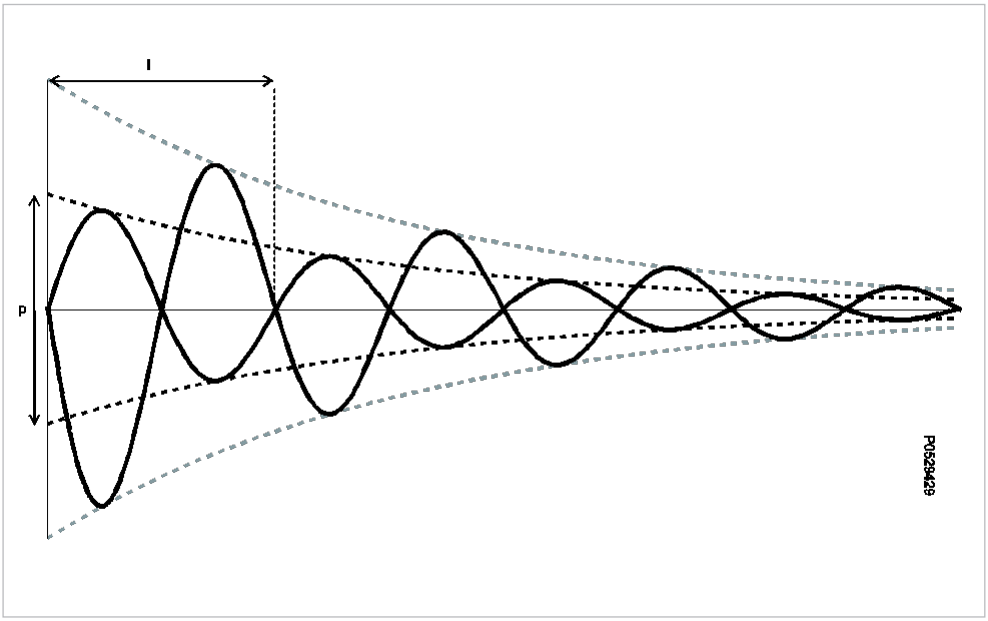
1.4 Water hammer

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.

1.4.1 Water hammer calculation

1 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 elasticit 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 hamymers.

2 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.

3 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)

4 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

3 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.

4 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.

$\sigma = 17.5\ N/mm^2$

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

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

5 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

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

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.

1.5 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, PEEK 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.

1.6 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 Industry & Infrastructure Flow Solutions 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 Industry & Infrastructure Flow Solutions 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

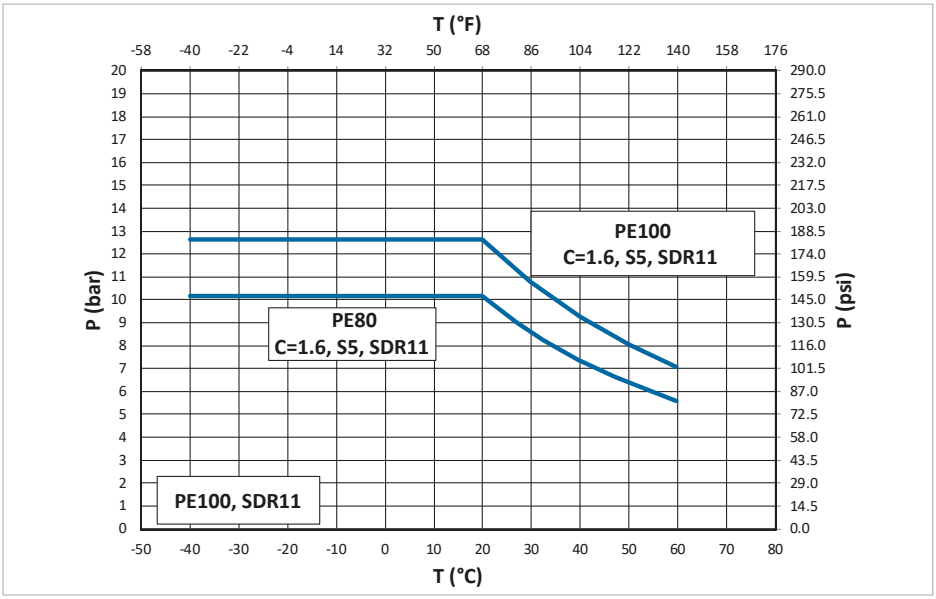
Synthetic oils (with O as an additional element of molecular structure)	Recommended
Polyalkylene glycols	✓
Poly-α-olefins	✓
Polyesters	x
Di-esters	x

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 Industry & Infrastructure Flow Solutions 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 Industry & Infrastructure Flow Solutions representative.

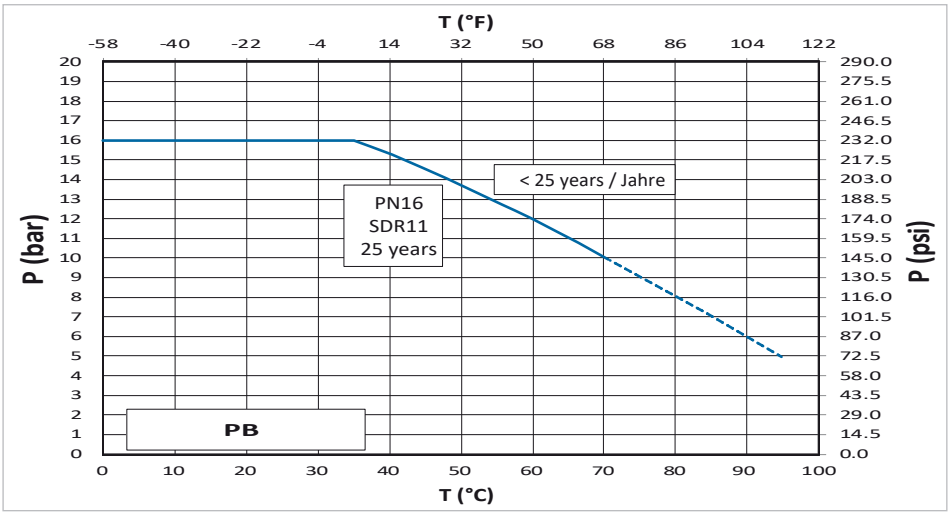


P Permissible pressure (bar, psi)
T Ambient temperature (°C, °F)

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 Industry & Infrastructure Flow Solutions 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 Industry & Infrastructure Flow Solutions representative. Don't use PB lines for compressed air below 0°C!



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

1.7 Pipes 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/mm²) (1 N/mm² = 10 bar)
Ec Long-term creep modulus (N/mm²)
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)

1.7.1 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

1.7.2 Fittings

Since GF Industry & Infrastructure Flow Solutions fittings have a typically 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.

1.7.3 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

1.7.4 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 565, 578, 567	50 - 200	1
	250, 300	0.65

1.8 Piping systems for surface finishing and varnishing technology

1.8.1 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 Industry & Infrastructure Flow Solutions – An experienced partner

GF Industry & Infrastructure Flow Solutions has worked closely from the beginning with manufacturers, plant constructors and operators in this special sector of surface finishing and varnishing technology. GF Industry & Infrastructure Flow Solutions 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

1.8.2 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.

1.8.3 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.

1.9 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.

1.10 Hydraulic calculation

1.10.1 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.

(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}
3'600	60'000	1'000	1.0

Conversion table with units for flow rate

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:

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

1.10.2 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

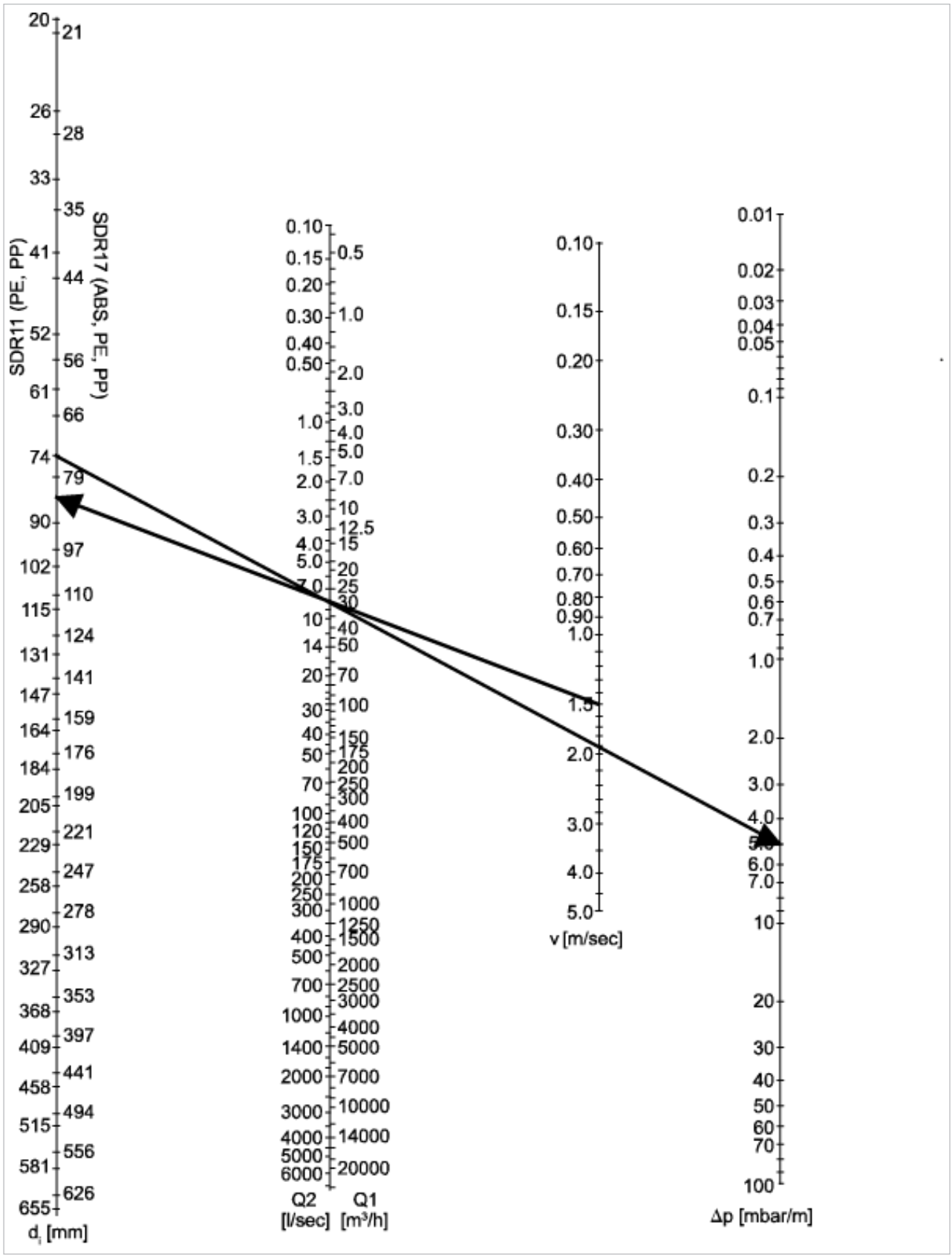
1.10.3 Nomogram for easy determination of diameter and pressure loss

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.

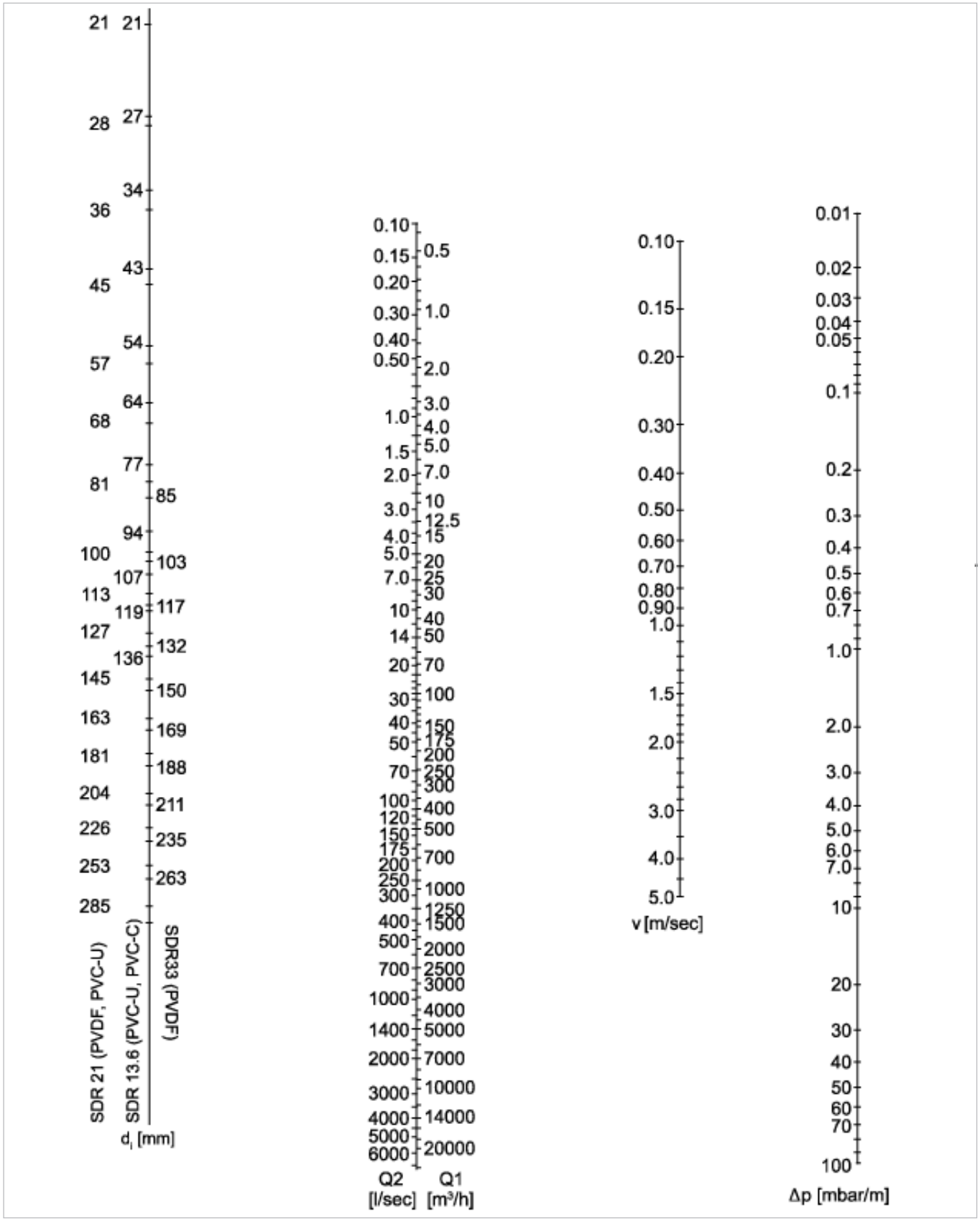
⚠ The determined pressure loss from the nomogram applies only to a density of the flow medium of 1,000 kg/m^3, e.g. for water. Further pressure losses of fittings, valves, etc. have to be considered as shown in the following.

1.10.4 Using the nomogram

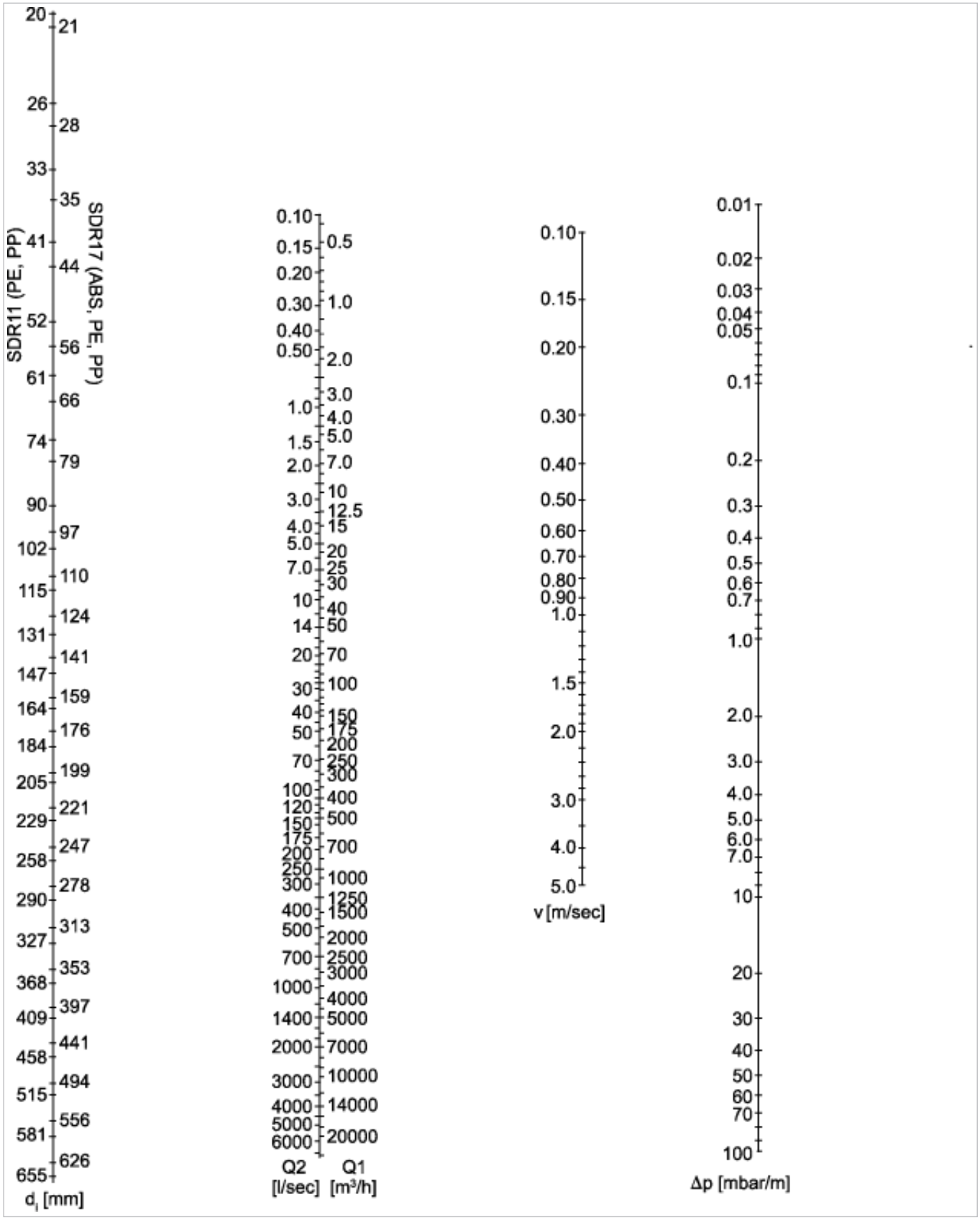
Based on a flow velocity of 1.5 m/s, a line is drawn through the desired flow rate (e.g. 30 m^3/h) to the axis with an inner diameter of di (≈ 84 mm). Then select a diameter nearby (74 mm for SDR11) and draw a 2nd line through the desired flow rate up to the pressure loss axis Δp
(5 mbar per meter pipe).



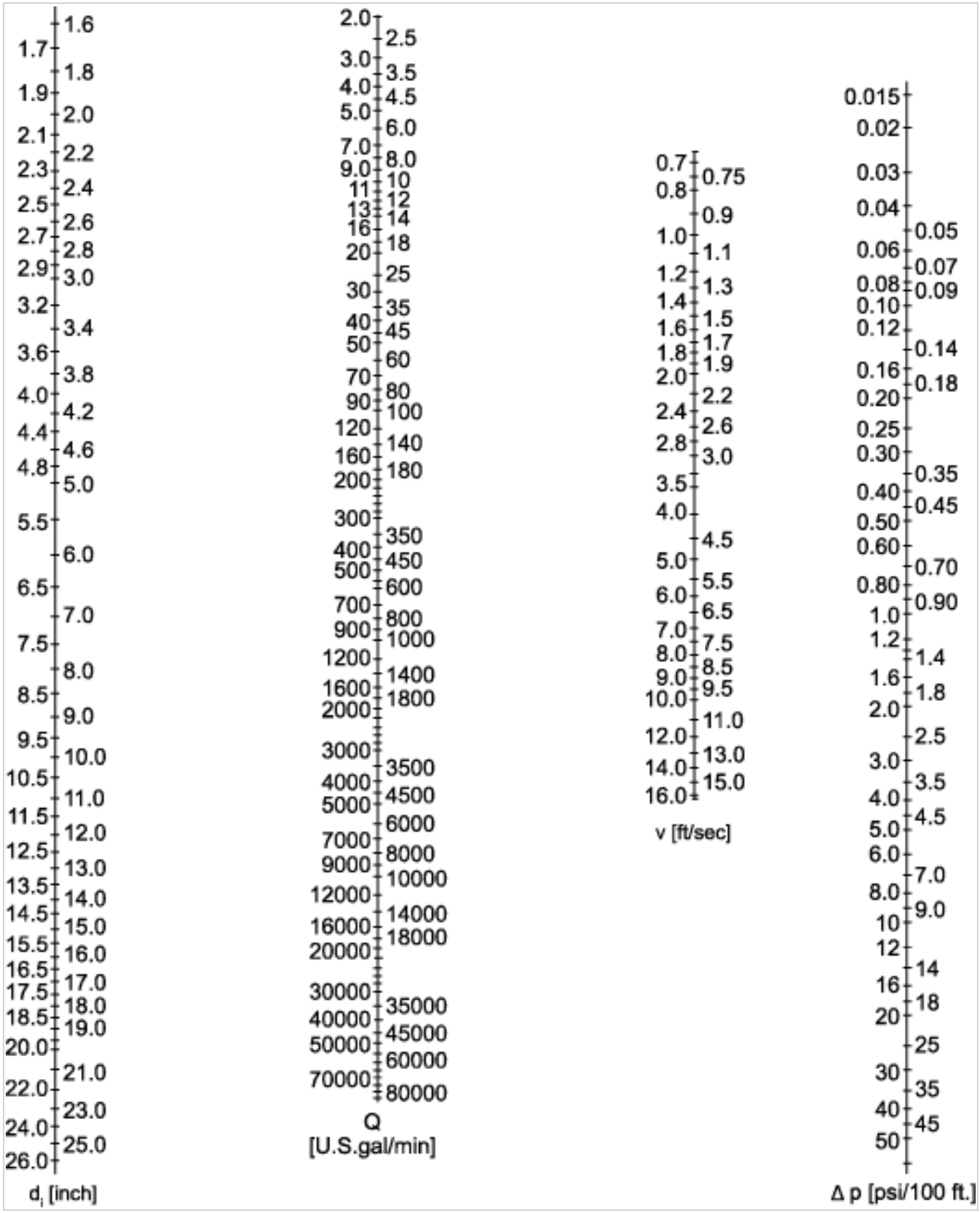
Nomogram for pipe SDR13.6, SDR21, SDR33 using the metric system



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



Nomogram for inch pipe



1.11 Pressure loss

1.11.1 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 λ = 0.02 to represent the hydraulic pressure loss.

1.11.2 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 theζ-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)

1.11.3 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 Industry & Infrastructure Flow Solutions 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)

1.11.4 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)

1.11.5 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	15 m	2 x flange connections
sections		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:

$$e = \frac{d}{SDR} = \frac{40\ mm}{21} = 1.9\ mm$$

The inner diameter of the pipeline is as follows:

$$d_i = d - 2 \cdot e = d - \frac{2 \cdot d}{SDR} = 36.2\ mm$$

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	$\Sigma\Delta p = 0.17\ bar + 0.47\ bar + 0.107\ bar + 0.38\ bar = 1.127\ bar$

1.12 CAD library

Product library of GF Industry & Infrastructure Flow Solutions

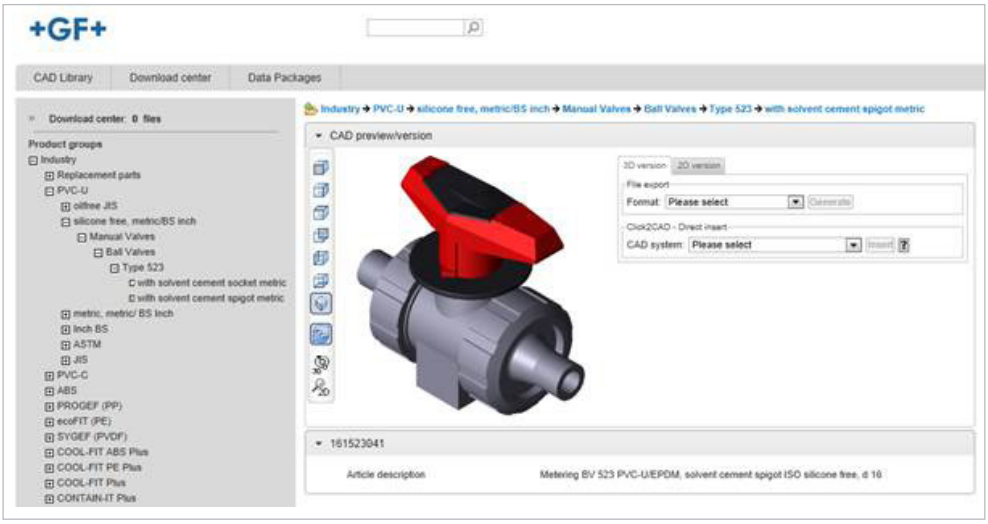
With this CAD library, GF Industry & Infrastructure Flow Solutions aims to provide designers and engineers with even better and more efficient support for the design of piping systems.

Three-dimensional models (3-D models) of all piping components by GF Industry & Infrastructure Flow Solutions 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

2 Installation of Plastic Piping Systems

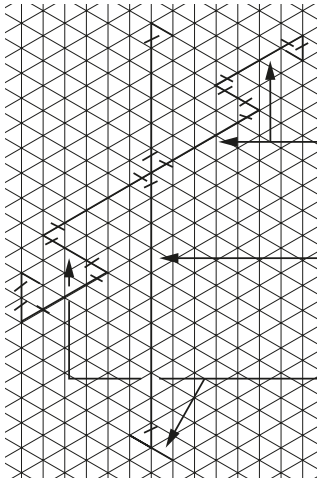
2.1 z-dimension method

2.1.1 Overview

The pressure of competition and high costs on site makes it essential to install pipeline systems efficiently. The GF Industry & Infrastructure Flow Solutions 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 Industry & Infrastructure Flow Solutions.

Please adhere to the following guidelines for drawing:

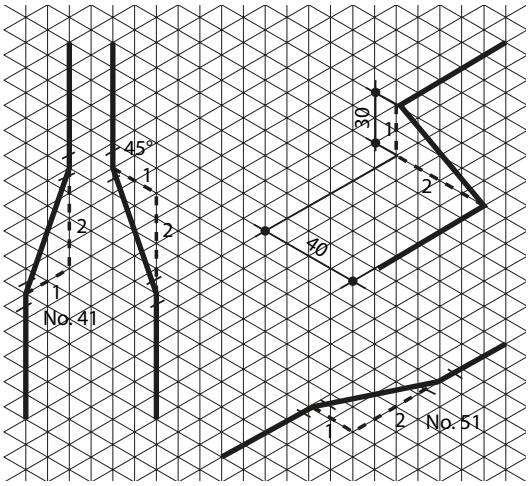
Pipe running perpendicular to one another	Pipe running diagonally



Horizontal:
from left to right

Vertical

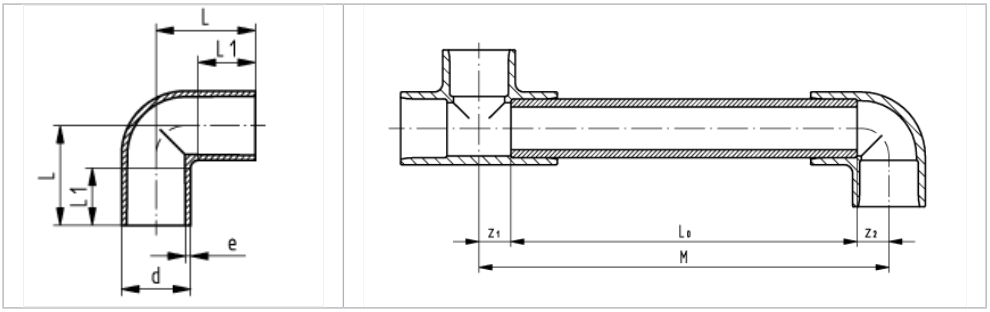
Horizontal:
to front and rear



The z-dimensions of the fittings are needed for determining the actual cutting lengths of the pipe. The tables in our product ranges and in the online 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.

2.1.2 Procedure

Socket fusion and socket adhesive fittings



Formula for determining the required pipe length

$L_0 = M - z1 - z2$

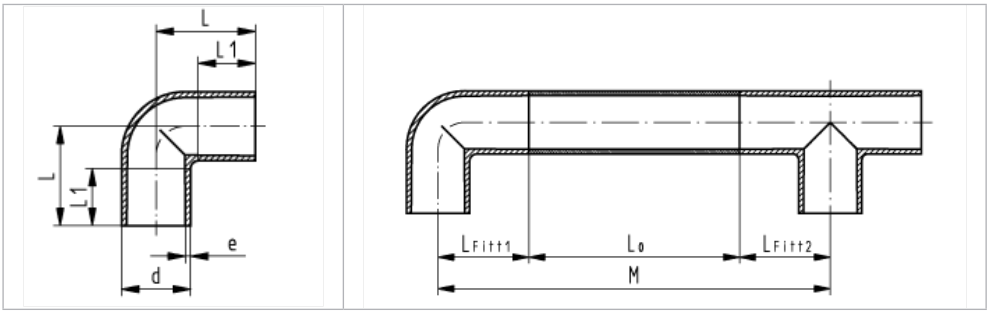
L_o	Length of pipe to be cut
M	Center-to-center distance of fitting
z	z-dimension of the fitting

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

2.1.3 Material losses for IR fusion procedure

Fusion machine IR-63 M and IR-63 Plus

d (mm)	PP-natural SDR11 (mm)	PE100 SDR11 (mm)	PE100[1] SDR17.6 (mm)	PP-H SDR11 (mm)	PP-H[1] SDR17.6 (mm)	PVDF (mm)	ECTFE (mm)	PVC-U[1] SDR9/13.6 (mm)	PFA (mm)
20	5.0	5.5		5.0		4.5	4.5	5.5	4.5
25	5.0	5.5		5.0		4.5	4.5	5.5	4.5
32	5.0	5.5		5.0		4.5	4.5	5.5	4.5
40	5.0	6.0		5.0		4.5	4.5	5.5	4.5
50	5.0	6.0	6.0	5.0	5.5	4.5	4.5	5.5	4.5
63	5.5	6.0	6.0	5.0	5.5	4.5	4.5	5.5	4.5

[1] only weldable on IR-63 M

Fusion machine IR-110 A and IR-110 Plus

d (mm)	PP-natural SDR11/17.6 (mm)	PE100 SDR11 (mm)	PE100 SDR17.6 (mm)	PP-H SDR11 (mm)	PP-H SDR17.6 (mm)	PVDF (mm)	ECTFE (mm)	PVC-U[1] SDR9/13.6 (mm)	PFA[2] (mm)
20	5.0	5.5		5.0		4.5	5.0	5.5	4.5
25	5.0	5.5		5.0		4.5	5.0	5.5	4.5
32	5.0	5.5		5.0		4.5	5.0	5.5	4.5
40	5.0	5.5		5.0		4.5	5.0	5.5	4.5
50	5.0	5.5	5.5	5.0	5.0	5.0	5.0	5.5	4.5
63	5.0	5.5	5.5	5.0	5.0	5.0	5.0	5.5	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		

[1] only weldable on IR-110 A
[2] only weldable on IR-110 Plus

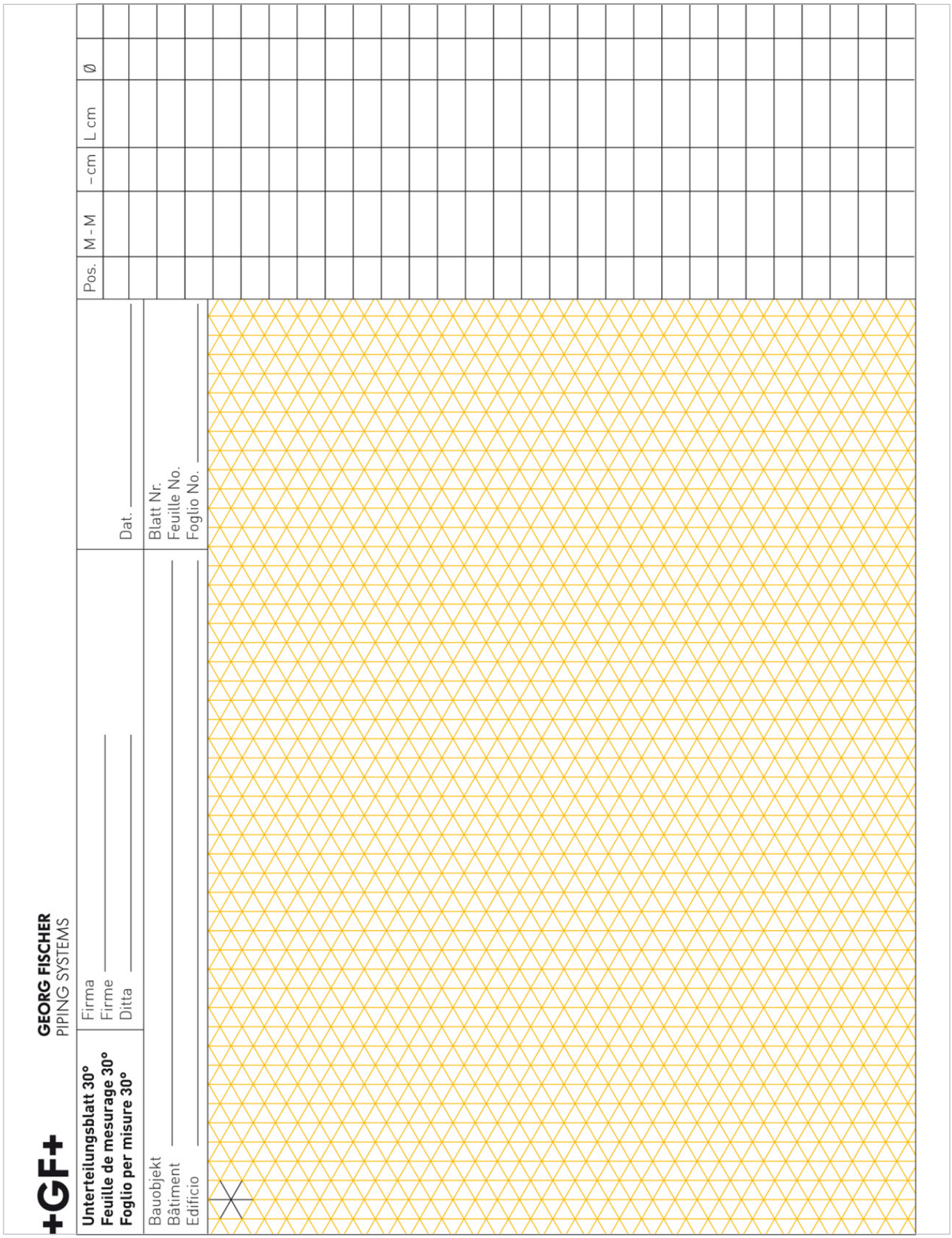
Fusion machine IR-225 M, IR-315 A, IR-400 A, IR-225 Plus and IR-315 Plus

d (mm)	PP-natural SDR11/17.6 (mm)	PE100 SDR11 (mm)	PE100 SDR17.6 (mm)	PP-H SDR11 (mm)	PP-H SDR17.6 (mm)	PVDF (mm)	ECTFE[1] SDR21 (mm)	PVC-U[2] SDR9/13.6 (mm)
63	5.0	6.5	6.5	6.0	6.0	4.5	5.0	5.0
75	5.0	6.5	6.5	6.0	6.0	4.5	5.0	
90	5.0	6.5	6.5	6.0	6.0	5.0	5.5	
110	5.5	6.5	6.5	6.0	6.0	5.0	5.5	
125		6.5	6.5	6.0	6.0	5.0		
140		6.5	6.5	6.0	6.0	5.0		
160		7.0	6.5	6.0	6.0	5.0		
180		7.0	6.5	6.0	6.0			
200		7.0	6.5	6.0	6.5	5.0		
225		7.0	6.5	6.0	6.5	5.0		
250		7.0	6.5	6.0	6.5	5.5		
280		7.0	6.5	6.0	6.5	5.5		
315		7.0	6.5	6.0	6.5	5.5		
350						5.5		
400						5.5		

[1] only weldable on IR-225 M & IR-225 Plus
[2] only weldable on IR-225 M

⚠ Material loss is caused by facing 2 mm on both pipe ends, plus the overlap.

Isometric paper



G2.1 Template for isometric paper

2.2 Length changes and flexible sections

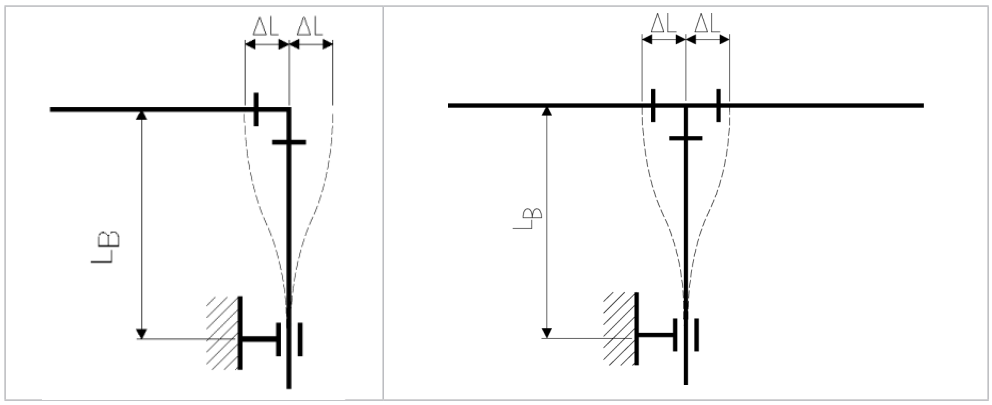
2.2.1 Overview

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

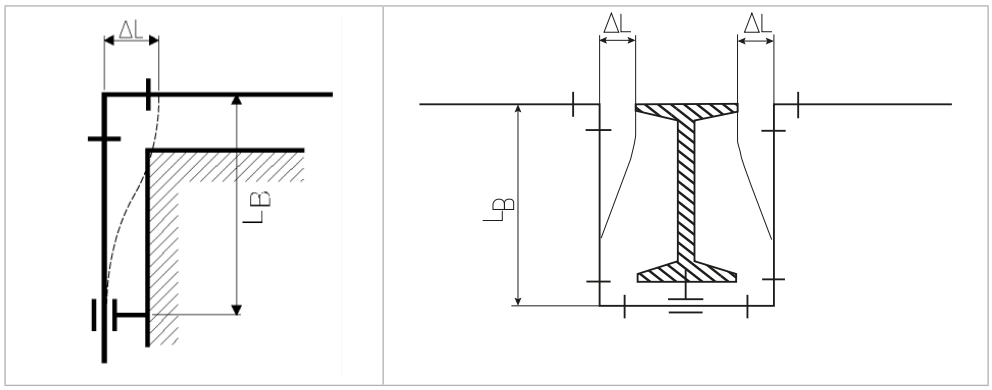
Flexible sections are the most common, the simplest and the most economical solution. The calculations for and the positioning of flexible sections are therefore described in detail.



ΔL Length change
L_B Flexible section

2.2.2 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.

2.2.3 Calculation of length changes

The change in length caused by temperature can be calculated using the following formula:

$\Delta L = L \cdot \Delta T \cdot \alpha$

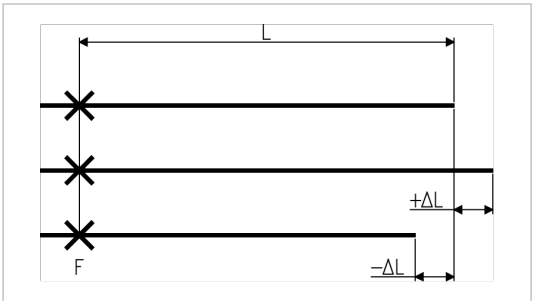
ΔL Temperature-related length change (mm)
L Length of the pipe section (m)
ΔT Difference of temperature (K)
α Coefficient of linear expansion (mm/m K)

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
PEEK	0.04 – 0.048 (0°C – 140°C)
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

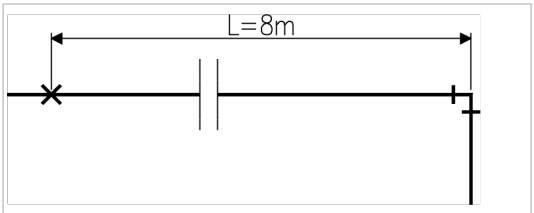
$-\Delta L_2 = L \cdot \Delta T_2 \cdot \alpha = 8 \cdot 40 \cdot 0.10 = 32$ mm

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

The values needed to determine the necessary length are:

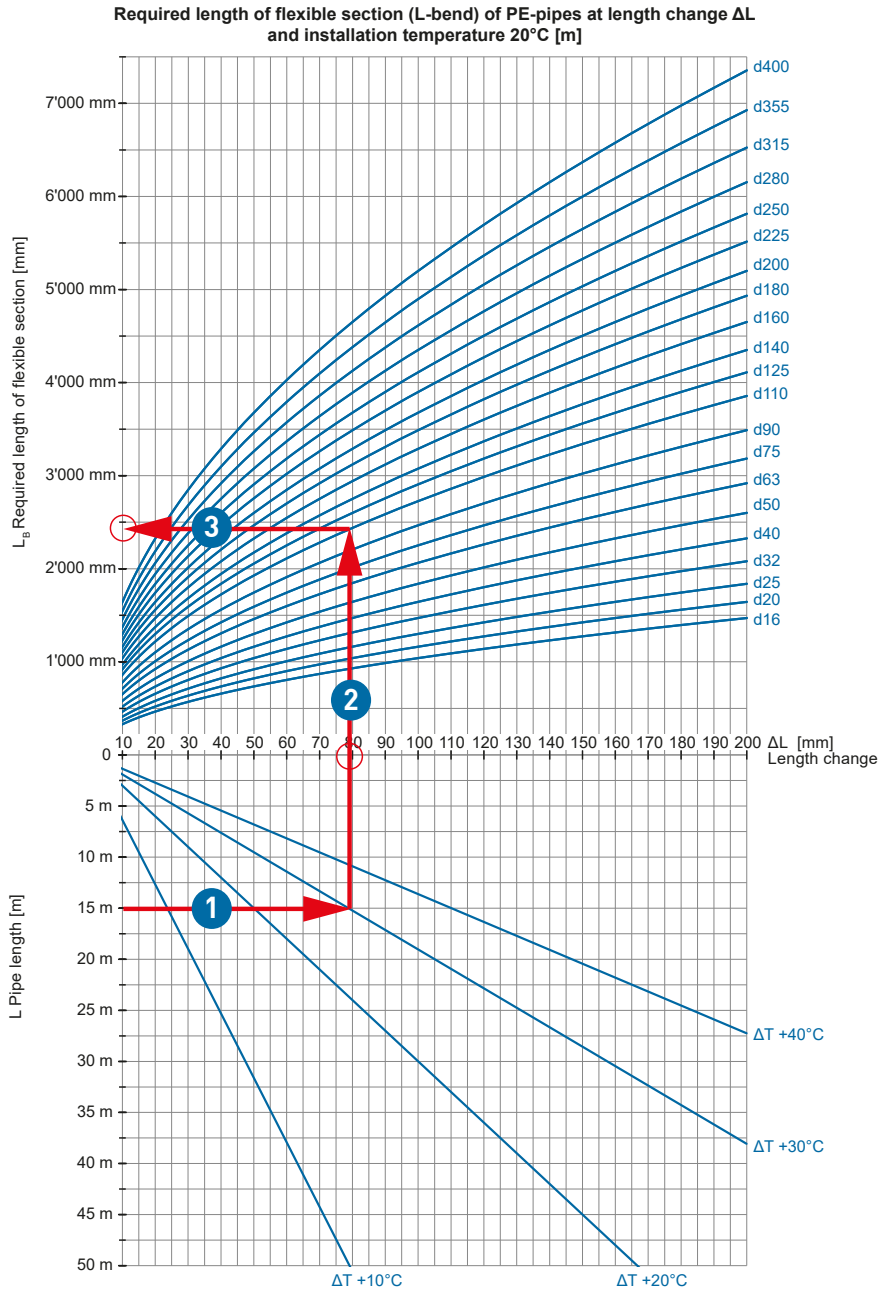
- The maximum change in temperature from the 0-position (i.e. from the position in which the pipe was installed). But remember that the pipe could contract just as well as expand.
- Inner pipe diameter d
- Length of pipe section L

With these values, the required length of the flexible section can be read from the diagram.

The following information can be gained from the calculation example above:

Length of pipe section L = 15 m

1 Maximum change in temperature ΔT = 30°C
2 Installing a pipe with d = 90 mm
3 Required length of flexible section L_B = 2400 mm (see diagram)

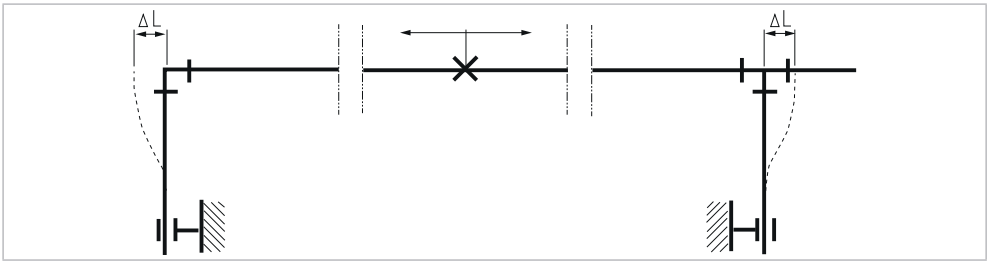


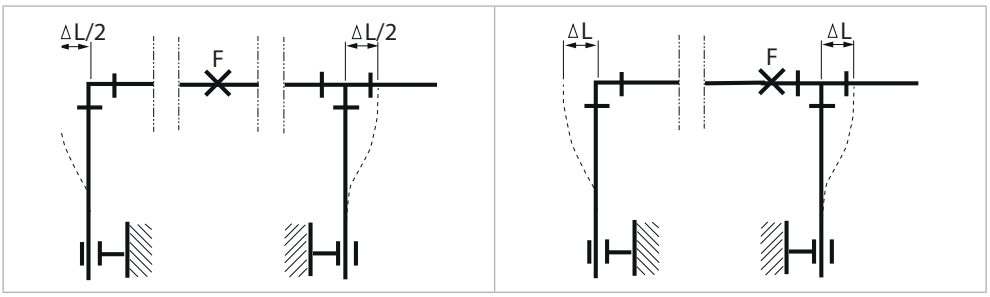
L Length of pipe section (mm)
L_B Required length of flexible section (mm)

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.

2.2.4 Recommendations for installation

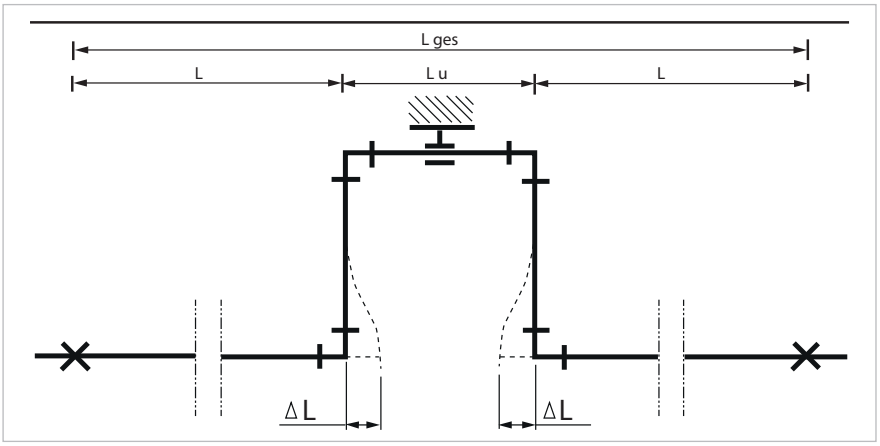
Length changes in pipe sections should always be accommodated through the arrangement of fixed brackets. The following examples show how the changes can be distributed in pipe sections by suitable positioning of fixed brackets:





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

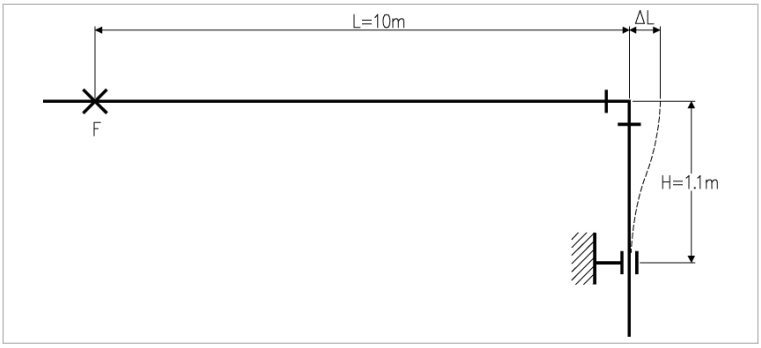
Length change:

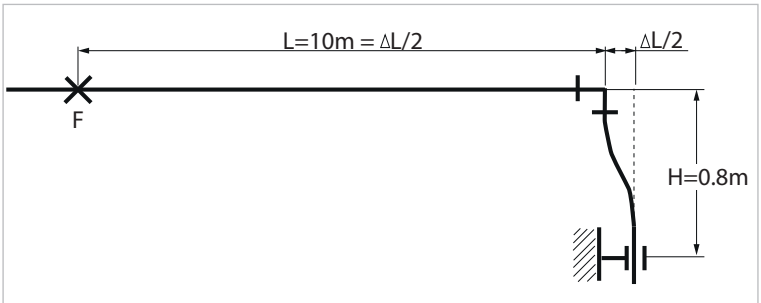
$+\Delta L = L \cdot \Delta T \cdot \alpha ABS = 10\ m \cdot 25\ K \cdot 0.10\ mm/mK = 25\ mm$

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.



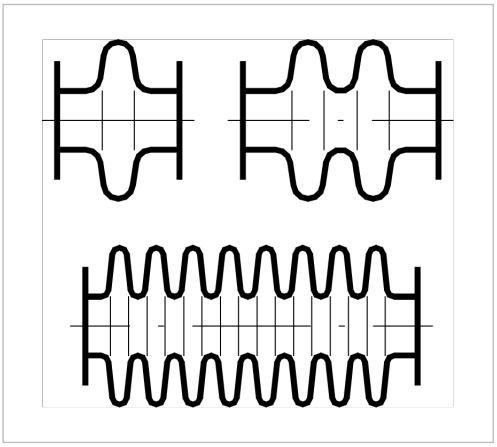


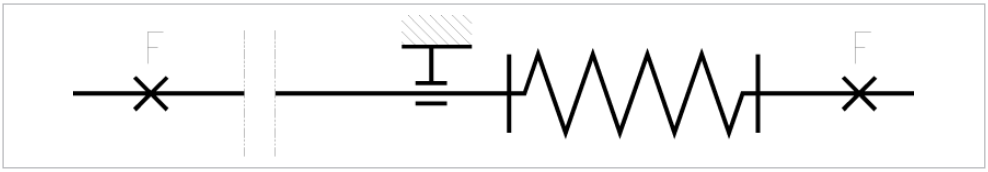
2.2.5 Installation of compensators

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.



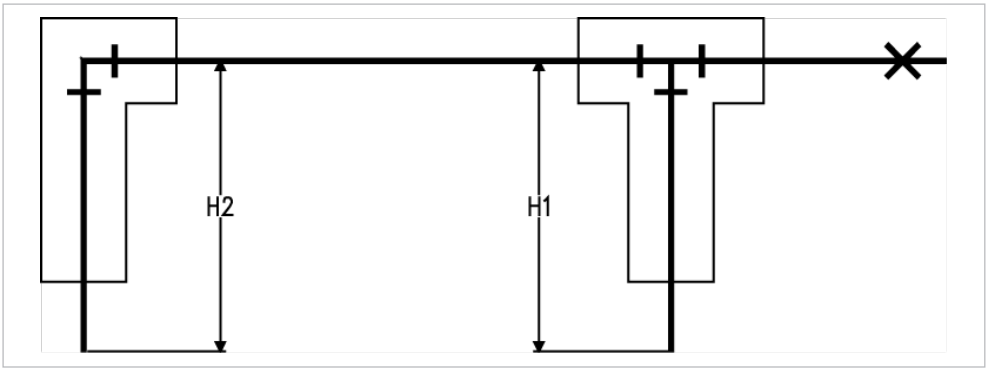


2.2.6 Installation of valves

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 Industry & Infrastructure Flow Solutions 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.

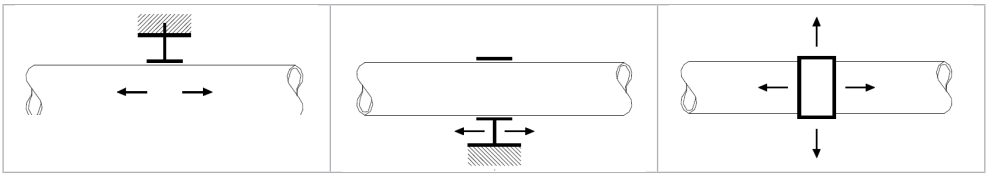
2.3 Pipe support spacing and installation of pipes

2.3.1 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.

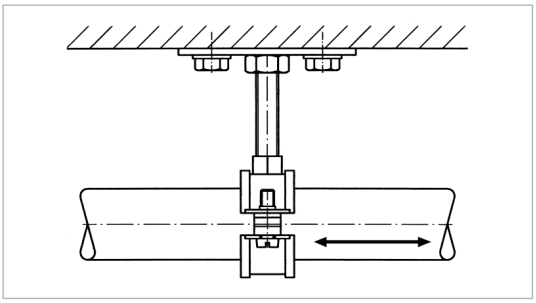


Movement of the pipe in the pipe bracket.

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

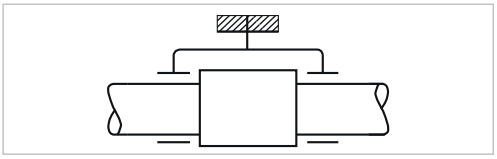
The pipe must not be fixed by clamping it in the pipe bracket. This can cause deformation and physical damage to the pipe, damage that sometimes does not appear until very much later.

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

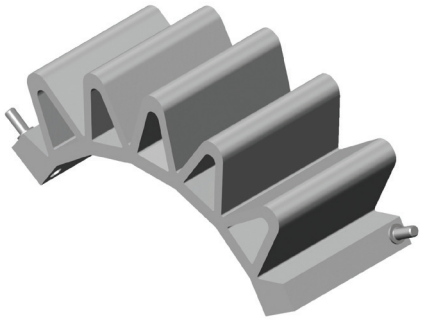
Pipe brackets must be robust and mounted firmly to be able to take up the forces arising from changes in length in the pipeline. Hanging brackets or KLIP-IT pipe brackets are unsuitable for use as fixed points.

2.3.2 Flex Restraint Electrofusion Fittings

Flex Restraint Overview

Flex Restraints are welded onto HDPE pipes using electrofusion and restrict their movement in one or both directions.

Flex Restraints are manufactured from a pre-mixed virgin plastic with a PPI listing of PE4710 and comply with ASTM D3350 standards.

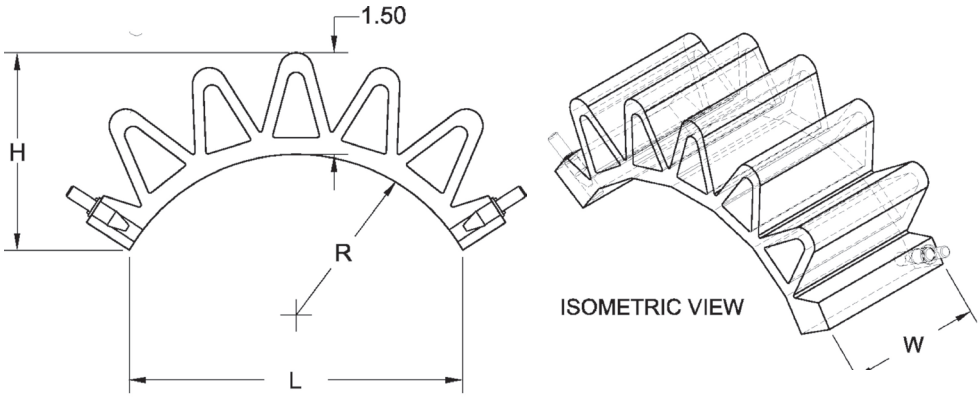


Features:

- Restrict the movement of HDPE polyethylene pipes
- Manufactured to work on all polyethylene pipes d160/6" and larger
- PE4710 resin complies with ASTM D3350
- Axial resistance rated at 40 kN/9,000 lb-ft per Flex Restraint
- Permanently attached to pipe by electrofusion
- Quick and easy installation
- No cumbersome equipment is required
- Manufactured in U.S.A.

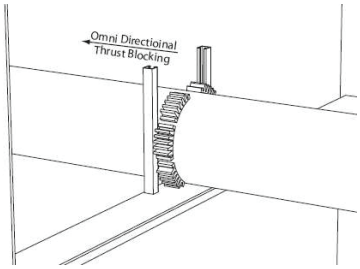
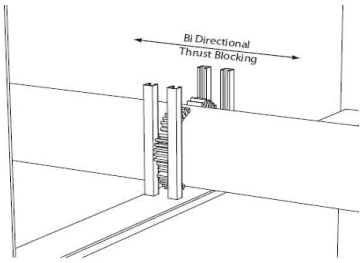
Specification		
Material	Flex Restraint	PE4710
Connection technology	Electrofusion	
Pipe requirements	Pipe material	HDPE solid wall pipe
	Pipe diameter range	DN150 - DN1600 mm 6" - 63"
Axial resistance	Axial shear strength	40 kN / 9000 lb-ft
Standards and Guidelines	ASTM D3350	Standard Specification for Polyethylene Plastics Pipe and Fittings Materials
Environment	Resistance	Weather resistant UV resistant

Dimensions



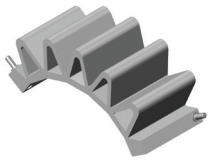
H	W	L	Weight
74 mm	65 mm	125 mm	0.18 kg
2.91"	2.56"	4.92"	0.4 pounds

Why Flex Restraints are Important

Omni-Directional Blocking	Bi-Directional Blocking
	
Forces pipe movement into one direction.	Establishes a fixed point to control expansion and contraction results.



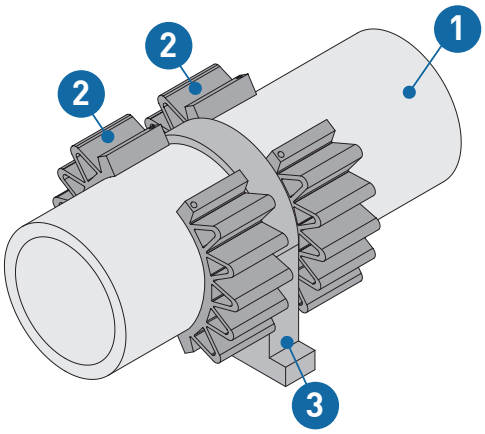
Order overview

Code	Description	Product picture
360 000 070	Flex Restraint	

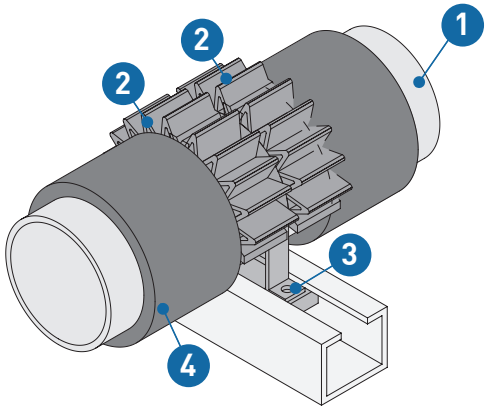
Mounting

- No direct metal contact
- Avoid supports that create point load stress
- No supports directly on weld beads or sharp edges

Mounting with standard pipes

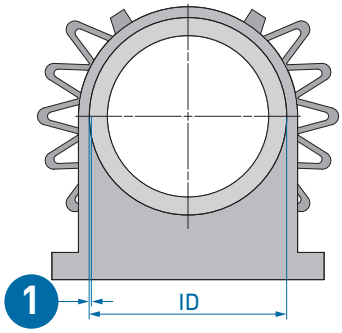


Mounting with insulated pipes

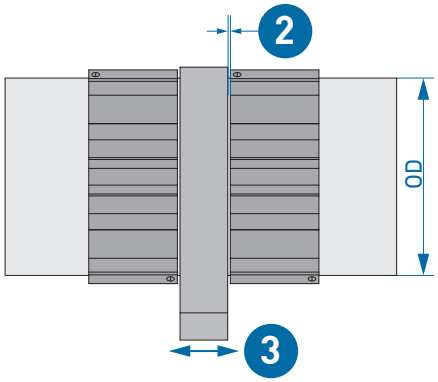


1 Pipe
2 Flex Restraints
3 Guide
4 Pipe insulation

Front view



Top view

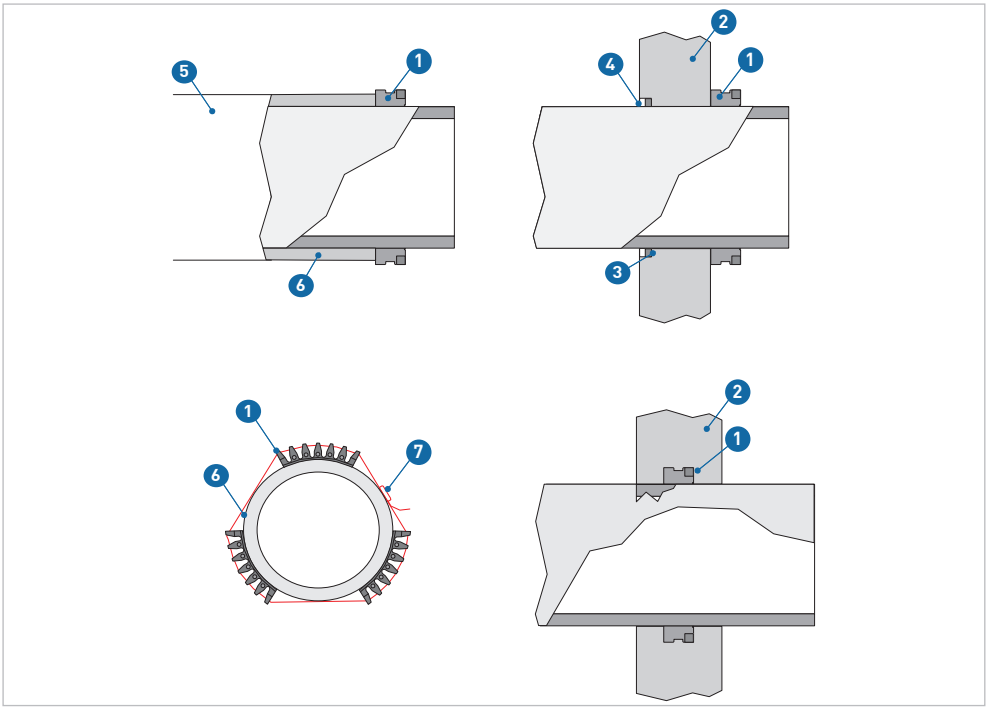


Recommendation to minimize impact on structural design due to acceleration effect:

1 3 - 6 mm (⅛" to ¼") gap between OD of pipe and ID of guide
2 3 - 6 mm (⅛" to ¼") gap between pipe and guide
3 Force in both directions

Axial Resistance Calculations

Scope: This guide is intended to be used to assist with the calculation of the recommended number of Electrofusion Flexible Restraint Saddles to be used for HDPE pipe axial restraint.



1 Flex Restraint
2 Concrete
3 Rubber water seal
4 Grout
5 Host pipe
6 Polyethylene pipe
7 Ratched strap

Symbol	Bezeichnung	ISO/USCS-Einheiten
ΔT	Temperature difference	°K °F
d	Pipe Outside Diameter	mm in
t	d/SDR; Pipe Wall Thickness	mm in
E	Elastic Modulus of Pipe Material	MPa psi
α	Linear thermal expansion coefficient	mm/mm/°K in/in/°F
F	Force	kN lb-ft

Equation 1

The two anticipated axial loads resisted by the Flex Restraints are: 1) axial force generated by temperature drops after installation; 2) 0.5% axial contraction during pressurization due to HDPE Poisson's ratio. The axial force generated in the pipe due to the temperature drop is calculated using the formula:

$$F = -\pi\alpha\Delta\mathrm{T}E(d-t)t$$

Equation 2

The restraint device is capable of withstanding an axial force $F_{restraint}$. This enables to calculate the number n of Flex Restraints needed for a particular application, with additional design factor applied (DF).

$$n = \frac{d^2 E \pi \alpha \Delta T (SDR-1)}{F_{restraint} SDR^2} DF$$

Equation 3

Product approval tests have shown that a minimum axial resistance force of 40 kN (9000 lb-ft) can be obtained from the flexible axial restraint device if the fusion is carried out in accordance with accepted practice. The elastic modulus values for various materials show considerable variation and should be verified by the pipe manufacturer. E = 862 MPa (125,000 psi) is a reasonable value for HDPE or PE4710 materials. The thermal expansion coefficient is in the region of α = 0.000144 mm/mm/°K (0.00008 in/in/°F). Inserting these values and a design factor (DF) of 2.0 into Equation 2 to account for Poisson's ratio contraction force and providing reserve capacity gives a conservative approximate formula for the number of Flex Restraints required:

ISO units

$$n = \frac{d^2 \Delta T (SDR-1)}{51'340 SDR^2}$$

USCS units

$$n = \frac{d^2 \Delta T (SDR-1)}{143 SDR^2}$$

Note: For use on polyethylene pipe with a minimum wall thickness of 11mm / 7/16" and a min Diameter of d160mm / 6" IPS.

Estimated Number of Flex Restraints Needed for SDR**

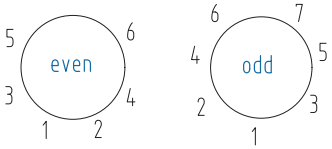
ISO Pipes	d 160	d 180	d 200	d 225	d 250	d 280	d 315	d 355	d 400	d 450	d 500	d 560	d 630	d 710	d800
SDR 9	2	2	2	2	2	3	3	4	5	6	7	9	11	14	18
SDR 11	2	2	2	2	2	2	3	3	4	5	6	8	9	12	15
SDR 17	2	2	2	2	2	2	2	2	3	4	4	5	6	8	10
Max # of Flex Restraints in Perimeter in one row*	3	3	4	4	5	5	6	7	8	9	10	11	12	14	16

USCS Pipes	6"	8"	10"	12"	14"	16"	18"	20"	24"	28"	30"	32"	36"	42"	48"
SDR 9	2	2	2	3	4	5	6	7	10	14	16	18	23	31	40
SDR 11	2	2	2	3	3	4	5	6	9	12	13	15	19	26	34
SDR 17	2	2	2	2	2	3	4	4	6	8	9	10	13	18	23
Max # of Flex Restraints in Perimeter in one row*	3	4	5	6	7	8	9	10	12	14	15	16	18	21	25

* Flex Restraints in multiple rows to be offset with rows being a minimum of 25.4mm (1") apart, with actual row separation based upon the strength of the encapsulating concrete and re-bar position.

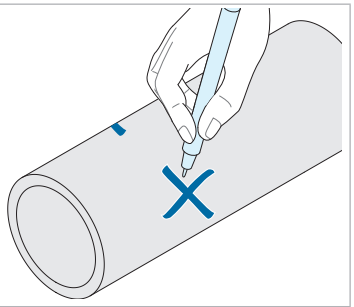
** Number of Flex Restraints based upon 13.9°K (25°F) temperature drop with full pressurization; @40 kN (9000 lb-ft) per Flex Restraint and DF = 2.0.

Position of flex restrains with odd or even quantity



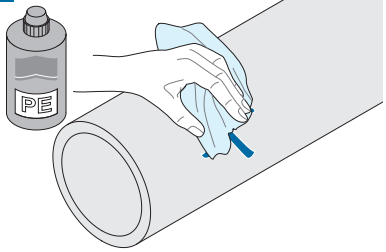
Flex Restraint assembly recommendation

1



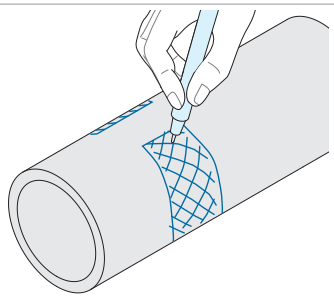
Identify the desired location for the Flex Restraints and mark them.
General Note: For required quantity and further information refer to chapter " Axial Resistance Calculations".

2



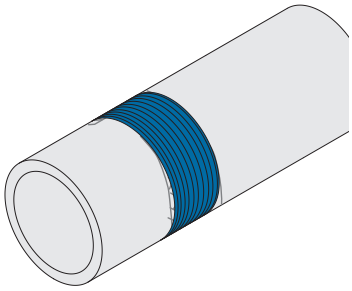
The pipe must be clean.
Remove all contaminants with a lint-free cloth and at least 90% isopropyl alcohol.

3



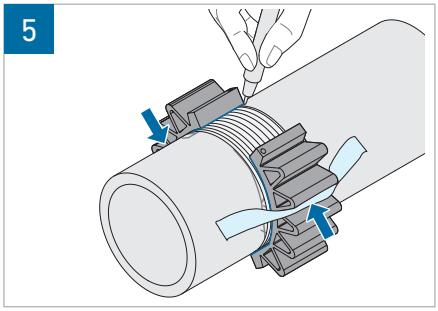
Draw marks on the pipe surface or, alternatively, mark the area to be scraped/removed in a cross pattern.

4



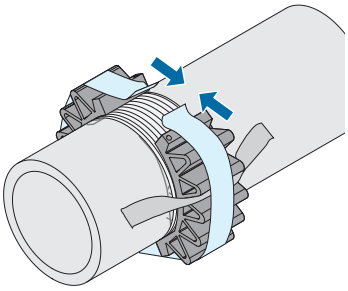
Scrape/Peel the pipe to remove the surface layer and expose clean virgin pipe material beneath. If witness marks remain, scrape the pipe again.
Repeat cleaning procedure as described in step 2.

5



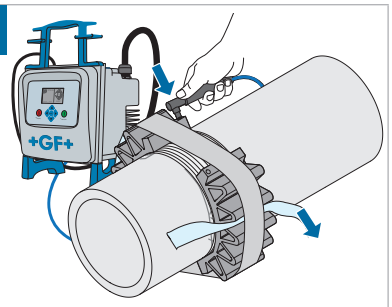
The Flex Restraints must be positioned on the prepared (scraped) area of the pipe. Ensure the restraints are evenly spaced around the pipe circumference.
Tape may be used temporarily to hold the Flex Restraints in place before tightening the strap.
Mark both the pipe and Flex Restraint to verify correct alignment and prevent movement during installation.

6



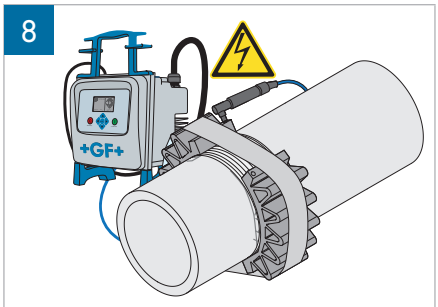
Ratchet straps are recommended for final fastening due to their ease of use and uniform tensioning force. Other options include worm gear clamps, or C-clamps.
Before tightening the strap completely, ensure that all Flex Restraints are evenly distributed around the pipe circumference and that they are in contact with the pipe wall across the entire welding area.

7



Remove the temporarily applied tape.
Connect the MSA leads to the Flex Restraint.
Note: Depending on the MSA, an adapter pin 4 to 4.7 mm is required.

8



Enter welding data.
If the data is entered by barcode mode, the fusion parameters should be automatically set. If the data is entered in manual mode, make sure to set the fusion time as stated on the table in the next step.

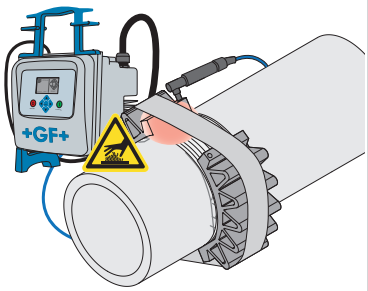
9

Fusion time setting depending on ambient temperature.

Temp. Range °C	Temp. Range °F	Fusion time s
-23 ... -18	-10 ... -1	310
-17 ... -7	0 ... 19	300
-6 ... +4	20 ... 39	280
+5 ... +15	40 ... 59	260
+16 ... +49	60 ... 120	240

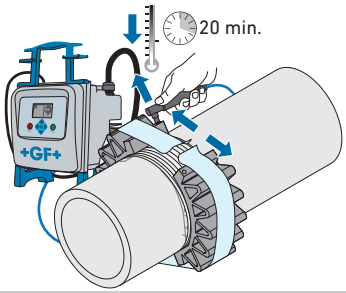
Fusion time setting for manual mode, depending on ambient temperature.

10



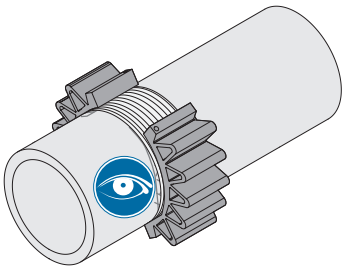
Start welding process.
CAUTION: Hot!
The fusion zone of the flex restraint gets very hot and it is also a potential shock hazard! Do not touch the restraint wires during the fusion cycle or the cooling time!

11



After the fusion cycle is complete, the restraints and clamping device being used must remain in place and be allowed to cool for 20 minutes. The Flex Restraints should be completely cool before it is subjected to any forces.

12



Check welding.

All Electrofusion Couplings must have the pipe restrained and adequately supported on both sides of the joint. This prevents movement during fusion and cooling and eliminates any stress or strain in the fusion zone until both heating and cooling cycles are fully completed.

CAUTION:

The fusion zone of the flex restraint gets very hot and it is also a potential shock hazard!

Do not touch the Flex Restraint wires during the fusion process or cooling time!

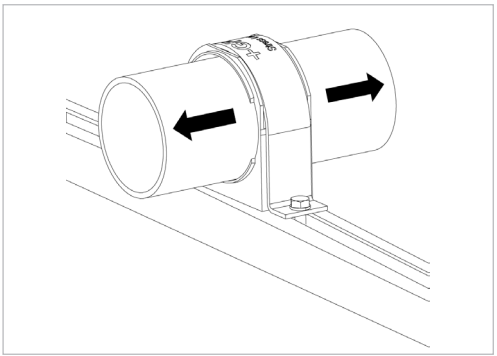
2.3.3 Stress Less® Pipe Support System

Stress Less Overview

Stress Less is a pipe support system specifically designed to eliminate stress transfer to the pipe caused by thermal expansion and overtightening clamps onto the pipe. The patented design consists of a uniquely designed Polypropylene plastic insert that allows for pipe movement during thermal expansion and prevents severe pipe impact when seismic accelerations occur. The trivalent chrome-coated metal hoop meets pipe hanger and support standards and withstands a myriad of operating conditions, including seismic and corrosive enviornment.

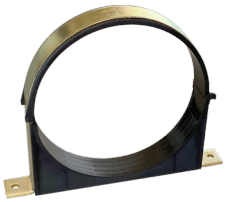
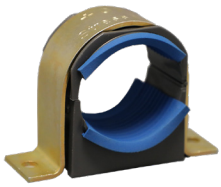
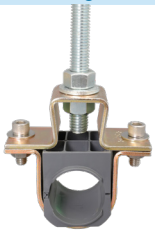
Loose Bracket

Stress Less pipe guides allows the pipe to have axial movement in the pipe bracket. This allows stress-free compensation of temperature changes and allows movement during other dynamic loading events, countering undesirable stress. The inner diameter of the smooth plastic insert is larger than the outer diameter of the pipe to allow free movement of the pipe.



Stress Less Pipe Support System

Stress Less Pipe Support System includes pipe guides, vertical supports, clevis hangers, and valve supports allowing installers the flexibility ot mount directly on any surface, on pipe support rail, horizontally as a hanger, or vertically.

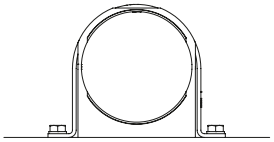
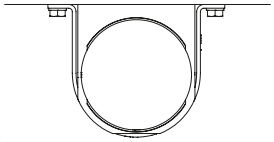
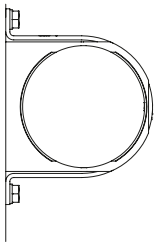
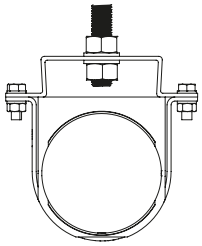
Pipe Guides	Vertical Supports	Clevis Hanger	Valve Supports
			
d20-d315 (Metric) 0.5" to 12" (IPS)	d20-d63 (Metric) 0.5" to 2" (IPS)	d20-d315 (Metric) 0.5" to 12" (IPS)	d20-d63 (Metric) 0.5" to 2" (IPS)

Other Stress Less pipe support types are available upon request:

- Linestop Clamp Kits
- Fixpoint Flange Restraint Kits
- Accessories

Stress Less Install Configuration

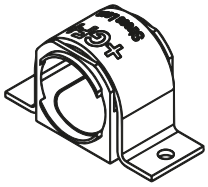
Stress Less can be mounted to any flat surface or strut support in the different configurations shown below. Please see design load table for maximum recommended load in each configuration. With the addition of the clevis hanger kit, Stress Less guides can be installed as a clevis hanger hung from a threaded rod.

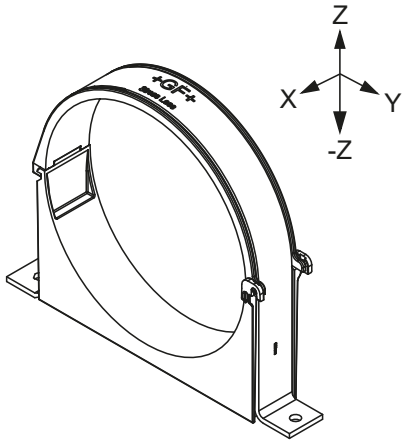
Flat	Hung	Horizontal	Vertical	Clevis Hanger
				

Stress Less Pipe Supports Load Rating

Fy, Fz, and – Fz are rated design loads, in lb-f (pounds-force) and N (Newtons), for respective y, z, and –z directions.

Load directions





Pipe Size (OD)		Design Load			Bolt size*
Metric	Inch	Fz	F-z	Fy	
20 mm	½"	150 lb-f / 660 N	180 lb-f / 800 N	150 lb-f / 660 N	M6 - ¼"
25 mm	¾"	150 lb-f / 660 N	180 lb-f / 800 N	150 lb-f / 660 N	M6 - ¼"
32 mm	1"	150 lb-f / 660 N	180 lb-f / 800 N	150 lb-f / 660 N	M6 - ¼"
40 mm	1 ¼"	150 lb-f / 660 N	180 lb-f / 800 N	150 lb-f / 660 N	M6 - ¼"
50 mm	1 ½"	150 lb-f / 660 N	180 lb-f / 800 N	150 lb-f / 660 N	M6 - ¼"
63 mm	2"	200 lb-f / 800 N	240 lb-f / 880 N	200 lb-f / 800 N	M8 - 5/16"
75 mm	2 ½"	300 lb-f / 1300 N	360 lb-f / 1600 N	300 lb-f / 1300 N	M8 - 5/16"
90 mm	3"	450 lb-f / 2000 N	540 lb-f / 2400 N	450 lb-f / 2000 N	M8 - 5/16"
110 mm	4"	650 lb-f / 2800 N	780 lb-f / 3400 N	600 lb-f / 2670 N	M8 - 5/16"
125 mm		700 lb-f / 3100 N	840 lb-f / 3700 N	600 lb-f / 2670 N	M8 - 5/16"
140 mm	5"	700 lb-f / 3100 N	840 lb-f / 3700 N	600 lb-f / 2670 N	M8 - 5/16"
160 mm	6"	900 lb-f / 4000 N	1080 lb-f / 4800 N	600 lb-f / 2670 N	M8 - 3/8"
225 mm	8"	1750 lb-f / 7700 N	2100 lb-f / 9300 N	800 lb-f / 3560 N	M8 - 3/8"
250 mm	10"	1750 lb-f / 7700 N	2100 lb-f / 9300 N	800 lb-f / 3560 N	M12 - ½"
280 mm		1750 lb-f / 7700 N	2100 lb-f / 9300 N	800 lb-f / 3560 N	M12 - ½"
315 mm	12"	1750 lb-f / 7700 N	2100 lb-f / 9300 N	800 lb-f / 3560 N	M12 - ½"

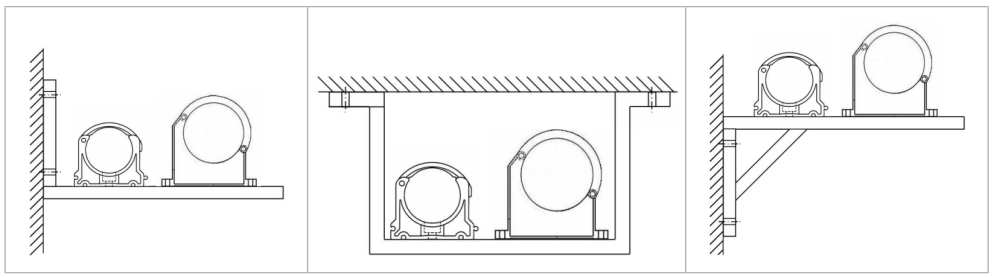
*Bolts with a tensile strength of at least 70,000 Psi (482 Mpa) recommended.

2.3.4 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 Industry & Infrastructure Flow Solutions 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.



2.3.5 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.

2.3.6 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.

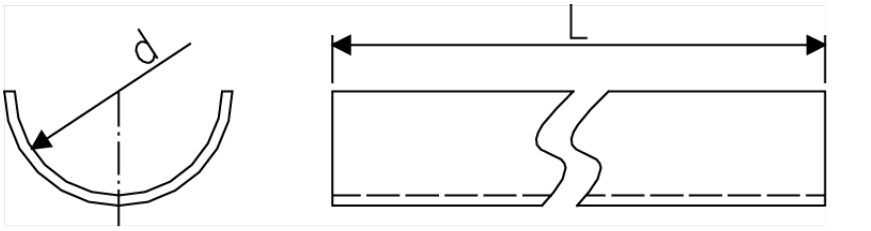
Pipe which are fixed in the axial direction (fixed installation) must be checked for buckling. In most cases, this leads to a reduction of maximum inner pressure as well as shorter distances between the support brackets. Furthermore, the forces which act on the fixed points must be taken into consideration.



2.3.7 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	1'600
20	1'750
25	1'900
32	2'000
40	2'150
50	2'300
63	2'500
75	2'600
90	2'750
110	2'900

2.3.8 Protection against mechanical impact

⚠ Plastic piping systems and welded joints installed in exposed areas shall be protected against unintended mechanical impact.

Suitable protective measures include
- Protective covers
- Mechanical guards
- Insulation systems with protective jackets
- Structural shielding
- Other equivalent protective devices

Additional protection should be considered in areas such as
- Walkways and pedestrian routes
- Stairways and access areas
- Transport and handling zones
- Areas with protruding piping components
- Locations exposed to maintenance activities

Potential sources of mechanical impact include
- Dropped tools or equipment
- Personnel stepping on piping components
- Contact with transport equipment
- Contact with adjacent structures, supports or equipment

The system designer and the installer are responsible for evaluating the installation environment and implementing appropriate protective measures where required.

2.4 Pressure and leak test

2.4.1 Introduction to pressure testing

Overview of the different testing methods

Testing method	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 $0.85 \bullet P_{p\,(perm)}$	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 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 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 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!

2.4.2 Pressure test with water or a similar incompressible test medium

Overview

The 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 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 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")	≤ $P_{p\,(perm)}$	≤ 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
PEEK	0.5
ECTFE	0.9
PA-U*	0.8

*According to DVS 2210-1ff

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.

2.4.3 Filling the pipeline

Before starting with the 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.

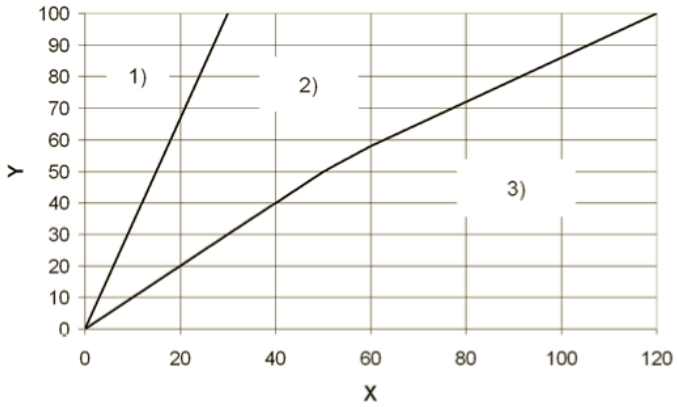
Reference values for the filling volume are given in the table below.

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

In general, the weakest link in the system (in terms of PN rating) determines the maximum test pressure.
If valves are installed in the system, the maximum test pressure shall not exceed the nominal pressure (PN) of the valves.
At test temperatures above 20 °C, the maximum test pressure shall be limited according to the valve-specific pressure-temperature diagrams.

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
PEEK	1.3
ECTFE	1.6

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

2.4.4 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 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 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 Industry & Infrastructure Flow Solutions valve shows a leak during 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.

2.4.5 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 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 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.

2.5 Modifications, repairs, commissioning

2.5.1 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 pressure test should be done.

2.5.2 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.

2.6 Handling plastic pipeline systems

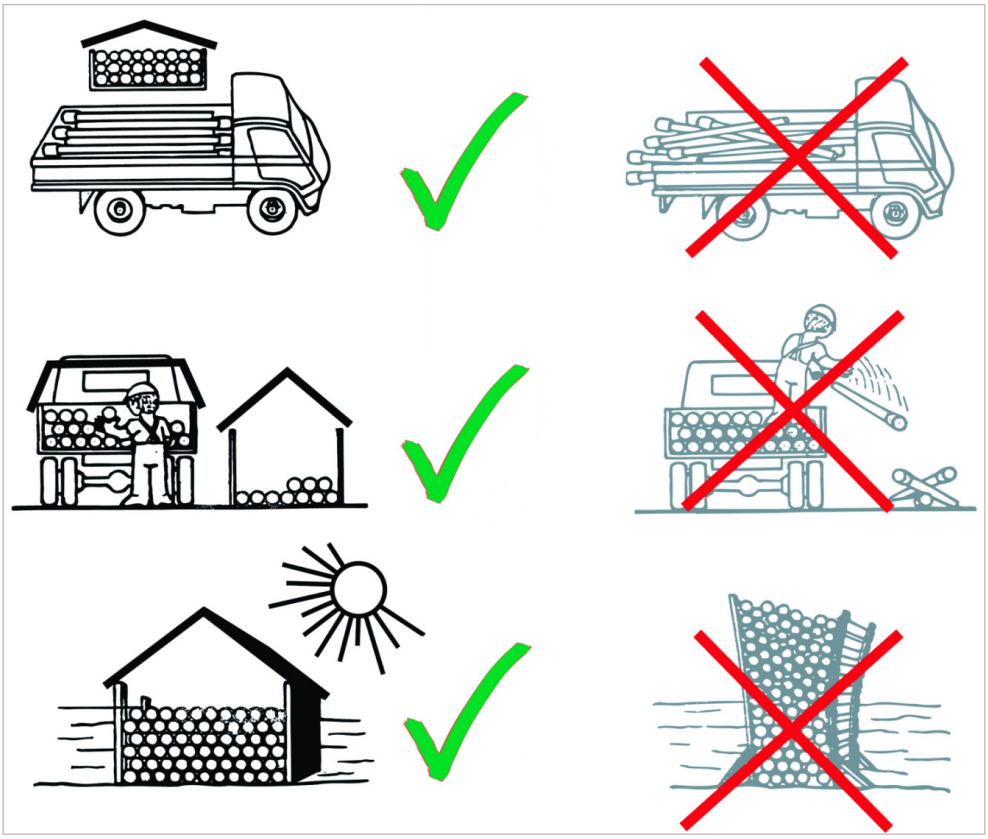
2.6.1 Transportation

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 Industry & Infrastructure Flow Solutions fittings and equipment are only unpacked immediately prior to use.



2.6.2 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
PEEK	1.5*
ECTFE	1.0

* At least 6 months reliable storage with functional packaging.

3 Jointing technologies

3.1 Mechanical joints

3.1.1 Overview

Of the many diverse solutions offered by GF Industry & Infrastructure Flow Solutions 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

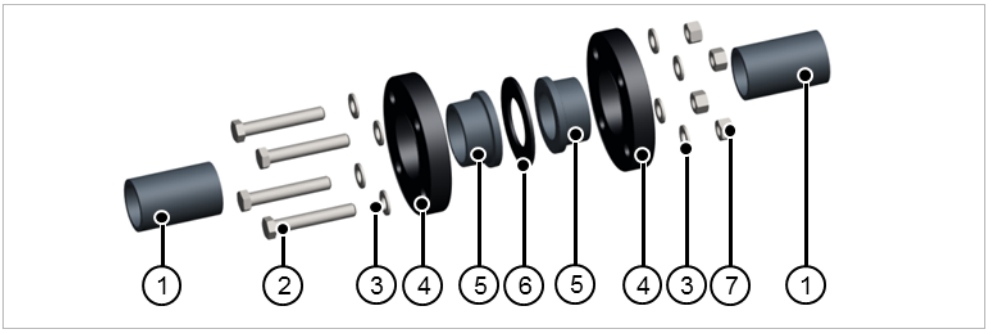
Thread types

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

3.1.2 Flange connections

Flanges with sufficient thermal and mechanical stability must be used. The different flange types by GF Industry & Infrastructure Flow Solutions 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. • For ambient Temperatures above 80°C, suitable backing Flanges must be used. Possible options are PVDF coated steel flanges (155 701 806- 923) or non-coated stainless-steel flanges. • 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 Industry & Infrastructure Flow Solutions.
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, initial system loading under Temperature-(cycle), the tightening torque must be checked in any case and, if necessary, 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 Industry & Infrastructure Flow Solutions. 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 Industry & Infrastructure Flow Solutions 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, MPTFE, 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	75	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			

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.

i 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		

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	

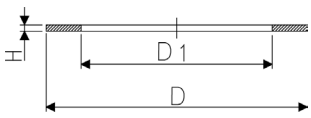
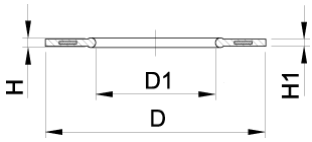
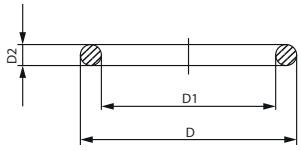
Valves installed in flange connection (mm)	Installation length (mm)		
	Butterfly valve Type 567/578	Butterfly valve Type 037/038	Wafer check type 369
DN32			15
DN40			16
DN50	45	43	18
DN65	46	46	20
DN80	49	46	20
DN100	56	52	23
DN125	64	56	23
DN150	72	56	26
DN200	73	60	35
DN250	113	68	40
DN300	113	78	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 Industry & Infrastructure Flow Solutions 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 Industry & Infrastructure Flow Solutions 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.

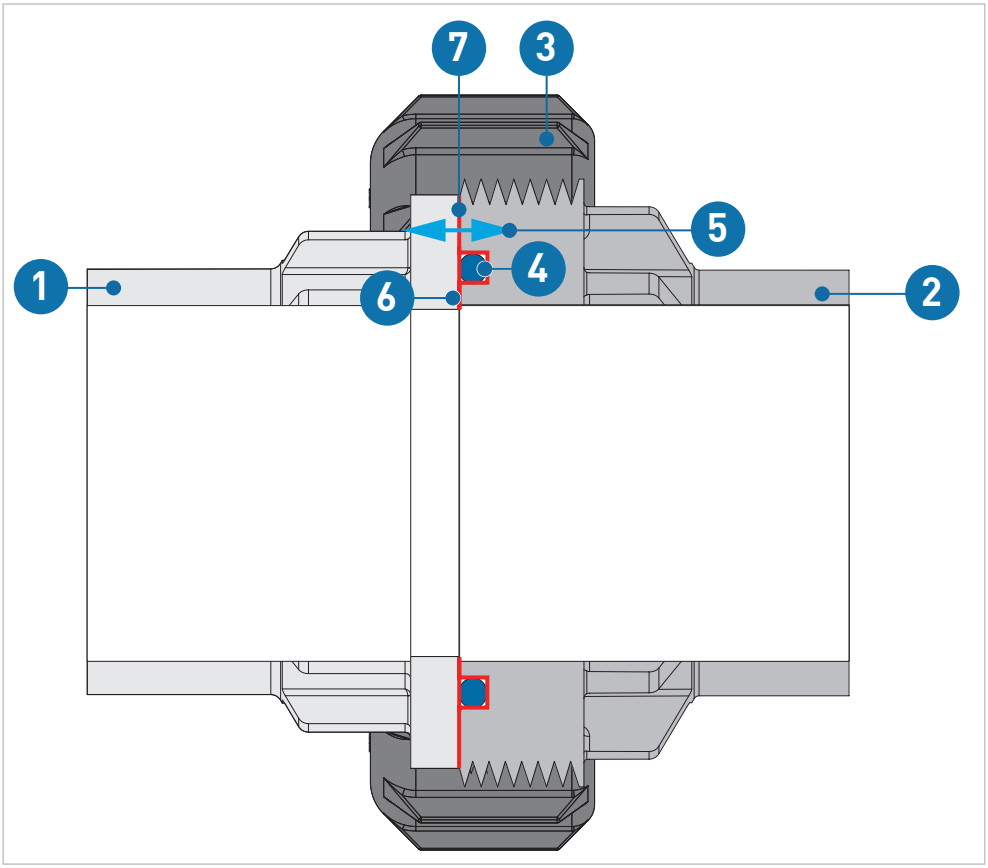
Gasket dimension

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.

3.1.3 Union joints for plastic piping systems

Wherever possible, union connections are the preferred choice over flange connections for mechanical jointing of plastic piping systems. By eliminating metal components, unions remove the risk of corrosion while reducing overall connection weight. They also provide the most compact, space-saving solution for mechanical joints. In addition, unions are quick and easy to assemble and are available in a wide range of materials and material combinations.

Correctly assembled union connection



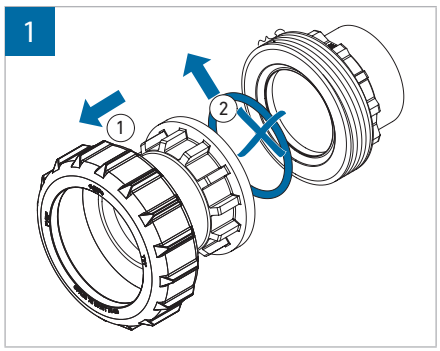
1 Union end/Valve end
2 Unioin bush
3 Union nut
4 O-ring
5 Flux of force (plastic-to plastic)
6 Sealing surface (red marking)
7 No gap (very important)

The plastic-to-plastic contact connection ensures:

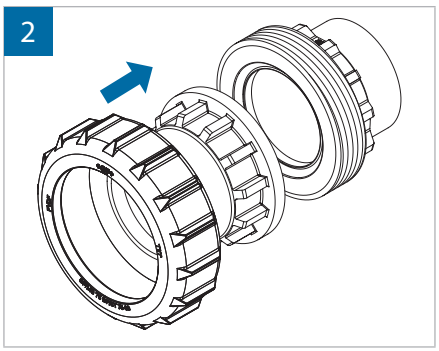
- Low risk of leakage due to bending and movement of the piping system.
- Defined O-ring compression according to design with proper contact pressure (destruction of the sealing is not possible)
- No risk of extrusion and blow for the O-rings.
- Functional separation; the seal is used exclusively for sealing.
- Minimized creep-relaxation.

Assembly recommendation for non-high purity union joints

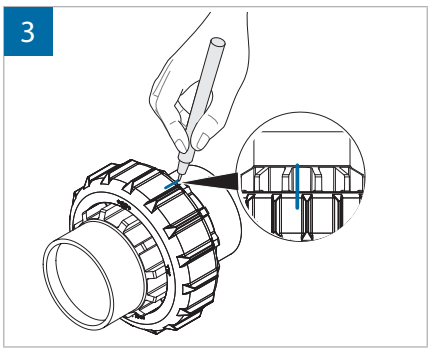
Install union joints made out of **ABS, PVC-U, PVC-C, PVDF (only SYGEF Standard), PP (only PROGEF Standard) or ECTFE** as shown:



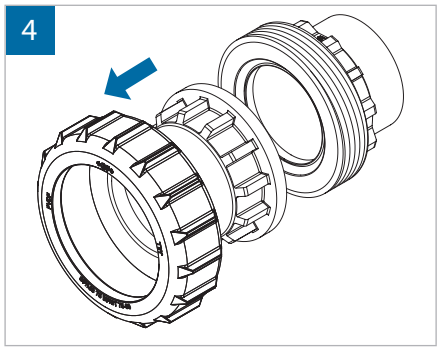
Step 1
Disassemble the union and remove the O-ring.



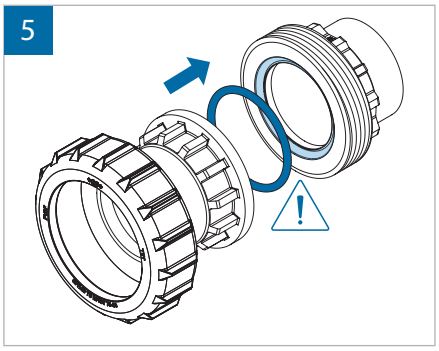
Step 2
Assemble the union without the O-ring. Screw in the union nut in by hand until it reaches the stop.



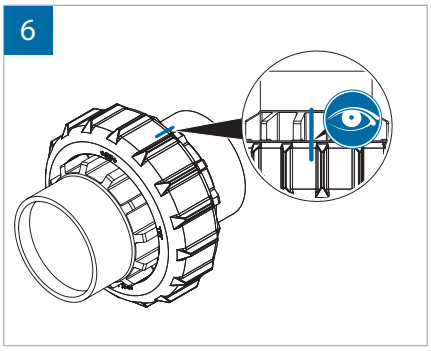
Step 3
To ensure the position can be relocated later, mark the union nut and union bush in alignment. The marking method must comply with application-specific requirements.



Step 4
Disassamble the union again.



Step 5
Carefully place the O-ring back into the groove and reassemble the union.



Step 6
Tighten the union nut, until the marking is aligned. To avoid damage, do not apply any further force after the mark is aligned.

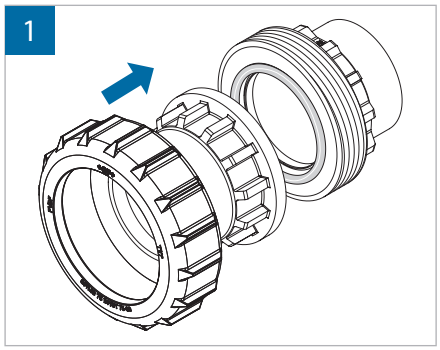
General notes on assembly

- Ensure stress-free installation when using unions.
- Plastic unions seal with an O-ring (only O-rings supplied by GF should be used. Take care not to damage the seal).
- Always keep the O-ring and sealing surfaces clean and undamaged, as even the smallest particles or scratches can cause leakage.
- GF recommends following the procedure described to ensure optimal sealing and durability of the union.
- To prevent additional mechanical stress on the valve body, the use of two strap wrenches is recommended.
- For large unions, threads may be moistened with water to ease assembly.
  Use of lubricants other than water is only permitted after approval from GF Global Sales Support and if the application allows.
- In all cases it is required to check the tightness of the union once the medium is flowing.

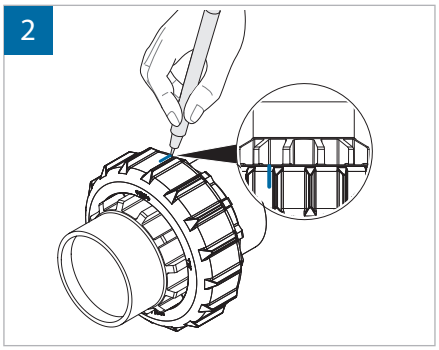
- Since torque can vary under different conditions (time, temperature, and axial alignment), it is not sufficient to rely on just the torque value.
- In the area of flexible sections and expansion loops, unions cannot be used! Due to the bending stress, leaks may occur.

Assembly recommendation for high-purity union joints

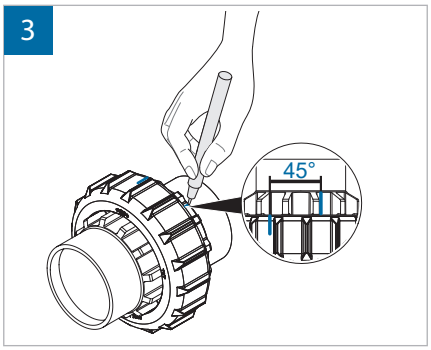
Install high-purity union joints made out of **PVDF (only SYGEF Plus), PP (only PROGEF Plus and PROGEF Natural) or PEEK (SYGEF Ultra)** as shown:



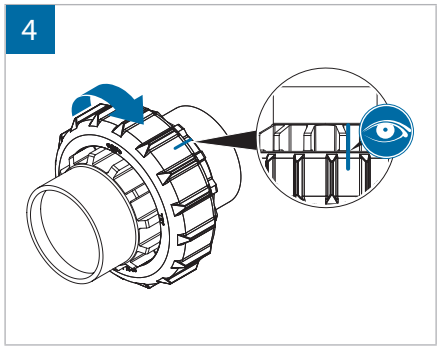
Step 1
Pre-assemble the union. Mount the union nut onto the thread by hand until the nut no longer turns (hand-tight only).



Step 2
Mark a first reference line on the union nut.



Step 3
Mark a second reference line on the union bush, offset by 45° in the tightening direction from the first reference mark.



Step 4
Tighten the union nut using the appropriate tool until both reference lines are aligned.

General notes on assembly

- Ensure stress-free installation when using unions.
- Plastic unions seal with an O-ring (only O-rings supplied by GF should be used. Take care not to damage the seal).
- Always keep the O-ring and sealing surfaces clean and undamaged, as even the smallest particles or scratches can cause leakage.
- GF recommends following the procedure described to ensure optimal sealing and durability of the union.
- Do not apply any additional force after the reference lines are aligned, as overtightening may damage the union.
- To prevent additional mechanical stress on the valve body, the use of two strap wrenches is recommended.
- A second marking offset by 45° in the tightening direction is recommended.
- In all cases it is required to check the tightness of the union once the medium is flowing.

- Since torque can vary under different conditions (time, temperature, and axial alignment), it is not sufficient to rely on just the torque value.
- In the area of flexible sections and expansion loops, unions cannot be used! Due to the bending stress, leaks may occur.

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.

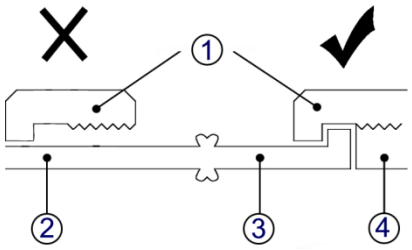
Threads on coupling nut and union bush for PP, PVDF and PE

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

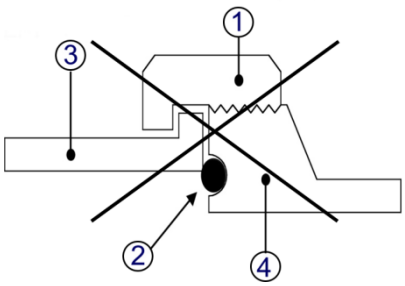
Fusion bead at unions for butt fusion

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.



1 Coupling nut
2 Pipe
3 Union end
4 Union bush

Union bushes and union ends with various nominal diameters



1 Coupling nut d75
2 Insufficient seal
3 Butt fusion union end d90
4 Butt fusion union bush d75

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.

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.

3.1.4 Adaptor unions for connections between plastic and metal pipe

The GF Industry & Infrastructure Flow Solutions 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.

3.1.5 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 Industry & Infrastructure Flow Solutions 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.

3.1.6 Hose connections to plastic piping systems

GF Industry & Infrastructure Flow Solutions 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, PEEK and ECTFE only)

3.1.7 SYGEF Plus, SYGEF Ultra 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.

3.1.8 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.

3.2 Cementing



3.2.1 Solvent cement jointing using Tangit

Overview

Material/cement

PVC-U	PVC-U PLUS	PVC-C PLUS	DTX	ABS
				
Standard PVC-U cement	THF free Drinking water approval	THF free Applications up to 80°C	For aggressive media	Applications from -50°C to +60°C

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 Industry & Infrastructure Flow Solutions 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.

i 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

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 PLUS	0.7 kg can
		PVC-U	0.125 kg tube 0.25 kg can 0.50 kg can 1.0 kg can
		PVC-U Plus	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

Dimensions and tolerances

The dimensions of pipe, fittings and valves made of PVC-U, PVC-C and ABS by GF Industry & Infrastructure Flow Solutions 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.

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

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.

Cementing with solvent-based adhesives

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.

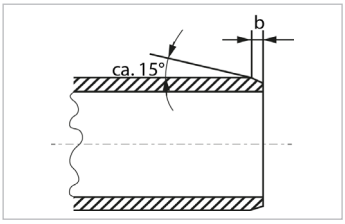


2 Chamfering the pipe

Chamfer the end of the pipe with the chamfer device according to the following figure and table to enable a perfect cementing joint.



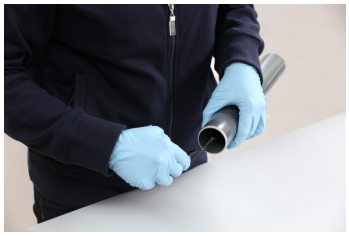
d (mm)	b (mm)
6 – 16	1 – 2
10 – 55	2 – 3
63 – 225	3 – 6
250 – 400	6 – 8



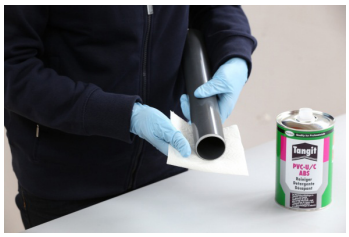
Well-chamfered pipe ends prevent the layer of cement from being removed as the pipe is inserted into the fitting.

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/primer 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. 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.

i PVC-C Plus: The new consistency has a structure-viscous appearance, i.e. it may appear gelatinous/paste-like. However, when stirring, liquefaction occurs depending on the duration and intensity.
Recommended stirring time = min. 2 minutes.

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**

Store cement and cleaner in a cool, dry place (5 to 35°C). The optimum temperature is up to 20°C. Higher temperatures may affect the shelf life.
Adhesive and cleaner are stable under these conditions according to the printed expiration date (DDMMYY batch).

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.


Tangit ABS
Henkel
Charge/Batch-No.: _____
Abfülldatum/Filling date: _____
Diese Chargenkennzeichnung ist auf dem Prüf-/Abnahmeprotokoll anzubringen. / Put this product identification on the final test report.

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.

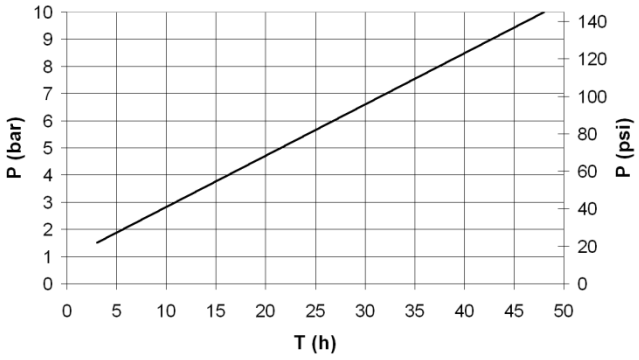
The following table shows the corresponding waiting times:

Materials and dimension	Temperature: 10 °C - 30 °C			Temperature: <10 °C / >30 °C		
	Between joints on the same component	Operating pressure after the last joint or a repair	Pressure test water max. 1.5 x PN	Between joints on the same component	Operating pressure after the last joint or a 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.

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!

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.

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 Industry & Infrastructure Flow Solutions 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 Industry & Infrastructure Flow Solutions 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

3.2.2 Solvent-free cement jointing Tangit RAPID (2-component cement)

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/cm^3
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.

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 Industry & Infrastructure Flow Solutions 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

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

Dimensions and tolerances

The dimensions of pipe, fittings and valves by GF Industry & Infrastructure Flow Solutions 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.

Adhesive amount

Approximately the following quantities of adhesive and cleaner are required to produce an adhesive bond:

Pipe-dimension d mm	Tangit KS Cleaner ca. ml	Tangit RAPID approx. g
d20	3,5	1
d32	5	1,5
d50	9	3
d63	11	5
d75	13	7
d90	15	12
d110	17	20
d140	21	28
d160	25	38
d200	40	65
d225	45	100
d315	70	200

The amount of adhesive consumed depends on a number of factors. The table indicates average values. Exceeding these values is usually not required.

Cementing

1 Cutting the pipe to length

Cut off the pipe at a right angle by using a pipe cutter.

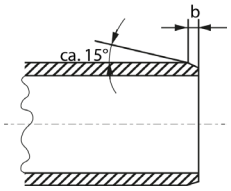


2 Chamfering the pipe

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.

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)

ⓘ 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 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.

7 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).



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.

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.

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.

3.2.3 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 Industry & Infrastructure Flow Solutions
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

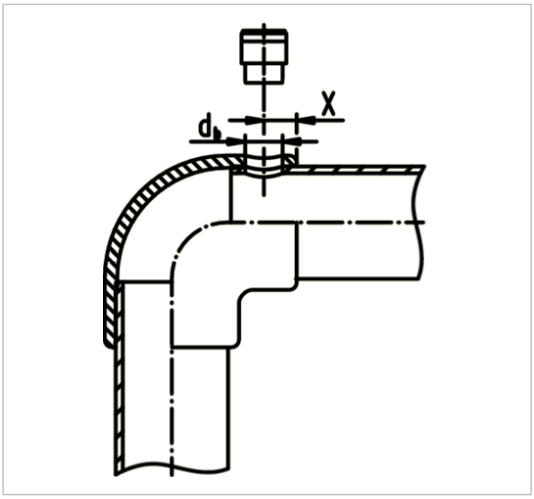
ABS PN10		Wall thickness e (mm)		Outlet dimension d (mm)	
Pipe dimension (mm)	S8, SDR17	20	25	32	40
75	4.5	✓	✓	x	x
90	5.4	✓	✓	x	x
110	6.6	✓	✓	x	x
125	7.4	✓	✓	x	x
140	8.3.	✓	✓	x	x
160	9.5	✓	✓	x	x
180	10.7	✓	✓	✓	x
200	11.9	✓	✓	✓	x
225	13.4	✓	✓	✓	✓

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

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**

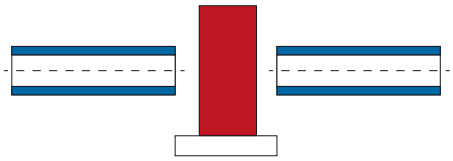
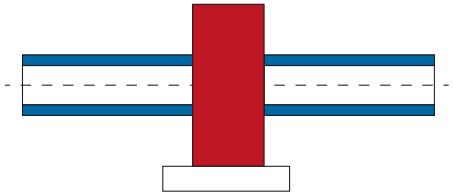
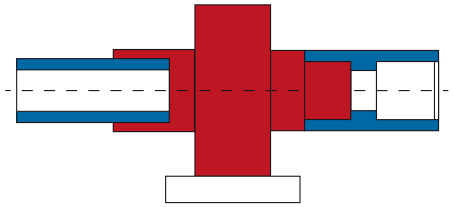
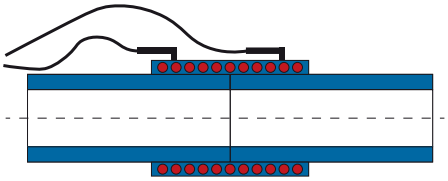
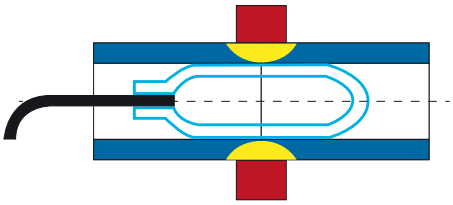
3.2.4 Cementing different pipe materials

It is possible to cement the pipe materials ABS, PVC-U and PVC-C with one another; certain conditions must, however, be observed.

If different pipe materials are to be cemented, please contact your authorized GF Industry & Infrastructure Flow Solutions representative.

3.3 Welding

3.3.1 Overview of fusion technologies

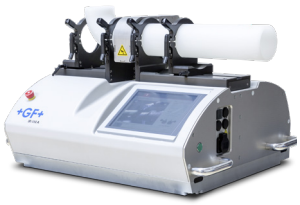
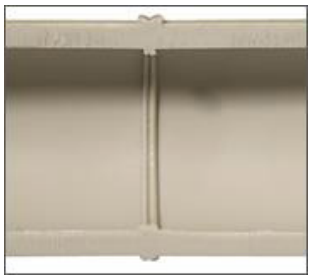
Fusion technology	Materials	Dimensions (mm)	Fusion principle	Cross section
Infrared fusion jointing	• PVDF • ECTFE • PP • PP-n • PE100 • IR PVC-U	d20 - d400		
Butt fusion jointing	• PE • PP • PVDF	d40 - d1600		
Socket fusion jointing	• PE • PP • PVDF	d16 - d125		
Electrofusion jointing	• PE100	d20 - d1200		
Bead and crevice-free jointing	• PVDF • PP-n	d20 - d110		

3.3.2 Infrared fusion jointing

Overview

Material

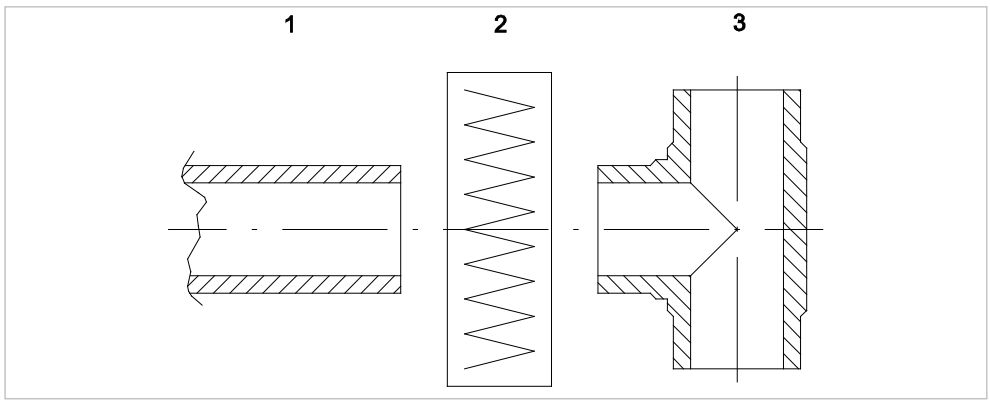
- PVDF
- PEEK
- ECTFE
- PP
- PP-n
- PE100
- IR PVC-U

Fusion device	Jointing cross section (PP-H)	Macro view
		

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

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.



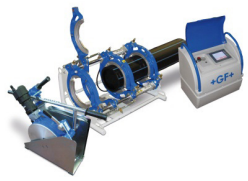
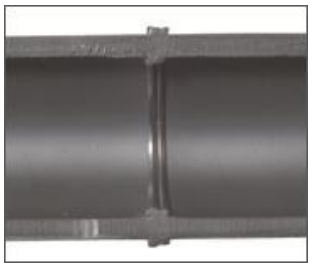
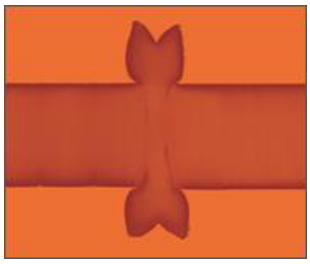
For additional information about using the fusion procedure for corresponding materials, see www.gfps.com

3.3.3 Butt fusion jointing (heating element butt fusion conventional butt fusion)

Overview

Material

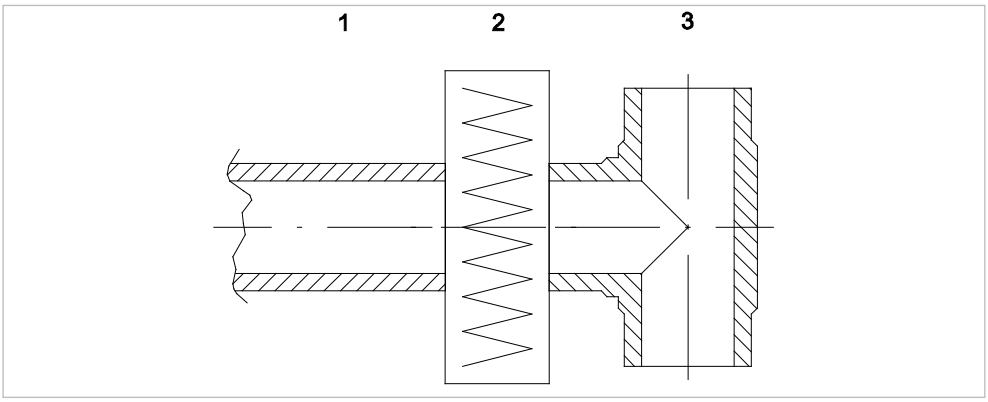
- PE
- PP
- PVDF

Fusion device	Jointing cross section	Macro view
		

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

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.

i For additional information about using the fusion procedure for corresponding materials, see www.gfps.com

3.3.4 Socket fusion jointing (heating element socket fusion)

Overview

Material

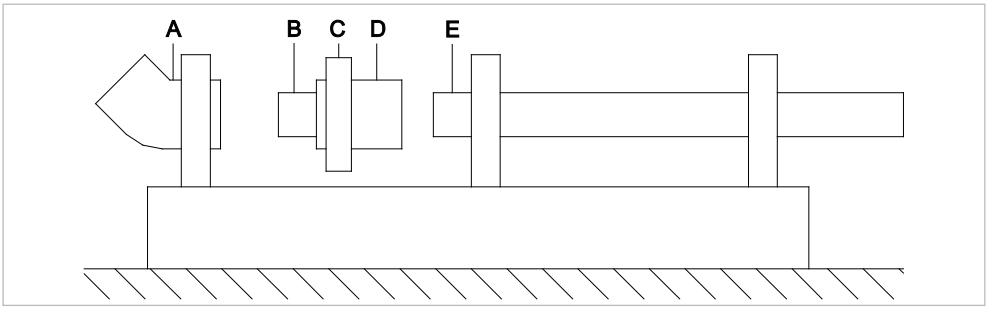
- PE
- PP
- PVDF

Fusion device	Jointing cross section	Macro view
		

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.

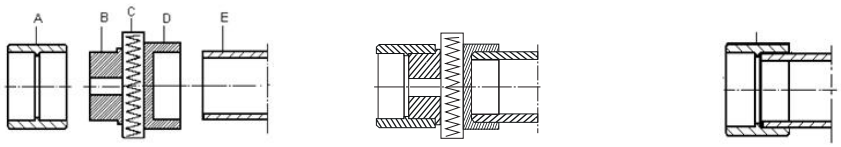
Fusion device



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

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

3.3.5 Electrofusion (heating element fusion joints)

Overview

Material

- PE100

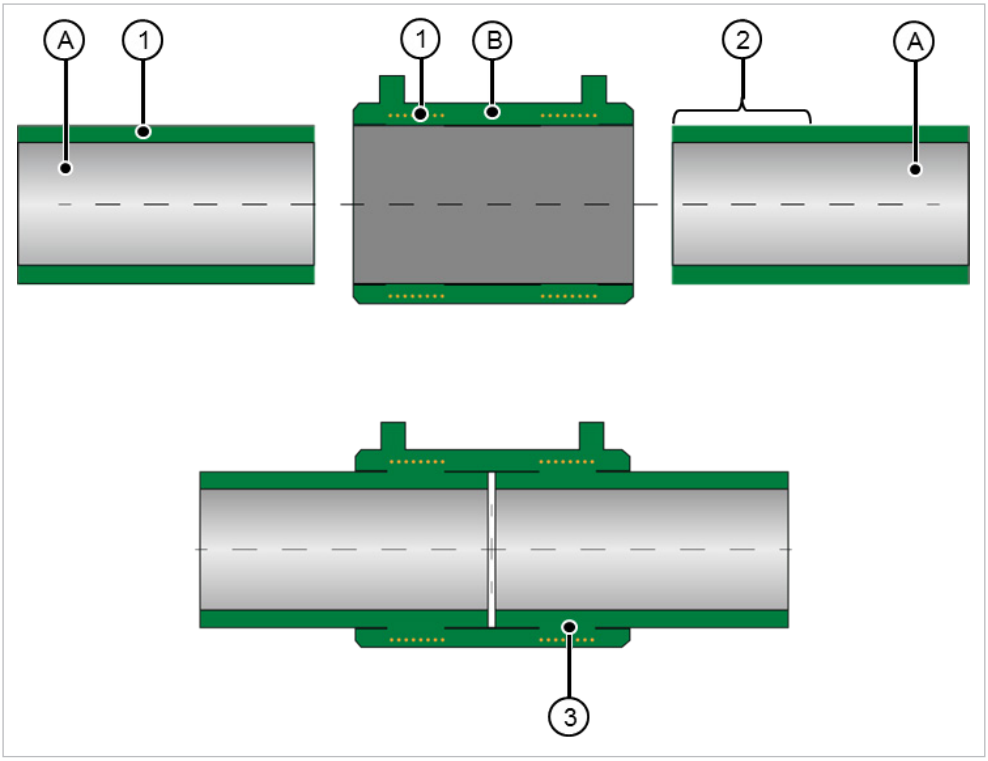
Fusion device	Jointing cross section	Macro view
		

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

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)

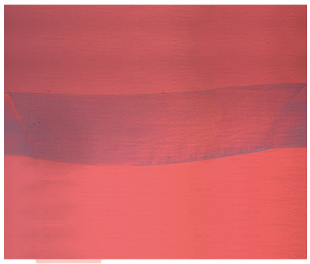
i For additional information about using the fusion procedure for corresponding materials, see www.gfps.com

3.3.6 BCF Plus fusion jointing (bead and crevice-free)

Overview

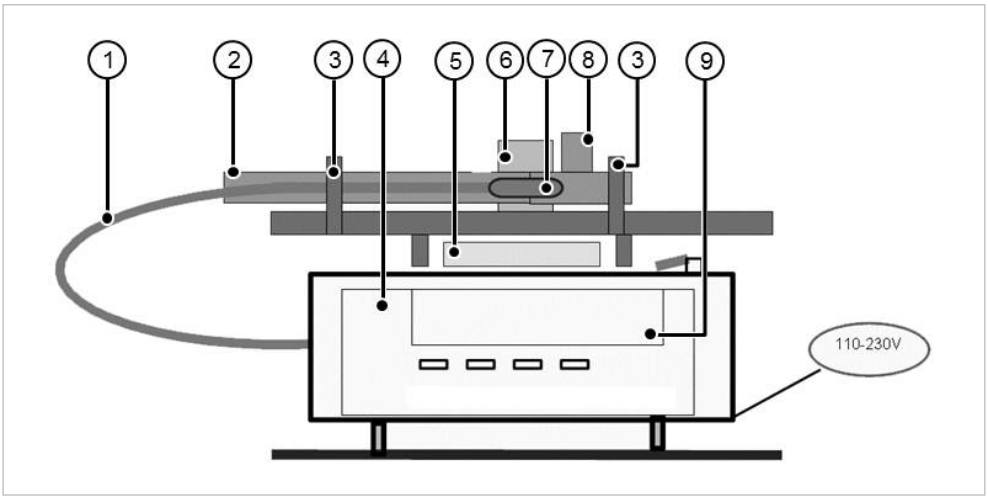
Material

- PVDF
- PP-n (PP Natural)

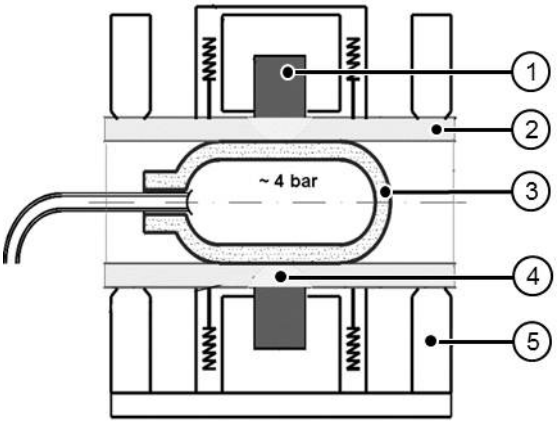
Fusion device	Jointing cross section	Macro view
		

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 Industry & Infrastructure Flow Solutions 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



1 Heating element
2 Pipe/fitting
3 Bladder (elastic pressure vessel)
4 Fusion zone
5 Clamping position

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

4 Symbols, SI-Units and Conversion Tables

4.1 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
1'000	1'000	40

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

4.2 Identification

4.2.1 Fittings

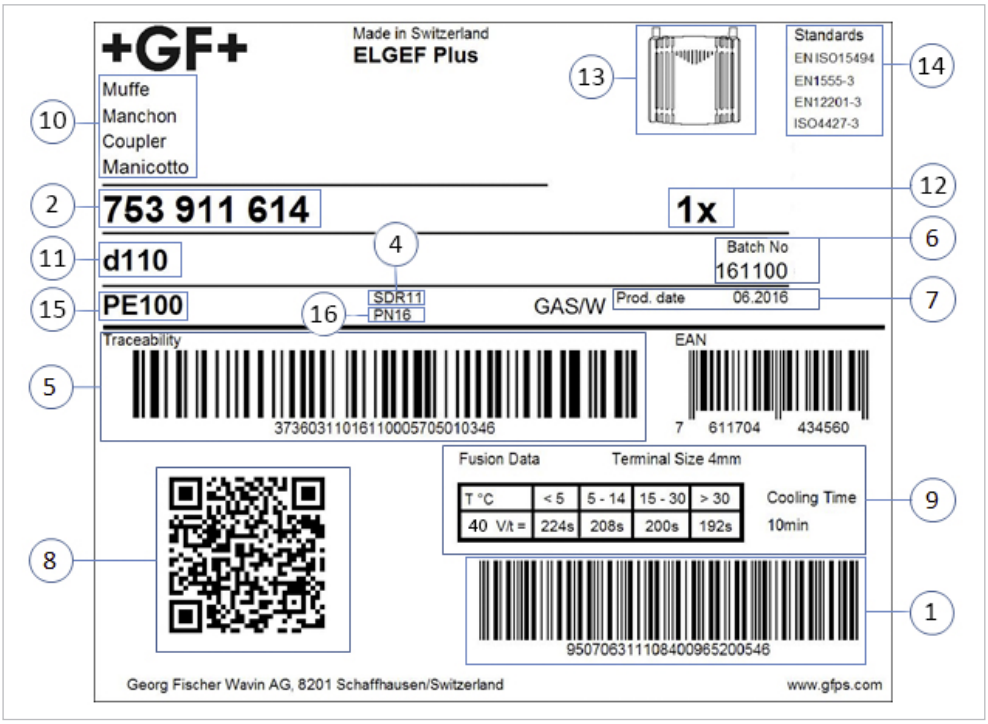
Packaging label using PE electrofusion fitting with the most comprehensive content as an example

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

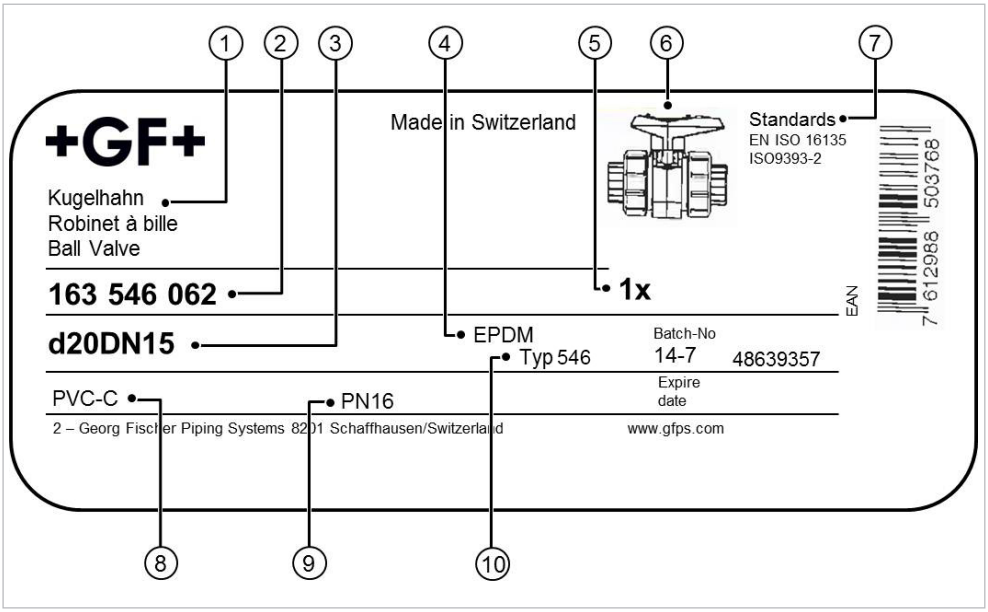
Bag label



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.

4.2.2 Valves

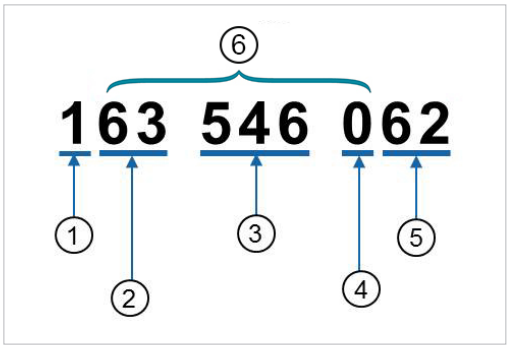
Packaging label using ball valve type 546 as an example



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

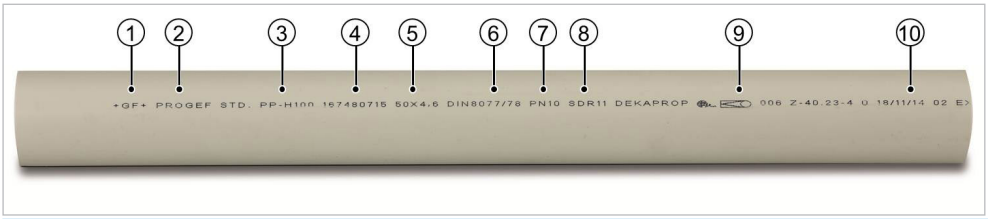
Code numbers

The code numbers typically consist of the following:



1 Class
2 Material
3 Type
4 Variant
5 Size

4.2.3 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

4.3 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
5%	Slope		Butterfly valve
	Connection		Check valve
DN200/150	Reduction		Actuator
	Container, flanged		

4.4 Abbreviations and units of measure

4.4.1 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
PEEK	Polyetheretherketone
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

4.4.2 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

4.4.3 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.

4.5 SI units

4.5.1 SI base units

Base size Name	Sign	SI base units 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

4.5.2 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

4.5.3 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 = 1'852 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 = 3'600 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 = 1'000 kg/m^3 1 kg/l = 1'000 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

4.6 Conversion tables

4.6.1 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			3'640		0.02	2.0×10^{-6}
3.0	3.0	1.2	35	33			2'426		0.03	3.0×10^{-6}
4.0	4.0	1.3	37	35			1'820			4.0×10^{-6}
5.0	5.0	1.39	42	38			1'300		0.05	5.0×10^{-6}
6.0	6.0	1.48	45.5	40.5			1'085		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	1'888	1'632	184	111	15.9	18.4	4.0	4.0×10^{-4}
600	600	79.2	2'832	2'448	276	162	10.6	26.9	6.0	6.0×10^{-4}
800	800	106	3'776	3'264	368	217	8.1	35	8.0	8.0×10^{-4}
1'000	1'000	132	7'080	4'080	460	415	6.6	68	10	1.0×10^{-3}
5'000	5'000	660	23'600	20'400	2'300	1'356	1.23	240	50	5.0×10^{-3}
10'000	10'000	1'320	47'200	40'800	4'600	2'713		481	100	1.0×10^{-2}
50'000	50'000	6'600	236'000	204'000	23'000	13'560		2'403	500	5.0×10^{-2}

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

4.6.2 Flow volume

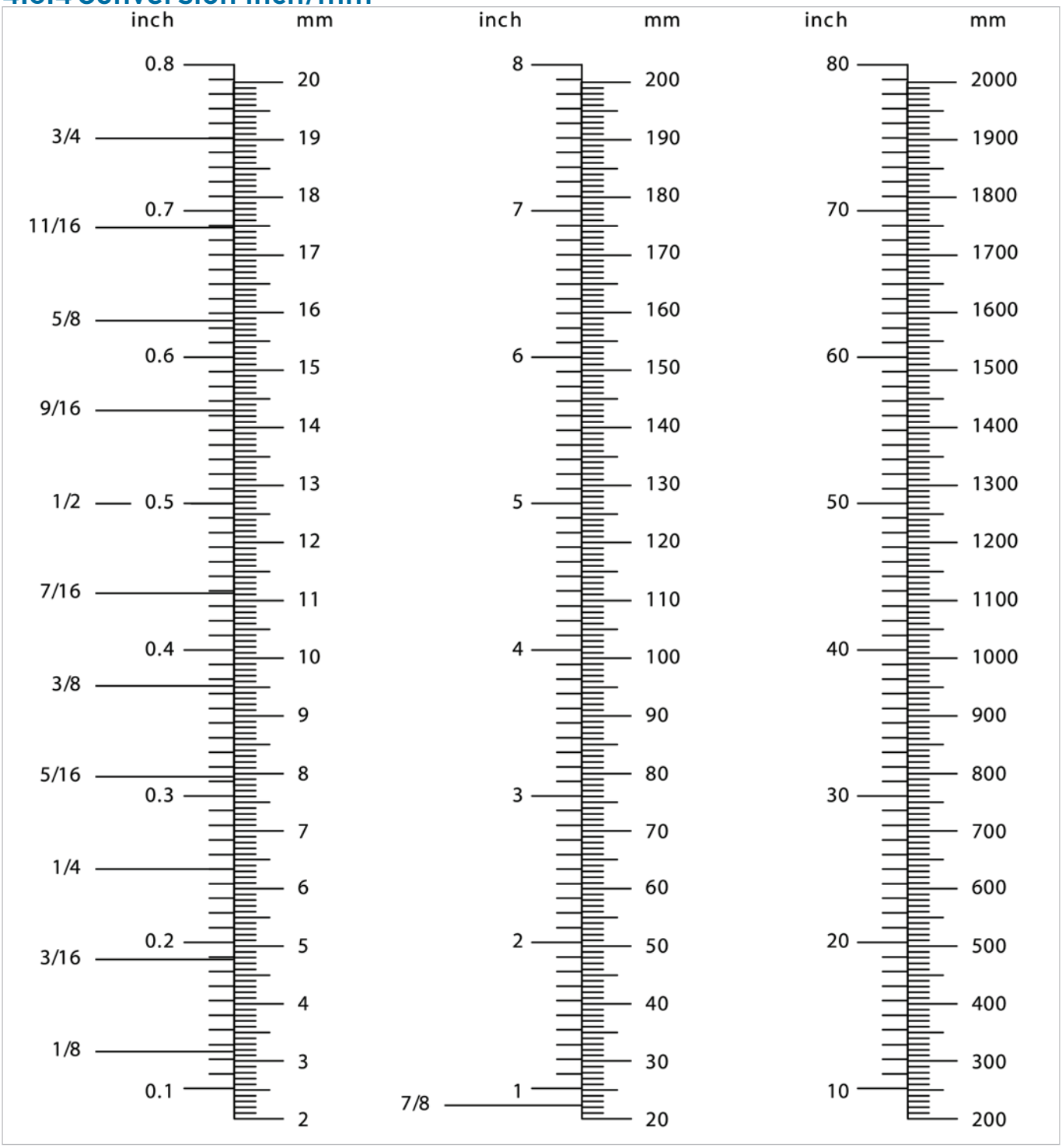
m^3/h	l/min	l/s	m^3/s	Imp. gal/min	US gal/min	cu. ft./h	cu. ft./s
1.0	16.67	0.278	$2.78 \cdot 10^{-4}$	3.667	4.404	35.311	$9.81 \cdot 10^{-3}$
0.06	1.0	0.017	$1.67 \cdot 10^{-5}$	0.220	0.264	2.119	$5.89 \cdot 10^{-4}$
3.6	60	1.0	$1.00 \cdot 10^{-3}$	13.20	15.853	127.12	$3.53 \cdot 10^{-2}$
3'600	60'000	1'000	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

4.6.3 Pressure and pressure heads

bar	kg/cm²	lbf/in²	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 • 10^{-4}	0.0014	0.0193	13.2 • 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 • 10^{-5}	10.2 • 10^{-6}	14.5 • 10^{-5}	9.87 • 10^{-6}	3.34 • 10^{-4}	10.2 • 10^{-5}	75.0 • 10^{-4}	29.5 • 10^{-5}	1.0

atm International standard atmosphere
kg/cm² Metric atmosphere

4.6.4 Conversion inch/mm



5 Approvals and standards

5.1 Approvals of products

Various approvals are in place for all piping systems from GF Industry & Infrastructure Flow Solutions. The most important approvals are listed in the following overview. The current status of the approvals can be obtained from an authorized GF Industry & Infrastructure Flow Solutions 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	Gaskets	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

5.2 Standards and guidelines

5.2.1 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

5.2.2 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
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

5.2.3 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
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

5.2.4 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
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

Standard	Name
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

6 Glossary and Explanations

Abrasion	Mechanical removal of material caused by solid particles in the medium.
Absorption	Uptake of substances or energy into a material.
Additives	Substances used to modify polymer or processing properties.
Adhesion	Bonding between different materials at an interface.
Aerosol	Fine liquid droplets dispersed in a gas.
Activated carbon	Highly porous carbon used for adsorption of organic compounds.
Aliphatic compounds	Non-aromatic hydrocarbons with chain structures.
Amorphous/semi-crystalline	Structural disorder or ordered crystalline regions in polymers.
Inorganic	Non-carbon-based substances (except specific carbon compounds).
AOX	Parameter for adsorbable organic halogen compounds in water.
Aromatic compounds	Ring-structured hydrocarbons with stable electron systems.
Service life	Time-dependent behaviour of materials under operating conditions.
Fire behaviour	Reaction of a material under heat exposure.
Flammability	Ignitability depending on structure and additives.
Chromic acid test	Test for stress cracking in polypropylene.
COD/CSB	Chemical oxygen demand.
DAB	German Pharmacopoeia.
Diffusion	Molecular transport driven by concentration gradients.
DIN 4102	Fire classification of building materials.
Density determination	Measurement of mass relative to volume.
DIBt	German Institute for Building Technology.
Water hammer	Short-term pressure peaks in piping systems.
Dielectric strength	Voltage at which an insulator becomes conductive.
DVS	Guidelines for plastic joining technologies.
Residual stresses	Internal stresses from processing or cooling.
Elasticity	Reversible deformation capability.
Elastomers	Lightly crosslinked, elastic polymers.
Elastic modulus	Material stiffness parameter.
Ex-zones	Areas with potentially explosive atmospheres.
FAR	Aviation fire-safety requirements.
FDA	US authority for food-contact materials.
Drop test	Impact resistance test.
Moisture absorption	Water uptake through diffusion in polymers.
Flame retardants	Additives that reduce flammability.
GRP pipes	Glass-fibre reinforced plastic pipes.
Glass	Amorphous solid without long-range order.
Glass transition	Temperature range where amorphous polymers soften.
Lubricants	Additives reducing melt friction.
Harmonised tolerances	Reduced dimensional tolerances for bonding.
Hydrolysis	Bond cleavage caused by water.
Hygroscopy	Ability to absorb moisture.
Ion exchangers	Polymer resins for water treatment.
Catalyst	Substance accelerating chemical reactions.
CFU (colony forming unit)	Microbiological count unit.
Hoop stress formula	Calculation of circumferential stress in pipes.
Notched impact strength	Energy absorption of a notched specimen.
Creep	Time-dependent deformation under constant load.
KTW	Hygiene guideline for plastics in drinking water.
Paint-compatible (silicone-free)	Free from paint-disturbing substances.
Long-term behaviour	Behaviour of a material over extended time periods.
Legionella	Bacteria that occur in warm-water systems.
Conductivity	Ability of a medium to conduct electricity.
Liner pipe	Thermoplastic inner pipe reinforced by GRP.
Solution	Homogeneous mixture of solvent and solute.
Solvent	Liquid capable of dissolving other substances.

Voids	Cavities caused by processing errors.
MAC value	Maximum workplace concentration.
Masterbatch	Additive concentrate in a carrier polymer.
Migration	Movement of low-molecular substances in polymers.
Microorganisms	Micro-scale living organisms.
Microtome section	Thin section for microscopic analysis.
Molecule/macromolecule	Chemical unit / long-chain polymer.
Monomer	Building block of polymer chains.
Recrystallisation	Formation of crystalline regions over time.
Nucleation	Initiation of crystal growth using additives.
Osmosis	Solvent movement through a semipermeable membrane.
OSU (Ohio State University)	Fire test measuring heat release (HR/HRR).
Oxidation	Loss of electrons by a substance.
Permeation	Penetration of a medium through a material.
Permeability	Material property determining degree of permeation.
Pigments	Insoluble colour particles.
Polarity	Electron distribution in molecules.
Polyethylene (PE)	Chemically resistant thermoplastic.
Polypropylene (PP)	Thermoplastic with high chemical resistance.
Polymer synthesis	Chemical processes forming polymers.
Pyrolysis	Thermal decomposition without oxygen.
Swelling	Volume change caused by absorption of substances.
Radical	Highly reactive intermediate.
Relaxations	Molecular motion processes.
Resistance factor	Factor indicating medium-related degradation.
SEM	Scanning electron microscopy.
Acid/base	Proton donors and acceptors.
Melt flow index (MFI)	Indicator of melt flow behaviour.
Bulk density	Mass-to-volume ratio of granules.
SDR	Ratio of outside diameter to wall thickness.
Shear strength	Resistance to shear loading.
Spherulite	Spherical crystalline polymer structure.
Stabilisers	Additives protecting polymers from degradation.
Sterilisation	Elimination of all microorganisms.
Radiation resistance	Resistance to UV or ionising radiation.
Tacticity	Arrangement of side groups in polymer chains.
Annealing	Reduction of internal stresses by heat.
Surfactants	Surface-active substances, can cause stress cracking.
Thermal stability	Resistance to thermal degradation.
Thermoplastics	Polymers deformable when heated.
TOC	Total organic carbon.
Toxicology	Effects of chemicals on organisms.
Crosslinking	Chemical linking of polymer chains.
Compatibility	Miscibility of polymer components.
Thermal conductivity	Ability to transfer heat.
Plasticisers	Additives increasing flexibility.
Water hardness	Content of alkaline earth ions.
Weathering resistance	Resistance to UV and environmental effects.
Tensile test	Test for mechanical tensile strength.
Creep rupture test	Long-term internal pressure test.

Pre-Insulated Solutions

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Pre-Insulated Solutions

COOL-FIT 2.0

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COOL-FIT 2.0

1.1 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.



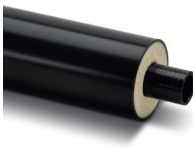
The COOL-FIT 2.0 system is a completely pre-insulated plastic piping system for secondary refrigerant circuits run with water, brine, or Glycol based solutions.

The COOL-FIT 2.0 system is suitable for use in applications like:

Comfort Cooling	Safe Cooling
• Air conditioning	• Data centers
• Airports	• Hotels
• Apartments	• Shopping centers
• Hospitals	• Sports center / leisure center
• Industrial buildings	• Universities
	• Bank / public institutions

1.2 System Specification

1.2.1 COOL-FIT 2.0

Specification		COOL-FIT 2.0	COOL-FIT 2.0F	COOL-FIT 2.0 Push System
				
Materials[1]	Pipe	PE100	PE100	Multilayer composite pipe PE-RT/Al/PE-RT
	Insulation	GF-HE foam, halogen free, closed-cell	GF-HE foam, halogen free, closed-cell	Pipe: EPDM foam Fitting: EPP foam
	Outer jacket	Pipe HDPE	Flame retardant - GF-FR	Stainless steel polyester fabric
		Fitting GF-HE		TPE
Size [2]		d32DN25 – d140DN125	d32DN25 – d140DN125	d16DN12 - d32DN25
Connection technology		Electrofusion	Electrofusion	Push-in connector
Nominal pressure[3]		16 bar, SDR11	16 bar, SDR11	16 bar
Temperature	Medium	0 °C to +60 °C	0 °C to +60 °C	+5 °C to +60°C
	Environment	0 °C to +55 °C	0 °C to +55 °C	+0 °C to +55°C
Insulation	Thermal conductivity $\lambda_{10°C}$ PE Inner pipe HE Foam PE jacket GF-FR jacket Multilayer composite pipe EPDM Foam	 0.38 W/mK 0.022 W/mK 0.38 W/mK	 0.38 W/mK 0.026 W/mK 0.15 W/mK	 0.43 W/mK 0.037 W/mK
	Density	≥ 70 kg/m³	≥ 70 kg/m³	50-60 kg/m³
	Foam cell size	max. Ø 0.5 mm	max. Ø 0.5 mm	
	Nominal thickness	22 mm	22 mm	13 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	Black
Weight (without medium)	Pipe d32	1.12 kg/m	1.06 kg/m	0.62 kg/m
	Pipe d110	5.5 kg/m	5.39 kg/m	
Oxygen diffusion at ≤ 5°C	ISO 17455	≤ 0.083 mg/(m² d)	Oxygen diffusion tight acc. DIN 4726	Oxygen diffusion tight acc. DIN 4726
Fire classification [4]	EN 13501-1	E	B - s2, d0	C - s2, d0
Environment	Stability	Moisture and vapor-tight	Moisture and vapor-tight	Moisture and vapor-tight
	Wheather/UV resistance	For indoor use	For indoor use	For indoor use
	Ozone Depletion Potential	Zero	Zero	Zero

Standards and Guidelines	DIN EN 12201-2	Plastics piping systems for water supply, and for drainage and sewerage under pressure - Polyethylene (PE)	
	DIN EN 15494	Plastics piping systems for industrial applications - Polybutene (PB), polyethylene (PE) and polypropylene (PP) - Specifications for components and the system - Metric series	
	DIN 8074	Polyethylene (PE) - Pipes PE 80, PE 100 - Dimensions	
	DIN 8075	Polyethylene (PE) - Pipes PE 80, PE 100 - General quality requirements, testing	
	ISO 7	Threaded Joints	
		Industrial valves ...	
	EN ISO 16135	– Ball valves made of thermoplastics	
	EN ISO 16136	– Butterfly valves made of thermoplastics	
	EN ISO 16137	– Backflow protection made of thermoplastics	
	EN ISO 16138	– 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)	eco 1	eco 2

1) All three materials are firmly bonded together. Does not apply to COOL-FIT 2.0 Push System.
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) The pipes were tested according to DIN EN 13823. Additional information in chapter "Fire behavior and fire prevention measures".

1.2.2 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 PE100, 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 179-1/1eA
Charpy notched impact strength at -40 ° C	13	kJ/m^2	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: $-(CH_2-CH_2)n$. PE 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 Industry & Infrastructure Flow Solutions, or contact the person responsible at GF Industry & Infrastructure Flow Solutions 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.

1.3 Technical Details

1.3.1 COOL-FIT 2.0

COOL-FIT 2.0 pipe

COOL-FIT 2.0 pipes are made from PE100. 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

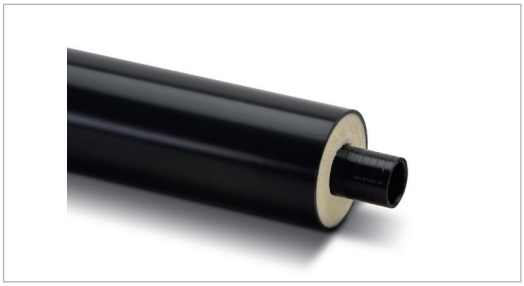
d	Nominal outer diameter of the PE pipe
d_i	Nominal inside diameter of the pipe
D	Nominal outside diameter of the outer PE jacket
e, e1	Nominal wall thickness

COOL-FIT 2.0F 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

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.



Reducer as an example

Type B:

Spigot fitting with free ends for pipe-to-fitting electrofusion with COOL-FIT 2.0 electrofusion fittings.



Reducer 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.



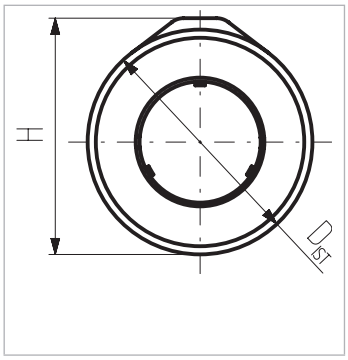
Angle marking

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).

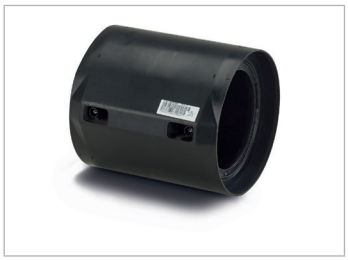
The connection of a COOL-FIT 2.0 fitting Type A and Type B is also possible.

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.



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).



Combination of T90° and Reducer

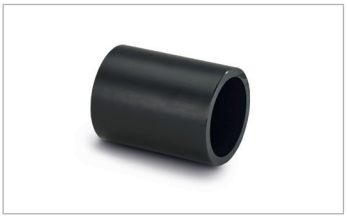
If a reduction step should be done after the branch of a T90°, either a COOL-FIT 2.0 T90° reduced, or a COOL-FIT 2.0 T90° reduced/ equal connected to a reducer should be used.

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

COOL-FIT 2.0 barrel nipple

COOL-FIT 2.0 barrel nipple serves as a compact direct connector for type A fittings.



COOL-FIT 2.0 Sliding coupler kit

The sliding coupler kit is a radially insertable element for connecting two fixed pipe spigots.



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.



Sealant

The silicone-free sealant is used to join the EPDM insulation of Weld-in ports to the COOL-FIT pipes.



Y-Cable kit for COOL-FIT Fixpoints

Cuts the welding time by 50% and includes the required welding adapters.

Article no.: 790 156 032.



Tangit Rapid cement

Cement and cement gun for attaching the COOL-FIT 2.0F fixed point sets to the outer casing of the pipe.

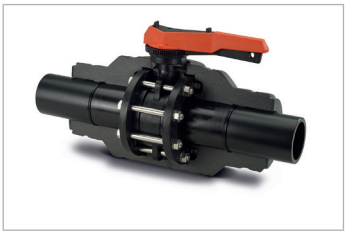


COOL-FIT 2.0 valves

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, e.g. Belimo.

Interfaces:

F03 and F05 for ball valves d32DN25 – d63DN50

F07 for all ball- and butterfly valves d75DN65 – d90DN80

Belimo actuators

The following Belimo actuators are compatible with our COOL-FIT 2.0 valves.

SR..-R type

- Actuator for COOL-FIT 2.0 ball valve type 546 Pro, bare shaft, DN25 to DN50
- F05 interface with square turned 45°: wrench size 11mm / shaft projection 11mm
- Required torque: max. 20Nm
- Torque of actuator: 20Nm

Actuator	Adapter	Nominal voltage	Control	Emergency function	Duration	Class	Auxiliary switch
SR230A-R	ZSV-11	AC 100...240 V	Open/close, 3 point	No	90 s / 90°	IP 54	No
SR230P-R	ZPV-11	AC 100...240 V	Open/close, 3 point	No	90 s / 90°	IP 66/67	No
SR230P-SR-R	ZPV-11	AC 230 V	Continous	No	90 s / 90°	IP 66/67	No
SR24A-MF-R	ZSV-11	AC/DC 24 V	Continous	No	90 s / 90° (veränderbar 90...350 s)	IP 54	No
SR24A-MP-R	ZSV-11	AC/DC 24 V	Continous, MP-Bus	No	90 s / 90° (veränderbar 90...350 s)	IP 54	No
SR24A-R	ZSV-11	AC/DC 24 V	Open/close, 3 point	No	90 s / 90°	IP 54	No
SR24P-MF-R	ZPV-11	AC/DC 24 V	Continous	No	90 s / 90° (changeable 90...350 s)	IP 66/67	No
SR24P-MP-R	ZPV-11	AC/DC 24 V	Continous, MP-Bus	No	90 s / 90° (changeable 90...350 s)	IP 66/67	No
SR24P-R	ZPV-11	AC/DC 24 V	Open/close, 3 point	No	90 s / 90°	IP 66/67	No
SR24P-SR-R	ZPV-11	AC/DC 24 V	Continous	No	90 s / 90°	IP 66/67	No
SRF24A-R	ZSFV-11	AC/DC 24 V	Open/close	Yes	75 s / 90°	IP 54	No
SRF24A-S2-R	ZSFV-11	AC/DC 24 V	Open/close	Yes	75 s / 90°	IP 54	2 x EPU
SRFA-R	ZSFV-11	AC 24...240 V / DC 24...125 V	Open/close	Yes	75 s / 90°	IP 54	No
SRFA-S2-R	ZSFV-11	AC 24...240 V / DC 24...125 V	Open/close	Yes	75 s / 90°	IP 54	2 x EPU

GR..-R type

- Actuator for COOL-FIT 2.0 ball valve type 546 Pro, DN65 and DN80
- F07 interface with square turned 45°: wrench size 11mm / shaft projection 27mm
- Required torque: max. 21Nm (DN65) / max. 35Nm (DN80)
- Torque of actuator: 40Nm

Actuator	Adapter	Nominal voltage	Control	Emergency function	Duration	Class	Auxiliary switch
GR230A-R	ZGV-16 + ZGI-004	AC 100.240 V	Open/close	No	150 s / 90°	IP 54	No
GR24A-MF-R	ZGV-16 + ZGI-004	AC/DC 24 V	Continous	No	90 s / 90° (changeable 75...270 s)	IP 54	No
GR24A-MP-R	ZGV-16 + ZGI-004	AC/DC 24 V	Continous, MP-Bus	No	90 s / 90° (changeable 75...270 s)	IP 54	No
GR24A-R	ZGV-16 + ZGI-004	AC/DC 24 V	Open/close	No	150 s / 90°	IP 54	No

Note: For DN65: motorization with 20 Nm via special interface on request

PR.. type

- Actuator for COOL-FIT 2.0 butterfly valve kit type 567, bare shaft, DN100
- F07 interface with square turned 45°: wrench size 14mm / shaft projection 16mm
- Required torque: max. 160Nm
- Torque of actuator: 160Nm

Actuator	Adapter	Nominal voltage	Control	Emergency function	Duration	Class	Auxiliary switch
PRCA-BAC-S2-T	ZPR06	AC 24...240 V / DC 24...125 V	Continous, BACnet MS/TP, Modbus RTU, MP-Bus	No	35 s / 90° (changeable 30...120 s)	IP 66/67	2 x EPU
PRCA-S2-T	ZPR06	AC 24...240 V / DC 24...125 V	Open/close, 3 point	No	35 s / 90° (changeable 30...120 s)	IP 66/67	2 x EPU
PRKCA-BAC-S2-T	ZPR06	AC 24...240 V / DC 24...125 V	Continous, BACnet MS/TP, Modbus RTU, MP-Bus	Yes (selectable positon 0...100%)	35 s / 90° (changeable 30...120 s)	IP 66/67	2 x EPU

SY4.. type

- Actuator for COOL-FIT 2.0 butterfly valve kit type 567, bare shaft, DN125
- F07 interface with square turned 45°: wrench size 14mm / shaft projection 16mm
- Required torque: max. 200Nm
- Torque of actuator: 400Nm

Actuator	Adapter	Nominal voltage	Control	Emergency function	Duration	Class	Auxiliary switch
SY4-230-3-T	ZSY-005	AC 230 V	Open/close, 3 point	No	21 s / 90°	IP67	2 x EPU
SY4-230-MF-T	ZSY-005	AC 230 V	Continous	No	16 s / 90°	IP67	2 x EPU
SY4-230-MP-T	ZSY-005	AC 230 V	Continous, MP-Bus	No	16 s / 90°	IP67	2 x EPU
SY4-230-SR-T	ZSY-005	AC 230 V	Continous	No	16 s / 90°	IP67	2 x EPU
SY4-24-3-T	ZSY-005	AC/DC 24 V	Open/close, 3 point	No	30 s / 90°	IP67	2 x EPU
SY4-24-MF-T	ZSY-005	AC/DC 24 V	Continous	No	23 s / 90°	IP67	2 x EPU
SY4-24-MP-T	ZSY-005	AC/DC 24 V	Continous, MP-Bus	No	23 s / 90°	IP67	2 x EPU
SY4-24-SR-T	ZSY-005	AC/DC 24 V	Continous	No	23 s / 90°	IP67	2 x EPU

SY4.. type

- Actuator for COOL-FIT 4.0 butterfly valve kit type 567, DN150 and DN200 (for use in chilled water applications from 0°C - 60°C)
- F07 interface with square turned 45°: wrench size 17mm / shaft projection 19mm
- Required torque: max. 360Nm
- Torque of actuator: 400Nm

Actuator	Adapter	Nominal voltage	Control	Emergency function	Duration	Class	Auxiliary switch
SY4-230-3-T	ZSY-013	AC 230 V	Open/close, 3 point	No	21 s / 90°	IP67	2 x EPU
SY4-230-MF-T	ZSY-013	AC 230 V	Continous	No	16 s / 90°	IP67	2 x EPU
SY4-230-MP-T	ZSY-013	AC 230 V	Continous, MP-Bus	No	16 s / 90°	IP67	2 x EPU
SY4-230-SR-T	ZSY-013	AC 230 V	Continous	No	16 s / 90°	IP67	2 x EPU
SY4-24-3-T	ZSY-013	AC/DC 24 V	Open/close, 3 point	No	30 s / 90°	IP67	2 x EPU
SY4-24-MF-T	ZSY-013	AC/DC 24 V	Continous	No	23 s / 90°	IP67	2 x EPU
SY4-24-MP-T	ZSY-013	AC/DC 24 V	Continous, MP-Bus	No	23 s / 90°	IP67	2 x EPU
SY4-24-SR-T	ZSY-013	AC/DC 24 V	Continous	No	23 s / 90°	IP67	2 x EPU

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“	1'000	276	119
25	20	¾“	1'000	161	156
32	25	1“	1'000	68	192
40	32	1 ¼“	1'500	233	252
50	40	1 ½“	2'000	396	312
63	50	2“	2'000	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.



COOL-FIT 2.0 Fixed point

The fixed point is used to direct pipe movement or retain forces from pipe weight at risers. The electrofusion welding tapes allow a permanent connection and transmit occuring forces between pipe and clamp.



COOL-FIT 2.0 Fixed point for high forces

The fixpoint placed on the media pipe alows the transmition of higher forces. The fixed point is placed between two electrofusion fittings.



COOL-FIT 2.0 Weld-In Port

The COOL-FIT Weld-in port significantly increases the flexibility by enabling the branching-off on already laid, unfilled and dry COOL-FIT pipes in dimensions d63-d225.

The product range of fittings includes Weld-in ports with transitions to female threads, as well as Weld-in ports that allow transitions within the GF piping portfolio.

The EPDM soft foam insulation supplied with the Weld-in ports is designed to ensure a condensation-free connection to the COOL-FIT pipe, and to insulate the ports up to the corresponding interface.



Connection type, material	Size	Purpose
Female thread Rp, PE/Brass	½", ¾", 1"	Installation of instruments, probes, sensors as well as transition to other piping systems
iFIT, PE/Brass	16/20, 25/32	Transition from COOL-FIT 2.0 and COOL-FIT 4.0 to COOL-FIT 2.0 Push System
Sanipex MT, PE/Brass	32	Transition from COOL-FIT 2.0 and COOL-FIT 4.0 to GF Sanipex MT
PE spigot SDR11	32, 40, 50	Connection within COOL-FIT 2.0 and COOL-FIT 4.0

The Weld-in ports can be used with pipes COOL-FIT 2.0, COOL-FIT 2.0F, COOL-FIT 4.0 and COOL-FIT 4.0F

Jointing

After the controlled local tapping of jacket and inner pipe of the respective COOL-FIT pipe, the welded joint is made.

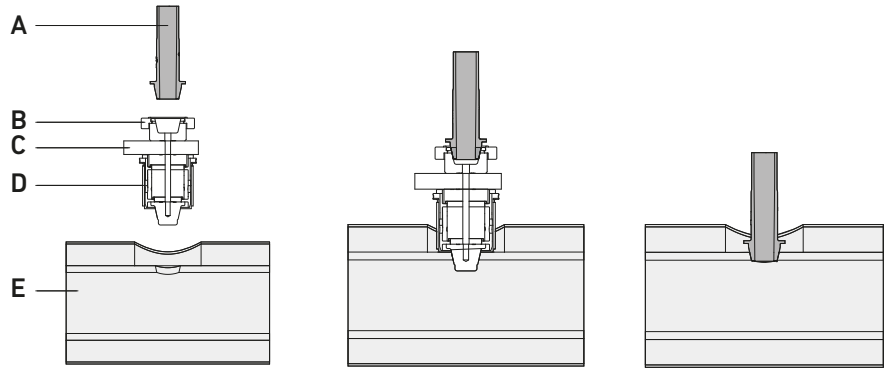
In the cone welding process used here, a modified version of heating element socket welding, the inner pipe of the COOL-FIT pipe and the Weld-in port are welded in an overlapping material-to-material bond without the use of additional filler materials.

The welding surfaces of the pipe and the fitting are heated to welding temperature on a conical socket- or spigot-shaped heating element and then joined together.

The dimensionally matched geometry of the components ensures the welding pressure during joining and a homogeneous joint.

Jointing principle

Components	Heating	Finished joint



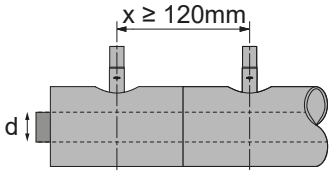
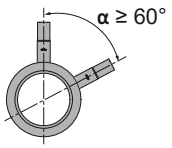
A Weld-in port
B Heating bush
C Fusion tool
D Heating spigot
E COOL-FIT Pipe

After the fusion process, the EPDM insulation is mounted to the Weld-in port. Bonding of insulation the COOL-FIT pipe is done using the COOL-FIT sealant.

Distance of COOL-FIT Weld-in ports and pressure de-rating of main pipes

On positioning the Weld-in ports on the COOL-FIT pipe, the following distances must be taken into account:

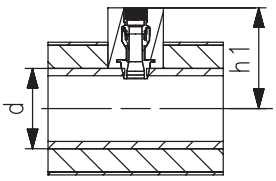
- Distances between Weld-in ports along the pipe axis.
- Arrangement around the circumference of the pipe.

		Ports with metal insert	Ports with PE spigot
Distances along pipe axis*		x ≥ 120 mm ► no pressure de-rating of main pipe	x ≥ 2 * d main pipe ► no pressure de-rating of main pipe or x < 2 * d main pipe ► pressure de-rating factor of main pipe of 0.8
Arrangement around circumference		x ≥ 0 mm (along pipe axis), α ≥ 60° ► no pressure de-rating of main pipe	

* The minimum distance due to the tool dimensions is 120 mm.

Heigth of Weld-in ports ½"-1" towards the pipe axis

Heigth h1 [mm]/d [mm]	d63	d75	d90	d110	d140	d160	d225
½" Rp	117	123	130	140	155	165	198
¾" RP	117	123	130	140	155	165	198
1" Rp	118	124	131	141	156	166	199



1.3.2 COOL-FIT 2.0 Push System

COOL-FIT 2.0 Push System pipe

Inside the multilayer composite pipes of the COOL-FIT 2.0 push system is a medium-bearing layer made of polyethylene (PE-RT). The outer layer, which protects the pipe from mechanical loads, is also made of PE-RT. In between is a longitudinally butt-welded aluminum carrier pipe, which is permanently bonded to the other two layers by means of bonding agents - also PE-based.

The EPDM insulation has a thermal conductivity of 0.037W/mK at 10°C and is covered with an additional polyester/stainless steel mesh, which prevents wrinkling and protects the pipe from mechanical stress.

The pipes are available in 5m rod and 25m roll.

Pipe size	Inner Pipe	Inner Pipe	Outer jacket	Weight		Volume	Insu-lation thick-ness	Heat transfer coeffi-cient (U)	Fire load	Ben-ding radius R with ben-ding spring	Ben-ding radius R with tool
				Weight empty	Weight with water						
(mm)	d x e (mm)	d_i (mm)	D x e1 (mm)	(kg/m)	(kg/m)	(l/m)	(mm)	(W/m K)	(kWh/m)	5x d (mm)	3,5 x d (mm)
d16/44	16 x 2	12	44 x 1	0.299	0.412	0.113	13	0.20	0.93	80	56
d20/48	20 x 2	16	48 x 1	0.354	0.556	0.201	13	0.23	1.13	100	70
d25/54	25 x 2.5	20	54 x 1	0.521	0.836	0.314	13.5	0.26	1.60	200	98
d32/61	32 x 3	26	61 x 1	0.621	1.152	0.523	13.5	0.31	2.28		112

d	Nominal outer diameter of the PE pipe
d_i	Nominal inside diameter of the pipe
D	Nominal outside diameter of the outer jacket
e, e1	Nominal wall thickness

COOL-FIT 2.0 Push System Fittings

General

The Push System fittings are made of high-performance polyphenylsulfone (PPSU) plastic. This material has proven itself for fittings in building services and is characterized above all by excellent corrosion resistance and low incrustation. The Push System fittings have a high degree of robustness, i.e. special impact strength and impact resistance.

To further increase mechanical strength, the iFIT adapters are additionally protected by a glass-fiber-reinforced polyamide (PA-GF30).

The insulation half-shells supplied fit onto the Push System fittings and can be closed quickly and easily with integrated tabs and hooks.



Connection

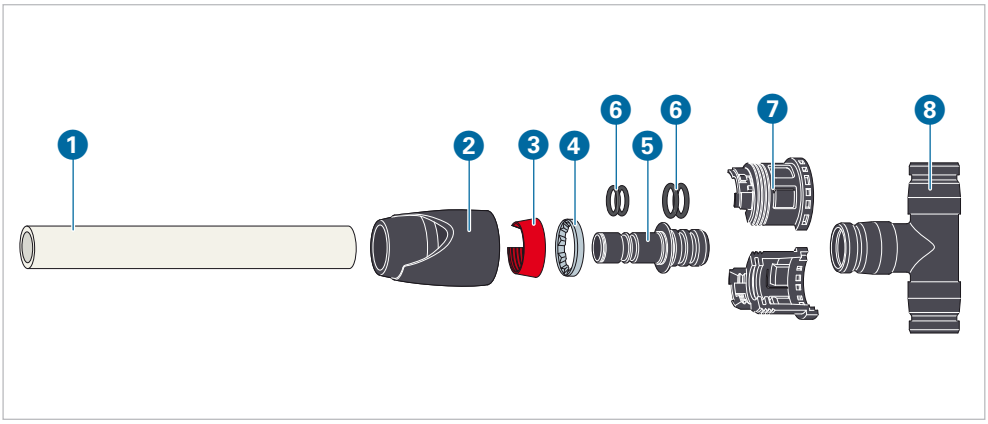
The connection is made using adapter module technology, a push system that requires few tools and no electrical power. It is possible to work across dimensions via the module.

The adapters are pushed onto the tube and module. A viewing window and "click" sounds allow the correct assembly to be checked during the installation process.

Push fitting

An iFIT tool is used for the processing and it is done manually. The iFIT push fitting guarantees a secure, fast and detachable connection. The modules are reusable. The adaptors can only be used once. This also applies to adaptors if the clicking action was not completed.

An iFIT push fitting consists of several components:



iFIT push fitting
1 Multilayer pipe

Adaptor
2 Adaptor housing
3 Clamping ring
4 Toothed ring
5 Insert
6 O-rings (EPDM)
7 Half shells
8 Module made of PPSU or low-lead, dezincification-resistant brass

The iFIT adaptor is plugged into a chamfered pipe end. The push fitting is then closed by clicking the module into the adaptor.

Inadmissible system connections

! NOTE! Damage due to inadmissible system connections!
→ When using the COOL-FIT 2.0 Push System, **use** only multilayer composite pipes from the COOL-FIT 2.0 Push System or iFIT assortment.

Components

COOL-FIT-2.0 Push System coupler

The sockets are used for straight connection of pipes.



COOL-FIT 2.0 Push System 90° elbow

The 90° elbows can be used to change the direction of the pipe when space is limited and it is not possible to bend the pipe.



COOL-FIT 2.0 Push System, T90° equal and T90° reduced

The T90° equal and T90° reduced are supplied with two adapters and compression rings only. At the outlet, a choice can be made between two dimensions in any case. Additional adapters must be ordered separately.



COOL-FIT 2.0 Push System reducer

By means of the COOL-FIT 2.0 Push System reducer, the flow of the output dimension can be reduced by up to 2 dimensional sizes.



COOL-FIT 2.0 Push System ball valve

The ball valves suitable for the COOL-FIT 2.0 Push System can be connected directly to the pipe via the adapters through a push fitting connection.



COOL-FIT 2.0 Push System flow control valve

The COOL-FIT 2.0 Push System volume flow controller, based on the TacoSetter, can be used to balance a wide variety of systems such as fan coils.



COOL-FIT 2.0 Transition fitting PE/iFIT

The COOL-FIT 2.0 transition fitting PE/iFIT provides a direct connection option from COOL-FIT 2.0 to the COOL-FIT 2.0 Push System.



1.3.3 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.



Weld-In Port installation tool

Using the installation tool, the different COOL-FIT Weld-in ports can be installed safe, reliable, reproducible and quick.

Drilling of jacket, drilling of inner pipe as well as the subsequent welding joint is supported in a clever way.

Depending on the need in Weld-in ports to be installed, the tool is available in 230V as well as in 110V in different equipment variants.



iFIT tool set

iFIT tool set enables a fast and safe installation of COOL-FIT 2.0 Push System components.



1.4 Dimensioning and Design

The following section describes only the COOL-FIT specific planning fundamentals. For prevailing information see general GF Planning Fundamentals.

1.4.1 General information about the dimensioning and installation of plastic piping

Plastics have different physical characteristics to metals. When designing and installing thermoplastic piping systems, this needs to be taken into account. Although PE and COOL-FIT 2.0 are very robust systems, care should be taken to avoid damage during handling and transportation.

For over 50 years, GF Industry & Infrastructure Flow Solutions 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 contact your local GF Industry & Infrastructure Flow Solutions representative. Additional information is available on the official GF Industry & Infrastructure Flow Solutions website.

1.4.2 COOL-FIT 2.0 pressure-temperature diagram

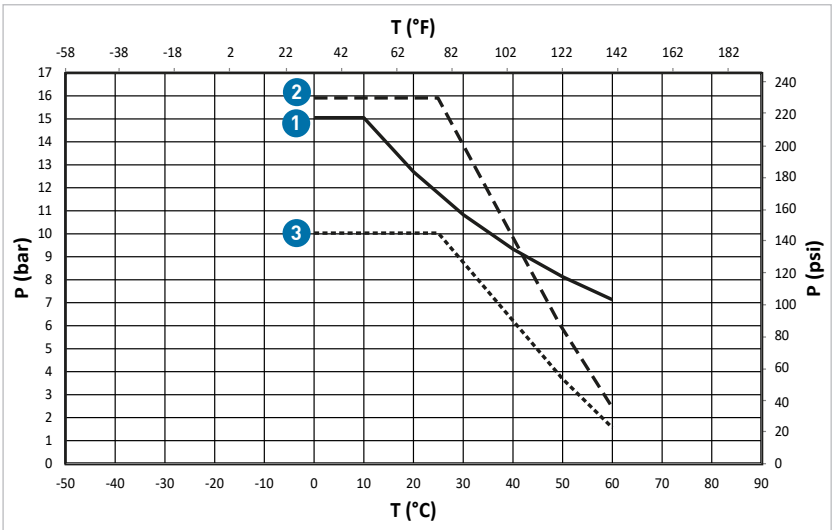
The pressure resistance for thermoplastic pipe for water is always specified at +20 °C. At higher temperatures allowance must be made for a lower maximum operating pressure.

The graphs show 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.

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 Industry & Infrastructure Flow Solutions representative.

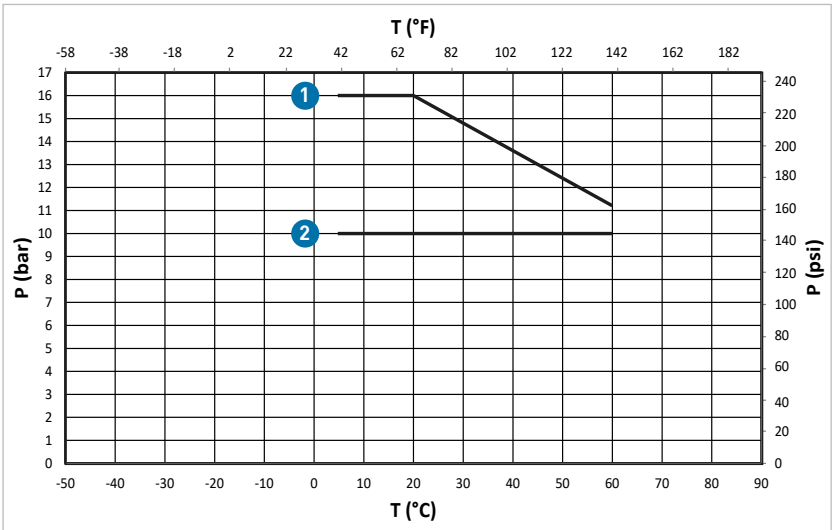


P Allowable pressure (bar, psi)
T Temperature (°C, °F)
C Safety factor
1 COOL-FIT pipe and fitting C=1.6, SDR11
2 COOL-FIT 2.0 ball valve PN16
3 COOL-FIT butterfly valve PN10

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.

Pressure/temperature limits for COOL-FIT 2.0 Push System fittings, pipe, valves – water coolant

Limits for COOL-FIT 2.0 Push System: 25-year values (with water as the coolant).



P Allowable pressure (bar, psi)
T Temperature (°C, °F)
1 COOL-FIT 2.0 Push System pipe, fitting and ball valve
2 COOL-FIT 2.0 Push System Flow control valve

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.

For COOL-FIT 2.0 Push System, no reduction factor is necessary.

Reduction factors[1]	COOL-FIT 2.0 Pipe and Fitting
Inorganic brine solutions	F = 1
Organic salt solutions	F = 1
Glycol solutions (max. 50 %)	F = 1.1

[1] Valid for materials HD-PE, EPDM, PVC-U, metals

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 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 Industry & Infrastructure Flow Solutions.

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".

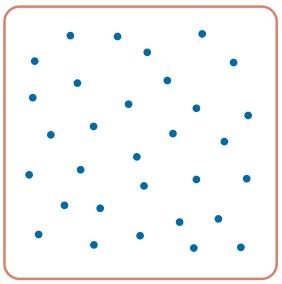
1.4.3 Condensation assessment and prevention

Introduction

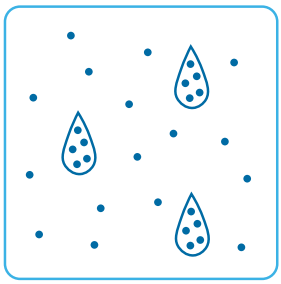
Piping in cooling applications is funeral to condensation due to its chilled media and therefore may need to contain preventive measures. Various factors influence the occurrence of condensation which, therefore, need to be considered during the planning stage.

Condensation occurs when humid air faces a cold surface such as a chilled pipe and releases some of its moisture as water droplets onto the pipe surface. This is since cold air cannot contain as much humidity as warm air. The state when condensation occurs is named dew point and is the temperature when air becomes saturated with water vapor.

Dew point



Molecules of water in warm air



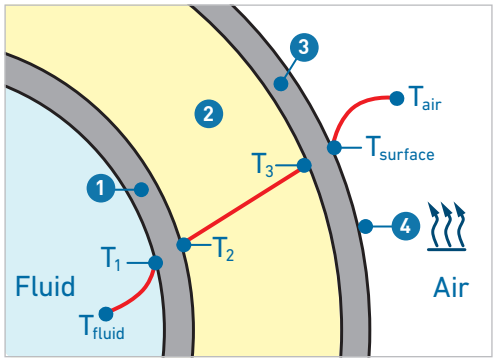
Molecules of water in cold air.
Excess water condenses into droplets.

Thus, if the temperature of a surface falls below the dew point temperature, condensation occurs. The dew point temperature (T_{dp}) depends on the ambient temperature (T_{air}) plus the ambient relative humidity (rH) and can be calculated with these two variables.

A high relative humidity increases the dew point temperature which raises the probability for condensation.

Next to the dew point temperature, also the surface temperature of the COOL-FIT system can be calculated by considering following information:

- material insulation properties (λ),
- dimensional information,
- media temperature (T_{fluid}),
- emittance (radiation and convection)



1 $\lambda_{inner\ pipe}$
2 $\lambda_{insulation}$
3 λ_{jacket}
4 ε_{mitt}

Emittance (radiation and convection) describes the dissipation of energy to the surrounding environment. Especially the convection is an important factor which is largely dependent on the air movement on the outer surface. Therefore, the air movement around the pipe surface is a critical variable to be considered during condensation assessment.

⚠ A low air movement lowers the convection and thus raises the risk of condensation occurrence.

Basic assessment

A calculation can support the assessment of the situation. The COOLING Tool-Box module “Condensation” uses a simplified calculation method for a rough assessment, see „1.4.15 COOLING Tool-Box“ on page 432. As pipe specific information, i.e., insulation and dimensional properties, are already set, representative environmental parameters such as air temperature (T_{air}), relative humidity (rH), air velocity (v_{air}) and media temperature (T_{fluid}) need to be provided.

The COOLING Toolbox calculates and matches the dew point and surface temperature and gives out a result per dimension:

√ **Calculation**

- $T_{dp} > T_{surface}$ = condensation
  ↳ dew point T_{dp} above the surface temperature result in condensation.
- $T_{dp} < T_{surface}$ = no condensation
  ↳ dew point T_{dp} below the surface temperature results in no condensation.

⚠ This calculation does only a simple matching between the 2 calculated temperatures. In case of a small deviation or harsh and ambiguous environments, a basic assessment should not be the only basis.

Advanced assessment

In case of a harsh or ambiguous environment, an advanced assessment is needed. Additionally, it needs to be considered that a basic calculation can only support the assessment of the occurrence of condensation but does not give information about the condensation intensity.

Additionally, for the determination of the input variables, it must be considered that the environment undergoes fluctuations and individual situations might deviate.

Factors influencing ambient temperature and humidity:

- local climate variances
- weather variances (rainy-sunny periods, day-night rhythm)
- microclimate in enclosed spaces
- influences in proximity of the pipe routing (another piping, cold walls, ...)
- opening/closing of doors to areas with other conditions

Deviations between input and actual values:

- tolerances in measured air movement
- tolerances in media temperature

Therefore, the worst-case conditions must be taken into account, and each area must be evaluated separately.

Certain environmental conditions might be so harsh that a technical solution without condensation might be not feasible or economical. These are typically,

- spaces which are concealed and have no air movement (pipe trays, intermediate ceilings)
- spaces with extreme relative humidity

In such situations additional measures, such as increasing air movement or lowering relative humidity might be inevitable.

⚠ For an advanced evaluation - Get support by your local GF Industry & Infrastructure Flow Solutions representative.

1.4.4 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).

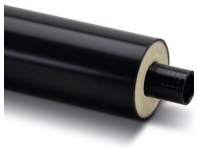
Smoke release:

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

	COOL-FIT 2.0	COOL-FIT 2.0F	COOL-FIT 2.0 Push System	COOL-FIT 2.0/ mineral wool [1)]
				
EN 13501-1*	E	B – s2, d0	C – s2, d0	$A2_L$

[1)] Type: Rockwool 800

* The pipes were tested acc to DIN EN 13823

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
d/D (mm)	16/44	20/48	25/54	32/61				
Thermal load COOL-FIT 2.0 Push System pipes (kWh/m)	0.93	1.13	1.60	2.28				

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.

Firestop collars/Fire sealing

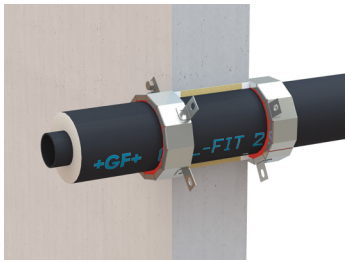
When pipes are installed through fire-rated assemblies, whose reliable functioning must not be affected, firestop collars that comply with local requirements and legislation must be used.

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

Info | Shop

qr.hilti.com/r3069

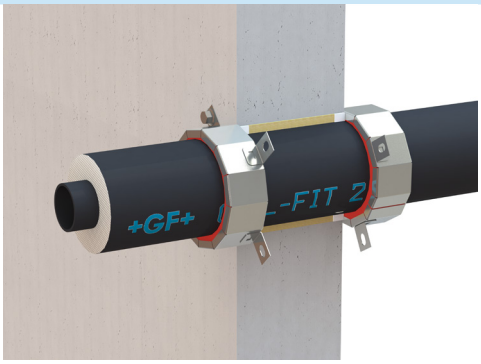
Hilti CFS-C P

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

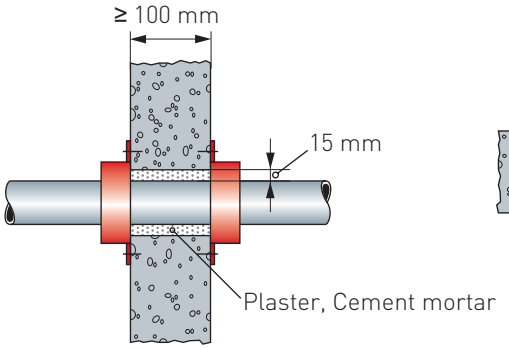
* here exclusively gap sealing with non-combustible construction materials

Annular gap sealing

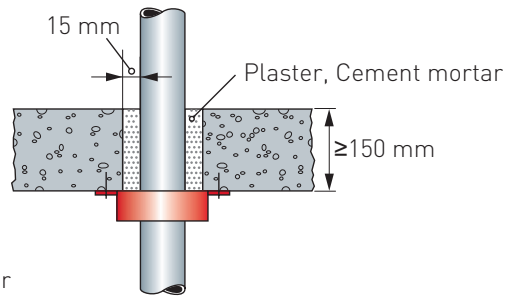
For the installation situations there are several options for sealing gaps against smoke gas.

Gap sealing with non-combustible construction materials:

Rigid wall

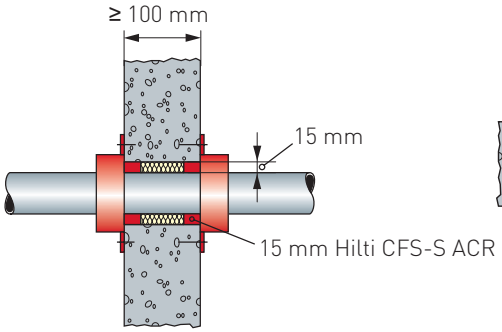


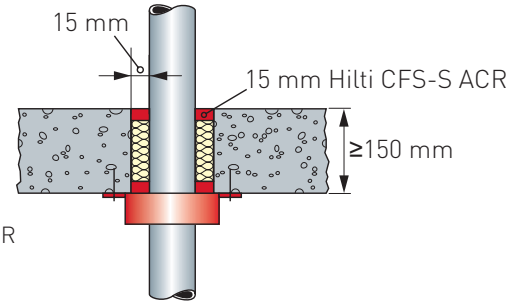
Rigid floor



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



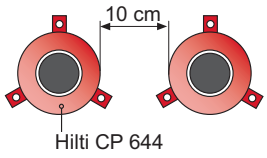


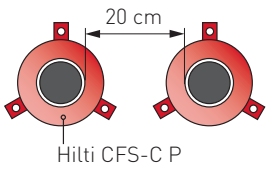
Distance regulations

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	

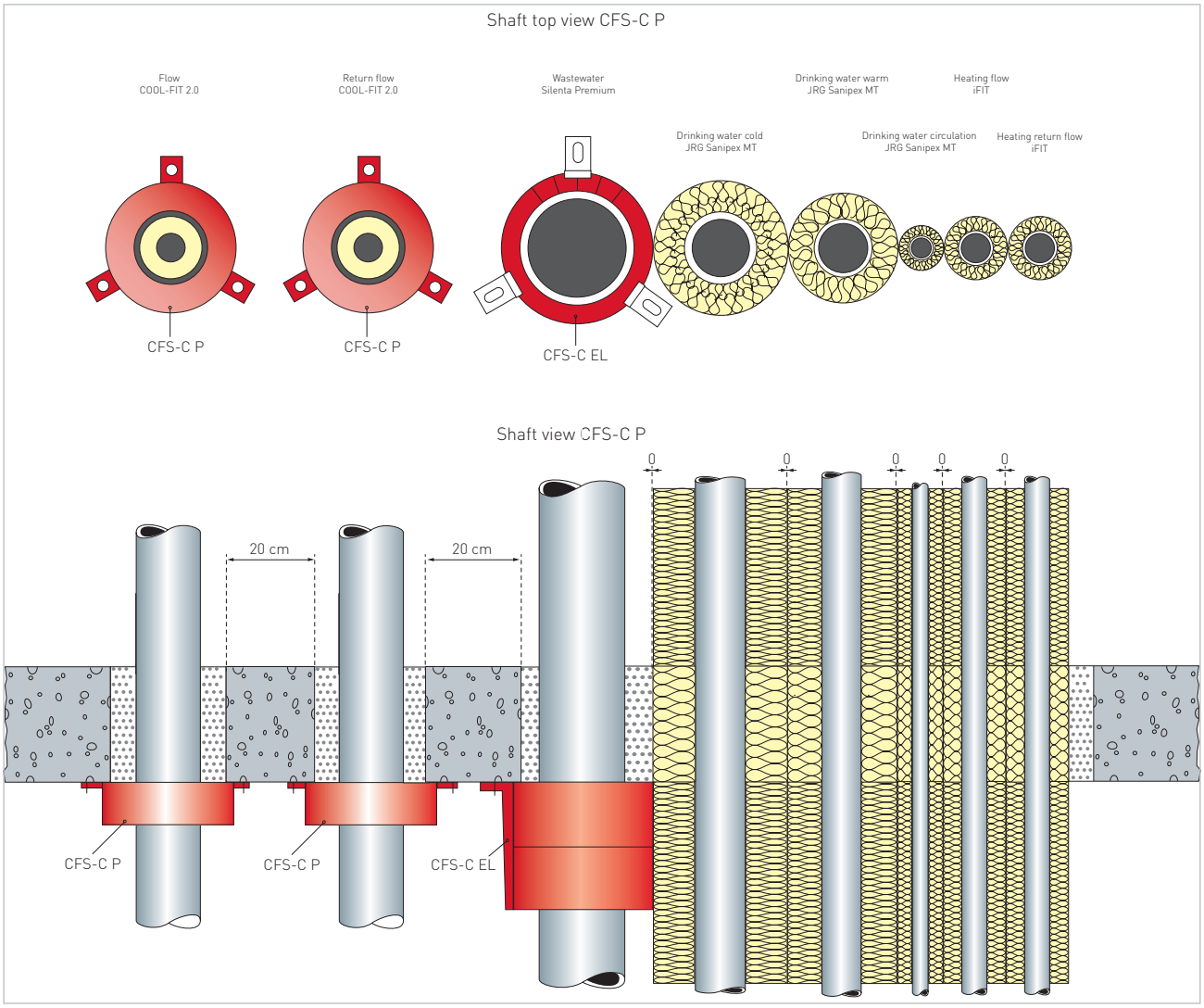
The following pipe distances between the openings of the pipe lead through are derived from this for pipe sealing with the Hilti firestop collar for COOL-FIT 2.0:

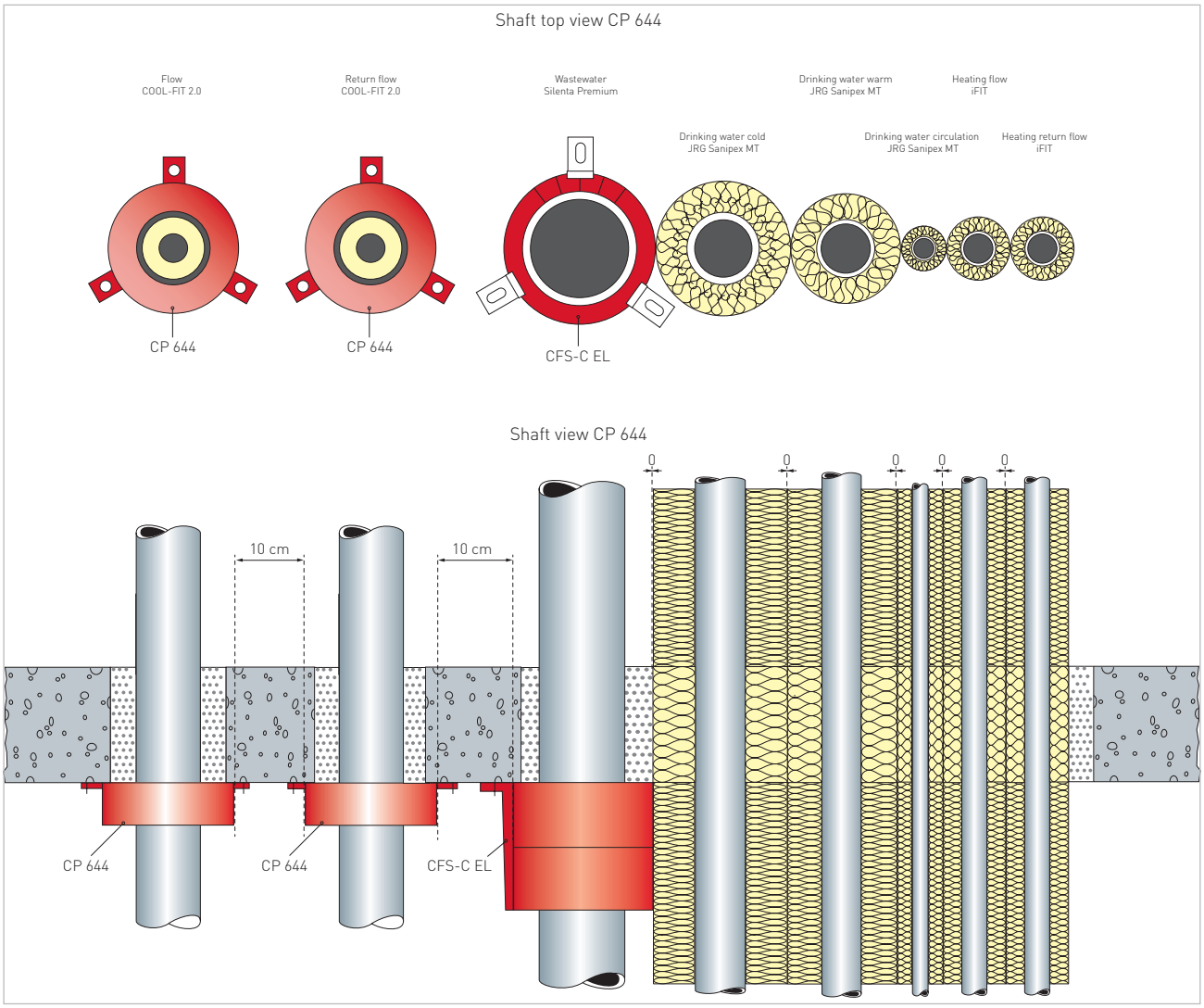




Shaft installation

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.svt-global.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



Roxtec RS PPS seal

System description

The Roxtec RS PPS is a sealing for pipes through steel decks and bulkheads in vessels. The intumsecent-based sealing stips that wrap around the plastic pipe ensure blocking of smoke, flames and water in case of fire.

Fire-retarding sealing	Manufacturer	Approval
Roxtec RS PPS und RS PPS/S	Roxtec International AB	MEDB000036A LR2090258SF

For detailed information about Roxtec see www.roxtec.com

1.4.5 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.

(m³/h)	(l/min)	(l/s)	(m³/s)
1.0	16.67	0.278	2.78×10^{-4}
0.06	1.0	0.017	1.67×10^{-5}
3.6	60	1.0	1.00×10^{-3}
3'600	60'000	1'000	1.0

Conversion table with units of flow rate.

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

1.4.6 Nomogram for easy calculation of diameter and pressure loss

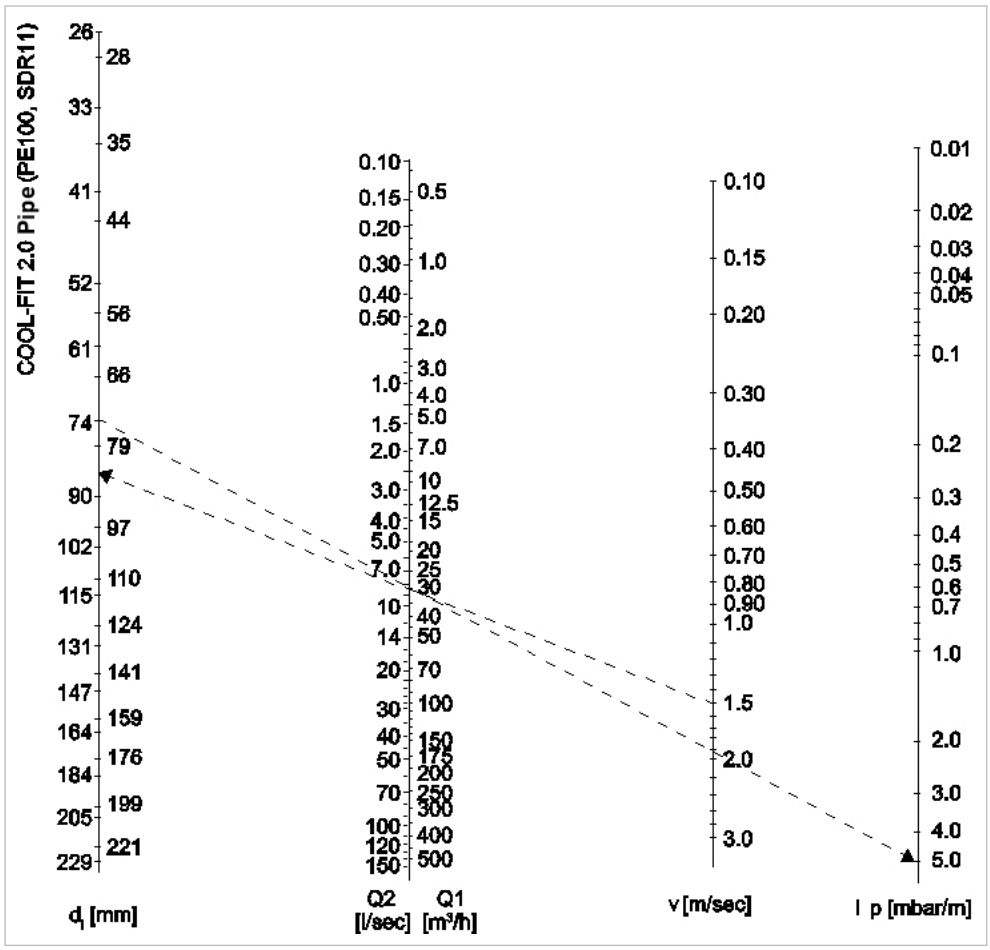
The nomogram below can be used to simplify the determination of the diameter required .The pressure loss in the pipe can be read off per meter of the pipe length.

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

Using the nomogram

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

Nomogram for COOL-FIT 2.0 pipe (PE100, SDR11) using the metric system.



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

1.4.7 Dimension comparison COOL-FIT 2.0 / 2.0F / 2.0 Push System vs. metal

COOL-FIT 2.0 / 2.0F			Stainless steel pipe		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

COOL-FIT Push System			Stainless steel pipe		Copper pipe
d (mm)	d_i (mm)	DN	Inch	da (mm)	da (mm)
16	12	12	⅜	17.1	15
20	16	15	½	21.3	18
25	20	20	¾	26.7	22
32	26	25	1	33.4	28

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

1.4.8 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/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 of 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.

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 (kg/m³)

Ceta-values fittings COOL-FIT 2.0

Designation	Symbol	Coefficient of resistance ζ
Couplers		0.1
Elbow 90°		1.2
Elbow 45°		0.3
Tee [1]		1.3
Reducer (contraction)		0.5
Reducer (enlargement)		1.0
Flange joint, transition fitting		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
Weld-in port with female thread		0.2
Weld-in port PE spigot		0.1
		0.9
		1.4

[1] For a more detailed view, differentiate between coalescence and separation. Ceta values up to a maximum of 1.3 can be found in the respective literature.

Designation	Symbol	Coefficient of resistance ζ
Weld-in port PE/iFIT		0.1
		1.1
		3.3
Weld-in port PE/ Sanipex MT		0.1
		1
		1.3

Ceta-values fittings COOL-FIT 2.0 Push System

Designation		Symbol	Dimension	Coefficient of resistance ζ
Couplers			d16	3.7
			d20	4.7
			d25	2.8
			d32	6.7
90° angle			d16	6.3
			d20	8.7
			d25	5.2
			d32	11.0
Pipe bend 90°, bent manually			d16	0.1
			d20	0.1
			d25	0.1
			d32	0.1
Pipe bend 45°, bent manually			d16	0.1
			d20	0.1
			d25	0.1
			d32	0.1
Tee	Main		d16	3.8
			d20	4.8
			d25	2.8
			d32	6.4
Tee	Branch		d16	6.4
			d20	9.5
			d25	5.5
			d32	12.4
Tee, reduced	Main		d20-d16	3.1
			d25-d16	2.5
			d25-d20	3.4
			d32-d16	2.5
			d32-d20	3.4
			d32-d25	2.6

Designation		Symbol	Dimension	Coefficient of resistance ζ
Tee, reduced	Branch		d20-d16	4.6
			d25-d16	3.1
			d25-d20	5.0
			d32-d16	3.2
			d32-d20	4.7
			d32-d25	4.9
Reducer			d20-d16	3.1
			d25-d16	2.5
			d25-d20	3.4
			d32-d16	2.5
			d32-d20	3.3
			d32-d25	2.7

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:

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

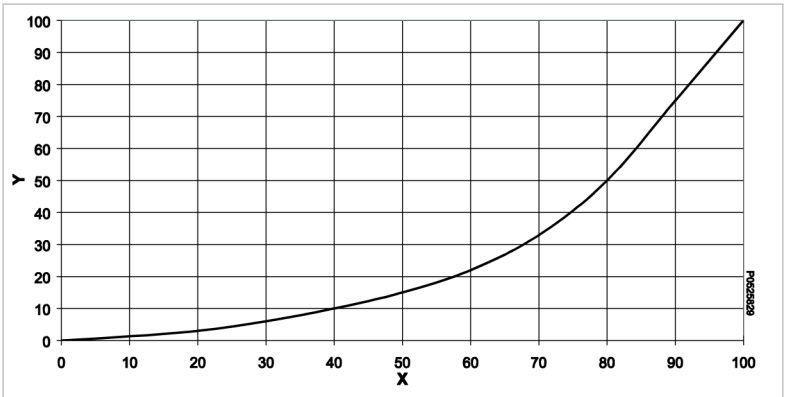
Δp_{Ar}	Pressure loss for the valve (bar)
Q	Flow rate (m^3/h)
ρ	Density of the conveyed medium (kg/m^3) (1 g/cc = 1000 kg/m^3)
k_v	Valve characteristic value (m^3/h)

kv 100-values COOL-FIT 2.0

DN (mm)	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	1'000	70.0	60
40[1]	1 ½	50	1'600	112.0	96
50[1]	2	63	3'100	217.1	186
65[1]	2 ½	75	5'000	350.0	300
80[1]	3	90	7'000	490.0	420
100[2]	4	110	3'800	455	390
125[2]	5	140	8'600	602	516

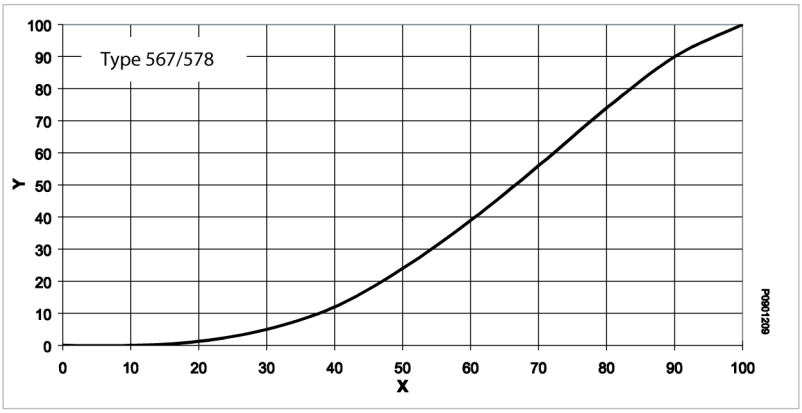
1 COOL-FIT 2.0 Ball valve
2 COOL-FIT 2.0 Butterfly valve

Flow characteristic Ball valve



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

Flow characteristic butterfly valve



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

kv 100-values Ball valve COOL-FIT 2.0 Push System

DN (mm)	Inch (")	d (mm)	k_v 100 (l/min)	Cv 100 (gal/min)	k_v 100 (m^3/h)
12	⅜	16	16.3	4.3	1.0
15	½	20	16.3	4.3	1.0
20	¾	25	29.5	7.8	1.8
25	1	32	29.5	7.8	1.8

kv 100-values Flow control valve COOL-FIT 2.0 Push System

DN (mm)	Inch (")	d (mm)	k_v 100 (l/min)	Cv 100 (gal/min)	k_v 100 (m^3/h)
12	⅜	16	30.8	8.2	1.85
15	½	20	30.8	8.2	1.85
20	¾	25	83.3	22.0	5.0
25	1	32	83.3	22.0	5.0

⚠ The use of antifreeze agents changes the viscosity and density of the medium. Depending on the proportion added, the actual flow rate therefore deviates from the displayed flow rate. Please contact GF Industry & Infrastructure Flow Solutions for further information.

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. This is typically the case for cooling systems.

Sum of pressure losses

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

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

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:

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

The inner diameter of the piping system is as follows:

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

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

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

Pressure loss	Formula
Pressure loss for straight pipe sections	$\Delta p_R = 0.02 \cdot \frac{15}{32.8} \cdot \frac{1000}{2 \cdot 10^2} 1.78^2 = 0.14$ bar
Pressure loss for fittings incl. connections	$\Sigma\zeta = (12 \cdot 1.2) + (4 \cdot 0.3) + (3 \cdot 1.3) + (5 \cdot 0.7) = 23$ $\Delta p_{Fi} = 23 \cdot \frac{1.78^2}{2 \cdot 10^5} \cdot 1000 = 0.36$ bar
Pressure loss for the valve 80 % opened. With the flow characteristics diagram for ball valves type 546, from an 80% 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
Whole pressure loss of the piping	$\Sigma\Delta p = 0.14$ bar + 0.36 bar + 0.03 bar = 0.53 bar

Formulas for calculating pressure losses

1.4.9 Z-dimension method

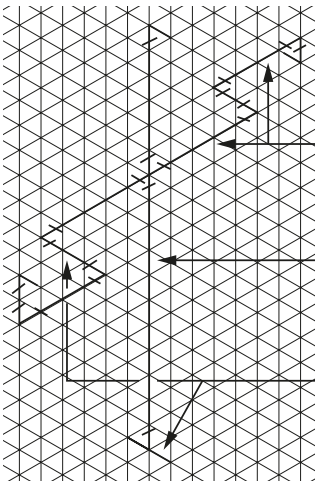
Overview

The pressure of competition and high costs on site makes it essential to install piping system systems efficiently. The 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 Industry & Infrastructure Flow Solutions.

Please adhere to the following guidelines for drawing:

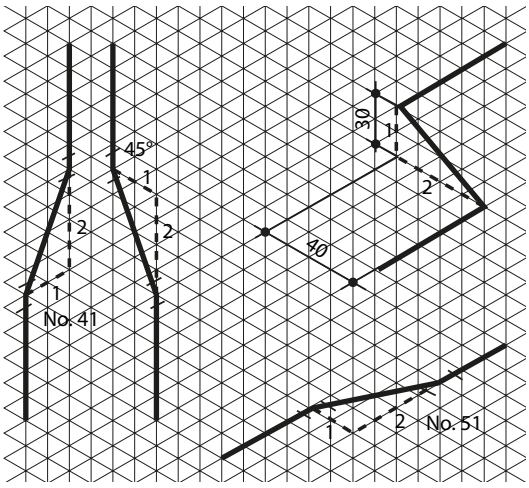
Pipe running perpendicular to one another	Pipe running diagonally



Horizontally: left and right

Vertical

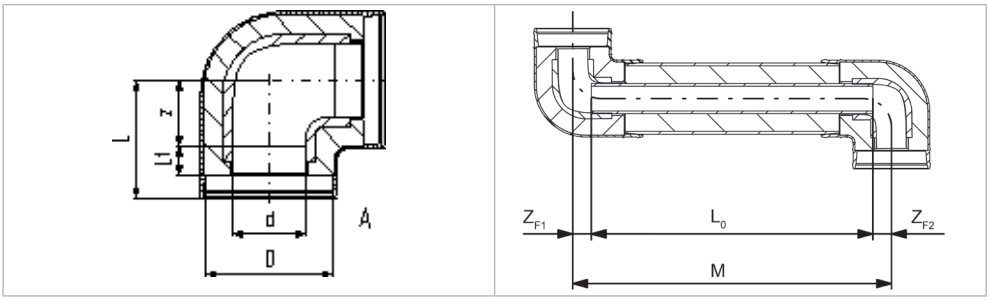
Horizontally: front and rear



The z-dimensions of the fittings are needed for determining the actual cutting lengths of the pipe. The tables in our product ranges and in the online 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	1'000 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

+GF+

GEORG FISCHER
PIPING SYSTEMS

Unterteilungsblatt 30°
Feuille de mesurage 30°
Foglio per misure 30°

Firma
Firme
Ditta

Dat.

Bauobjekt
Bâtiment
Edificio

Blatt Nr.
Feuille No.
Foglio No.

Pos.	M - M	– cm	L cm	Ø	

1.4.10 Length changes and flexible sections

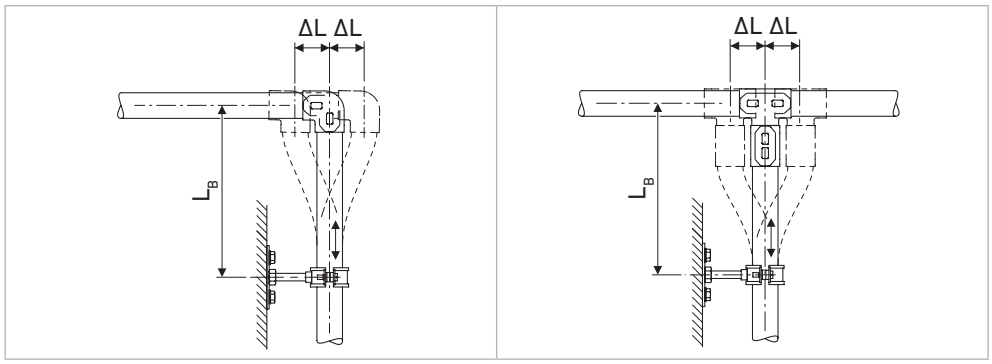
Overview

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

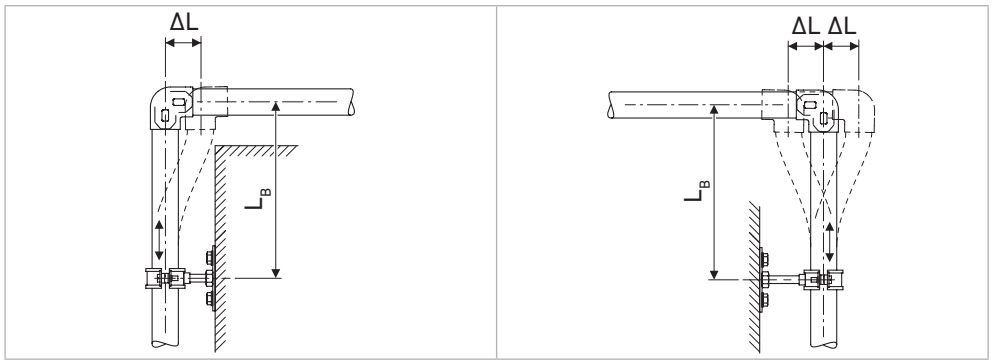
Flexible sections are the most common, the simplest and the most economical solution. The calculations for and the positioning of flexible sections are therefore described in detail.



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.

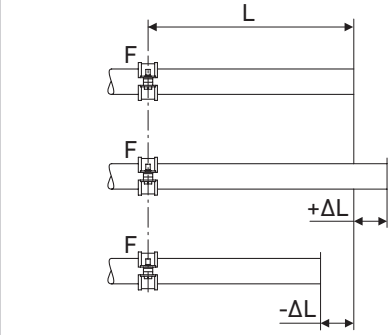


Flexible sections arise naturally at any branching or change in direction of the piping system. The movement LB of the flexible section as a result of a change ΔL in the length must not be restrained by fixed pipe brackets, wall protrusions, girders or the like.

Calculation of length changes and flexible sections COOL-FIT 2.0 / 2.0F

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:

- 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 Industry & Infrastructure Flow Solutions 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

COOL-FIT 2.0

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	-5	-10	-21	-31	d32	-11	-21	-42	-63
d40	-6	-12	-24	-36	d40	-12	-25	-49	-74
d50	-8	-16	-32	-48	d50	-16	-32	-65	-97
d63	-8	-17	-34	-51	d63	-17	-35	-69	-104
d75	-9	-18	-36	-54	d75	-18	-36	-73	-109
d90	-10	-20	-40	-59	d90	-20	-40	-80	-120
d110	-11	-22	-44	-66	d110	-22	-45	-90	-134
d140	-11	-23	-45	-68	d140	-23	-46	-91	-137

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	-16	-32	-65	-97	d32	-22	-44	-88	-132
d40	-19	-38	-75	-113	d40	-26	-51	-102	-154
d50	-25	-49	-99	-148	d50	-33	-67	-133	-200
d63	-26	-53	-105	-158	d63	-36	-71	-142	-213
d75	-28	-55	-111	-166	d75	-37	-75	-149	-224
d90	-30	-61	-122	-183	d90	-41	-82	-164	-246
d110	-34	-68	-136	-203	d110	-46	-91	-182	-273
d140	-34	-69	-138	-207	d140	-46	-93	-185	-278

L laid pipe length

COOL-FIT 2.0F

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

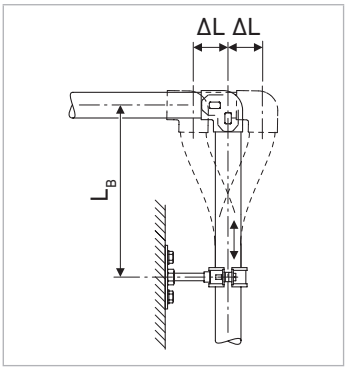
Length change ΔL (mm) at 10° C flow temperature					Length change ΔL (mm) at 5° C flow temperature				
L (m)	25	50	100	150	L (m)	25	50	100	150
d32	-9	-18	-37	-55	d32	-13	-25	-51	-76
d40	-11	-23	-45	-68	d40	-15	-31	-62	-92
d50	-15	-31	-62	-93	d50	-21	-42	-84	-126
d63	-18	-36	-73	-109	d63	-25	-49	-99	-148
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

L laid pipe length

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:

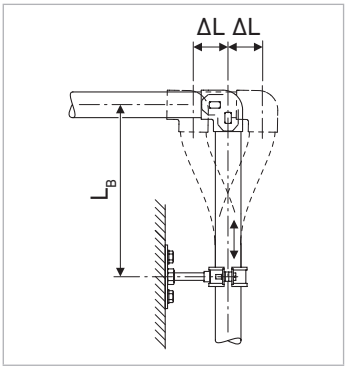
Flexible section L_B (cm)													
ΔL (mm)	10	20	30	40	50	60	70	80	90	100	150	200	300
d32/75	71	101	123	142	159	174	188	201	214	225	276	318	390
d40/90	78	110	135	156	174	191	206	221	234	247	302	349	427
d50/90	78	110	135	156	174	191	206	221	234	247	302	349	427
d63/110	86	122	149	172	193	211	228	244	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



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



Reduction of the flexible sections

The specified flexible section lengths are based on the maximum permissible operating pressure according to the pressure-temperature diagram (SDR11/17, C = 1.6).

P_{perm} for dimensions d32-d140

Maximum permissible operating pressure according to the pressure-temperature diagram for SDR11, considering medium-specific derating factors.

For lower operating pressures, the flexible section lengths may be reduced as follows:

Operating Pressure	Permissible Reduction
≤ 25% of P_{perm}	30%
> 25% to 60% of P_{perm}	15%
> 60% of P_{perm}	No reduction

Example:

For a COOL-FIT d110 pipe, the permissible operating pressure according to the pressure-temperature diagram at 10°C is 15 bar. When using a water-glycol mixture with a derating factor of 1.1, the permissible operating pressure is P_{perm} = 15/1.1 = 13.6 bar.

If the actual system operating pressure is 5 bar, this corresponds to 36.7% of P_{perm}. Since this value is between 25% and 60% of P_{perm}, the tabulated flexible section length may be reduced by 15%. A possible flexible section length of 2.0 m may therefore be reduced to 1.7 m.

Calculation of length changes and flexible section COOL-FIT 2.0 Push System

As a first approximation, the change of the pipe length can be calculated using the following formula.

$$\Delta L = \alpha \cdot L \cdot \Delta T$$

ΔL	Length difference in mm
ΔT	Temperature difference in K
L	Length of pipeline in m
α	Linear coefficent of thermal expansion; 0.024 mm/(mK)

Change in length

Pipe length [m]	Temperature difference ΔT [K]					
	10	20	30	40	50	60
	Change in length [mm]					
1	0.2	0.5	0.7	1.0	1.2	1.4
2	0.5	1.0	1.4	1.9	2.4	2.9
3	0.7	1.4	2.2	2.9	3.6	4.3
4	1.0	1.9	2.9	3.8	4.8	5.8
5	1.2	2.4	3.6	4.8	6.0	7.2
6	1.4	2.9	4.3	5.8	7.2	8.6
7	1.7	3.4	5.0	6.7	8.4	10.1
8	1.9	3.8	5.8	7.7	9.6	11.5
9	2.2	4.3	6.5	8.6	10.8	13.0
10	2.4	4.8	7.2	9.6	12.0	14.4
20	4.8	9.6	14.4	19.2	24.0	28.8
30	7.2	14.4	21.6	28.8	36.0	43.2
40	9.6	19.2	28.8	38.4	48.0	57.6
50	12.0	24.0	36.0	48.0	60.0	72.0

Flexible section

Sample calculation

The length of the pipeline is 7 m. The thermally induced change in length of this pipe section must be absorbed by a flexible pipe leg. The difference between the installation temperature and the maximum operating temperature is 60 K.

Example: COOL-FIT 2.0 Push System

PE-RT pipe, dimension	d16
Material constant C	33
Change in length Δl	10.08 mm

Calculation of the length of the flexible pipe leg

$$L_B = C \cdot \sqrt{d \cdot \Delta l}$$

$$L_B = 33 \cdot \sqrt{(16\ mm \cdot 10.08\ mm)}$$

$$L_B = 419.1\ mm$$

The length of the flexible pipe leg is derived from the pipe's change in length:

Graph reading example

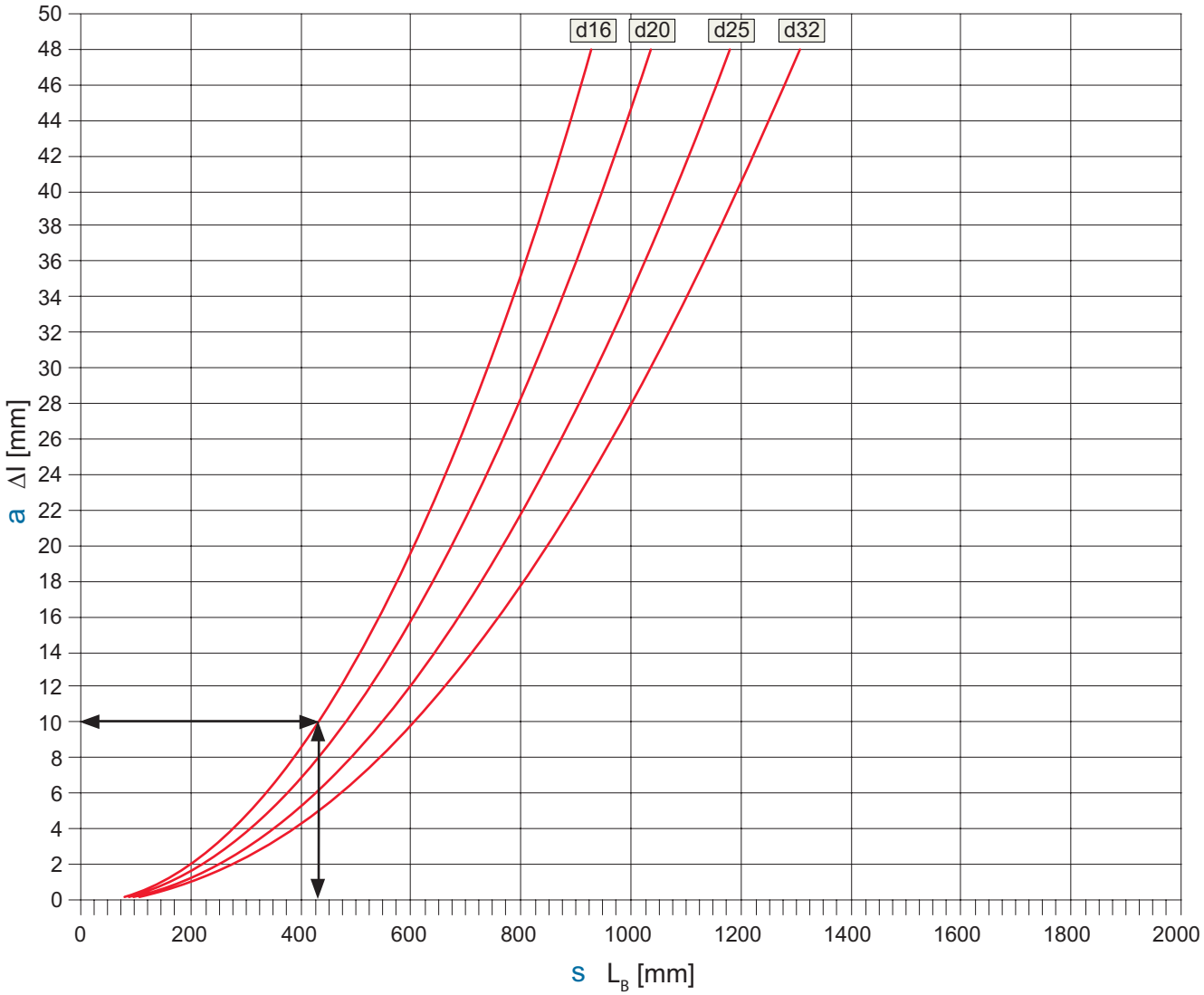
PE-RT pipe, dimension	d16
Material constant C	33
Change in length Δl	10.08 mm

L_B = 419.1 mm

Length of flexible pipe leg

a Change in length of the pipe

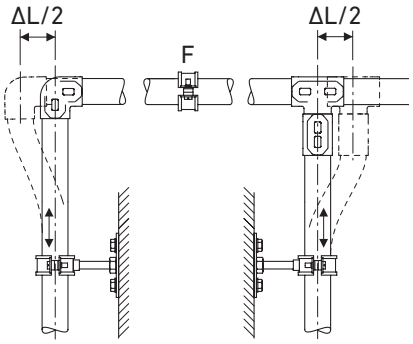
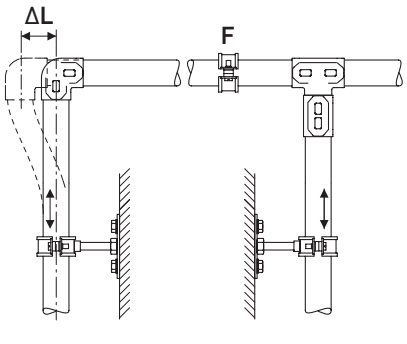
s Length of flexible pipe leg



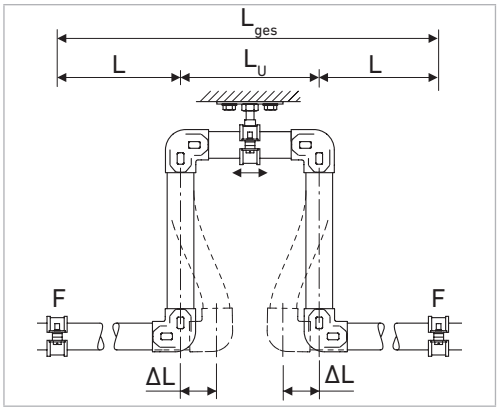
1.4.11 Handling expansion and contraction

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

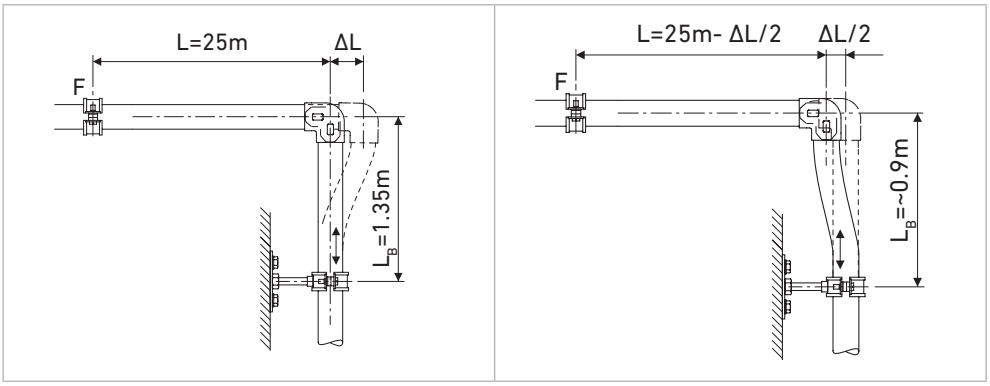
Pipe length L	25 m
Diameter	d50/D90 mm
Installation temperature	25 °C
Min ambient temperature	25 °C konstant
Max ambient temperature	25 °C konstant
Min flow temperature	10 °C
Max flow temperature	25 °C

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.

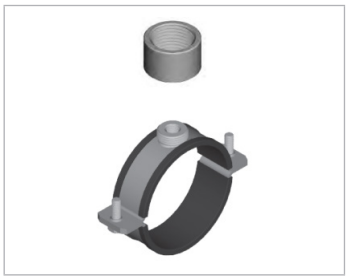


1.4.12 Pipe bracket spacing and support of piping systems

Overview

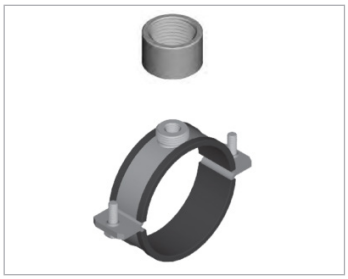
Installation of plastic pipe

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.



Installation of COOL-FIT 2.0 Push System

COOL-FIT 2.0 Push System tubes must be installed using suitable tube supports. In doing so, the pipes must not be under too much tension.
The COOL-FIT 2.0 Push System, pipes can be inserted into standard sliding pipe clamps with the COOL-FIT 2.0 Push System, support carrier. Special insulation pipe clamps or cold clamps are not necessary.



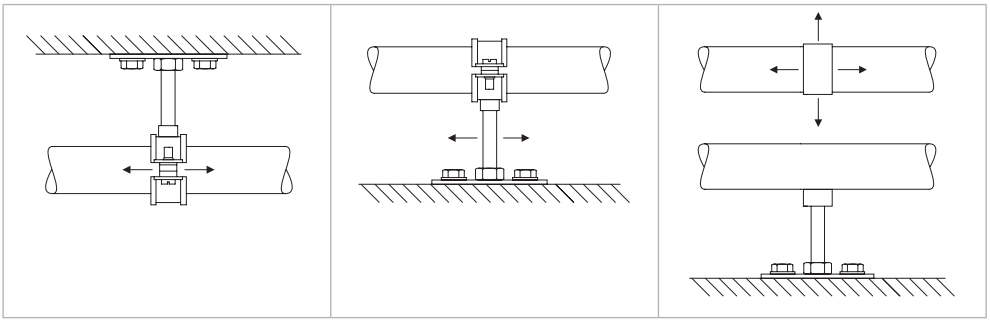
A retaining clamp must be placed next to each fitting.



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.

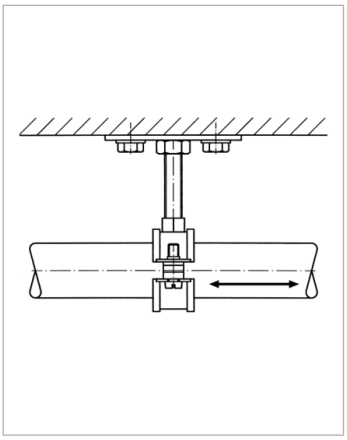
Displacement of the pipe in 2 axes.

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.

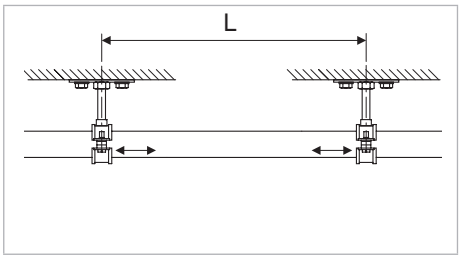


Spacers prevent pinching the pipe

Maximum pipe support distance

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

The maximum pipe support distance for COOL-FIT 2.0 pipes is always consistent independent of pressure and temperature.



L Pipe clamp spacing

Maximum pipe support distance 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)	1'600	1'700	1'700	1'850	1'950	2'000	2'100	2'350

Maximum pipe support distance 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)	2'200	2'300	2'300	2'400	2'500	2'600	2'700	2'900

Maximum pipe support distance L for COOL-FIT 2.0 Push System

d/D (mm)	16/44	20/48	25/54	32/61
L (mm)	1'200	1'200	1'700	2'200

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.

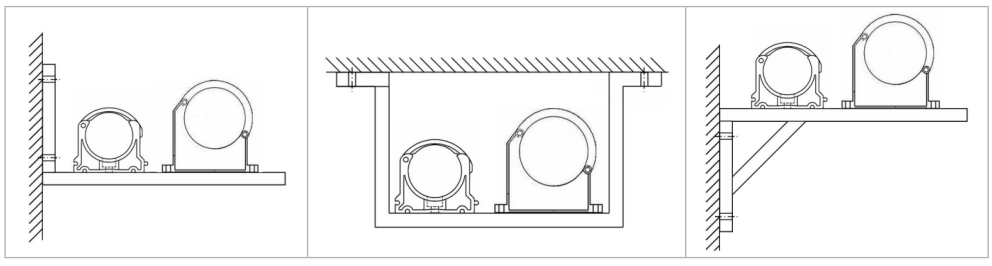
⚠ Pipe which are axially clamped and rigidly fixed must be tested for their resistance to kinking. In most cases, this test results in a reduction of the maximum internal pressure and more tightly spaced supports. The forces acting on the fixed points should be considered.

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 Industry & Infrastructure Flow Solutions 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.

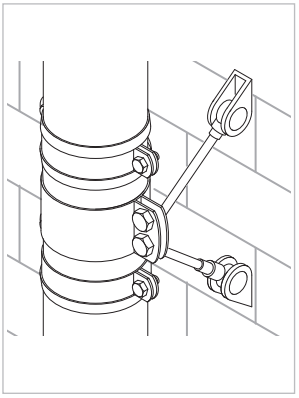
⚠ Fixed point design

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 Industry & Infrastructure Flow Solutions, use the y-cable kit wit code No. 790 156 032. Please take note of the maximum allowed forces in the table below.

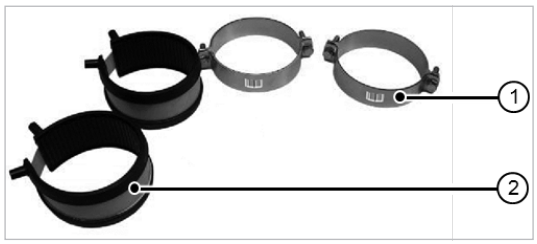


Diameter (mm)	d32/ D75	d40/ D90	d50/ D90	d63/ D110	d75/ D125	d90/ D140	d110 / D160	d140 / D200
Maximum force F (kN)	2.0	3.0	5.0	8.0	10.0	10.0	10.0	10.0

⚠ COOL-FIT 2.0 fixed points must be calculated on the basis of the application. Fixed point brackets and cross braces are not included.

⚠ The COOL-FIT Fixed points must not be used on non-insulated PE pressure pipes (e.g. SDR11 + SDR17).

Scope of delivery



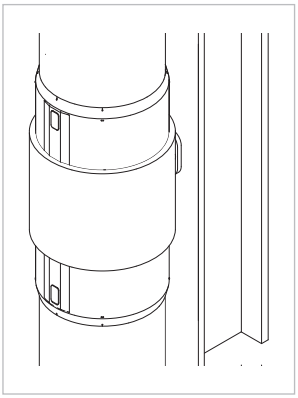
1 Clamps to maintain fusion pressure
2 Electrofusion band

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 2.0 fixed point for higher forces

For applications with higher forces, such as long risers, fixed points must be planned specifically for the application. Attachment to the beam is via a weld-on plate on the metal pipe clamp. The clamp is positioned between two COOL-FIT electrofusion fittings and is subsequently insulated. The insulation is designed for indoor applications, for outdoor applications further precautions are required to protect the insulation.



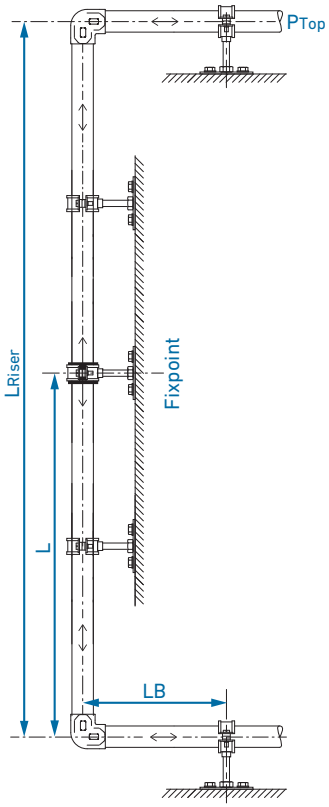
Diameter (mm)	d140 / D200
Maximum force F (kN)	35.0

⚠ COOL-FIT fixed points for higher forces must be calculated according to the application. The pipeline, support, weld seam type and other influencing factors must be taken into account in the force analysis. Please contact GF Advanced Engineering.

Example of maximal achievable riser length:

Installation temperature	-5 to +40°C
Ambient temperature	-5 to +45°C
Flow temperature	+6 to +47°C
Fixpoint position	Middle of the riser pipe
Pressure on top level	3 bar (PTop)
Support distance vertical	Equal to horizontal
Pipe class	d32 - d140 SDR11

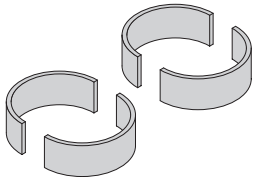
	Pipe support distance reduced for long riser		Fixpoint		Fixpoint for increased forces	
	Horizontal [m]	Vertical [m]	Max. riser length (LRiser) [m]	Fixpoint force [kN]	Max. riser length (LRiser) [m]	Fixpoint force [kN]
d32/75	1.6	1.6	32.5	0.6		
d40/90	1.7	1.7	40.5	1.0		
d50/90	1.7	1.7	32.5	1.0		
d63/110	1.9	1.9	39.5	1.9		
d75/125	2.0	2.0	43.5	2.9		
d90/140	2.0	2.0	48.0	4.4		
d110/160	2.1	2.1	52.0	6.6		
d140/200	2.4	2.4	48.5	10.0	54.5	11.2



⚠ Following sections are recommended to be proofed by GF Advanced Engineering before installation:

- Riser pipe with multiple dimensions
- Installation differ from normal installation with fixpoint in the middle

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

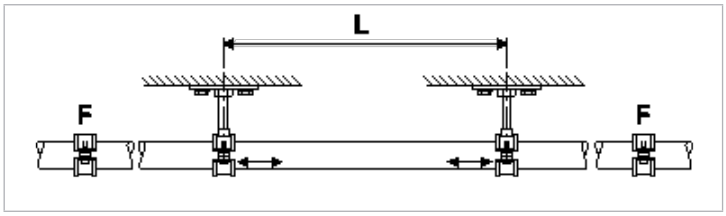
⚠ Pipe which are axially clamped and rigidly fixed must be tested for their resistance to kinking. In most cases, this test results in a reduction of the maximum internal pressure and more tightly spaced supports. The forces acting on the fixed points should be considered.

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)	1'600	1'700	1'700	1'850	1'950	2'000	2'100	2'350

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)	1'600	1'700	1'700	1'850	1'950	2'000	2'100	2'350
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)	1'600	1'700	1'700	1'850	1'950	2'000	2'100	2'350

* max allowed force for COOL-FIT fixed point exceeded

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)	2'200	2'300	2'300	2'400	2'500	2'600	2'700	2'900
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)	2'200	2'300	2'300	2'400	2'500	2'600	2'700	2'900
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)	2'200	2'300	2'300	2'400	2'500	2'600	2'700	2'900

⚠ Please contact GF Industry & Infrastructure Flow Solutions 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

1.4.13 Bending of COOL-FIT 2.0 Push System pipes

Manual bending

COOL-FIT 2.0 Push System pipes can be bent by hand without the use of bending tools. Ensure the pipes do not kink when bending them.

Hydraulic cylinders or bending springs

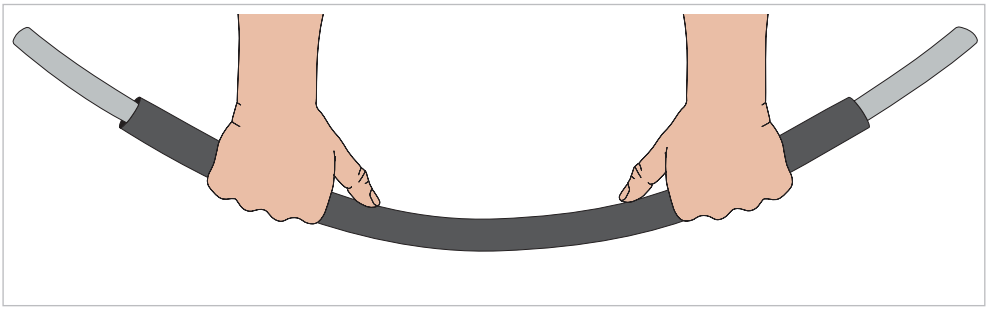
Commercially available hydraulic cylinders can be used, considering the following aspects:

☑ The shape of the bending gauge must correspond with the outside diameter of the media pipe.

☑ Do not use internal bending springs.

☑ Ensure the bending radius is not less then 3.5 · d.

COOL-FIT 2.0 Push System pipes can be easily shaped into the desired angle with the outside pipe bending tool.
Consider the removal of the insulation before bending with hydrailic cylinders or bending springs.



Bending the COOL-FIT 2.0 Push System multilayer composite pipe

Bending radius R	COOL-FIT 2.0 Push System			
d [mm]	16	20	25	32
Bending radius R, with bending spring: 5 · d [mm]	80	100	200	-
Bending radius R, with tool: 3.5 · d [mm]	56	70	98	112

Minimum bending radius of the COOL-FIT 2.0 Push System pipe

! NOTE! Risk of damaging the pipes due to improper bending!
→ Ensure the pipes do not kink when bending them.
→ Do not use internal bending springs.

1.4.14 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.

1.4.15 COOLING Tool-Box

The GF Industry & Infrastructure Flow Solutions 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 Industry & Infrastructure Flow Solutions representative or visit w gfps.com

1.5 Jointing and Installation

1.5.1 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!

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

Prepare pipe with stripping and peeling tool for electrofusion welding connection (stripping, peeling and sheath cutting) and check pipe spigot with circumferential measuring tape for compliance with minimum permissible pipe outer diameter.

Minimum permitted pipe external diameter after peeling for COOL-FIT 2.0/2.0F

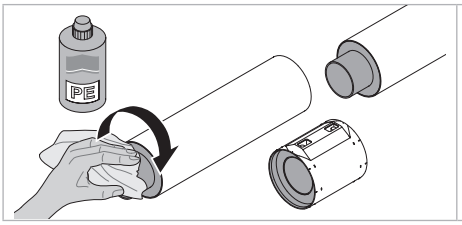
	d nominal diameter (mm)							
Temperature (°C)	32	40	50	63	75	90	110	140
	dmin after peeling (mm)*							
40	31.4	39.4	49.4	62.5	74.5	89.6	109.6	139.7
30	31.3	39.4	49.4	62.4	74.4	89.4	109.5	139.5
20	31.3	39.3	49.3	62.3	74.3	89.3	109.3	139.3
10	31.3	39.2	49.2	62.2	74.2	89.2	109.1	139.1
0	31.2	39.2	49.2	62.1	74.1	89.0	109.0	138.9

* Minimum diameter do not comply with the pipe tolerance specifications for GF electrofusion fittings. COOL-FIT minimum diameter are verified by release tests.

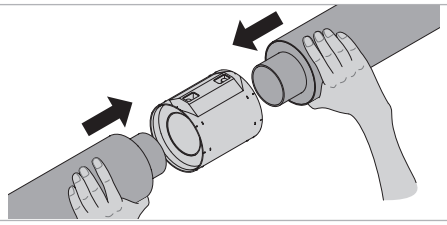
If the pipe outside diameter falls below the min. permissible value, cut off the spigot and check the blade quality by measuring the chip thickness with a caliper gauge: the reference dimension over the entire length is between 0.2 - 0.4 mm. Replace blade in case of deviation.

COOL-FIT 2.0 valves and COOL-FIT 2.0 fittings (type B and barrel nipple) need not to be peeled.

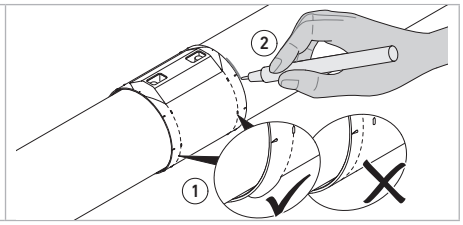
2 Cleaning and installation



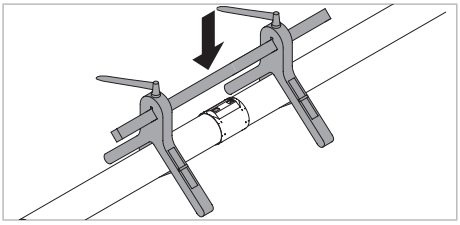
Step 1
Clean the fusion area of the components with PE cleaner and lintfree colourless and clean cloth in circumferential direction.



Step 2
Insert pipe in clamping tool and align free of stress. Push fitting up to the limit stop on the pipe.

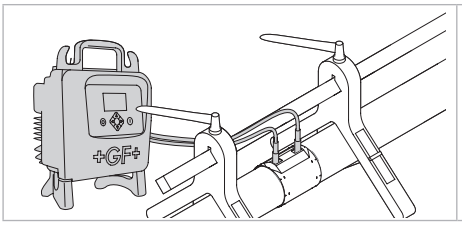


Step 3
Pay attention that the sealing lip arches upwards. Mark end of lip on pipe (to check the change in position during welding).

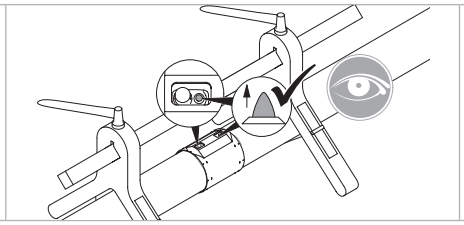


Step 4
Take care for low stress installation and secure the pipe and fitting against dislocation. Tight clamps of clamping tool.

3 Fusion process

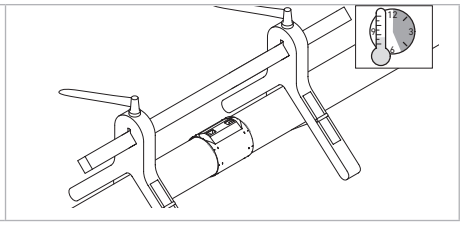


Step 5
Fuse in accordance to the operating instructions of the fusion unit.

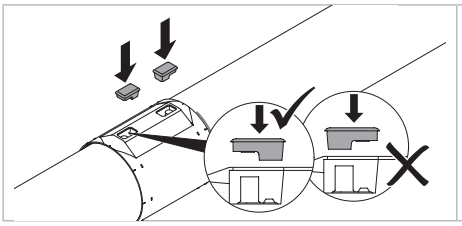


Step 6
During and after fusion, check fusion indicators on the electrofusion fitting and note the messages on the display of the electrofusion machine.
Afterwards mark the fitting with following information

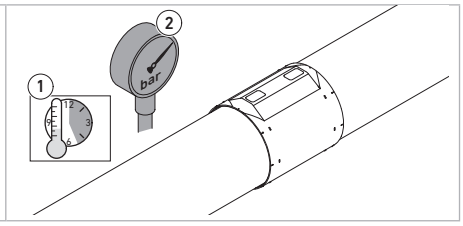
- Date
- Welder/ Weld number
- Time at the end of cooling time



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.

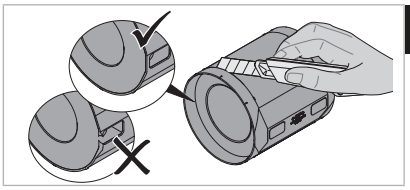
Cooling times before removing retention device and pressure/leak testing

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

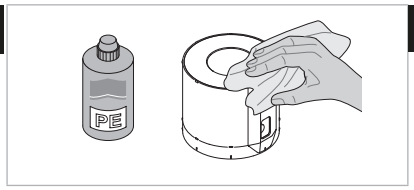
The values are valid for pressure tests using a liquid at ≤ 20 ° C. For testing with gas a cooling time of 12 hours is recommended.

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

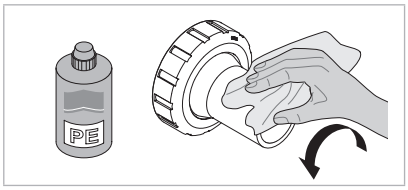
1



2



3

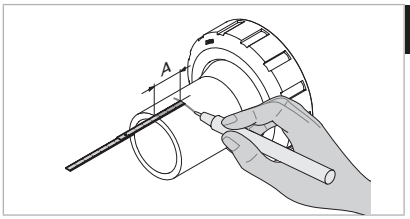


For the jointing to a valve or flange adaptor, the sealing lip of the fitting has to be removed at the valve or flange adaptor side and sealing and fusion surfaces have to be cleaned.

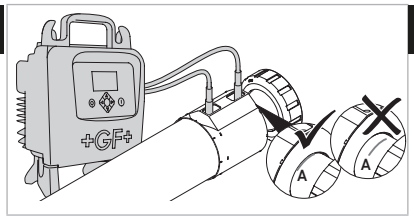
Standard fusion

Fuse both valve ends without valve mounted

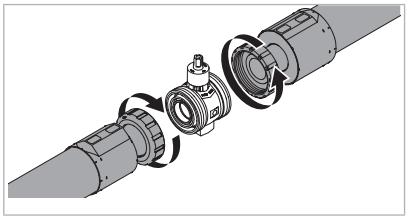
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5



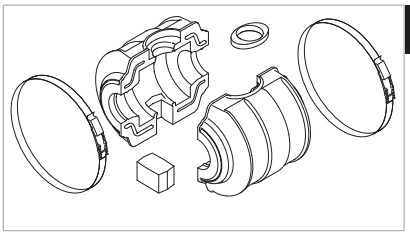
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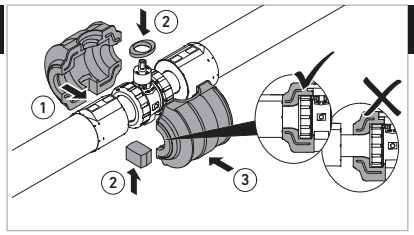
Following insertion depths are valid for COOL-FIT 2.0 components:

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

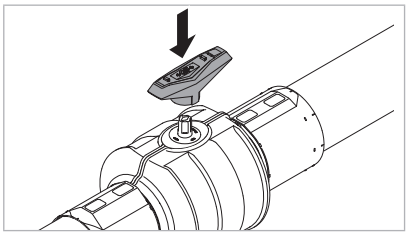
Mounting the valve insulation



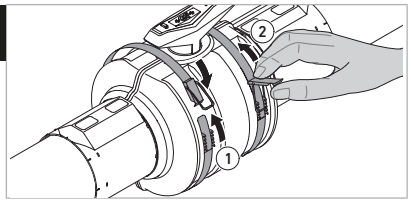
7



8



9



i 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.

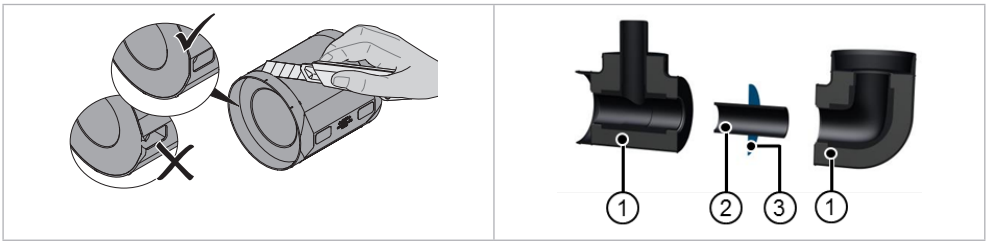
Shorter connections Fitting-to-Pipe-to-Fitting can be realized using an un-insulated PE100 SDR11 pipe in combination with a piece of insulation that results of an foam removal process of the foam removal tool.

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

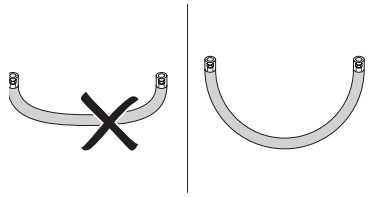
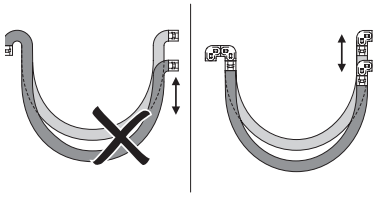
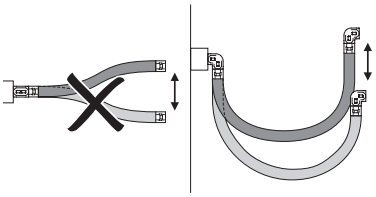
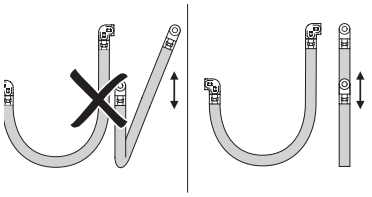
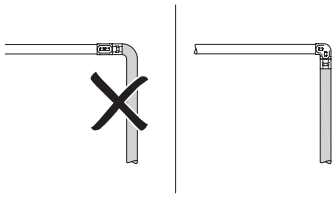
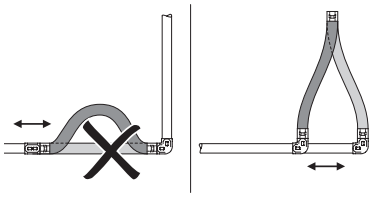
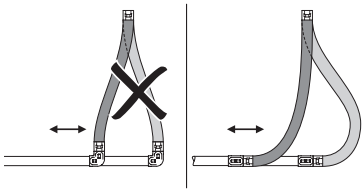
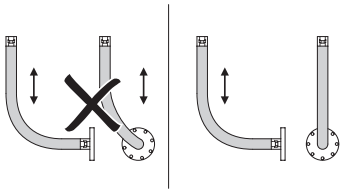
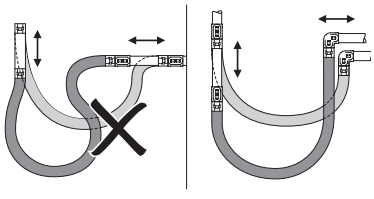
L : Length of un-insulated PE100 SDR11 pipe needed

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 Industry & Infrastructure Flow Solutions 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.

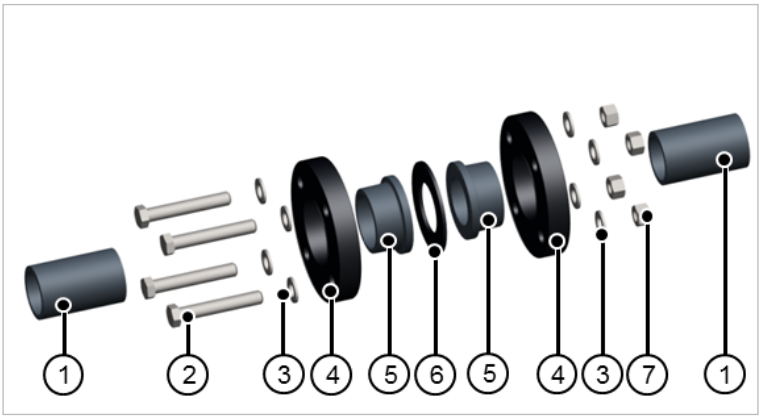
The open joint time is about 3:15 minutes depending on temperature and humidity of air.

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 Industry & Infrastructure Flow Solutions 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

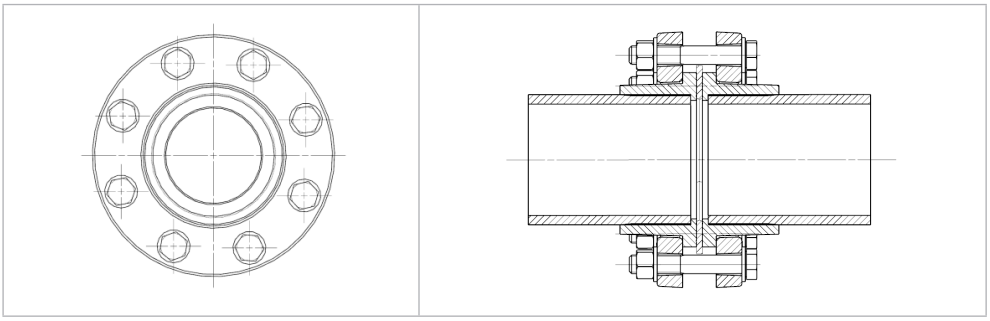
Flange connection	Properties
PP-V flange	• Corrosion-free all-plastic flange made of polypropylene PP-GF30 (fiber-glass reinforced) • High chemical resistance (hydrolysis-resistant) • Maximum possible break resistance due to elasticity (deforms if it is tightened too much) • Use for ambient temperatures 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 Industry & Infrastructure Flow Solutions. 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 Industry & Infrastructure Flow Solutions 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.

i 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 Industry & Infrastructure Flow Solutions 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.

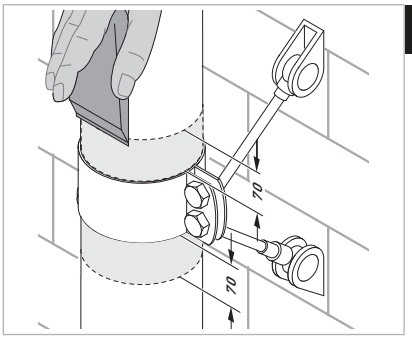
On installing Installation fittings in horizontal piping systems, the sensors should be in 1 – 5 or 7 – 11 clock position.

⚠ 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

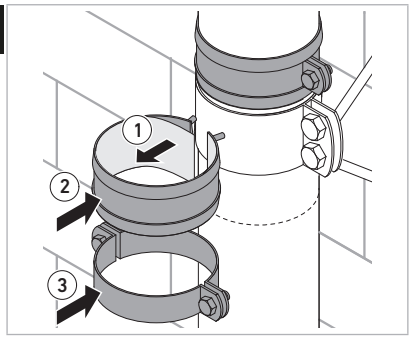
The COOL-FIT pipe shall be intstalled with a standard fix point as shown below.

1



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

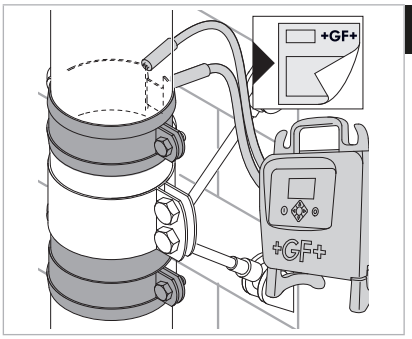
2



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.

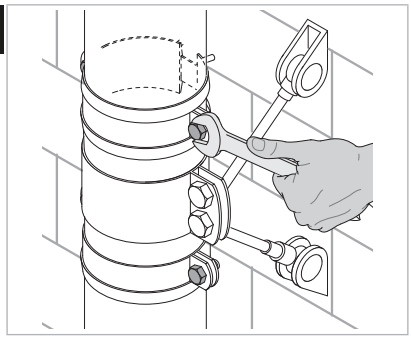
Note: The necessary welding pressure on the clean and dry COOL-FIT pipe is achieved by tightening the pipe clips. Take care that between fixed point clip and weld band there are no visible holes.

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.

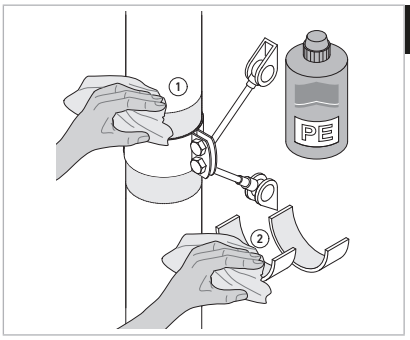
4



Step 4
Retighten the pipe clips after 10 minutes.

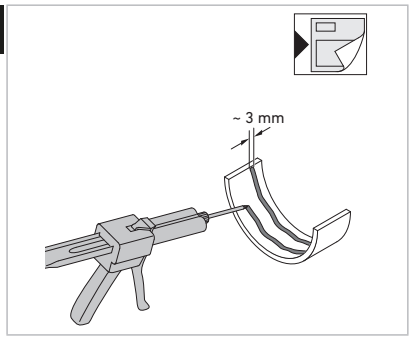
Installation of COOL-FIT 2.0F fixed points

1



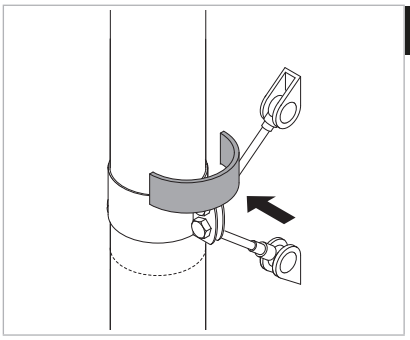
Step 1
Clean the cementing area on the pipe and the components with Tangit PE cleaner and lintfree colourless and clean cloth in circumferential direction.

2



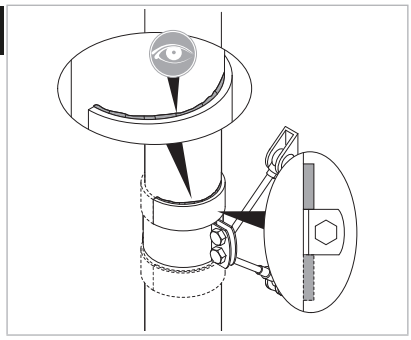
Step 2
Place the Tagit RAPID in about 3mm stripes on the inner side of the fixed point set half shells.

3



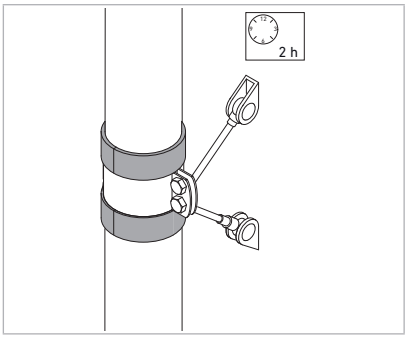
Step 3
Cement the half shelfs on the pipe next to the pipe clamp.

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.

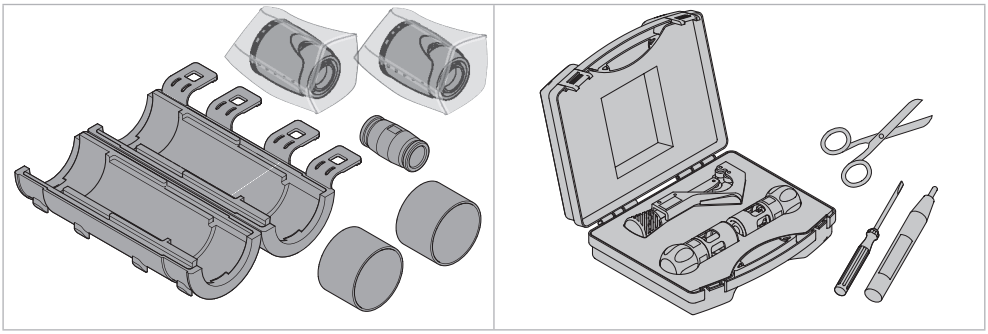
1.5.2 Jointing of COOL-FIT 2.0 Push System

General advice

The push-in fittings may only be installed by skilled personnel who have been regularly instructed in work safety and environmental protection on pressurized pipes. The quality of the mechanical connection is largely determined by the careful execution of the preparatory work. The mating area must be protected from adverse weather conditions such as rain, snow or wind. Permissible temperature range for processing is -10 °C to +45 °C. The national guidelines must be observed.

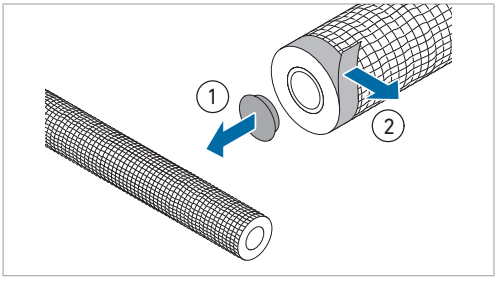
The surfaces to be welded on the pipe and fitting must be carefully protected from dirt, any grease, oil and lubricants. Only cleaning agents suitable for PE may be used.

Work preparation



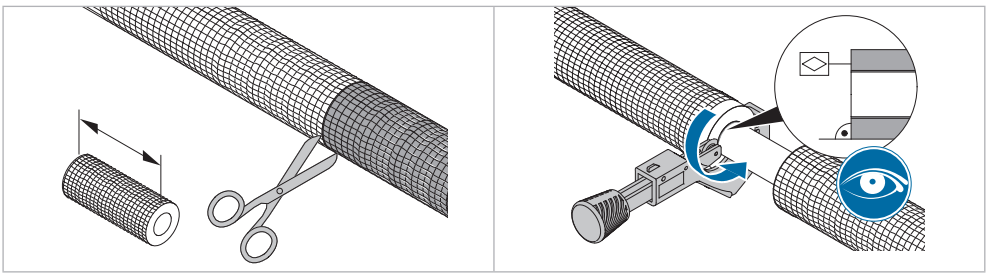
Remove products from packaging immediately before assembly and have necessary tools ready.

Prepare pipe



Step A

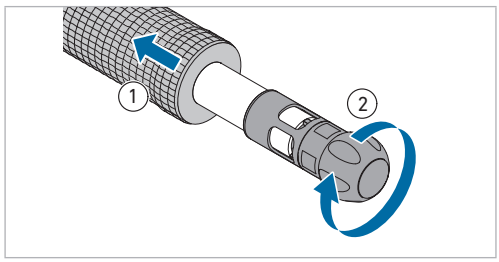
For new pipe start: Remove cap from pipe end and remove tape from insulation.



Step B

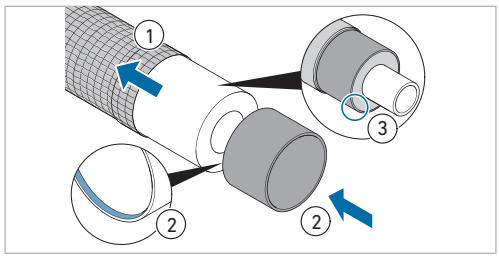
Pipe lengths: Cut the insulation at right angles at the interface using scissors. Push the insulation aside and cut the pipe flush with the insulation using a pipe cutter.

Joint



Step 1

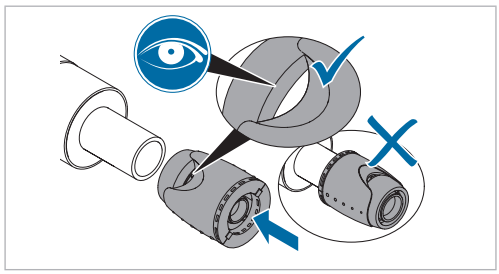
Push back the insulation and chamfer and calibrate the tube end with the chamfering tool. Visually check the chamfering. Remove any chips that may be adhering, also inside the tube.



Step 2

Pull the net of the insulation to the rear. Push the ring over the insulation with the chamfered side first. The surface of the insulation must lie flush in the ring.

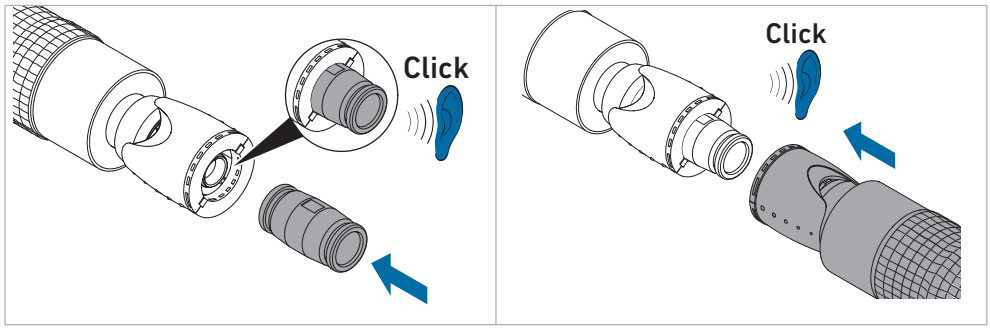
i It is easier to attach the ring if the insulation is first pulled off the pipe, then the ring is slid over the insulation. Then both are pushed back over the pipe.



Step 3

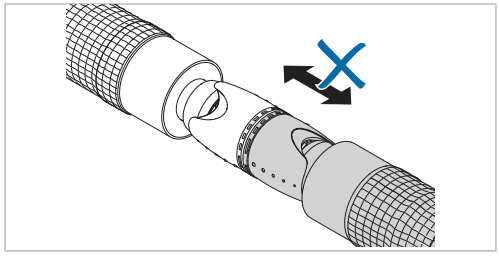
The adapters are packaged individually. The packaging is only opened immediately before use.

Push the adapter onto the tube end as far as it will go. Visually check that the viewing window of the adapter is completely filled by the tube.



Step 4- 5

Insert the module into the adapter and push it in until an audible click is heard (acoustic check). Prepare the second tube end and also push it onto the module until an audible click is heard.

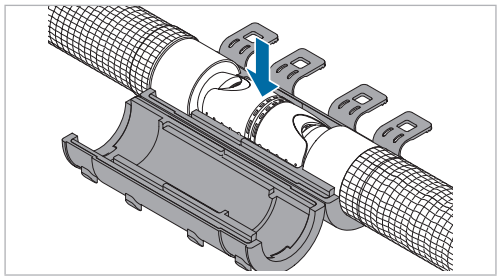


Step 6

Check by counter-tensioning whether the tube adapter and module are firmly connected to each other.

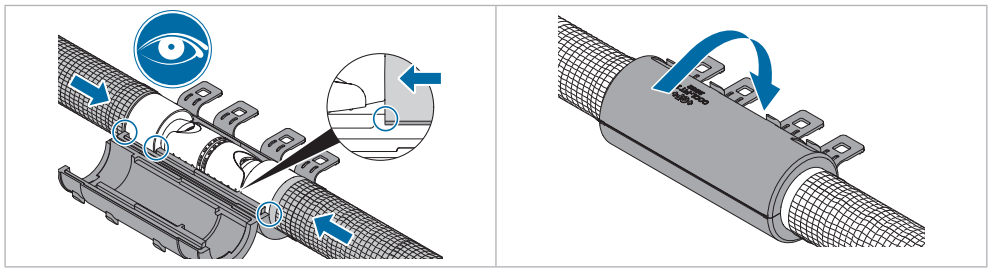
During the counter-tension test, the adapter and module may slide apart by up to 5 mm. Due to the dynamic holding mechanism, the pipe moves back slightly during operation or during the pressure test. This is not a defect of the assembly from a technical point of view.

Insert joint into shell



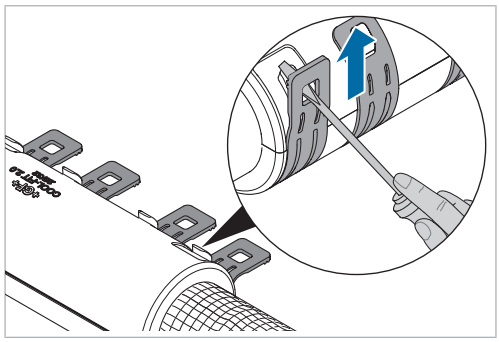
Step 7

Insulation with ring is pushed to butt against the adapter. The net must be outside the shell.



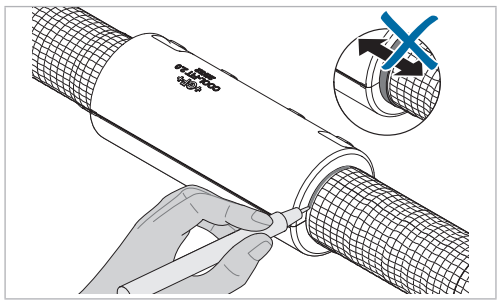
Step 8 - 9

Visually check that the insulation is butted in the shell and, if necessary, push the adapter into place. The ring must be completely in the shell. Then close the shell.



Step 10

Close the tabs with a screwdriver.



Step 11

After closing the shell, a mark is placed along the edge of the shell. The mark indicates whether the insulation has shifted during the further installation process. If the mark is no longer visible along the shell, the shell must be reopened and checked.

Disassembly

Fitting

The fitting can be opened and released again.

> NOTE! Loss of warranty if adapters are opened!
> If adapters have been opened, e.g. during disassembly, the warranty is no longer valid.
> → Do not reuse opened adapters.

Shell

The shell can be opened at the tabs and reused.

Plug connection

It is possible to loosen the connection, but the adapter will be destroyed in the process.

> NOTE! Destruction of the adapter by loosening the connection.
> Loosening the connection is possible, but the adapter will be destroyed in the process.
> → For the next assembly: Use a new adapter.

1. Use water pump pliers to fix the collar of the half shells. Use a second pair of water pump pliers to loosen the adapter housing in an anticlockwise direction.
2. This destroys the housing and it must not be used again.
3. Unscrew the adapter housing completely.
4. Pull the tube off the support nipple.
5. Remove the adapter housing, support ring and toothed ring from the tube.
6. Remove the half shells of the adapter from the support nipple of the module.
7. Pull the support nipple of the adapter out of the module.
8. Loosen the clamping ring by squeezing it lightly with pliers and remove it from the tube.
9. Dispose of all parts of the dismantled adapter properly.

Module

The module can be reused.

The tube end must be shortened by 6 mm (this complies with the insertion depth of the toothed ring) and recalibrated.

1.5.3 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).

1.5.4 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")	$\leq P_{p\,(zul)}$	$\leq 0.85\ P_{p\,(zul)}$
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.

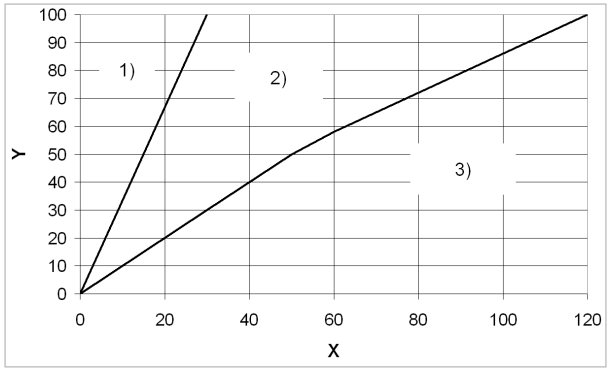
Reference values for the filling volume are given in the table below.

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

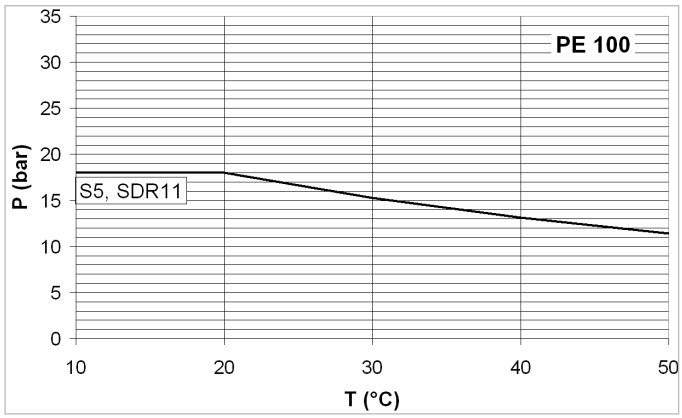
The permissible test pressure is calculated using the following formula:

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

$\sigma_{v(T,\,100\,h)}$ 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

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

1.5.5 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

1.6 Transport, Handling and Storage

1.6.1 Transport

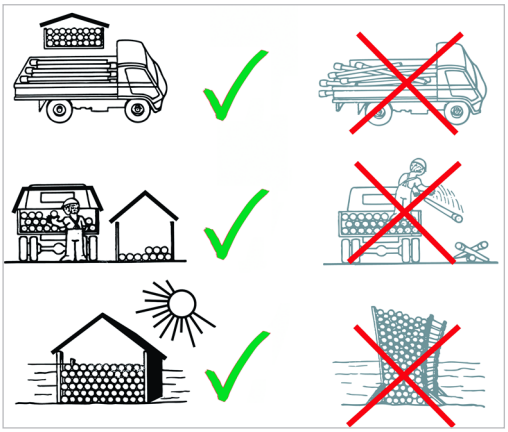
On trucks/in crates, manual transport.

For hygienic reasons, all openings on pipes, fittings and valves must be closed until final assembly.

- Protect the product against external force (impact, shock, vibration, etc.) during transport.
- Transport and/or store product in unopened original packaging.
- Protect the product from dust, dirt, moisture, heat and UV radiation.
- Make sure that the product is not damaged by mechanical or thermal influences.
- Check the product for transport damage before assembly.

1.6.2 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.



1.7 Environment

The materials used for COOL-FIT 2.0 are suitable for recycling. GF Industry & Infrastructure Flow Solutions aims to satisfy its customer's wishes concerning environmental aspects.

For more information at www.coolfit.georgfischer.com

1.7.1 Disposal

Country-specific regulations

Disposal and recycling may be regulated differently in different countries by laws, directives, ordinances, standards, regulations and instruction leaflets.

When disposing of or recycling the product, the single components and the packaging, the locally applicable regulations must be observed.

Pre-Insulated Solutions

COOL-FIT 4.0

Content

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COOL-FIT 4.0

1.1 General Information

COOL-FIT 4.0 is a pre-insulated piping system for the delivery of secondary refrigerants. The COOL-FIT 4.0 system is a completely pre-insulated plastic piping system for secondary refrigerant circuits that run with water, brine, or Glycol based solutions. Thanks to its insulation thickness of 40 mm, typical areas of application are industrial refrigeration systems with medium temperatures up to -50 °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.

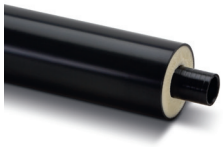


The COOL-FIT 4.0 system is suitable for use in applications like:

- 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

1.2 System Specification

1.2.1 COOL-FIT 4.0

Specification		COOL-FIT 4.0	COOL-FIT 4.0F	COOL-FIT 4.0 Push System
				
Materials[1]	Pipe	PE100	PE100	Multilayer composite pipe PE-RT/Al/PE-RT
	Insulation	GF-HE foam, halogen free, closed-cell	GF-HE foam, halogen free, closed-cell	Pipe: EPDM foam Fitting: XPE foam
	Outer jacket	Pipe HDPE	Flame retardant - GF-FR	Stainless steel polyester fabric
		Fitting GF-HE		TPE
Size		d32DN25 – d450DN450	d32DN25 - d225DN200	d25DN20 - d32DN25
Connection technology		Electrofusion	Electrofusion	Push-in connector
Nominal pressure[2]	16 bar, SDR 11 10 bar, SDR17	d32DN25-d450DN450 d160DN150-d450DN450	d32DN25-d225DN200 d160DN150 + d225DN200	16 bar
Temperature	Medium	-50 °C to +60 °C	SDR11: -30 °C to +60 °C SDR17: 0 °C to +60 °C	-20 °C to +60°C
	Environment	-30 °C to +60 °C	0 °C to +55 °C	+0 °C to +55°C
Insulation	Thermal conductivity $\lambda_{10°C}$			
	PE Inner pipe	0.38 W/mK	0.38 W/mK	
	GF-HE foam	0.022 W/mK (d32-d110); 0.026 W/mK (d140-d450)	0.026 W/mK	
	PE jacket	0.38 W/mK		
	GF-FR jacket		0.15 W/mK	
	Multilayer composite pipe			0.43 W/mK
	EPDM Foam			0.037 W/mK
	Density	≥ 70 kg/m³	≥ 70 kg/m³	50-60 kg/m³
	Foam cell size	max. Ø 0.5 mm	max. Ø 0.5 mm	
	Nominal thickness	40 mm	40 mm	20 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	Black
Weight (without medium)	Pipe d32	1.39 kg/m		0.84 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)	Oxygen diffusion tight acc. DIN 4726	Oxygen diffusion tight acc. DIN 4726
Fire classification[3]	EN 13501-1	E	B-s2, d0	D-s2, d0
Environment	Stability	Moisture and vapor-tight	Moisture and vapor-tight	Moisture and vapor-tight
	Resistance	Weather resistant UV resistant	For indoor use	For indoor use
	Ozone Depletion Potential	Zero	Zero	Zero
	Hail resistance acc. to SIA 261/1	HW5 (VKF hail register No 40470)		

Specification		COOL-FIT 4.0	COOL-FIT 4.0F	COOL-FIT 4.0 Push System
Standards and Guidelines	DIN EN 12201-2	Plastics piping systems for water supply, and for drainage and sewerage under pressure - Polyethylene (PE)		
	DIN EN 15494	Plastics piping systems for industrial applications - Polybutene (PB), polyethylene (PE) and polypropylene (PP) - Specifications for components and the system - Metric series		
	DIN 8074	Polyethylene (PE) - Pipes PE 80, PE 100 - Dimensions		
	DIN 8075	Polyethylene (PE) - Pipes PE 80, PE 100 - General quality requirements, testing		
	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		
	SIA261/1	Loads on Structures – Supplementary Specifications		
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)	basic	basic	

1) All three materials are firmly bonded together. Does not apply to COOL-FIT 4.0 Push System.

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) The pipes were tested according to DIN EN 13823. Additional information in chapter "Fire behavior and fire prevention measures".

1.2.2 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 PE100, its properties are of particularly high relevance.

Properties of PE (approximate)

Property	PE100-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 179-1/1 eA
Charpy notched impact strength at -40 ° C	13	kJ/m²	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. PE is a non-polar material. Therefore, it is insoluble and scarcely swellable in conventional solvents. PE pipe cannot therefore be adhesively bonded to fittings. Welding is the appropriate connection method for the material.

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

Advantages of PE

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

Mechanical properties, chemicals, weathering and abrasion resistance

UV and weather resistance



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

Chemical resistance



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

Abrasion resistance



PE has excellent resistance to abrasive wear. You can therefore find PE piping systems in use in numerous applications for transporting solids and media containing solids. For many applications, PE has proven especially advantageous with metals.

Thermal and electrical properties

Operating limits



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

Electrical properties



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

1.3 Technical Details

1.3.1 COOL-FIT 4.0 Pipe and Fittings

COOL-FIT 4.0 Pipe

COOL-FIT 4.0 pipe are made from PE100. 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 (d140-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		Volume	Insulation thickness	Heat transfer coefficient (U)	Fire load
					empty	with water				
(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
d140/225	140 x 12.7	114.6	11	225 x 5	9.68	19.99	10.31	37.5	0.35	109.43
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 5.3	23.61	71.45	47.84	54.7	0.46	264.28
d315/450	315 x 18.7	277.6	17	450 x 5.6	29.46	89.99	60.52	61.9	0.46	329.19
d355/500	355 x 21.1	312.8	17	500 x 6.3	36.88	113.73	76.85	66.2	0.48	413.79
d400/560	400 x 23.7	352.6	17	560 x 7.0	46.31	143.95	97.65	73.0	0.49	520.18
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		Volume	Insulation thickness	Heat transfer coefficient (U)	Fire load
					empty	with water				
(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 5.3	29.86	71.12	41.26	54.7	0.46	340.54
d315/450	315 x 28.6	257.8	11	450 x 5.6	37.37	89.57	52.2	61.9	0.46	425.69
d355/500	355 x 32.2	290.6	11	500 x 6.3	46.87	113.20	66.33	66.2	0.48	535.73
d400/560	400 x 36.3	327.4	11	560 x 7.0	59.09	143.28	84.19	73.0	0.49	676.16
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

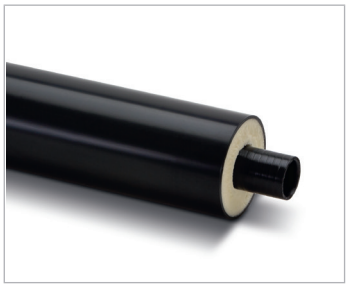
d	Nominal outer diameter of the PE pipe
d_i	Nominal inside diameter of the pipe
D	Nominal outside diameter of the outer PE jacket
e, e1	Nominal wall thickness

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		Pipe class	Outer jacket	Weight		Volume	Insulation thickness	Heat transfer coefficient (U)	Fire load
					empty	with water				
(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 9.5	141.0	17	250 x 3	9.48	25.09	15.61	42.0	0.36	81.51
d225/315	225 x 13.4	198.2	17	315 x 3.5	15.79	46.65	30.85	41.5	0.48	144.33

Pipe size	Inner Pipe		Pipe class	Outer jacket	Weight		Volume	Insulation thickness	Heat transfer coefficient (U)	Fire load
					empty	with water				
(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 1.8	1.32	1.86	0.54	27.2	0.13	9.06
d40/110	40 x 3.7	32.6	11	110 x 1.8	1.82	2.65	0.83	33.2	0.13	12.95
d50/110	50 x 4.6	40.8	11	110 x 1.8	1.99	3.29	1.31	28.2	0.17	15.31
d63/125	63 x 5.8	51.4	11	125 x 1.8	2.59	4.66	2.07	29.2	0.20	21.14
d75/140	75 x 6.8	61.4	11	140 x 2.5	3.62	6.58	2.96	30.0	0.22	29.31
d90/160	90 x 8.2	73.6	11	160 x 2.5	4.65	8.90	4.25	32.5	0.24	39.24
d110/180	110 x 10	90.0	11	180 x 2.8	6.21	12.58	6.36	32.2	0.28	54.39
d140/225	140 x 12.7	114.6	11	225 x 2.8	9.20	19.52	10.31	39.7	0.33	83.61
d160/250	160 x 14.6	130.8	11	250 x 3.0	11.55	24.98	13.44	42.0	0.35	106.75
d225/315	225 x 20.5	184.0	11	315 x 3.5	19.84	46.43	26.59	41.5	0.47	193.74

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 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

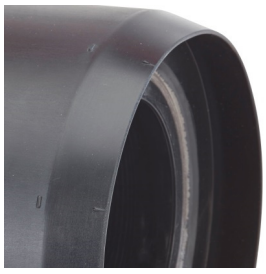
After the welding process, the indicator pin shows that energy has been applied to the welding zone.



Sealing lip at fittings Type A d32-d225 (plus coupler d250)

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

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



Label

The fittings have abrasion-resistant marking.



Trace code

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



Angle marking

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



Jointing

Pipe and Fitting

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

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

Fitting-to-fitting

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

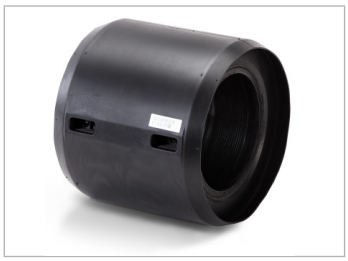
Two COOL-FIT 4.0 Type B fittings can be joined using an electrofusion fittings type A.

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

Components

COOL-FIT 4.0 Electrofusion coupler

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



COOL-FIT 4.0 Elbows 45° and 90°

(Refer to „General Information“ chapter above)



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

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



COOL-FIT 4.0 Reducer

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



Combination of T90° and Reducer

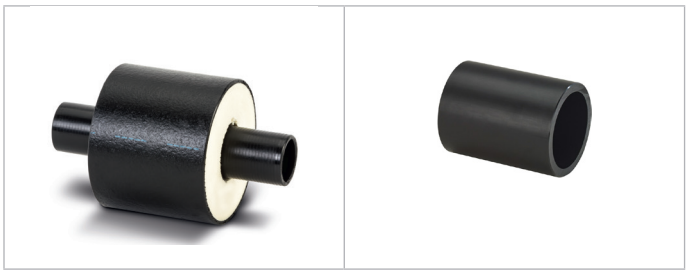
If a reducer in a system is fitted behind a tee, either a COOL-FIT 4.0 T90° reduced or a COOL-FIT 4.0 T90° reduced/equal connected to a reducer should be used.

Run Branch	40	50	63	75	90	110	140	160	225
32	X	X	X	O	O	O	O	O	O
40		X	X	O	O	O	O	O	O
50			X	O	O	O	O	O	O
63				Δ	Δ	Δ	Δ	Δ	Δ
75					Δ	Δ	Δ	[ ]	[ ]
90						Δ	Δ	Δ	Δ
110							Δ	Δ	Δ
140								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

COOL-FIT 4.0 Barrel nipple

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



COOL-FIT 4.0 Sliding coupler kit

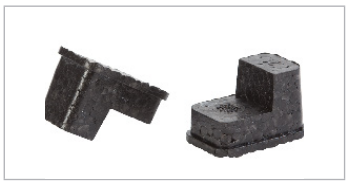
The sliding coupler kit is a radially insertable element for connecting two fixed pipe spigots.



1.3.2 Accessories for dimensions d32 - d250

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.



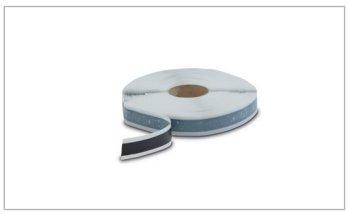
Sealing clamps

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.



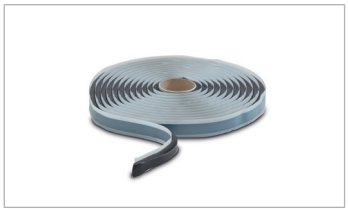
Sealant

The silicone-free sealant is used to join the EPDM insulation of Weld-in ports to the COOL-FIT pipes, as well as to cement the end caps d250-d450.



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.



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 Installation fittings type 313

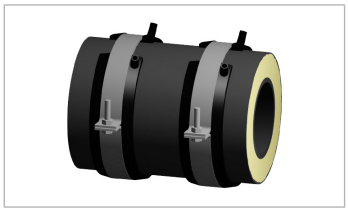
Installation fittings are used to install various types of sensors to the system. Pressure or temperature sensors can be connected using the ½ "or ¾" Rp or NPT female thread.

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



COOL-FIT 4.0 Fixed point

The fixed point is used to direct pipe movement or retain forces from pipe weight at risers. The electrofusion welding tapes allow a permanent connection and transmit occuring forces between pipe and clamp.



COOL-FIT 4.0 Fixed point for high forces

The fixpoint placed on the media pipe alows the transmition of higher forces. The fixed point is placed between two electrofusion fittings.



COOL-FIT 4.0 Weld-In Port

The COOL-FIT Weld-in port significantly increases the flexibility by enabling the branching-off on already laid, unfilled an dry COOL-FIT pipes in dimensions d63-d225.

The product range of fittings includes Weld-in ports with transitions to female threads, as well as Weld-in ports that allow transitions within the GF piping portfolio.

The EPDM soft foam insulation supplied with the Weld-in ports is designed to ensure a condensation-free connection to the COOL-FIT pipe, and to insulate the ports up to the corresponding interface.



Connection type, material	Size	Purpose
Female threads RP + NPT, PE/Stainless steel	½", ¾", 1"	Installation of instruments, probes, sensors as well as transition to other piping systems
iFIT, PE/Brass	25/32	Transition from COOL-FIT 2.0 and COOL-FIT 4.0 to COOL-FIT 4.0 Push System
Sanipex MT, PE/Brass	32	Transition from COOL-FIT 2.0 and COOL-FIT 4.0 to GF Sanipex MT
PE spigot SDR11	32, 40, 50	Connection within COOL-FIT 2.0 and COOL-FIT 4.0

The Weld-in ports can be used with pipes COOL-FIT 2.0, COOL-FIT 2.0F, COOL-FIT 4.0 and COOL-FIT 4.0F.

Jointing

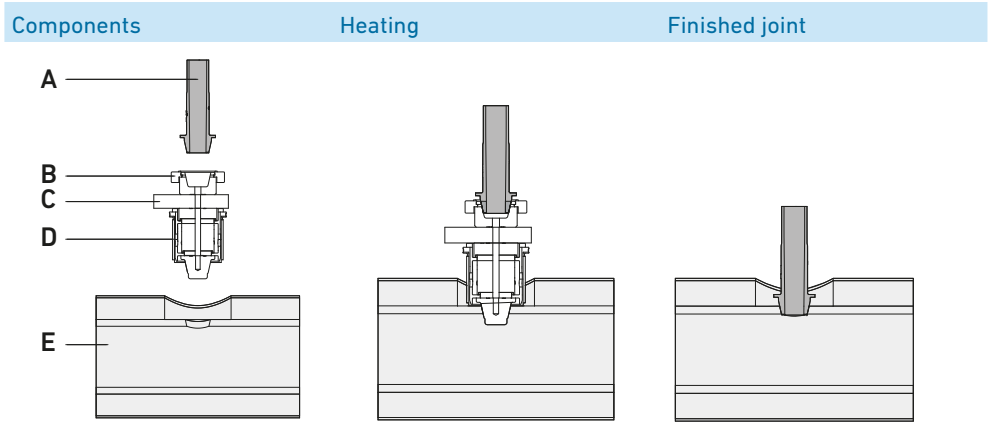
After the controlled local tapping of jacket and inner pipe of the respective COOL-FIT pipe, the welded joint is made.

In the cone welding process used here, a modified version of heating element socket welding, the inner pipe of the COOL-FIT pipe and the Weld-in port are welded in an overlapping material-to-material bond without the use of additional filler materials.

The welding surfaces of the pipe and the fitting are heated to welding temperature on a conical socket- or spigot-shaped heating element and then joined together.

The dimensionally matched geometry of the components ensures the welding pressure during joining and a homogeneous joint.

Jointing principle



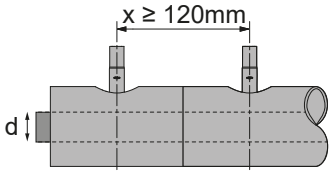
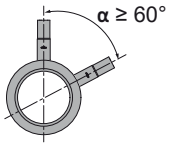
A Weld-in port
B Heating bush
C Fusion tool
D Heating spigot
E COOL-FIT Pipe

After the fusion process, the EPDM insulation is mounted to the Weld-in port. Bonding of insulation the COOL-FIT pipe is done using the COOL-FIT sealant.

Distance of COOL-FIT Weld-in ports and pressure de-rating of main pipes

On positioning the Weld-in ports on the COOL-FIT pipe, the following distances must be taken into account:

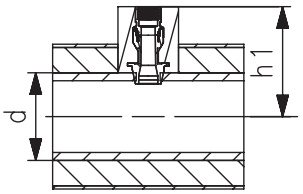
- Distances between Weld-in ports along the pipe axis.
- Arrangement around the circumference of the pipe.

		Ports with metal insert	Ports with PE spigot
Distances along pipe axis*		x ≥ 120 mm ► no pressure de-rating of main pipe	x ≥ 2 * d main pipe ► no pressure de-rating of main pipe or x < 2 * d main pipe ► pressure de-rating factor of main pipe of 0.8
Arrangement around circumference		x ≥ 0 mm (along pipe axis), α ≥ 60° ► no pressure de-rating of main pipe	

* The minimum distance due to the tool dimensions is 120 mm.

Heigth of Weld-in ports ½"-1" towards the middle of the pipe axis

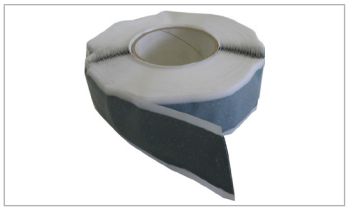
Heigth h1 [mm]/d [mm]	d63	d75	d90	d110	d140	d160	d225
½" Rp	117	123	130	140	155	165	198
½" NPT	120	126	134	144	159	169	201
¾" RP + NPT	117	123	130	140	155	165	198
1" Rp + NPT	118	124	131	141	156	166	199



1.3.3 Accessories for dimensions d280 - 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.



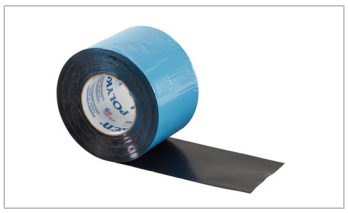
End cap

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.



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.



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.



1.3.4 COOL-FIT 4.0 Push System

COOL-FIT 4.0 Push System pipe

Inside the multilayer composite pipes of the COOL-FIT 4.0 Push System is a medium-bearing layer made of polyethylene (PE-RT). The outer layer, which protects the pipe from mechanical loads, is also made of PE-RT. In between is a longitudinally butt-welded aluminum carrier pipe, which is permanently bonded to the other two layers by means of bonding agents - also PE-based.

The EPDM insulation has a thermal conductivity of 0.037W/mK at 10°C and is covered with an additional polyester/stainless steel mesh, which prevents wrinkling and protects the pipe from mechanical stress.

The pipes are available in 5m rod and 25m roll.

Pipe size	Inner Pipe	Inner Pipe	Outer jacket	Weight		Volume	Insu-lation thick-ness	Heat transfer coeffi-cient (U)	Fire load	Ben-ding radius R with ben-ding spring	Ben-ding radius R with tool
				Weight empty	Weight with water						
(mm)	d x e (mm)	d_i (mm)	D x e1 (mm)	(kg/m)	(kg/m)	(l/m)	(mm)	(W/m K)	(kWh/m)	5x d (mm)	3,5 x d (mm)
d25/78	25 x 2.5	20	78 x 1	0.728	1.042	0.314	25.5	0.19	2.34	200	98
d32/85	32 x 3	26	85 x 1	0.843	1.374	0.521	25.5	0.22	3.09		112

d	Nominal outer diameter of the PE pipe
d_i	Nominal inside diameter of the pipe
D	Nominal outside diameter of the outer jacket
e, e1	Nominal wall thickness

COOL-FIT 4.0 Push System Fittings

General

The Push System fittings are made of high-performance polyphenylsulfone (PPSU) plastic. This material has proven itself for fittings in building services and is characterized above all by excellent corrosion resistance and low incrustation. The Push System fittings have a high degree of robustness, i.e. special impact strength and impact resistance.

To further increase mechanical strength, the iFIT adapters are additionally protected by a glass-fiber-reinforced polyamide (PA-GF30).

The insulation half-shells supplied fit onto the Push System fittings and can be closed quickly and easily with integrated tabs and hooks.



Connection

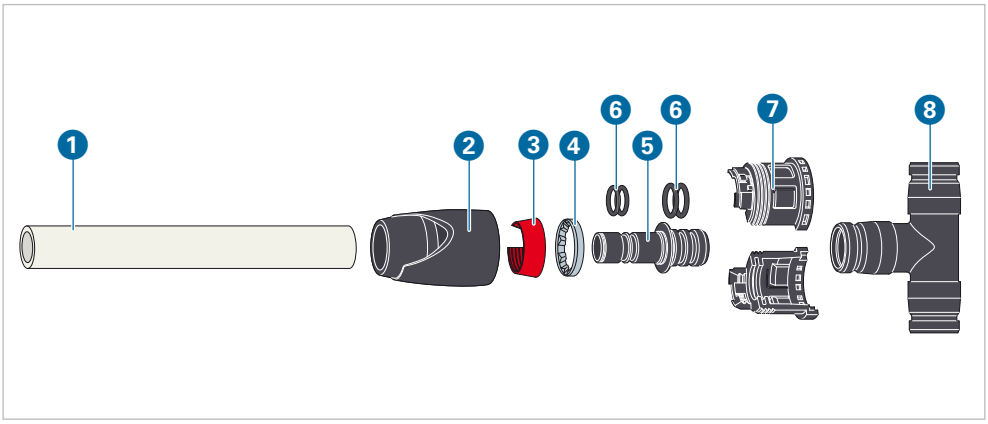
The connection is made using adapter module technology, a push system that requires few tools and no electrical power. It is possible to work across dimensions via the module.

The adapters are pushed onto the tube and module. A viewing window and "click" sounds allow the correct assembly to be checked during the installation process.

Push fitting

An iFIT tool is used for the processing and it is done manually. The iFIT push fitting guarantees a secure, fast and detachable connection. The modules are reusable. The adaptors can only be used once. This also applies to adaptors if the clicking action was not completed.

An iFIT push fitting consists of several components:



iFIT push fitting
1 Multilayer pipe

Adaptor
2 Adaptor housing
3 Clamping ring
4 Toothed ring
5 Insert
6 O-rings (EPDM)
7 Half shells
8 Module made of PPSU or low-lead, dezincification-resistant brass

The iFIT adaptor is plugged into a chamfered pipe end. The push fitting is then closed by clicking the module into the adaptor.

Inadmissible system connections

! NOTE! Damage due to inadmissible system connections!
→ When using the COOL-FIT 4.0 Push System, **use** only multilayer composite pipes from the COOL-FIT 4.0 Push System or iFIT assortment.

Components

COOL-FIT-4.0 Push System coupler

The sockets are used for straight connection of pipes.



COOL-FIT 4.0 Push System 90° elbow

The 90° elbows can be used to change the direction of the pipe when space is limited and it is not possible to bend the pipe.



COOL-FIT 4.0 Push System T90° equal

The T90° equal are supplied with two adapters and compression rings only. At the outlet, a choice can be made between two dimensions in any case. Additional adapters must be ordered separately.



COOL-FIT 4.0 Push System ball valve

The ball valves suitable for the COOL-FIT 4.0 Push System can be connected directly to the pipe via the adapters through a push fitting connection.



COOL-FIT 4.0 Push System flow control valve

The COOL-FIT 4.0 Push System volume flow controller, based on the TacoSetter, can be used to balance a wide variety of systems such as fan coils.



COOL-FIT 4.0 Transition fitting PE/iFIT

The COOL-FIT 4.0 transition fitting PE/iFIT provides a direct connection option from COOL-FIT 4.0 to the COOL-FIT 4.0 Push System.



1.3.5 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



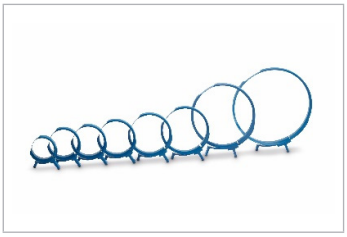
Y-cable kit for COOL-FIT fixed point

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 three dimension range 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.





Weld-In Port installation tool

Using the installation tool, the different COOL-FIT Weld-in ports can be installed safe, reliable, reproducible and quick.

Drilling of jacket, drilling of inner pipe as well as the subsequent welding joint is supported in a clever way.

Depending on the need in Weld-in ports to be installed, the tool is available in 230V as well as in 110V in different equipment variants.



Plastic pipe cutter PEcut 1200

Plastic pipe cutter for precise and safe cutting of COOL-FIT pipes in dimension from d160.



iFIT tool set

iFIT tool set enables a fast and safe installation of COOL-FIT 4.0 Push System components.



1.4 Dimensioning and Design

1.4.1 General information about the dimensioning and installation of plastic piping

Plastics have different physical characteristics to metals. When designing and installing thermoplastic piping systems, this needs to be taken into account. Although PE and
COOL-FIT 4.0 are very robust systems, care should be taken to avoid damage during handling and transportation.

For over 50 years, 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 contact your local GF Industry & Infrastructure Flow Solutions representative. Additional information is available on the official GF Industry & Infrastructure Flow Solutions website.

1.4.2 COOL-FIT 4.0 pressure-temperature diagram

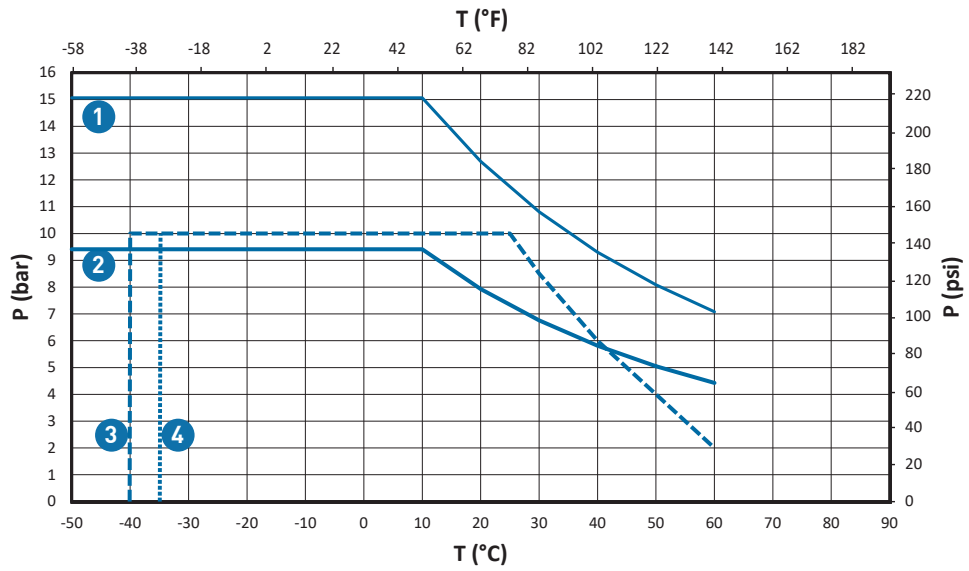
The pressure resistance for thermoplastic pipe for water is always specified at +20 °C. At higher temperatures allowance must be made for a lower maximum operating pressure.

The graphs show the maximum permissible pressure for COOL-FIT 4.0 pipe and fittings at various temperatures, up to the maximum permissible media temperature of +60 °C. The graph is based on an ambient temperature of +20 °C. A safety factor of 1.6 and a minimum lifespan of 25 years have been allowed for in all calculations.

Pressure/temperature limits for COOL-FIT 4.0 pipe, fittings, valves – water as secondary refrigerant

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

In case of long-term operating pressure at temperatures above 47 °C, please contact your authorized GF Industry & Infrastructure Flow Solutions representative.

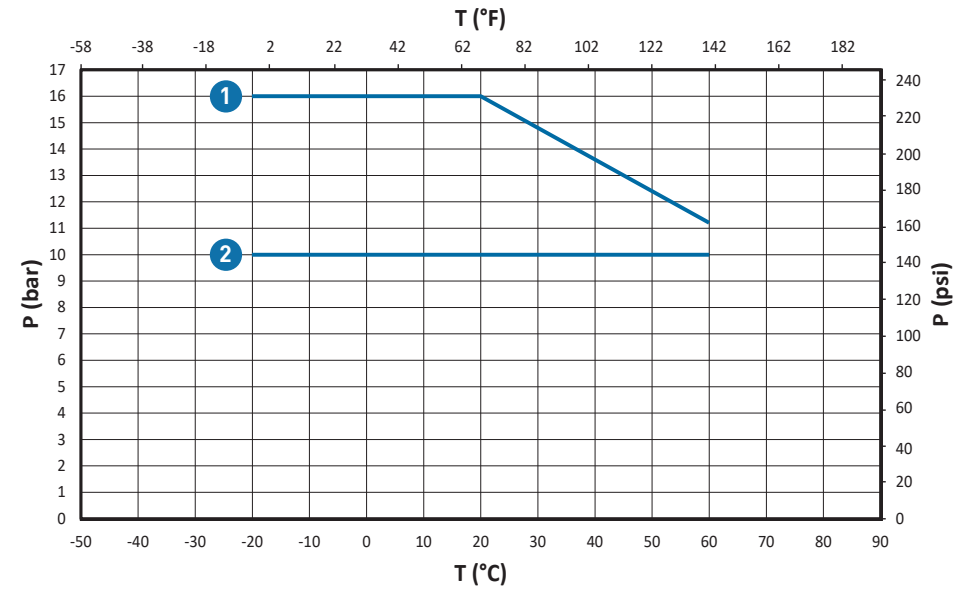


P Allowable pressure (bar, psi)
T Temperature (°C, °F)
C Safety factor

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

Pressure/temperature limits for COOL-FIT 4.0 Push System fittings, pipe, valves – water coolant

Limits for COOL-FIT 4.0: 25-year values (with water as the coolant).



P Allowable pressure (bar, psi)
T Temperature (°C, °F)
1 COOL-FIT 4.0 Push System pipe, fitting and ball valve
2 COOL-FIT 4.0 Push System Flow control valve

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.

For COOL-FIT 4.0 Push System, no reduction factor is necessary.

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".

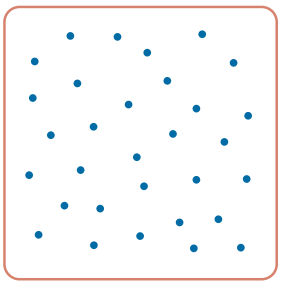
1.4.3 Condensation assessment and prevention

Introduction

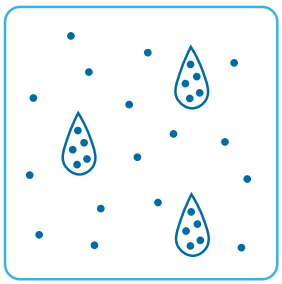
Piping in cooling applications is funeral to condensation due to its chilled media and therefore may need to contain preventive measures. Various factors influence the occurrence of condensation which, therefore, need to be considered during the planning stage.

Condensation occurs when humid air faces a cold surface such as a chilled pipe and releases some of its moisture as water droplets onto the pipe surface. This is since cold air cannot contain as much humidity as warm air. The state when condensation occurs is named dew point and is the temperature when air becomes saturated with water vapor.

Dew point



Molecules of water in warm air



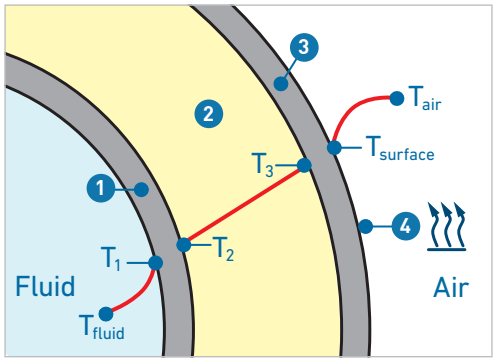
Molecules of water in cold air.
Excess water condenses into droplets.

Thus, if the temperature of a surface falls below the dew point temperature, condensation occurs. The dew point temperature (T_{dp}) depends on the ambient temperature (T_{air}) plus the ambient relative humidity (rH) and can be calculated with these two variables.

A high relative humidity increases the dew point temperature which raises the probability for condensation.

Next to the dew point temperature, also the surface temperature of the COOL-FIT system can be calculated by considering following information:

- material insulation properties (λ),
- dimensional information,
- media temperature (T_{fluid}),
- emittance (radiation and convection)



1 $\lambda_{inner\ pipe}$
2 $\lambda_{insulation}$
3 λ_{jacket}
4 ε_{mitt}

Emittance (radiation and convection) describes the dissipation of energy to the surrounding environment. Especially the convection is an important factor which is largely dependent on the air movement on the outer surface. Therefore, the air movement around the pipe surface is a critical variable to be considered during condensation assessment.

⚠ A low air movement lowers the convection and thus raises the risk of condensation occurrence.

Basic assessment

A calculation can support the assessment of the situation. The COOLING Tool-Box module "Condensation" uses a simplified calculation method for a rough assessment, see „1.4.17 COOLING Tool-Box" on page 523. As pipe specific information, i.e., insulation and dimensional properties, are already set, representative environmental parameters such as air temperature (T_{air}), relative humidity (rH), air velocity (v_{air}) and media temperature (T_{fluid}) need to be provided.

The COOLING Toolbox calculates and matches the dew point and surface temperature and gives out a result per dimension:

√ **Calculation**

- $T_{dp} > T_{surface}$ = condensation
  ↳ dew point T_{dp} above the surface temperature result in condensation.
- $T_{dp} < T_{surface}$ = no condensation
  ↳ dew point T_{dp} below the surface temperature results in no condensation.

⚠ This calculation does only a simple matching between the 2 calculated temperatures. In case of a small deviation or harsh and ambiguous environments, a basic assessment should not be the only basis.

Advanced assessment

In case of a harsh or ambiguous environment, an advanced assessment is needed. Additionally, it needs to be considered that a basic calculation can only support the assessment of the occurrence of condensation but does not give information about the condensation intensity.

Additionally, for the determination of the input variables, it must be considered that the environment undergoes fluctuations and individual situations might deviate.

Factors influencing ambient temperature and humidity:

- local climate variances
- weather variances (rainy-sunny periods, day-night rhythm)
- microclimate in enclosed spaces
- influences in proximity of the pipe routing (another piping, cold walls, ...)
- opening/closing of doors to areas with other conditions

Deviations between input and actual values:

- tolerances in measured air movement
- tolerances in media temperature

Therefore, the worst-case conditions must be taken into account, and each area must be evaluated separately.

Certain environmental conditions might be so harsh that a technical solution without condensation might be not feasible or economical. These are typically,

- spaces which are concealed and have no air movement (pipe trays, intermediate ceilings)
- spaces with extreme relative humidity

In such situations additional measures, such as increasing air movement or lowering relative humidity might be inevitable.

⚠ For an advanced evaluation - Get support by your local GF Industry & Infrastructure Flow Solutions representative.

1.4.4 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).

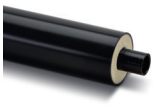
Smoke release:

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 according to EN13501-1

	COOL-FIT 4.0	COOL-FIT 4.0F	COOL-FIT 4.0 Push System	COOL-FIT 4.0/ mineral wool [1)]
				
EN 13501-1*	E	B – s2, d0	D – s2, d0	$A2_L$

[1)] Type: Rockwool 800

* The pipes were tested acc to DIN EN 13823

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	140/225
Thermal load COOL-FIT 4.0 SDR11 pipes (kWh/m)	15.0	21.7	24.0	32.7	41.4	53.1	68.9	109.43

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	264.3	329.2	413.8	520.2	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	340.5	425.7	535.7	676.2	850.7

d/D (mm)	32/90	40/110	50/110	63/125	75/140	90/160	110/180	140/225	160/250	225/315
Thermal load COOL-FIT 4.0F SDR11 pipes (kWh/m)	9.06	12.95	15.31	21.14	29.31	39.24	54.39	83.61	106.75	193.74

d/D (mm)	160/250	225/315
Thermal load COOL-FIT 4.0F SDR17 pipes (kWh/m)	106.75	193.73

d/D (mm)	25/78	32/85
Thermal load COOL-FIT 4.0 Push System pipes (kWh/m)	2.34	3.09

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

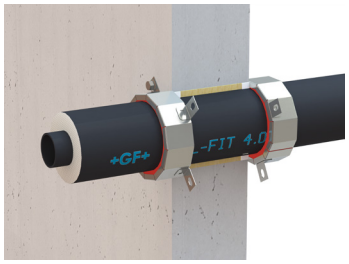
When pipes are installed through fire-rated assemblies, whose reliable functioning must not be affected, firestop collars that comply with local requirements and legislation must be used.

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

Info | Shop

qr.hilti.com/r3069

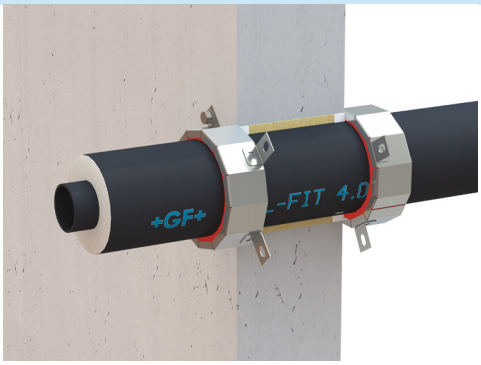
Hilti CFS-C P

Info | Shop

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

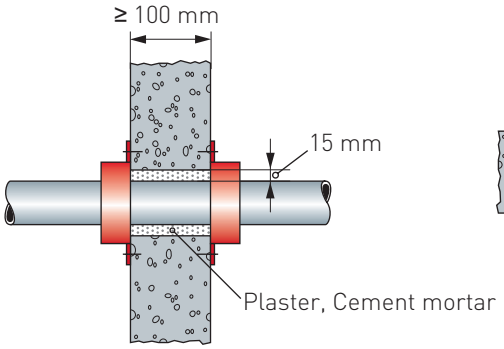
* For bigger dimensions see chapter "Additional approved fire retarding sealing".

Gap sealing

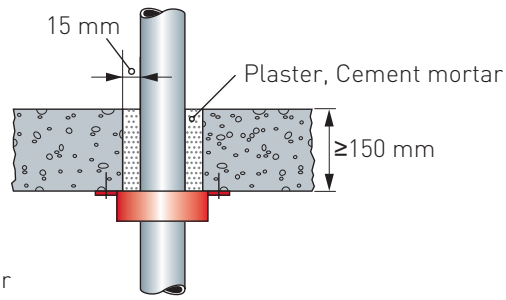
For the installation situations there are several options for sealing gaps against smoke gas.

Gap sealing with non-combustible construction materials:

Rigid wall

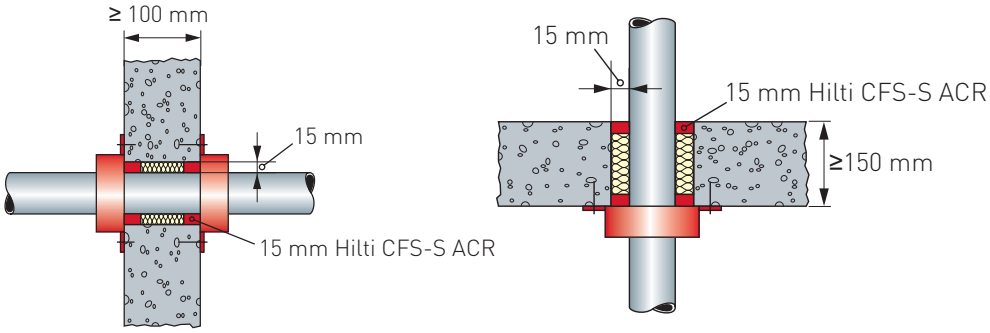


Rigid floor



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.

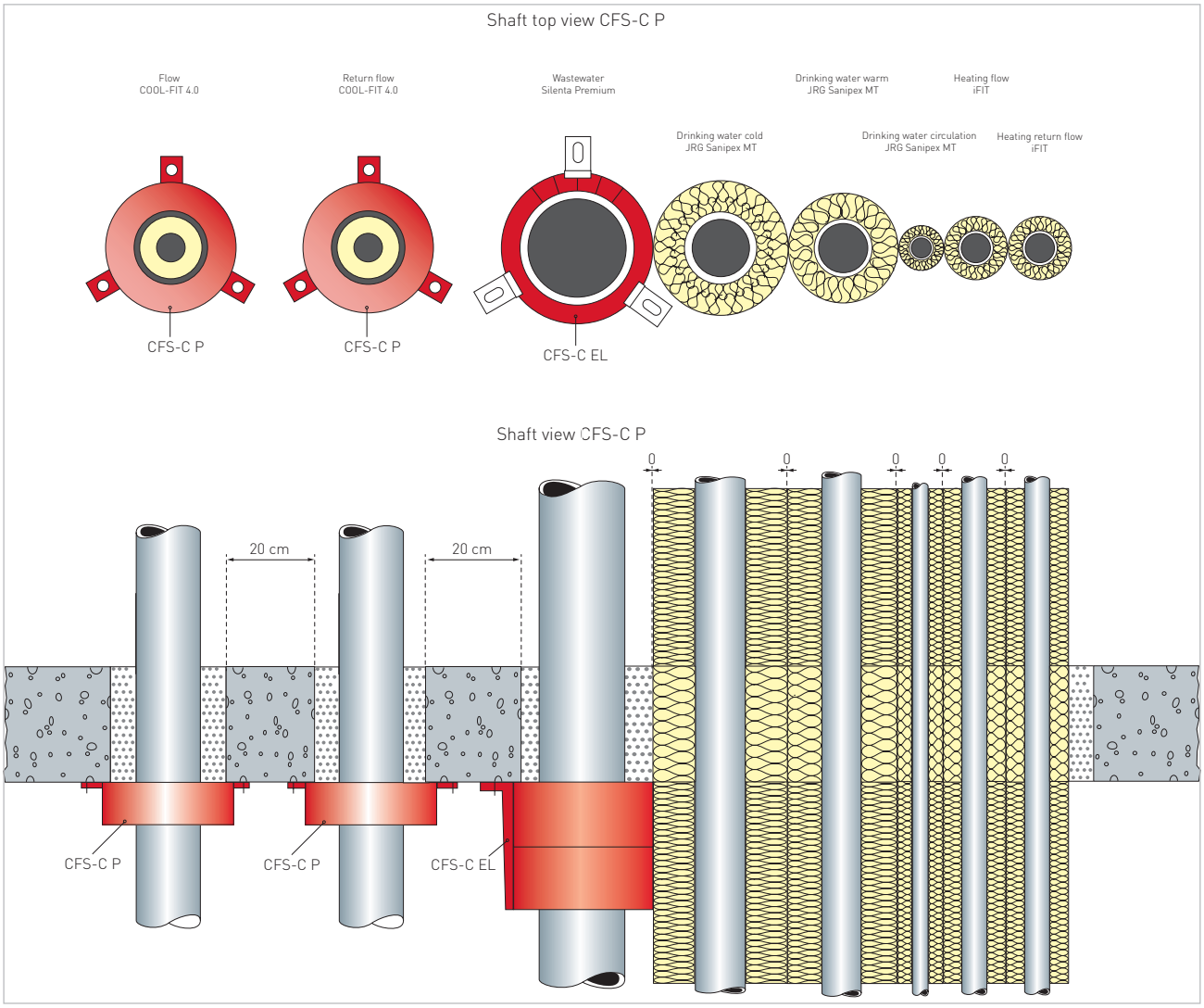
Distance of the pipe sealing to	Size of the adjacent openings	Distance between the openings DE, CH	Distance between the openings EU
Other cable or pipe sealing	one/both openings > 40cm x 40cm	≥ 20cm	≥ 20cm
	Both openings ≤ 40cm	≥ 10cm	
Other openings or installed elements	one/both openings > 20cm x 20cm	≥ 20cm	≥ 20cm
	Both openings ≤ 20cm	≥ 10cm	

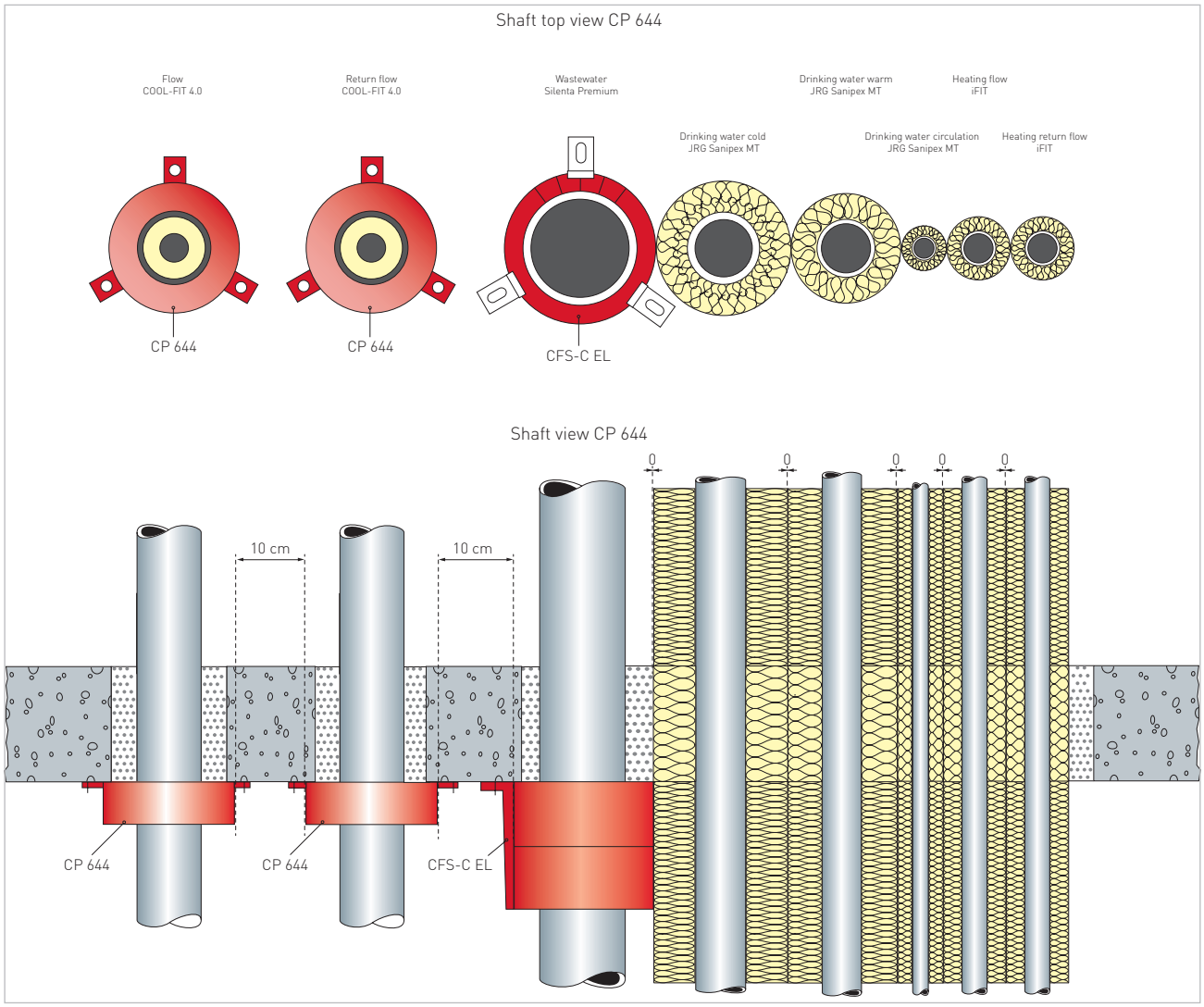
The following pipe distances between the openings of the pipe lead through are derived from this for pipe sealing with the Hilti firestop collar for COOL-FIT 4.0:



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.svt-global.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.



Roxtec RS PPS seal

System description

The Roxtec RS PPS is a sealing for pipes through steel decks and bulkheads in vessels. The intumsecent-based sealing stips that wrap around the plastic pipe ensure blocking of smoke, flames and water in case of fire.

Fire-retarding sealing	Manufacturer	Approval
Roxtec RS PPS und RS PPS/S	Roxtec International AB	MEDB000036A LR2090258SF

For detailed information about Roxtec see www.roxtec.com

1.4.5 Hydraulic design

Determination of pipe diameter based on flow rate

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

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

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

Example calculation of an internal diameter d_i

COOL-FIT 4.0 pipe	SDR17
Flow rate Q_2	55 l/s
Usual flow velocity v	1.5 m/s

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

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

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

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

Determination of pipe diameter based on cooling 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 di, based on cooling capacity with medium water.

Cooling capacity Q_L	2'000 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}
3'600	60'000	1'000	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	140
di SDR11 (mm)	26.2	32.6	40.8	51.4	61.4	73.6	90	114.6
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

1.4.6 Nomogram for easy calculation of diameter and pressure loss

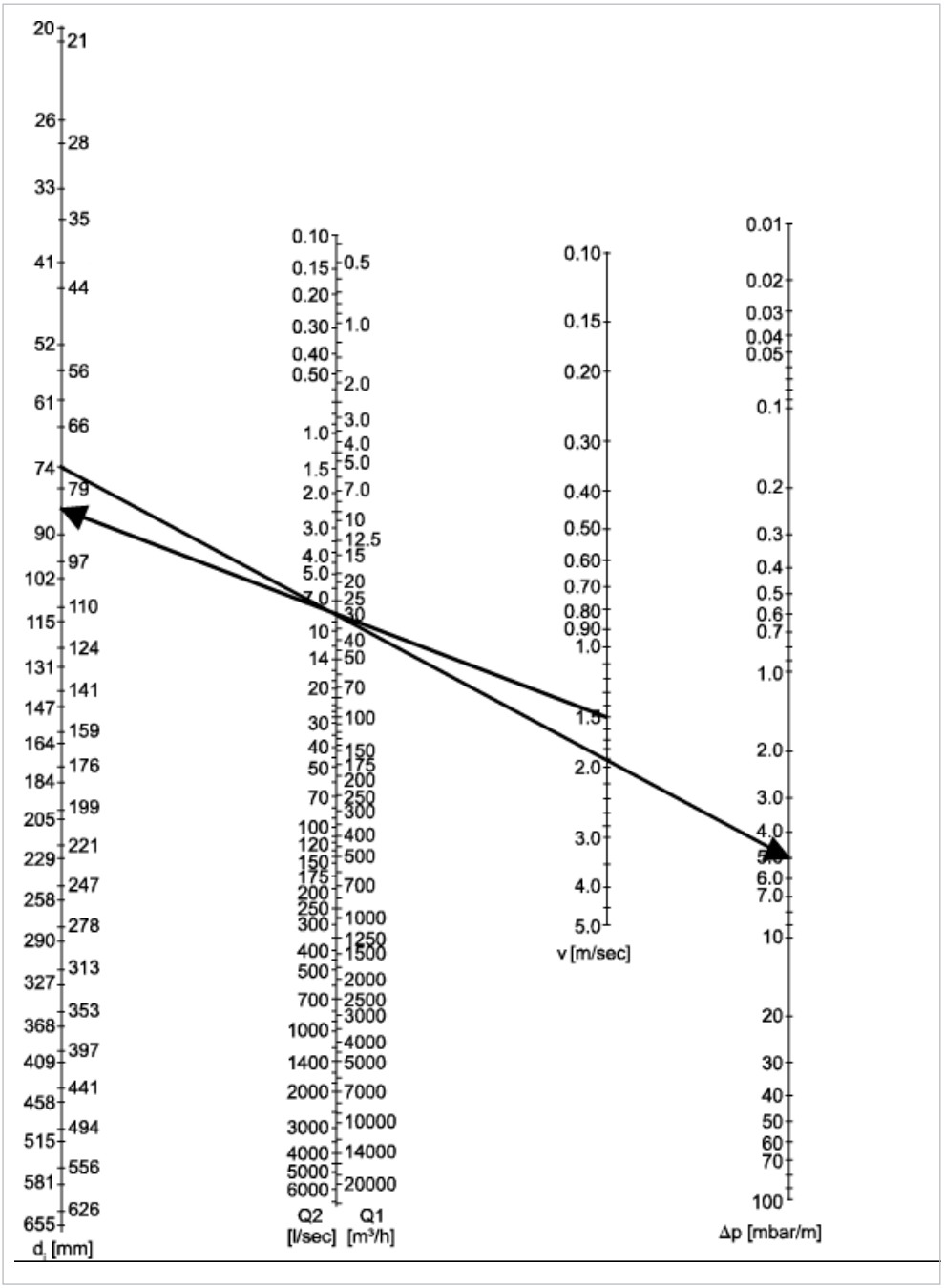
The nomogram below can be used to simplify the determination of the diameter required .The pressure loss in the pipe can be read off per meter of the pipe length.

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

Using the nomogram

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

Nomogram for COOL-FIT 4.0 pipe (PE100, SDR11) using the metric system



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

1.4.7 Dimension comparison COOL-FIT 4.0 / 4.0F / 4.0 Push System vs. metal

COOL-FIT 4.0 / 4.0F			Stainless steel		Copper pipe
d (mm)	d_i (mm)	DN	inch	da (mm)	da (mm)
32	26.2	25	1	33.4	28
40	32.6	32	1 ¼	42.2	35
50	40.8	40	1 ½	48.3	42
63	51.4	50	2	60.3	54
75	61.4	65	2 ½	73.0	76.1
90	73.6	80	3	88.9	88.9
110	90.0	90	4	114.3	108
140	114.6	125	5	141.3	133
160	141.0	150	6	168.3	159
225	198.2	200	8	219.1	219
250	220.4	250	10	244.5	
280	246.8	250	10	273.1	267
315	277.6	300	12	323.9	
355	312.8	350	14	355.6	
400	352.6	400	16	406.4	
450	396.6	450	18	457.2	

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

COOL-FIT Push System			Stainless steel		Copper pipe
d (mm)	d_i (mm)	DN	Inch	da (mm)	da (mm)
25	20	20	¾	26.7	22
32	26	25	1	33.4	28

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

1.4.8 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) 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.

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)

Ceta-values fittings COOL-FIT 4.0

Designation	Symbol	Coefficient of resistance ζ
Couplers		0.1
Elbow 90°		1.2
Elbow 45°		0.3
Tee [1]		1.3
Bend 90°	d250: 0.35 d280: 0.34 d315: 0.33	d355: 0.33 d400: 0.32 d450: 0.31
Bend 45°	d250: 0.25 d280: 0.24 d315: 0.23	d355: 0.23 d400: 0.23 d450: 0.22
Reducer (contraction)		0.5
Reducer (enlargement)		1.0
Flange joint, transition fitting	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
Weld-in port with female thread		0.2
Weld-in port PE spigot		0.1
		0.9
		1.4
Weld-in port PE/iFIT		0.1
		1.1
		3.3

[1] For a more detailed view, differentiate between coalescence and separation. Ceta values up to a maximum of 1.3 can be found in the respective literature.

Designation	Symbol	Coefficient of resistance ζ
Weld-in port PE/ Sanipex MT		0.1
		1
		1.3

Ceta-values fittings COOL-FIT 4.0 Push System

Designation		Symbol	Dimension	Coefficient of resistance ζ
Coupler			d25	2.8
			d32	6.7
90° angle			d25	5.2
			d32	11.0
Pipe bend 90°, bent manually			d25	0.1
			d32	0.1
Pipe bend 45°, bent manually			d25	0.1
			d32	0.1
Tee	Main		d25	2.8
			d32	6.4
Tee	Branch		d25	5.5
			d32	12.4
Tee, reduced	Main		d32-d25	2.6
Tee, reduced	Branch		d32-d25	4.9
Reducer			d32-d25	2.7

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:

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

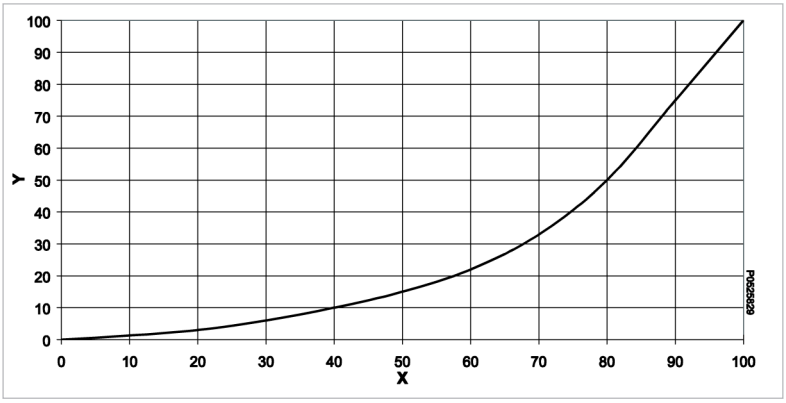
Δp_{Ar}	Pressure loss for the valve (bar)
Q	Flow rate (m^3/h)
ρ	Density of the conveyed medium (kg/m^3) (1 g/cc = 1000 kg/m^3)
k_v	Valve characteristic value (m^3/h)

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	1'000	70.0	60
40[1]	1 ½	50	1'600	112.0	96
50[1]	2	63	3'100	217.1	186
65[1]	2 ½	75	5'000	350.0	300
80[1]	3	90	7'000	490.0	420
100[2]	4	110	3'800	455	390
125[2]	5	140	8'600	602	516
150[2]	6	160	16'600	1'162	1'000
200[2]	8	225	39'600	2'772	2'380

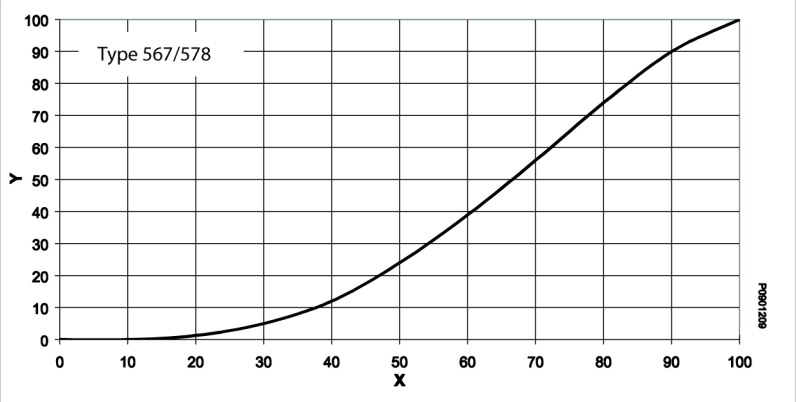
[1] COOL-FIT 4.0 Ball valve
[2] COOL-FIT 4.0 Butterfly valve

Flow characteristic Ball valve



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

Flow characteristic butterfly valve



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

kv 100-values Ball valve COOL-FIT 4.0 Push System

DN (mm)	Inch (")	d (mm)	k_v 100 (l/min)	Cv 100 (gal/min)	k_v 100 (m^3/h)
20	¾	25	29.5	7.8	1.8
25	1	32	29.5	7.8	1.8

kv 100-values Flow control valve COOL-FIT 4.0 Push System

DN (mm)	Inch (")	d (mm)	k_v 100 (l/min)	Cv 100 (gal/min)	k_v 100 (m^3/h)
20	¾	25	83.3	22.0	5.0
25	1	32	83.3	22.0	5.0

⚠ The use of antifreeze agents changes the viscosity and density of the medium. Depending on the proportion added, the actual flow rate therefore deviates from the displayed flow rate. Please contact GF Industry & Infrastructure Flow Solutions for further information.

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. This is typically the case for cooling systems.

Sum of pressure losses

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

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

Example for pressure drop calculations

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

		Number of Fittings
COOL-FIT 4.0 pipe	d40 mm	12 x 90° angle
SDR11 - flow rate	1.5 l/s	4 x 45° angle
Medium	Water	3 x T-piece
Density of the medium	1.0 g/cm³	3 x screws
Length straight pipe	15 m	2 x flange connections
Height difference	2.0 m	1 x ball valve, 80 % opened

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

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

The inner diameter of the piping system is as follows:

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

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

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

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 m³/ H (flow rate 1.5 l/s = 5.4 m³/h)	$\Delta p_{Ar} = \left(\frac{5.4}{0.5 \cdot 60}\right)^2 \cdot \frac{1000}{1000} = 0.03$ bar
Whole pressure loss of the piping	$\Sigma\Delta p = 0.14$ bar + 0.36 bar + 0.03 bar = 0.53 bar

1.4.9 Z-dimension method

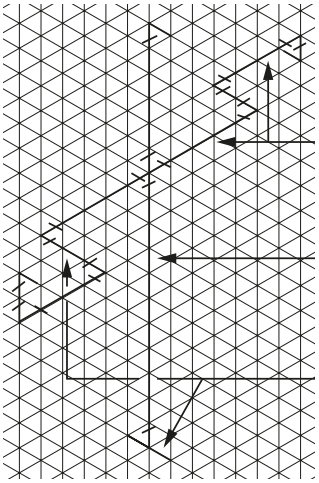
Overview

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

The respective pipe group with the corresponding design dimensions and cut lengths can be entered in the isometric paper of Georg Fischer Piping Systems, see Measuring SheetSeite 502.

Please adhere to the following guidelines for drawing:

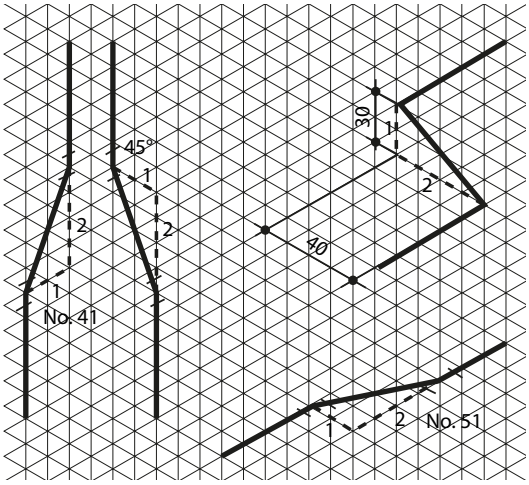
Pipe running perpendicular to one another	Pipe running diagonally



Horizontally:
left and right

Vertical

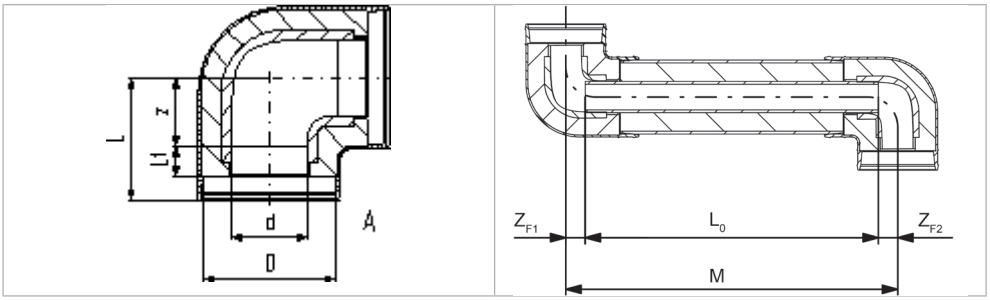
Horizontally:
front and rear



The z-dimensions of the fittings are needed for determining the actual cutting lengths of the pipe. The tables in our product ranges and in the online 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	1'000 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

+GF+

GEORG FISCHER
PIPING SYSTEMS

Unterteilungsblatt 30°
Feuille de mesurage 30°
Foglio per misure 30°

Firma
Firme
Ditta

Dat.

Bauobjekt
Bâtiment
Edificio

Blatt Nr.
Feuille No.
Foglio No.

Pos.	M - M	– cm	L cm	Ø	

1.4.10 Length changes and flexible sections

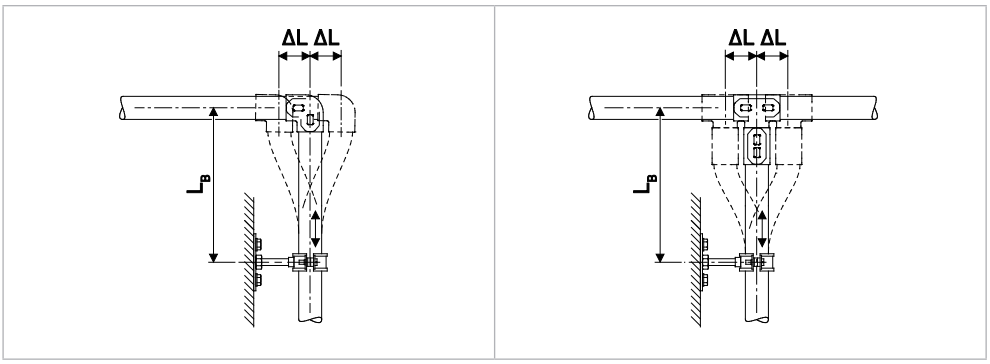
Overview

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

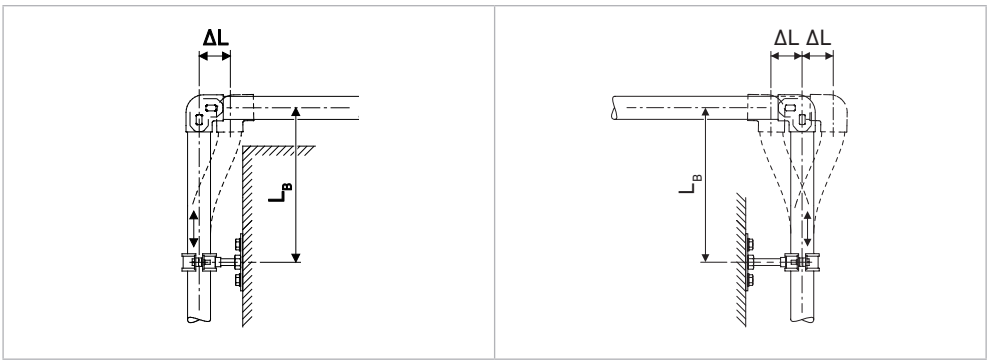
Flexible sections are the most common, the simplest and the most economical solution. The calculations for and the positioning of flexible sections are therefore described in detail.



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.



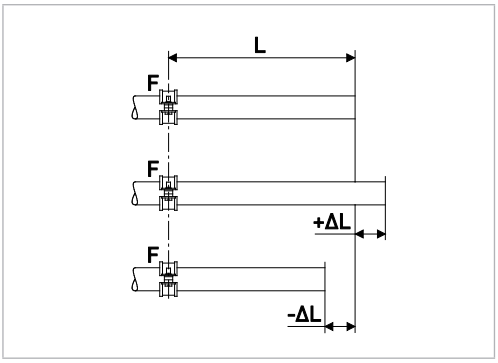
Flexible sections arise naturally at any branching or change in direction of the piping system. The movement L_B of the flexible section as a result of a change ΔL in the length must not be restrained by fixed pipe brackets, wall protrusions, girders or the like.

Calculation of length changes and flexible sections COOL-FIT 4.0 / 4.0F

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 Industry & Infrastructure Flow Solutions 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 - d140 SDR11 and d160 - d450 SDR17

COOL-FIT 4.0

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	-4	-9	-18	-27	d32	-9	-18	-37	-55
d40	-5	-10	-19	-29	d40	-10	-20	-40	-59
d50	-6	-13	-26	-38	d50	-13	-26	-52	-78
d63	-7	-15	-29	-44	d63	-15	-30	-60	-90
d75	-8	-16	-32	-48	d75	-16	-33	-65	-98
d90	-9	-18	-36	-54	d90	-18	-36	-73	-109
d110	-10	-20	-41	-61	d110	-21	-41	-82	-124
d140	-10	-21	-41	-62	d140	-21	-42	-84	-126
d160	-9	-18	-37	-55	d160	-19	-37	-75	-112
d225	-11	-21	-43	-64	d225	-22	-43	-86	-129
d250	-11	-23	-45	-68	d250	-23	-46	-91	-137
d280	-11	-22	-44	-66	d280	-22	-44	-89	-133
d315	-11	-22	-45	-67	d315	-23	-45	-91	-136
d355	-11	-23	-45	-68	d355	-23	-46	-91	-137
d400	-11	-23	-45	-68	d400	-23	-46	-92	-137
d450	-12	-24	-48	-72	d450	-24	-48	-96	-144

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	-14	-28	-56	-84	d32	-19	-38	-76	-115
d40	-15	-30	-61	-91	d40	-21	-41	-83	-124
d50	-20	-40	-80	-120	d50	-27	-54	-109	-163
d63	-23	-46	-91	-137	d63	-31	-62	-124	-185
d75	-25	-50	-100	-150	d75	-34	-67	-135	-202
d90	-28	-55	-111	-166	d90	-37	-75	-149	-224
d110	-31	-62	-125	-187	d110	-42	-84	-168	-252

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
d140	-32	-64	-127	-191	d140	-43	-86	-171	-257
d160	-28	-57	-114	-171	d160	-38	-77	-154	-230
d225	-33	-65	-130	-196	d225	-44	-88	-175	-263
d250	-34	-69	-138	-207	d250	-46	-93	-185	-278
d280	-34	-67	-134	-201	d280	-45	-90	-180	-270
d315	-34	-69	-138	-206	d315	-46	-92	-185	-277
d355	-35	-69	-138	-207	d355	-46	-93	-186	-278
d400	-35	-69	-139	-208	d400	-46	-93	-186	-279
d450	-36	-73	-145	-218	d450	-49	-97	-195	-292

Length change ΔL (mm) at 0° C flow temperature					Length change ΔL (mm) at -5° C flow temperature				
L (m)	25	50	100	150	L (m)	25	50	100	150
d32	-24	-49	-97	-146	d32	-30	-59	-119	-178
d40	-26	-53	-105	-158	d40	-32	-64	-128	-192
d50	-34	-69	-138	-207	d50	-42	-84	-168	-252
d63	-39	-78	-157	-235	d63	-48	-95	-190	-286
d75	-43	-85	-171	-256	d75	-52	-104	-207	-311
d90	-47	-94	-189	-283	d90	-57	-114	-228	-342
d110	-53	-106	-212	-318	d110	-64	-128	-256	-384
d140	-54	-108	-215	-323	d140	-65	-130	-260	-390
d160	-48	-97	-194	-291	d160	-59	-117	-234	-352
d225	-55	-110	-221	-331	d225	-67	-133	-266	-399
d250	-58	-116	-233	-349	d250	-70	-140	-280	-420
d280	-57	-113	-226	-340	d280	-68	-136	-273	-409
d315	-58	-116	-232	-348	d315	-70	-140	-279	-419
d355	-58	-117	-233	-350	d355	-70	-140	-281	-421
d400	-58	-117	-234	-350	d400	-70	-141	-281	-422
d450	-61	-122	-244	-367	d450	-73	-147	-294	-441

L Laid pipe length

Length change ΔL (mm) at -10° C flow temperature					Length change ΔL (mm) at -15° C flow temperature				
L (m)	25	50	100	150	L (m)	25	50	100	150
d32	-35	-71	-141	-212	d32	-41	-82	-163	-245
d40	-38	-76	-152	-228	d40	-44	-88	-176	-264
d50	-50	-99	-198	-297	d50	-57	-115	-229	-344
d63	-56	-112	-225	-337	d63	-65	-130	-259	-389
d75	-61	-122	-244	-366	d75	-70	-140	-281	-421
d90	-67	-134	-268	-402	d90	-77	-154	-308	-463
d110	-75	-150	-300	-450	d110	-86	-172	-344	-516
d140	-76	-152	-305	-457	d140	-87	-175	-349	-524
d160	-69	-138	-275	-413	d160	-79	-158	-316	-475
d225	-78	-156	-312	-467	d225	-89	-178	-357	-535
d250	-82	-164	-328	-491	d250	-94	-187	-375	-562
d280	-80	-160	-319	-479	d280	-91	-183	-366	-549
d315	-82	-163	-327	-490	d315	-93	-187	-374	-561
d355	-82	-164	-328	-492	d355	-94	-188	-376	-563
d400	-82	-164	-329	-493	d400	-94	-188	-376	-564
d450	-86	-172	-343	-515	d450	-98	-196	-392	-588

L Laid pipe length

COOL-FIT 4.0F SDR17

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
d160	-6	-12	-25	-37	d160	-13	-25	-51	-76
d225	-7	-15	-30	-45	d225	-15	-30	-61	-91

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
d160	-19	-39	-77	-116	d160	-26	-53	-105	-158
d225	-23	-47	-93	-140	d225	-32	-63	-126	-189

L Laid pipe length

COOL-FIT 4.0F SDR11

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	-5	-10	-15	d32	-5	-11	-21	-32
d40	-3	-6	-12	-18	d40	-6	-13	-25	-38
d50	-4	-8	-17	-25	d50	-9	-17	-34	-51
d63	-5	-10	-21	-31	d63	-11	-21	-43	-64
d75	-5	-10	-20	-30	d75	-10	-20	-41	-61
d90	-6	-11	-23	-34	d90	-12	-24	-47	-71
d110	-6	-13	-26	-39	d110	-13	-26	-53	-79
d140	-7	-15	-30	-44	d140	-15	-30	-60	-91
d160	-8	-16	-31	-47	d160	-16	-32	-64	-96
d225	-9	-18	-37	-55	d225	-19	-38	-75	-113

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	-8	-16	-32	-49	d32	-11	-22	-44	-66
d40	-10	-19	-39	-58	d40	-13	-27	-53	-80
d50	-13	-26	-53	-79	d50	-18	-36	-72	-108
d63	-16	-33	-66	-99	d63	-22	-45	-89	-134
d75	-16	-31	-62	-93	d75	-21	-42	-85	-127
d90	-18	-36	-72	-108	d90	-25	-49	-98	-147
d110	-20	-40	-81	-121	d110	-27	-55	-110	-164
d140	-23	-46	-92	-138	d140	-31	-63	-125	-188
d160	-24	-49	-97	-146	d160	-33	-66	-132	-198
d225	-29	-57	-114	-171	d225	-39	-77	-154	-231

L Laid pipe length

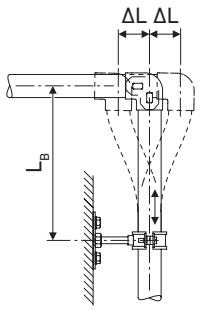
Length change ΔL (mm) at 0° C flow temperature				
L (m)	25	50	100	150
d32	-14	-28	-57	-85
d40	-17	-34	-68	-102
d50	-23	-46	-92	-138
d63	-28	-57	-114	-171
d75	-27	-54	-108	-163
d90	-31	-63	-125	-188
d110	-35	-70	-139	-209
d140	-40	-79	-159	-238
d160	-42	-84	-167	-251
d225	-49	-97	-195	-292

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
d140	123	174	214	247	276	302	326	349	370	390	478	552	675
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	1'007
d400	195	275	337	389	435	477	515	550	584	615	754	870	1'066
d450	206	292	357	413	461	505	546	584	619	653	799	923	1'130

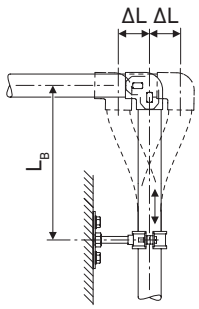


Flexible sections for COOL-FIT 4.0F

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	101	142	174	201	225	246	266	284	302	318	389	449	550
d40	111	157	192	222	248	272	294	314	333	351	430	497	609
d50	111	157	192	222	248	272	294	314	333	351	430	497	609
d63	118	168	205	237	265	290	313	335	355	375	459	530	649
d75	125	177	217	251	280	307	332	355	376	396	485	561	687
d90	134	190	232	268	300	328	355	379	402	424	519	599	734
d110	142	201	246	284	318	348	376	402	426	449	550	636	778
d140	159	225	275	318	355	389	420	449	477	503	615	711	870
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



Reduction of the flexible sections

The specified flexible section lengths are based on the maximum permissible operating pressure according to the pressure-temperature diagram (SDR11/17, C = 1.6).

P_{perm} for dimensions d32-d225

Maximum permissible operating pressure according to the pressure-temperature diagram for SDR11, considering medium-specific derating factors.

P_{perm} for dimensions d250-d450

Maximum permissible operating pressure according to the pressure-temperature diagram for the respective SDR, considering medium-specific derating factors.

For lower operating pressures, the flexible section lengths may be reduced as follows:

Operating Pressure	Permissible Reduction
≤ 25% of P_{perm}	30%
> 25% to 60% of P_{perm}	15%
> 60% of P_{perm}	No reduction

Example:

For a COOL-FIT d110 pipe, the permissible operating pressure according to the pressure-temperature diagram at 10°C is 15 bar. When using a water-glycol mixture with a derating factor of 1.1, the permissible operating pressure is P_{perm} = 15/1.1 = 13.6 bar.

If the actual system operating pressure is 5 bar, this corresponds to 36.7% of P_{perm}. Since this value is between 25% and 60% of P_{perm}, the tabulated flexible section length may be reduced by 15%. A possible flexible section length of 2.0 m may therefore be reduced to 1.7 m.

Calculation of length changes and flexible section COOL-FIT 4.0 Push System

As a first approximation, the change of the pipe length can be calculated using the following formula.

$$\Delta L = \alpha \cdot L \cdot \Delta T$$

ΔL	Length difference in mm
ΔT	Temperature difference in K
L	Length of pipeline in m
α	Linear coefficent of thermal expansion; 0.024 mm/(mK)

Change in length

Pipe length [m]	Temperature difference ΔT [K]					
	10	20	30	40	50	60
	Change in length [mm]					
1	0.2	0.5	0.7	1.0	1.2	1.4
2	0.5	1.0	1.4	1.9	2.4	2.9
3	0.7	1.4	2.2	2.9	3.6	4.3
4	1.0	1.9	2.9	3.8	4.8	5.8
5	1.2	2.4	3.6	4.8	6.0	7.2
6	1.4	2.9	4.3	5.8	7.2	8.6
7	1.7	3.4	5.0	6.7	8.4	10.1
8	1.9	3.8	5.8	7.7	9.6	11.5
9	2.2	4.3	6.5	8.6	10.8	13.0
10	2.4	4.8	7.2	9.6	12.0	14.4
20	4.8	9.6	14.4	19.2	24.0	28.8
30	7.2	14.4	21.6	28.8	36.0	43.2
40	9.6	19.2	28.8	38.4	48.0	57.6
50	12.0	24.0	36.0	48.0	60.0	72.0

Flexible section

Sample calculation

The length of the pipeline is 7 m. The thermally induced change in length of this pipe section must be absorbed by a flexible pipe leg. The difference between the installation temperature and the maximum operating temperature is 60 K.

Example: COOL-FIT 4.0 Push System

PE-RT pipe, dimension	d25
Material constant C	33
Change in length Δl	10.08 mm

Calculation of the length of the flexible pipe leg

$$L_B = C \cdot \sqrt{d \cdot \Delta l}$$

$$L_B = 33 \cdot \sqrt{(25\ mm \cdot 10.08\ mm)}$$

$$L_B = 523.9\ mm$$

The length of the flexible pipe leg is derived from the pipe's change in length:

Graph reading example

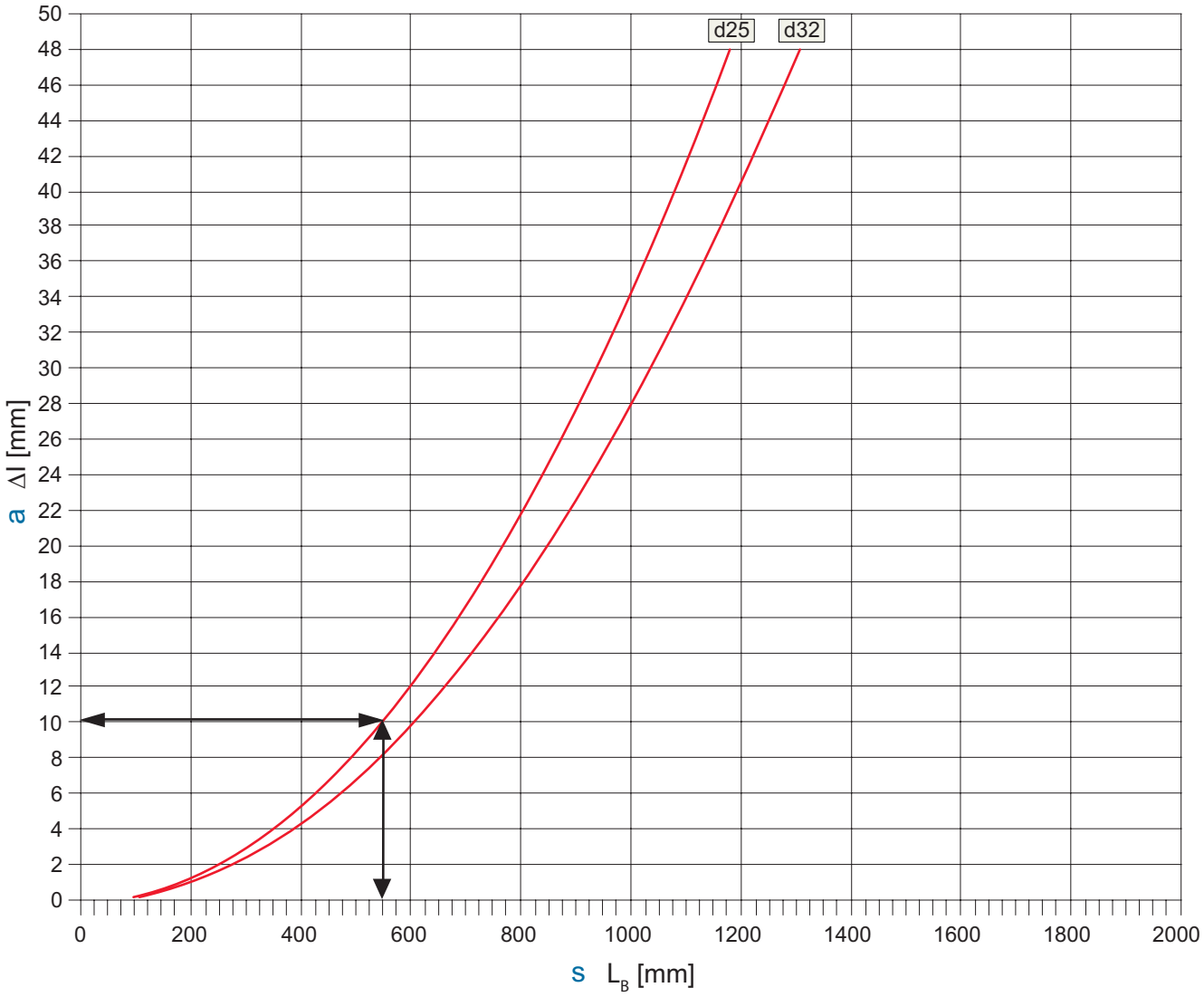
PE-RT pipe, dimension	d25
Material constant C	33
Change in length Δl	10.08 mm

L_B = 523.9 mm

Length of flexible pipe leg

a Change in length of the pipe

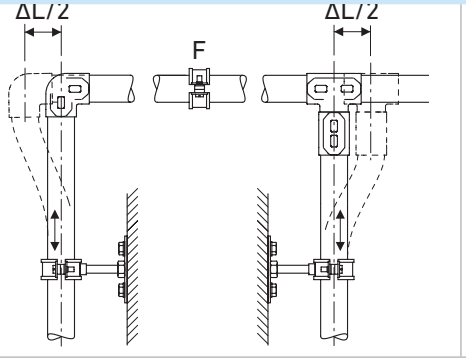
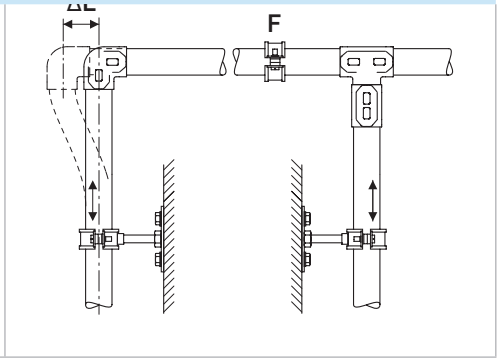
s Length of flexible pipe leg



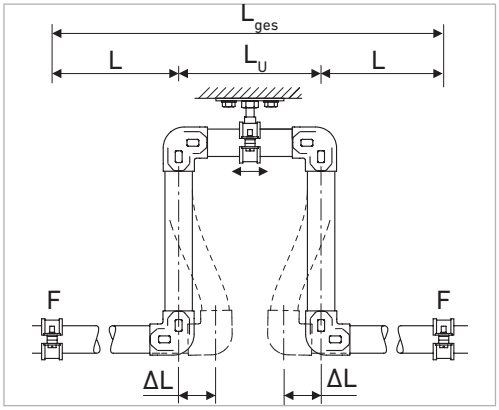
1.4.11 Handling expansion and contraction

Recommendations for installation

Length changes in pipe sections should always be accommodated through the arrangement of fixed brackets. The following examples show how the changes can be distributed in pipe sections by suitable positioning of fixed brackets:

Recommended installation	Not recommended installation
	

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



⚠ Bending stress can lead to leaks in mechanical joints.

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

Pre-tensioning

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

Example

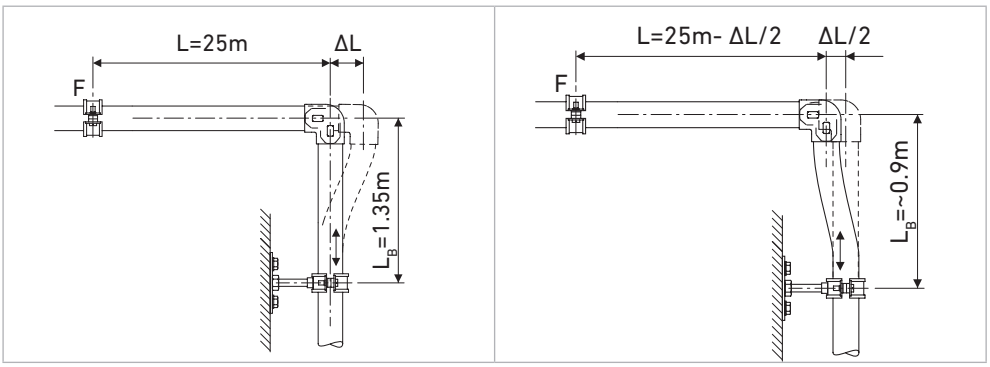
Pipe length L	25 m
Diameter	d225/D315 mm
Installation temperature	25 °C
Min ambient temperature	25 °C constant
Max ambient temperature	25 °C constant
Min flow temperature	10 °C
Max flow temperature	25 °C

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

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

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

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



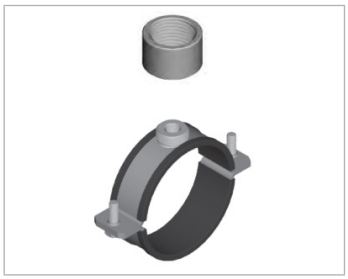
1.4.12 Pipe bracket spacing and support of piping systems

Overview

Installation of plastic pipe

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

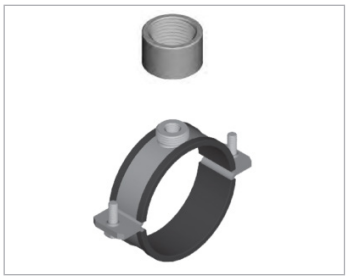
Thanks to the excellent insulating properties of the COOL-FIT 4.0 pipe and its hard, impact resistant outer jacket, standard pipe clamps with hard plastic inlay may be used. Special insulation pipe clamps or cold clamps are not necessary.



Installation of COOL-FIT 4.0 Push System

COOL-FIT 4.0 Push System tubes must be installed using suitable tube supports. In doing so, the pipes must not be under too much tension.

The COOL-FIT 4.0 Push System, pipes can be inserted into standard sliding pipe clamps with the COOL-FIT 4.0 Push System, support carrier. Special insulation pipe clamps or cold clamps are not necessary.



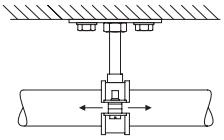
A retaining clamp must be placed next to each fitting.



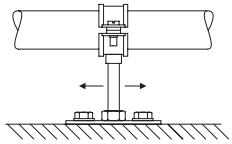
Arranging loose brackets

What is a loose bracket?

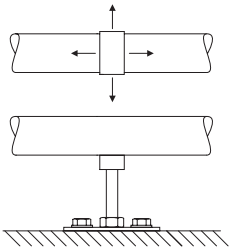
A loose bracket is a pipe bracket which allows axial movement of the pipe. This allows stress-free compensation of temperature changes and compensation of any other operating condition changes.



Axial displacement of the pipe in the clamp.



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



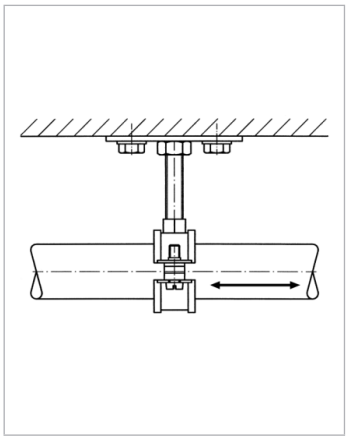
Displacement of the pipe in 2 axes.

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.

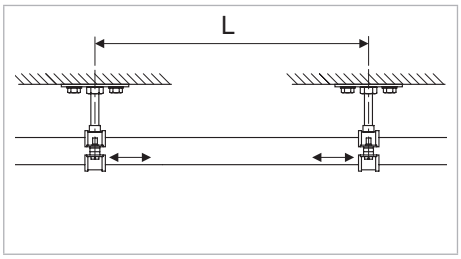


Spacers prevent pinching the pipe

Maximum pipe support distance

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

The maximum pipe support distance for COOL-FIT 4.0 pipes is always consistent independent of pressure and temperature.



L Pipe bracket spacing

Maximum pipe support distance L for COOL-FIT 4.0

d/D (mm)	d32/ D90	d40/ D110	d50/ D110	d63/ D125	d75/ D140	d90/ D160	d110/ D180	d140/ D225	d160/ D250	d225/ D315	d250/ D355	d280/ D400	d315/ D450	d355/ D500	d400/ D560	d450/ D630
L (mm)	1'800	1'950	1'950	2'000	2'100	2'150	2'300	2'450	2'600	2'850	3'300	3'500	3'700	3'900	4'100	4'300

Maximum pipe support distance L for COOL-FIT 4.0F

d/D (mm)	d32/ D90	d40/ D110	d50/ D110	d63/ D125	d75/ D140	d90/ D160	d110/ D180	d140/ D225	d160/ D250	d225/ D315
L (mm)	2'350	2'550	2'550	2'600	2'750	2'800	3'000	3'200	3'400	3'700

Maximum pipe support distance L for COOL-FIT 4.0 Push System

d/D (mm)	25/75	32/85
L (mm)	1'700	2'200

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

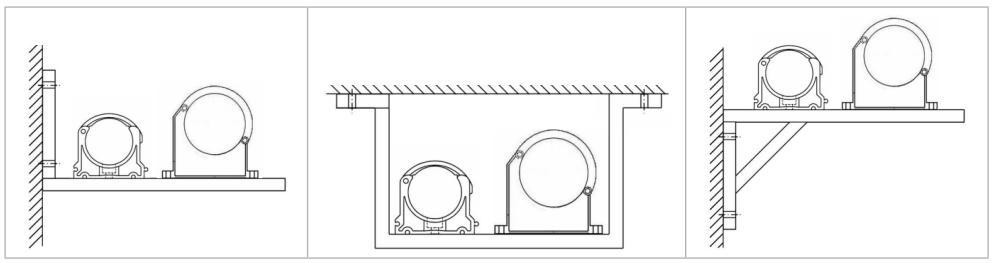
Valid for SDR11 and SDR17.

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.

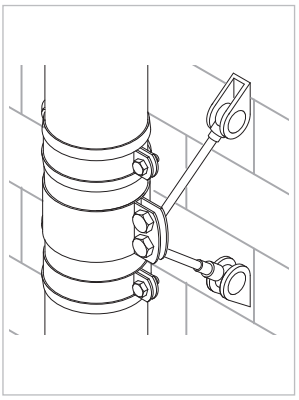
⚠ Fixpoint design

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 Fixed points

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)	d32/ D90	d40/ D110	d50/ D110	d63/ D125	d75/ D140	d90/ D160	d110/ D180	d140/ D225	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	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.

⚠ The COOL-FIT Fixed points must not be used on non-insulated PE pressure pipes (e.g. SDR11 + SDR17).

Scope of delivery



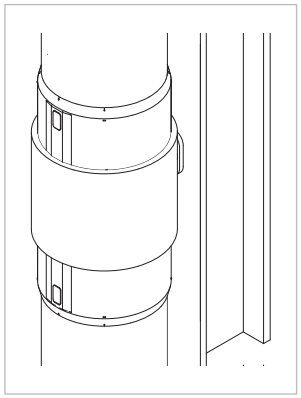
1 Clamps to maintain fusion pressure
2 Electrofusion band

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 4.0 fixed point for higher forces

For applications with higher forces, such as long risers, fixed points must be planned specifically for the application. Attachment to the beam is via a weld-on plate on the metal pipe clamp. The clamp is positioned between two COOL-FIT electrofusion fittings and is subsequently insulated. Please take note of the maximum allowed forces in the table below.



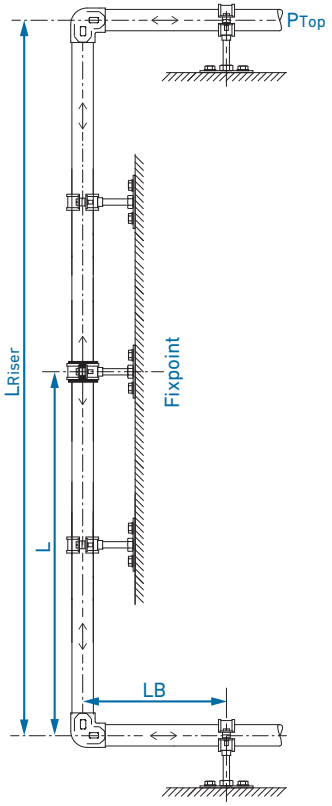
Diameter (mm)	d140/D225	d160/D250	d225/D315	d250/D355	d280/D400	d315/D450	d355/D500	d400/D560	d450/D630
Maximum force F (kN)	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0

⚠ COOL-FIT fixed points for higher forces must be calculated according to the application. The pipeline, support, weld seam type and other influencing factors must be taken into account in the force analysis. Please contact GF Advanced Engineering.

Example of maximal achievable riser length:

Installation temperature	-5 to +40°C
Ambient temperature	-5 to +45°C
Flow temperature	-33 to +47°C
Fixpoint position	Middle of the riser pipe
Pressure on top level	3 bar (P_{Top})
Support distance vertical	Equal to horizontal
Pipe class	d32 - d450 SDR11

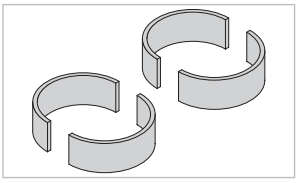
	Pipe support distance reduced for long riser		Fixpoint at jacket pipe		Fixpoint at media pipe	
	Horizontal [m]	Vertical [m]	Max. riser length (LRiser) [m]	Fixpoint force [kN]	Max. riser length (LRiser) [m]	Fixpoint force [kN]
d32/90	1.8	1.8	43	0.9		
d40/110	2.0	2.0	54	1.7		
d50/110	2.0	2.0	44	1.7		
d63/125	2.0	2.0	49	2.7		
d75/140	2.1	2.1	52	3.8		
d90/160	2.2	2.2	54	5.4		
d110/180	2.3	2.3	54	7.5		
d140/225	2.5	2.5	45	10	55	12
d160/250	2.6	2.6	35	10	55	16
d225/315	2.9	2.9	17	10	54	29
d250/355	3.3	3.3	14	10	54	35
d280/400	3.5	3.5			41	35
d315/450	3.7	3.7			32	35
d355/500	3.9	3.9			24	35
d400/560	4.1	4.1			18	35
d450/630	4.3	4.3			14	35



⚠ Following sections are recommended to be proofed by GF Advanced Engineering before installation: Riser pipe dimension >d160; Riser pipe with multiple dimensions; Installation differ from normal installation with fixpoint in the middle

COOL-FIT 4.0F Fixed points

Four half shells which are cemented on both sides to the fixed point pipe clamp.



Diameter (mm)	d32/ D90	d40/ D110	d50/ D110	d63/ D125	d75/ D140	d90/ D160	d110/ D180	d140/ D225	d160/ D250	d225/ D315
Maximum force F (kN)	3.0	5.0	8.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0

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

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.

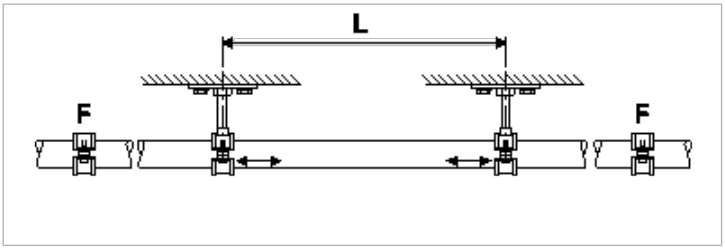
COOL-FIT 4.0 pipe and fittings are suitable for a rigidly fixed installation

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 - d140 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	140/225	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	6.7	6.0	11.6*	14.3*	18.0*	22.8*	29.0*	36.6*	46.4*
L (mm)	1'800	1'950	1'900	2'000	2'100	2'150	2'200	2'450	2'600	2'850	3'300	3'500	3'700	3'900	4'100	4'300
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	140/225	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*	10.4	9.3*	18.1*	22.3*	28.1*	36.6*	45.1*	57.1*	72.5*
L (mm)	1'800	1'950	1'900	2'000	2'100	2'150	2'200	2'450	2'600	2'850	3'300	3'500	3'700	3'900	4'100	4'300
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	140/225	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*	14.4	12.9*	25.1*	30.9*	38.9*	49.3*	62.5*	79.0*	100.2*
L (mm)	1'800	1'950	1'900	2'000	2'100	2'150	2'200	2'450	2'600	2'850	3'300	3'500	3'700	3'900	4'100	4'300
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	140/225	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*	18.6	16.7*	32.4*	40.0*	50.3*	63.7*	80.8*	102.2*	130.0*
L (mm)	1'800	1'950	1'900	2'000	2'100	2'150	2'200	2'450	2'600	2'850	3'300	3'500	3'700	3'900	4'100	4'300
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	140/225	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*	23.0	20.7*	40.2*	49.5*	62.2*	79.0*	100.0*	126.6*	160.6*
L (mm)	1'800	1'950	1'900	2'000	2'100	2'150	2'200	2'450	2'600	2'850	3'300	3'500	3'700	3'900	4'100	4'300
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	140/225	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*	27.7	24.8*	48.3*	59.3*	74.8*	94.9*	120.3*	152.1*	193.0*
L (mm)	1'800	1'950	1'900	2'000	2'100	2'150	2'200	2'450	2'600	2'850	3'300	3'500	3'700	3'900	4'100	4'300

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	140/225	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*	32.5	29.2*	56.8*	70.0*	87.9	111.5*	141.4*	178.8*	226.8*
L (mm)	1'800	1'950	1'900	2'000	2'100	2'150	2'200	2'450	2'600	2'850	3'300	3'500	3'700	3'900	4'100	4'300

* 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)	3'400	3'700

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)	3'400	3'700

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)	3'400	3'700

* max allowed force for COOL-FIT fixed point exceeded

⚠ Please contact GF Industry & Infrastructure Flow Solutions 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

1.4.13 Bending of COOL-FIT 4.0 Push System pipes

Manual bending

COOL-FIT 4.0 Push System pipes can be bent by hand without the use of bending tools. Ensure the pipes do not kink when bending them.

Hydraulic cylinders or bending springs

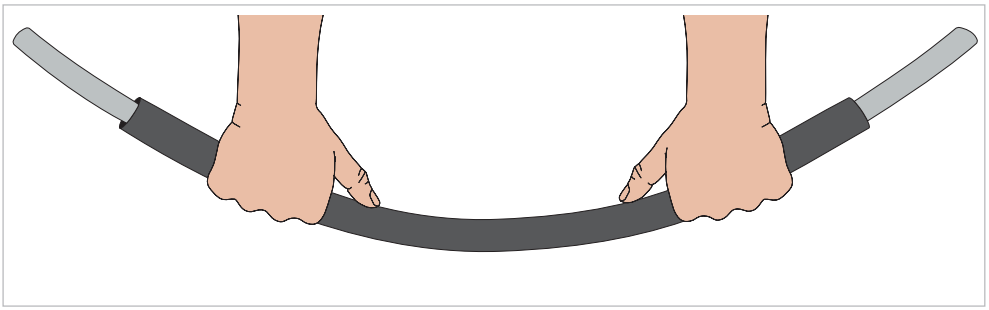
Commercially available hydraulic cylinders can be used, considering the following aspects:

☑ The shape of the bending gauge must correspond with the outside diameter of the media pipe.

☑ Do not use internal bending springs.

☑ Ensure the bending radius is not less then 3.5 · d.

COOL-FIT 4.0 Push System pipes can be easily shaped into the desired angle with the outside pipe bending tool.
Consider the removal of the insulation before bending with hydrailic cylinders or bending springs.



Bending the COOL-FIT 4.0 Push System multilayer composite pipe

Bending radius R	COOL-FIT 4.0 Push System	
d [mm]	25	32
Bending radius R, with bending spring: 5 · d [mm]	200	-
Bending radius R, with tool: 3.5 · d [mm]	98	112

Minimum bending radius of the COOL-FIT 4.0 Push System pipe

⚠ NOTE! Risk of damaging the pipes due to improper bending!
→ Ensure the pipes do not kink when bending them.
→ Do not use internal bending springs.

1.4.14 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

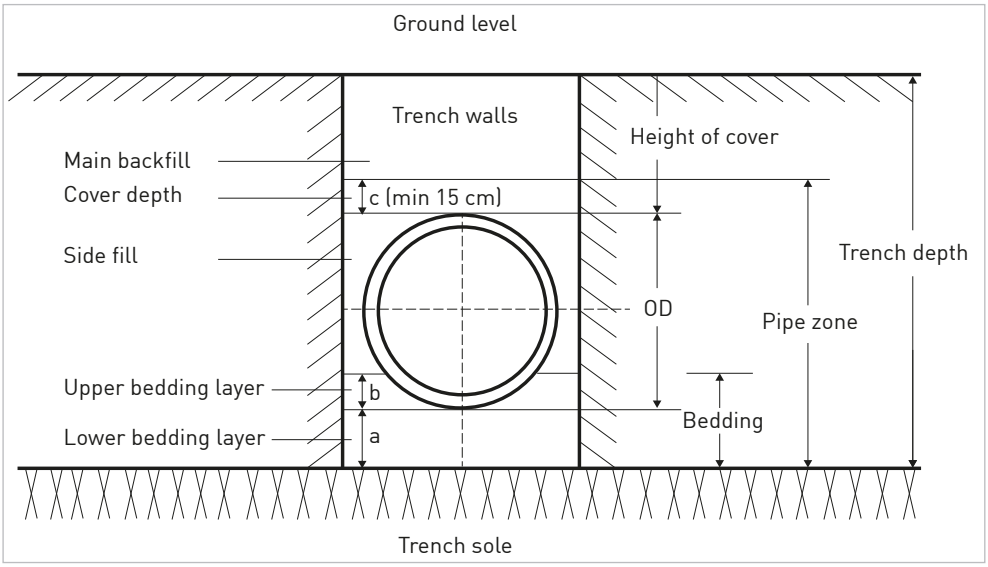
- Store in a cool, dry and dust-free area; avoid direct sunlight or ultraviolet irradiation; protect from nearby heat sources. Piping must not come into contact with substances that can cause damage.
- Hoses and hose assemblies must be stored horizontally, free of tension or bending forces.

Maintenance

We recommend a regular visual inspection of the hose line in case of high temperature fluctuations.

1.4.15 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

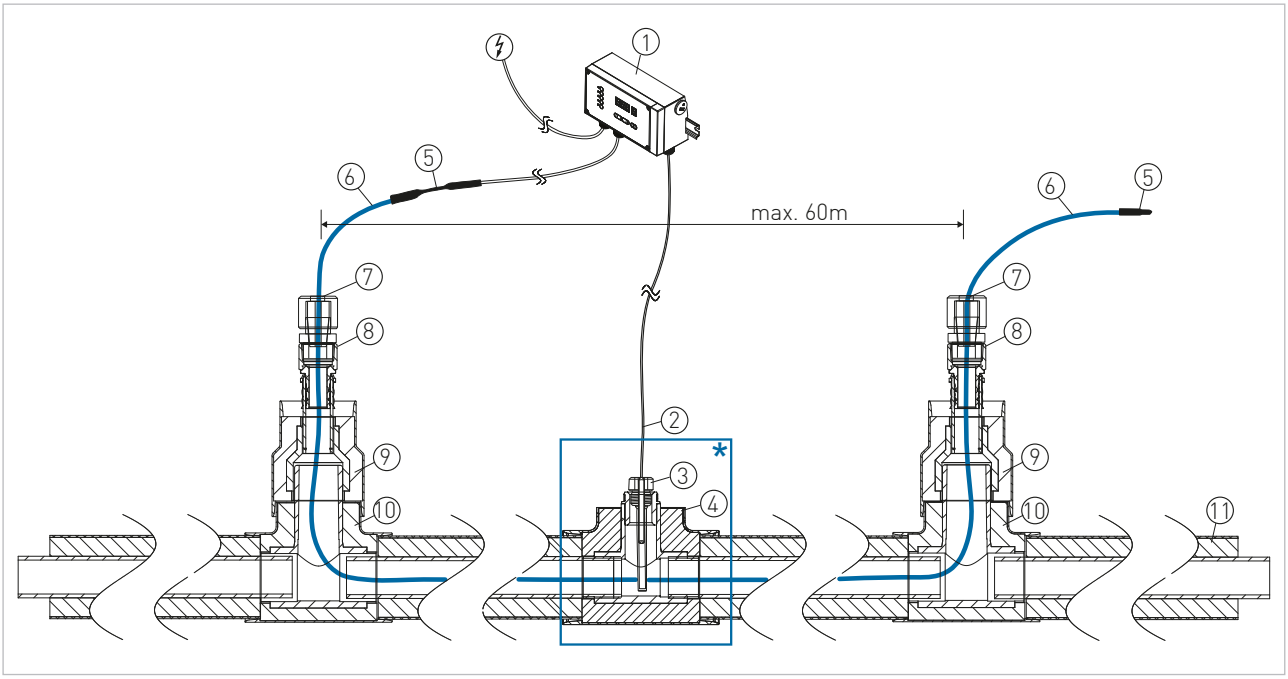
The upper bedding layer b is derived from static calculations. It is also important to ensure that no cavities are created below the pipe. The bedding dissipates all loads from the pipe securely and evenly into the ground. For this reason, the COOL-FIT 4.0 pipe has to rest solidly on the bedding across 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.

⚠ Installation in water is not permitted; any water that occurs must be able to drain off.

1.4.16 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.

1.4.17 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 Industry & Infrastructure Flow Solutions representative or visit www.g com**

1.5 Jointing and Installation

1.5.1 Jointing of COOL-FIT 4.0

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

General advice

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

Executing electrofusion

Protect the welding area

The surfaces to be welded on the pipe and the fitting must be carefully protected from dirt, grease, oils and lubricants. Only Tangit PE cleaner must be used for cleaning.

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

Jointing d32 – d225 (plus coupler d250)

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

Prepare pipe with stripping and peeling tool for electrofusion welding connection (stripping, peeling and sheath cutting) and check pipe spigot with circumferential measuring tape for compliance with minimum permissible pipe outer diameter.

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

	d nominal diameter (mm)										
Temperature (°C)	32	40	50	63	75	90	110	140	160	225	250
	dmin after peeling (mm)*										
40	31.4	39.4	49.4	62.5	74.5	89.6	109.6	139.7	159.8	225.0	250.0
30	31.3	39.4	49.4	62.4	74.4	89.4	109.5	139.5	159.5	224.6	249.7
20	31.3	39.3	49.3	62.3	74.3	89.3	109.3	139.3	159.3	224.3	249.3
10	31.3	39.2	49.2	62.2	74.2	89.2	109.1	139.1	159.1	224.0	248.9
0	31.2	39.2	49.2	62.1	74.1	89.0	109.0	138.9	158.8	223.6	248.6
-10	31.2	39.1	49.1	62.0	74.0	88.9	108.8	138.7	158.6	223.3	248.2

* Minimum diameters do not comply with the pipe tolerance specifications for GF electrofusion fittings. COOL-FIT minimum diameters are verified by release tests.

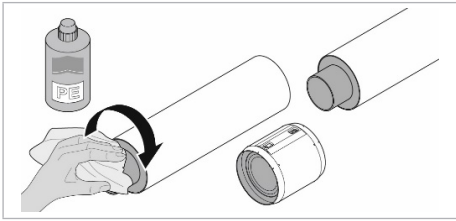
If the pipe outside diameter falls below the min. permissible value, cut off the spigot and check the blade quality by measuring the chip thickness with a caliper gauge: the reference dimension over the entire length is between 0.2 - 0.4 mm. Replace blade in case of deviation.

COOL-FIT 4.0 already factory-set free pipe ends (5 m lengths), COOL-FIT 4.0 Valves and COOL-FIT 4.0 Fittings d32 – d225 (Type B, barrel nipple and transition fittings) need not to be peeled.

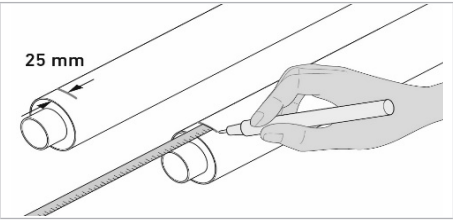
Pipe dimensions d160 to 225 in lengths 11.9 m are stripped, however need to be peeled upfront jointing.

Factory-set free pipe ends at pipe and fittings type B for dimension d250 have to be peeled for jointing before.

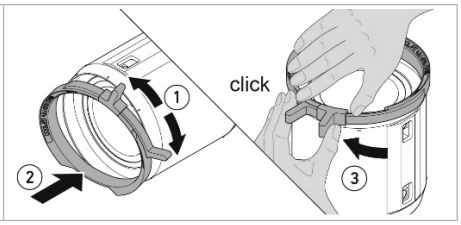
2 Cleaning and installation for welding preparation



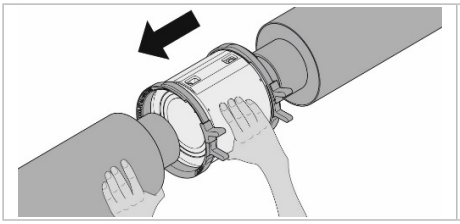
Step 1
Clean the fusion area of the components with Henkel Tangit PE cleaner and lintfree colourless and clean cloth in circumferential direction.



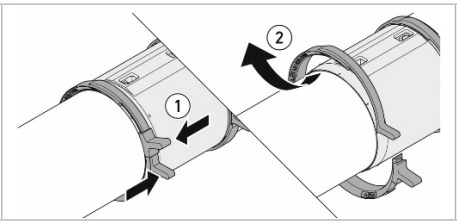
Step 2
Mark the jacket pipe at a distance of 25 mm



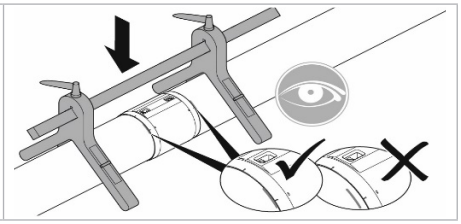
Step 3
Mount the assembly aids on the sealing lips of the COOL-FIT 4.0 fitting



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

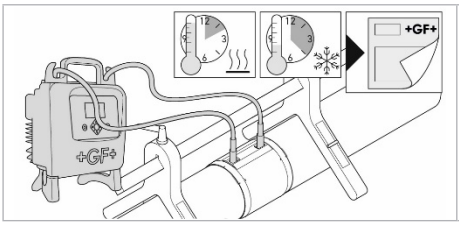


Step 5
Remove the assembly aids

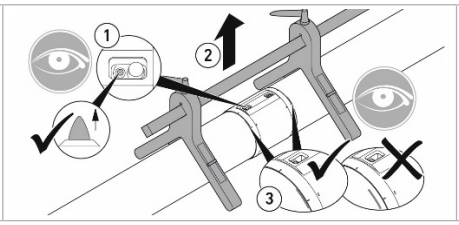


Step 6
Take care for low stress installation and secure the pipe and fitting against dislocation. Check insertions depths of both pipe into the fitting

3 Fusion process

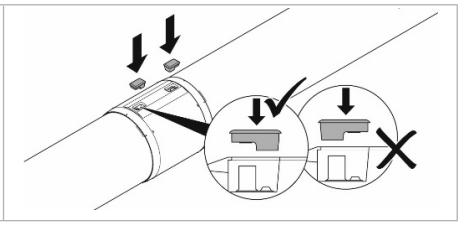


Step 1
Fuse in accordance to the operating instructions of the fusion unit. Use long fusion adaptors (790128035). Pay attention to fusion and cooling time.

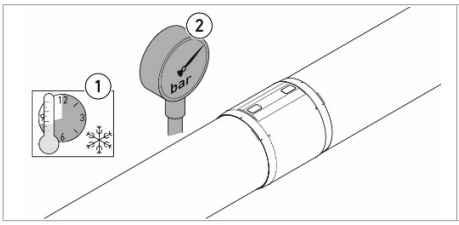


Step 2
After fusion, check fusion indicators on the electrofusion fitting and note the messages on the display of the electrofusion machine.
Mark the fitting with following information
- Date
- Welder/ Weld number
- Time at the end of cooling time

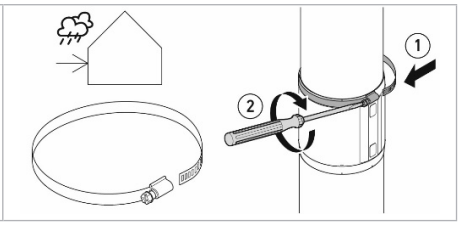
Remove the clamping tool after cooling time



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



Step 4
After cooling perform pressure tests as per table.



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

Jointing d250 – d450

Hint: Factory-set free pipe ends at pipe and fittings type B have to be peeled for jointing before.

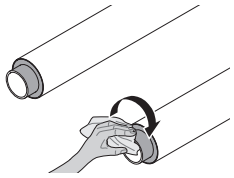
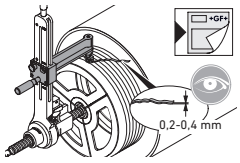
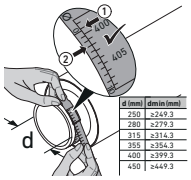
1 Preparation

Prepare pipe with stripping and peeling tool for electrofusion welding connection (stripping, peeling and sheath cutting) and check pipe spigot with circumferential measuring tape for compliance with minimum permissible pipe outer diameter.

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

Temperature (°C)	d nominal diameter (mm)					
	250	280	315	355	400	450
	dmin after peeling (mm)*					
40	250.0	280.1	315.2	355.4	400.5	450.6
30	249.7	279.7	314.8	354.8	399.9	450.0
20	249.3	279.3	314.3	354.3	399.3	449.3
10	248.9	278.9	313.8	353.8	398.7	448.6
0	248.6	278.5	313.4	353.2	398.1	448.0
-10	248.2	278.0	312.9	352.7	397.5	447.3

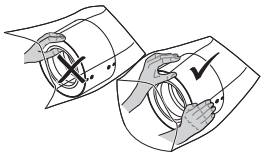
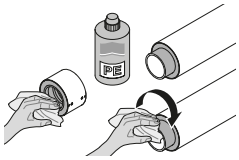
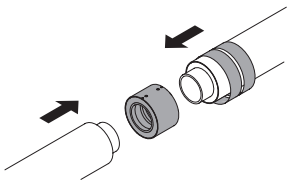
* Minimum diameters do not comply with the pipe tolerance specifications for GF electrofusion fittings. COOL-FIT minimum diameters are verified by release tests.

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 minimum permissible pipe outside diameter after peeling with a circumferential measuring tape.

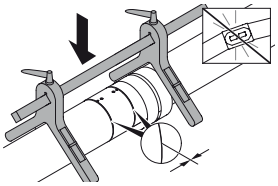
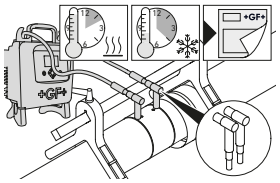
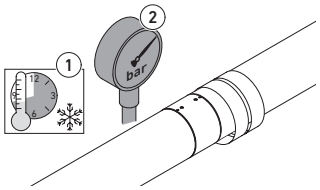
Overview of pipe outer diameter and open spigot length

Dimension (mm)	Factory-set spigot length (mm)
d250	120-126
d280	123-129
d315	129-137
d355	144-152
d400	145-155
d450	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.

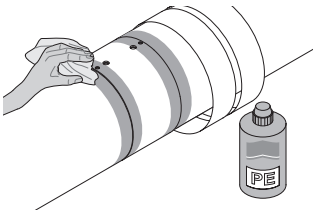
Cooling times before removing clamping tool and pressure/leak testing

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	
140	45	90	12	
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.

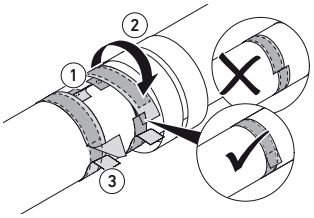
4 Sealing

Step 1



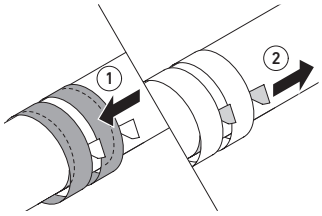
Clean the pipe/fitting type B and partially the coupler over the gap with Tangit PE cleaner.

Step 2



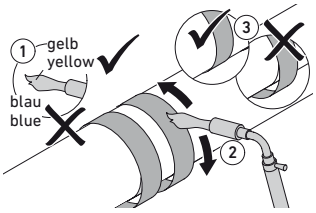
Affix the sealing tape centered over the gap and overlap it at the end. Press it on well and smooth out folds.

Step 3



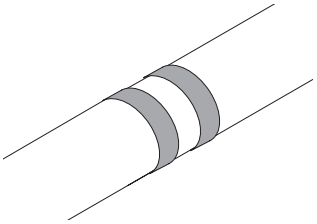
Position the shrink socket centered over the sealing tape, than remove the white separating tape.

Step 4



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.

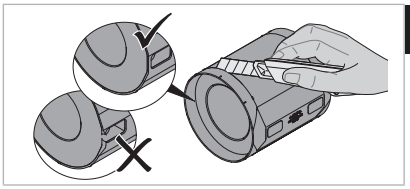
Step 5

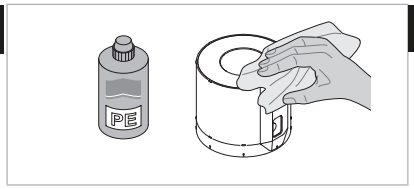


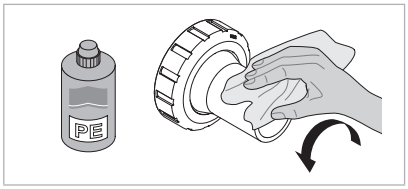
The jointing is now finished.

Valves and flange joints

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

1 

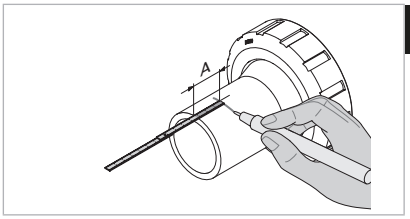
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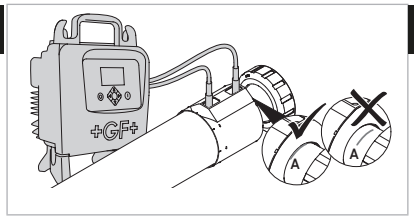
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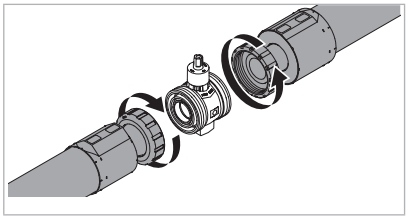
For the jointing to a valve or flange adaptor, the sealing lip of the fitting has to be removed at the valve or flange adaptor side and sealing and fusion surfaces have to be cleaned.

2 Standard fusion

Fuse both valve ends without valve mounted.

4 

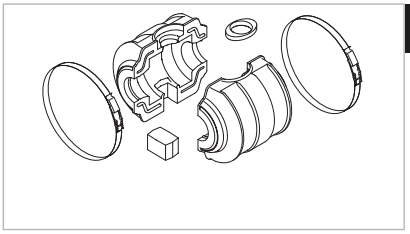
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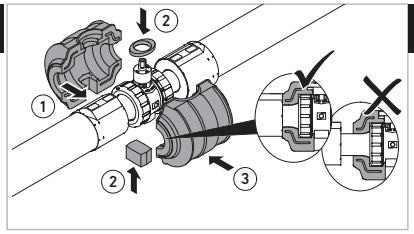
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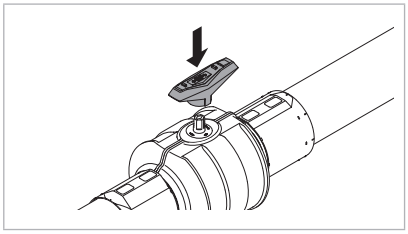
Following insertion depths A are valid for COOL-FIT 4.0 components:

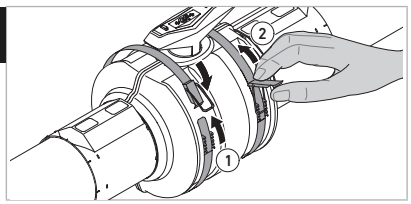
d/D (mm)	32/90	40/110	50/110	63/125	75/140	90/160	110/180	140/225	160/250	225/315
L1 (mm)	36	40	44	48	55	62	72	84	90	110

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.

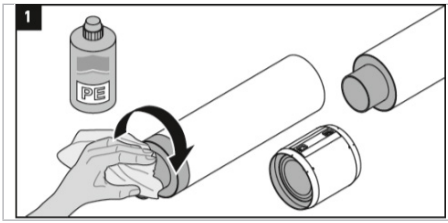
For compact fitting-to-fitting joints, COOL-FIT 4.0 barrel nipple can be used.

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.

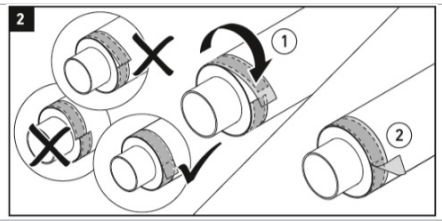
d	d75	d90	d110	d140	d160	d225
L (mm)	165	186	216	252	270	330

L: Length of un-insulated PE100 SDR11 pipe needed

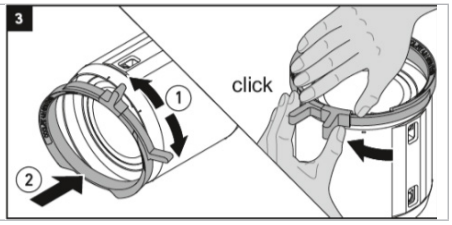
Mounting of sealing tape and transition of insulation



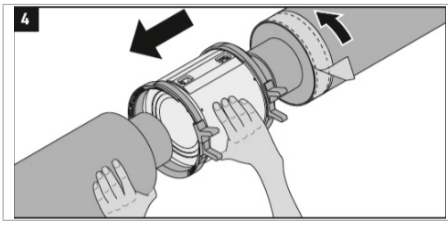
Step 1
In addition to the fusion zone, also clean the jacket of the pipe



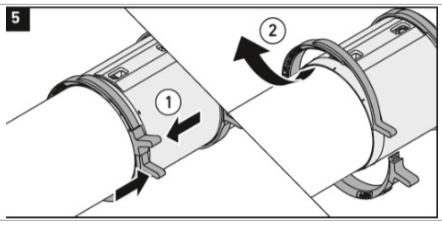
Step 2
Mount sealing tape/ transition of insulation, end to end without offset and fold down liner



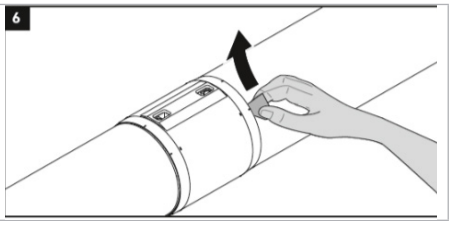
Step 3
Mount the assembly aids on the sealing lips of the COOL-FIT 4.0 fitting



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



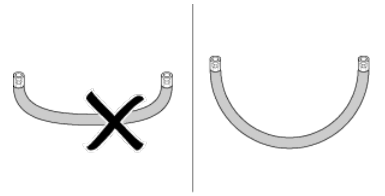
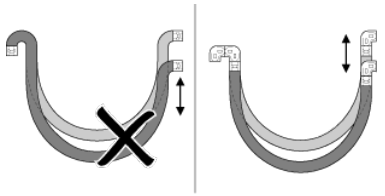
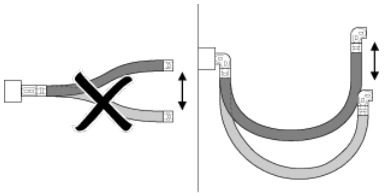
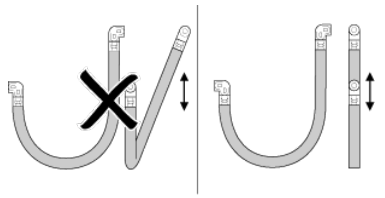
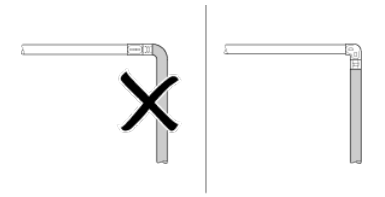
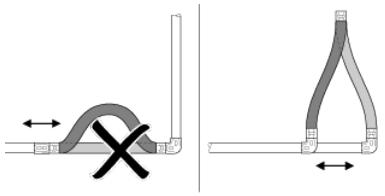
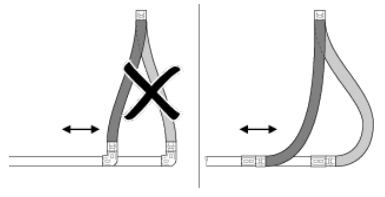
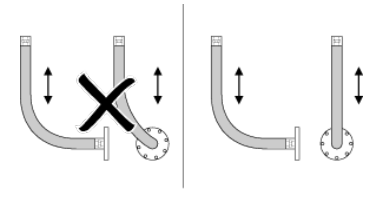
Step 5
Remove the assembly aids

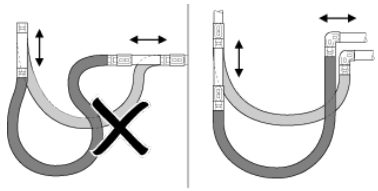


Step 6
Pull off the liner after removal of assembly aids

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.
	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.

Installation and handling instructions (false/correct)	Description
	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 established 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.

i 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/m^2.

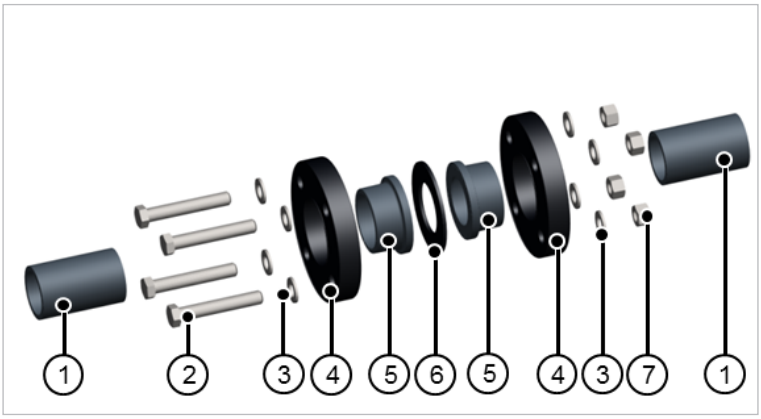
The open joint time is about 3 to 15 minutes depending on temperature and humidity of air.

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

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

Flange joints

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



Recommended backing flange of COOL-FIT 4.0 flange joints

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

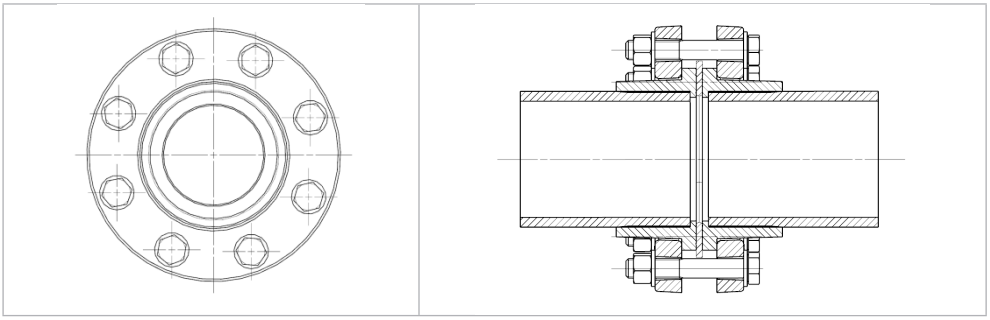
Flange	Properties
PP-steel flange	• Very robust and stiff due to the steel inlay • Corrosion-free plastic flange made of polypropylene PP-GF30 (fiber-glass reinforced) with steel inlay • High chemical resistance (hydrolysis-resistant) • UV-stabilized

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.

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

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

Pipe outside diameter d (mm)	Nominal Diameter DN (mm)	Tightening torque MD (Nm)		
		Flat ring maximum pressure 10 bar / 40 °C	Profile seal maximum pressure 16 bar	O-ring maximum pressure 16 bar
d32	DN25	15	10	10
d40	DN32	20	15	15
d50	DN40	25	15	15
d63	DN50	35	20	20
d75	DN65	50	25	25
d90	DN80	30	15	15
d110	DN100	35	20	20
d140	DN125	45	25	25
d160	DN150	45	25	25
d225	DN200	70[1)]	45	35
d250	DN250	65	35	
d280	DN250	65	35	
d315	DN300	90	50	
d355	DN350	90	50	
d400	DN400	100	60	
d450	DN450	190	70	

1) Maximum operating pressure 6 bar

Bolt tightening torque guidelines for ISO flange connections

Length of bolts

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

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

In order to ensure the fitting of the insulation half shells of the COOL-FIT 4.0 flange adaptors the used bolts must not be too long.

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

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

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

For COOL-FIT 4.0 Flange adaptors used together with PP-Steel backing flanges, the following bolt lengths can be used:

Dimension	d32	d40	d50	d63	d75	d90	d110	d140	d160	d225
Screws	M12x80	M16x80	M16x90	M16x90 or M16x100	M16x100	M16x100	M16x100	M16x130	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.

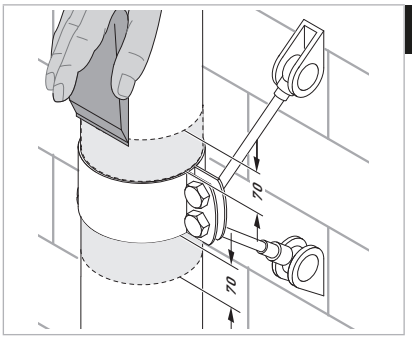
On installing Installation fittings in horizontal piping systems, the sensors should be in 1 – 5 or 7 – 11 clock position.

⚠ 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

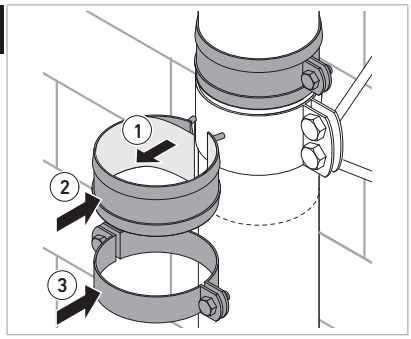
The COOL-FIT pipe shall be intstalled with a standard fix point as shown below.

1



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

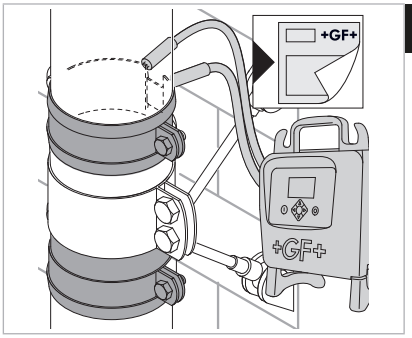
2



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.

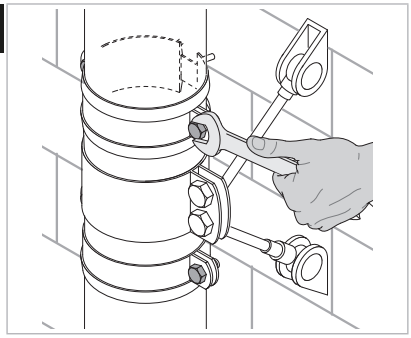
Note: The necessary welding pressure on the clean and dry COOL-FIT pipe is achieved by tightening the pipe clips. Take care that between fixed point clip and weld band there are no visible holes.

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.

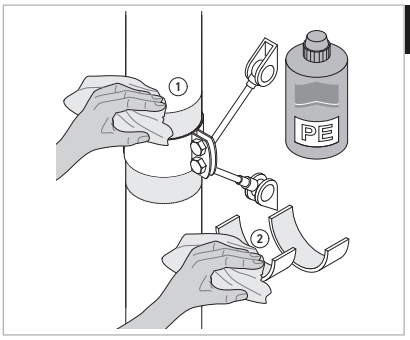
4



Step 4
Retighten the pipe clips after 10 minutes.

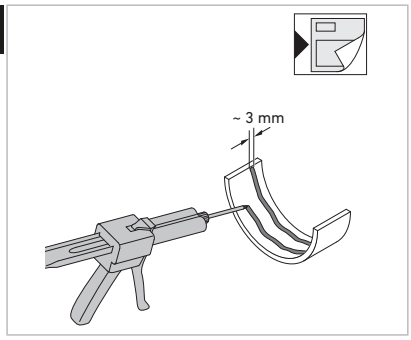
Installation of COOL-FIT 4.0F fixed points

1



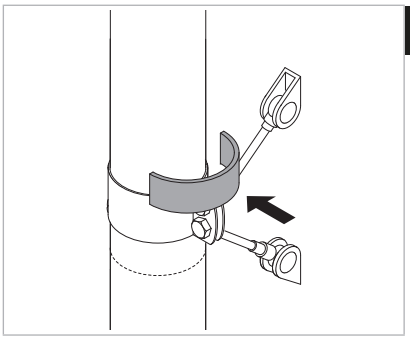
Step 1
Clean the cementing area on the pipe and the components with Tangit PE cleaner and lintfree colourless and clean cloth in circumferential direction.

2



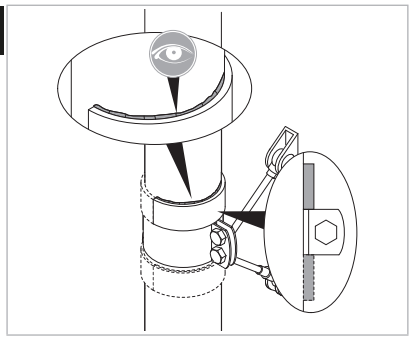
Step 2
Place the Tagit RAPID in about 3mm stripes on the inner side of the fixed point set half shells.

3



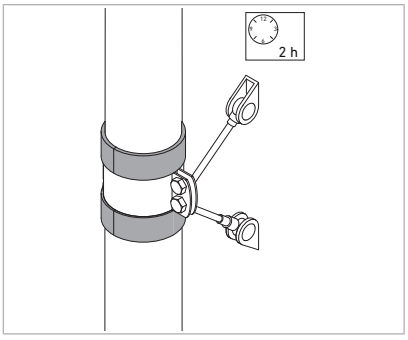
Step 3
Cement the half shelfs on the pipe next to the pipe clamp.

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 2hours.

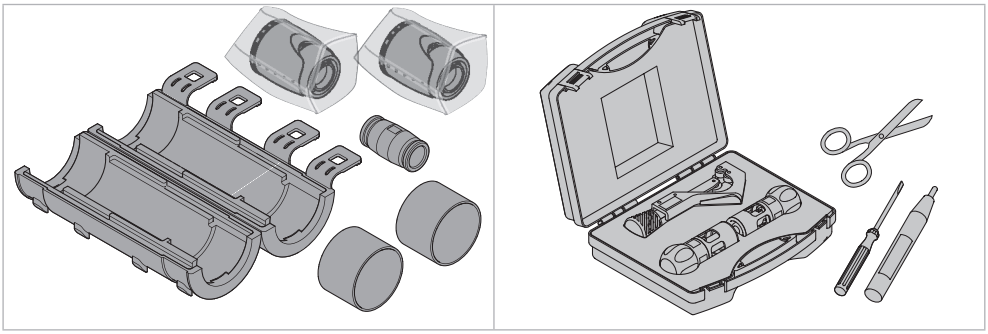
1.5.2 Jointing of COOL-FIT 4.0 Push System

General advice

The push-in fittings may only be installed by skilled personnel who have been regularly instructed in work safety and environmental protection on pressurized pipes. The quality of the mechanical connection is largely determined by the careful execution of the preparatory work. The mating area must be protected from adverse weather conditions such as rain, snow or wind. Permissible temperature range for processing is -10 °C to +45 °C. The national guidelines must be observed.

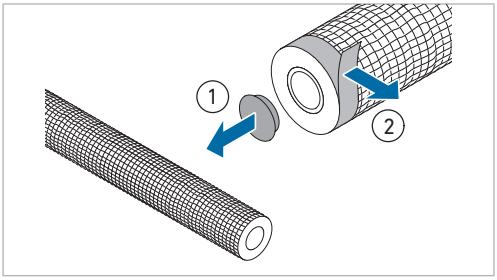
The surfaces to be welded on the pipe and fitting must be carefully protected from dirt, any grease, oil and lubricants. Only cleaning agents suitable for PE may be used.

Work preparation



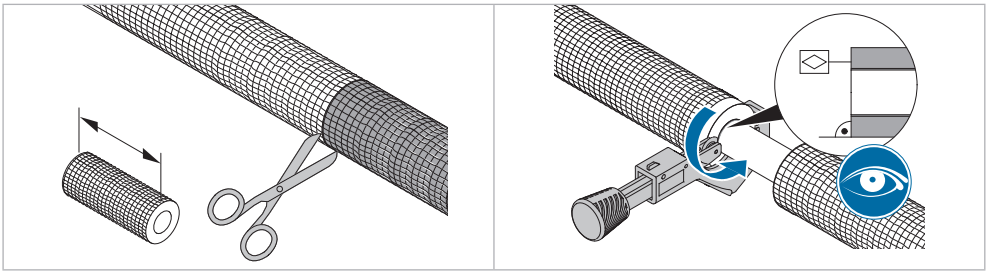
Remove products from packaging immediately before assembly and have necessary tools ready.

Prepare pipe



Step A

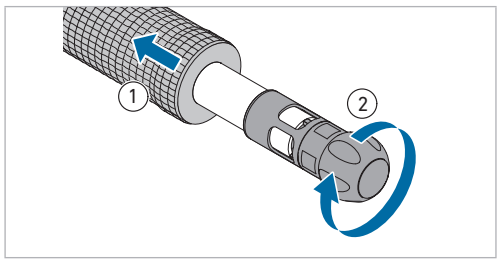
For new pipe start: Remove cap from pipe end and remove tape from insulation.



Step B

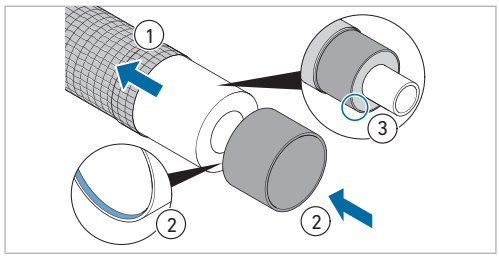
Pipe lengths: Cut the insulation at right angles at the interface using scissors. Push the insulation aside and cut the pipe flush with the insulation using a pipe cutter.

Joint



Step 1

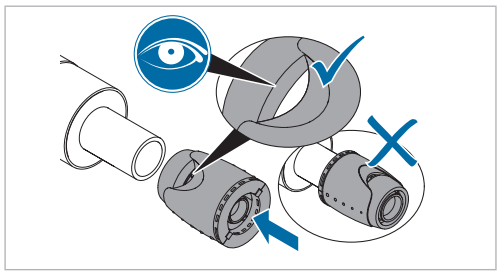
Push back the insulation and chamfer and calibrate the tube end with the chamfering tool. Visually check the chamfering. Remove any chips that may be adhering, also inside the tube.



Step 2

Pull the net of the insulation to the rear. Push the ring over the insulation with the chamfered side first. The surface of the insulation must lie flush in the ring.

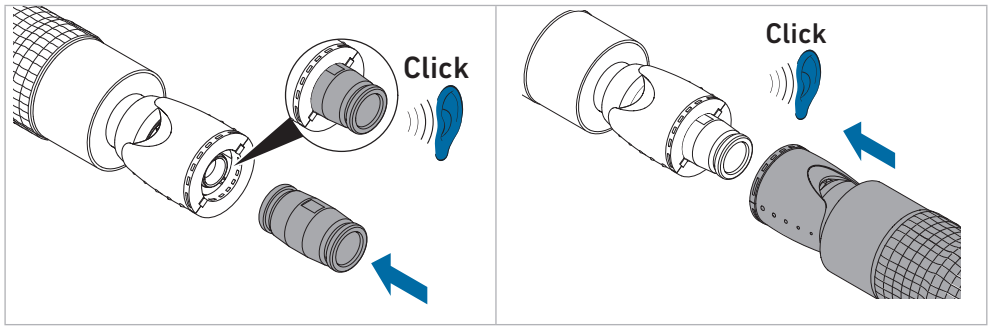
i It is easier to attach the ring if the insulation is first pulled off the pipe, then the ring is slid over the insulation. Then both are pushed back over the pipe.



Step 3

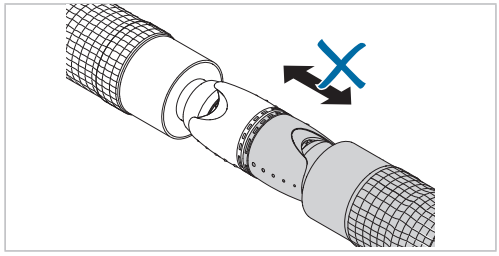
The adapters are packaged individually. The packaging is only opened immediately before use.

Push the adapter onto the tube end as far as it will go. Visually check that the viewing window of the adapter is completely filled by the tube.



Step 4- 5

Insert the module into the adapter and push it in until an audible click is heard (acoustic check). Prepare the second tube end and also push it onto the module until an audible click is heard.

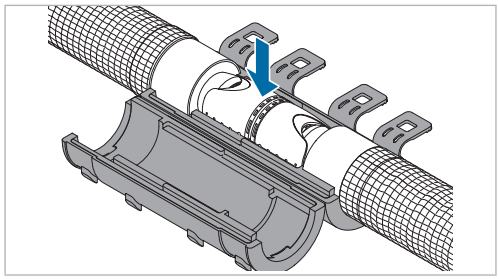


Step 6

Check by counter-tensioning whether the tube adapter and module are firmly connected to each other.

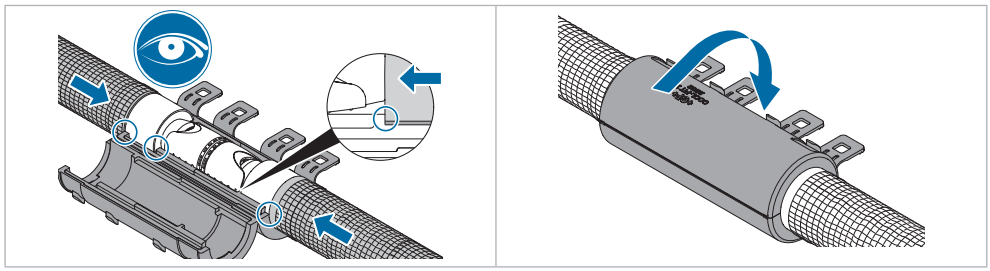
During the counter-tension test, the adapter and module may slide apart by up to 5 mm. Due to the dynamic holding mechanism, the pipe moves back slightly during operation or during the pressure test. This is not a defect of the assembly from a technical point of view.

Insert joint into shell



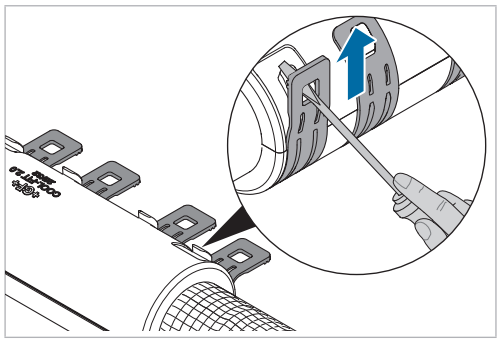
Step 7

Insulation with ring is pushed to butt against the adapter. The net must be outside the shell.



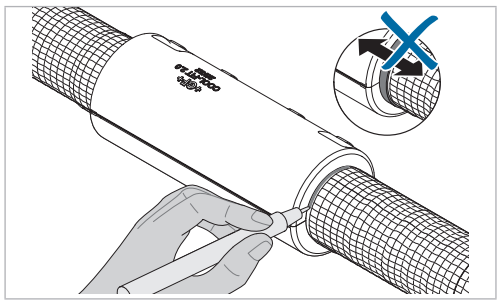
Step 8 - 9

Visually check that the insulation is butted in the shell and, if necessary, push the adapter into place. The ring must be completely in the shell. Then close the shell.



Step 10

Close the tabs with a screwdriver.



Step 11

After closing the shell, a mark is placed along the edge of the shell. The mark indicates whether the insulation has shifted during the further installation process. If the mark is no longer visible along the shell, the shell must be reopened and checked.

Disassembly

Fitting

The fitting can be opened and released again.

> NOTE! Loss of warranty if adapters are opened!
> If adapters have been opened, e.g. during disassembly, the warranty is no longer valid.
> → Do not reuse opened adapters.

Shell

The shell can be opened at the tabs and reused.

Plug connection

It is possible to loosen the connection, but the adapter will be destroyed in the process.

> NOTE! Destruction of the adapter by loosening the connection.
> Loosening the connection is possible, but the adapter will be destroyed in the process.
> → For the next assembly: Use a new adapter.

1. Use water pump pliers to fix the collar of the half shells. Use a second pair of water pump pliers to loosen the adapter housing in an anticlockwise direction.
2. This destroys the housing and it must not be used again.
3. Unscrew the adapter housing completely.
4. Pull the tube off the support nipple.
5. Remove the adapter housing, support ring and toothed ring from the tube.
6. Remove the half shells of the adapter from the support nipple of the module.
7. Pull the support nipple of the adapter out of the module.
8. Loosen the clamping ring by squeezing it lightly with pliers and remove it from the tube.
9. Dispose of all parts of the dismantled adapter properly.

Module

The module can be reused.

The tube end must be shortened by 6 mm (this complies with the insertion depth of the toothed ring) and recalibrated.

1.5.3 Pressure test

Internal pressure test

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

1.5.4 Internal pressure and leak testing

Introduction to the pressure test

Overview of the various test methods

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

[1] Observe the applicable safety precautions. More information is available in DVS 2210-1 addendum 2.

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

The purpose of a pressure test is:

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

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

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

Internal pressure test with water or similar incompressible test medium

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

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

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

Test parameters

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

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

Pre-test

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

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

Material	Pressure drop (bar/h)
COOL-FIT 4.0	1.2

Main test

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

Observe if using compensators

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

Observe if using valves

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

Filling the pipe

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

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

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

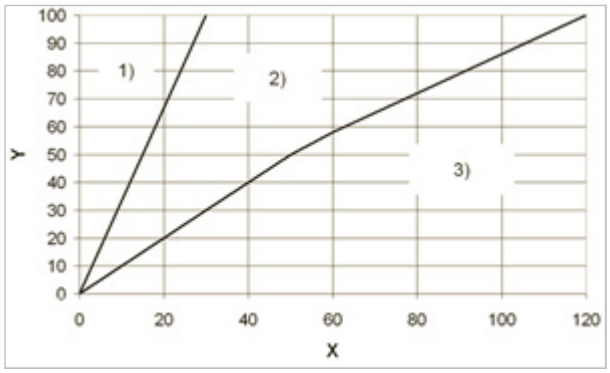
Reference values for the filling volume are given in the table below:

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

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

Applying the test pressure

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



Y Test pressure (%)
X Time of test pressure increase (min)
1) Rate of pressure increase up to DN100 mm
2) Range of pressure increase rates between DN100 and DN400 mm
3) Guideline rate of pressure increase for DN500 and higher: 500/DN (bar/10 min)

Determination of the test pressure

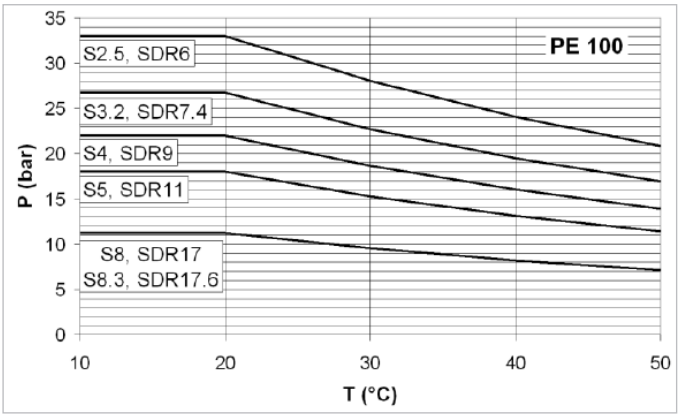
The permissible test pressure is calculated using the following formula:

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

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

Material	Sp minimum safety factor
COOL-FIT 4.0 Pipe and Fittings (PE100)	1.25
COOL-FIT 4.0 Valves (ABS)	1.6

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



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

Checks during testing

The following measurement values must be recorded consistently during testing:

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

1.5.5 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

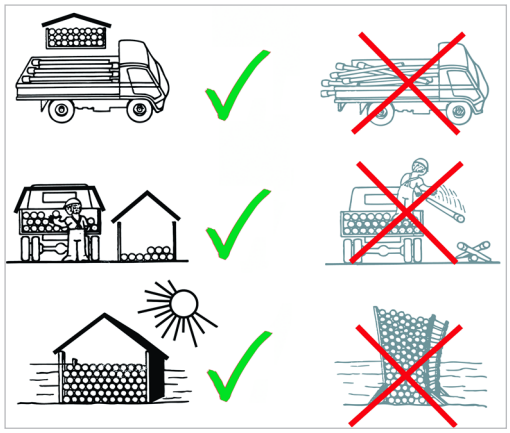
1.6 Transport, Handling and Storage

1.6.1 Transport

On trucks/in crates, manual transport

1.6.2 Storage

All plastic pipe including pre-insulated plastic pipe such as COOL-FIT 4.0 must be stacked on a flat surface with no sharp edges. During handling, care must be taken to avoid damage to the external surface of the pipe, i.e. by dragging along the ground). Pipe should not cross over each other in storage as this is likely to cause bending.



1.7 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.

For more information at www.coolfit.georgfischer.com

Double Containment Solutions

Content

CONTAIN-IT Plus 551

Double Containment Solutions

CONTAIN-IT Plus

Content

CONTAIN-IT Plus **551**

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CONTAIN-IT Plus

1.1 Introduction – Double Containment System

EHSQ – Environment, Health, Safety, Quality

Double containment systems are used for the safe transport of hazardous liquids or gaseous media. They protect the environment, people, production plants and ensure the quality of the end product (EHSQ: Environment, Health, Safety, Quality).

United Nations – Sustainable development goals

Georg Fischer Piping Systems addresses numerous sustainable development goals of the United Nations by providing the CONTAIN-IT Plus double containment system.



Responsible environmental awareness and an increased need for safety are becoming increasingly important in today's world. The transport of hazardous media can lead to personal injury in the event of unexpected leakage, property damage and environmental pollution. Corroded steel pipes, as well as unexpected leakages – especially creeping leakages from underground pipes – pose a serious risk for ensuring the good quality of our global water resources.

The goals of the United Nations are already reflected in various guidelines on environmental protection and personal safety. At European level, the Water Framework Directive 2000/60/EC (Environmental protection) and the Occupational Health and Safety Framework Directive 89/391/ EEC (Employee protection) have already entered into force. Numerous EU member states already consider Double containment systems in their national legislation and define these as a measure for the safe transport of hazardous media (protection of the environment and of employees).

Trend - Zero Pollution Action Plan (EU)

The Zero Pollution Action Plan was published in May 2021 and focuses on the implementation and enforcement of all EU pollution preventing legislation.

This approach will be increasingly reflected in national legislation, bringing the use of double containment piping systems into focus.

Impacts – Uncontrolled leakages

The CONTAIN-IT Plus double containment system from Georg Fischer Piping Systems minimizes the expensive impacts of leakages to a minimum. Consequently, liquid and gaseous media escaping unexpectedly from medium-carrying inner pipe do no longer pose a risk to the surrounding and help planners and plant operators to comply with the principle of concern.

Costly consequences such as heavy fines, high process and decontamination costs, long-term image loss, as well as tiresome occupational accidents, can be minimized or even eliminated by conducting hazard assessments and defining measurements like double containment systems. Moreover, depending on local legislation, double containment systems may be mandatory for the legally compliant operation of a plant.

Applications

Collection points

Double containment systems are used to ensure the safe transport of hazardous media from the truck intakte to the storage tanks.

Distribution systems

Double containment systems are used to ensure the safe transport of hazardous media (pressure pipings) from storage tanks into the production process. The structural situation often requires an underground double containment system. Depending on the transported medium, a double containment system must be used even for the smallest amounts of hazardous substances, since creeping leakages can escape unnoticed for many years and thus have a massive impact on water quality.

Wastewater systems

The safe transport of hazardous/contaminated pressureless wastewater mixtures is realized by using underground and over-ground double containment systems for the treatment of wastewater.

Wastewater treatment

The treatment of wastewater requires environmentally hazardous chemicals. The safe transport of hazardous media - from the storage tanks to the wastewater treatment plant - is ensured by means of double containment pipes.

Plant availability

There are also further applications that requires a high degree of process safety – to protect production-relevant equipment such as servers, machines, etc. – and where the piping system has to remain in operation, despite leakages.

A double containment system is likewise recommended for highly diffusing media such as HF, HCL, HNO3, as well as for valuable liquid media.

Market segments

Double containment systems are used in all market segments where uncontrolled leakage of a media-carrying pipe can cause damage.

Main fields of application:

- Microelectronics
- Data centers
- Batteries
- Water treatment plants
- Chemical process industry
- Food and beverage industry
- Pharmaceutical
- Mining industry
- Hospitals
- Municipal wastewater
- etc.

Legal provisions – Protection of the environment

Germany

According to the German Water Management Act (Section 62 g WHG), the principle of concern applies to the storage, filling, production and treatment of substances hazardous to water, as well as for in-plant piping systems.

Facilities for handling substances hazardous to water must be designed, installed, maintained and operated in such a way that there is no reason to fear contamination of water bodies. In accordance with a verdict of the federal administrative court, the principle of concern implies that there must be no probability, however slight, of water contamination.

Requirement of the German regulation on installations for handling substances that are hazardous to water (Section 17 AwSV)

- Plants must be planned, erected, constructed and operated in such a way that
  - substances that are hazardous to water cannot escape,
  - leakages on any parts of the installation coming into contact with substances that are hazardous to water can be identified quickly and reliably,
  - leaking substances hazardous to water are quickly and reliably detected and retained and properly disposed of; the same applies for splash and drip losses occurring during operation, and
  - in the event of a malfunction of the plant, any mixtures that may contain leaked substances hazardous to water are retained and properly disposed of as waste or disposed of as wastewater.
- Installations must be leak-tight, stable and adequately resistant to the expected mechanical, thermal and chemical influences.
- Single-walled, underground vessels for liquid substances that are hazardous to water are not permitted. Single-walled, underground vessels for gaseous substances that are hazardous to water are not permitted, if the gaseous substances which are hazardous to water emerge in a liquid state, are heavier than air or dissolve in existing moisture in the ground after escaping.
- When decommissioning a plant or parts of a plant, the operator must remove all substances hazardous to water contained in the plant or parts of the plant, as far as technically possible. He must secure the plant against misuse.

The above mentioned requirements for piping systems can be fulfilled by the existing containment room in-between inner and outer pipe of the double containment system.

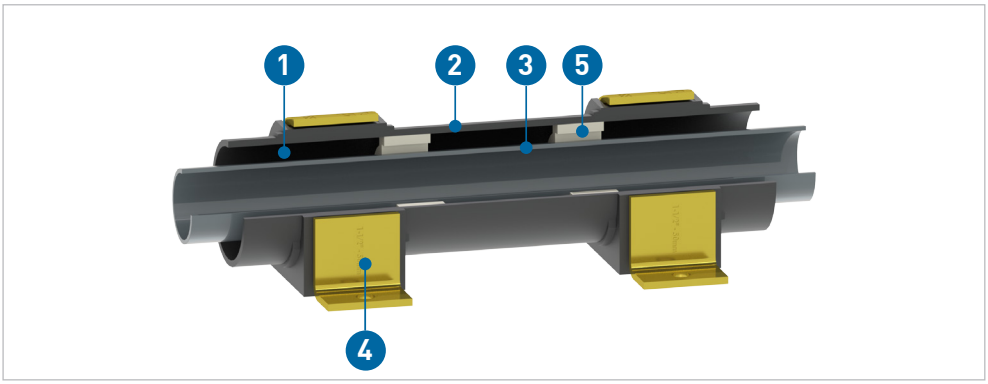
Switzerland

The regulation on the protection against failures (Section 3, General safety measures) states that operators must take all suitable measures for reducing the risk into account. This includes measures to reduce the hazard potential, prevent incidents, and limit their environmental impact.

The federal law on the protection of waters (Section 22, General requirements) states, that operators of plants with water-hazardous substances must ensure, that the constructional and instrumental equipments for the protection of waters are regularly inspected, properly operated and maintained. Liquid losses must also be prevented in storage and handling areas, and escaping liquids must be contained.

1.2 Double containment system – CONTAIN-IT Plus

1.2.1 CONTAIN-IT Plus – General design information

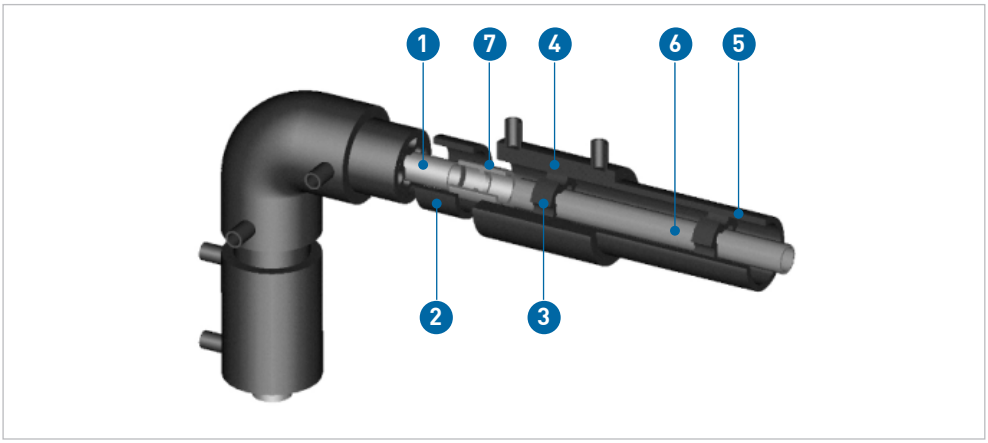


1 Monitoring room
2 Containment pipe
3 Inner pipe
4 Support clamps
5 Spacers

The CONTAIN-IT Plus system consists of a media-carrying inner pipe and an containment pipe, which provides protection for the environment, people and production facilities in the event of an unexpected leakage of the medium carrying inner pipe. The inner pipe is centralized in the containment pipe by the use of spacers to prevent buckling from the inner pipe in the containment pipe. Leakage detection devices have to be connected to the monitoring room so that operators can detect unexpected leakages after a maximum of 72 hours and initiate appropriate countermeasures.

1.2.2 CONTAIN-IT Plus – Basics connection technology

The patented double containment connection technology allows a double containment pipe to be connected in the same way as a single pipe using the familiar and proven jointing techniques in accordance with DVS Directive 2210-2. In the CONTAIN-IT Plus system, the inner and containment pipes are joined after each other . This unique connection technology makes it possible to visually inspect every internal piping connection and to execute a pressure-test of the internal pipe before the external pipe is joined. So-called "last connections", which occur with other system in each change of direction and then usually have to be done blind, are thus eliminated.



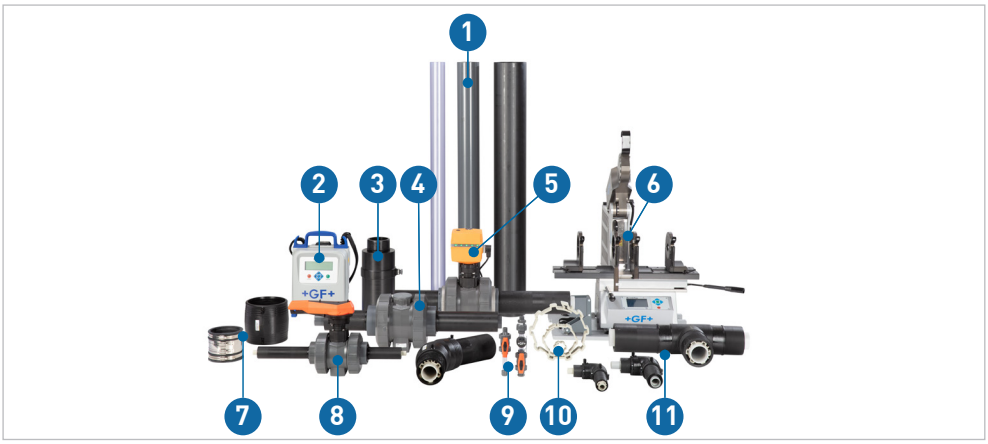
1 Fitting
2 Snap ring
3 Spacers
4 Electrofusion coupler
5 PE containment pipe
6 Inner pipe
7 Cementing/welding socket

Example: PE100 containment pipe

Further information relevant to planning and installation can be found in the chapters "Planning instructions" and "Installation instructions".

1.2.3 CONTAIN-IT Plus Product range

Georg Fischer Piping Systems offers a broad product portfolio of double containment fittings, ball valves, mechanical connections, leak detections solutions and numerous connection technologies, all the way through to expanded services.



1 Containment pipes
2 MSA Electro fusion machine
3 Termination fitting/End fitting
4 Double containment mechanical connection
5 Electrical/pneumatic double containment ball valve
6 Fusion machines
7 Couplers
8 Double containment ball valves
9 Leak detection solutions
10 Spacers
11 Double containment fittings

1.2.4 CONTAIN-IT Plus delivery program – Inner pipe

The selection of materials and connection technologies are crucial for operational safety and a long service life. The diverse choice of materials from various plastics for the inner pipe allows an optimal adaptation of the pipe material to the physical and chemical requirements: PVC-U, PVC-C, PP-H, PE, PVDF, ECTFE and PFA.

Georg Fischer Piping Systems provides comprehensive support in the selection of the materials and connection technologies based on your project-specific operation conditions in the "Questionnaire for static evidence and stress calculation".

The online tool: Chemical resistance - Georg Fischer Piping Systems (www.gfps.com) can be used as a general guidance for a rough material pre-selection.

Sulfuric Acid, > 78 - 93% solution

Formula: H_2SO_4
Synonyme:
Comments: Chemical de-rating factors apply only to metric DIN and not to ASTM SCH systems.

- not applicable
0 individual evaluation, please contact GF
+ (AF) conditionally applicable
++ unconditionally applicable

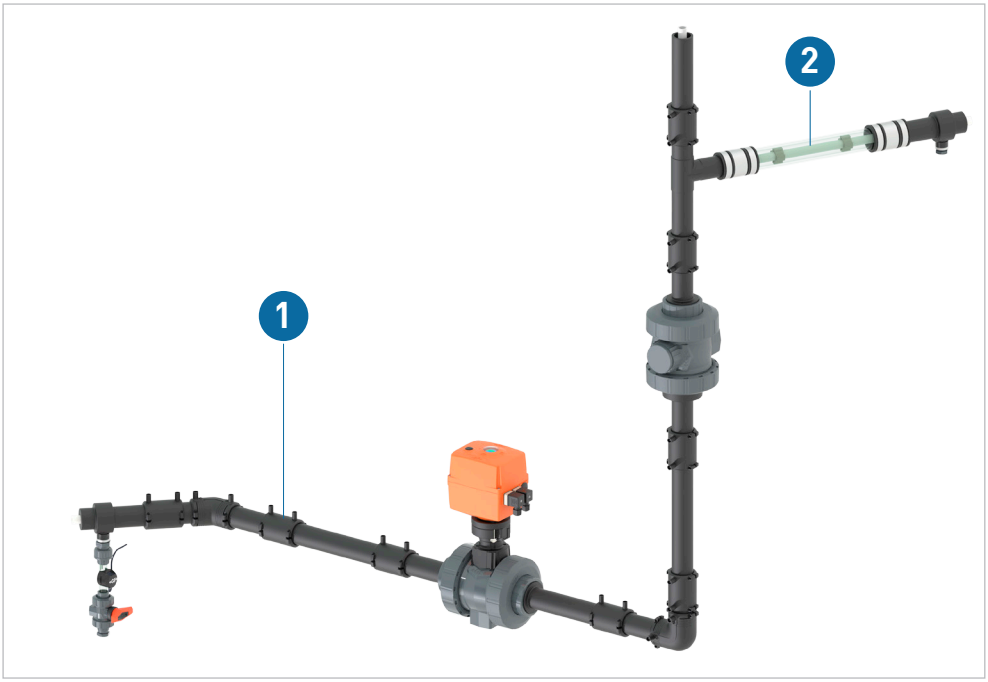
Piping Systems	20 °C	40 °C	60 °C	80 °C	100 °C	120 °C	140 °C
PVC-U	+ (1.1)	+ (1.1)	-				
PVC-C	++	++	0	-			
PE	-						
PP	-						
PVDF	+ (1.3)	+ (1.3)	0	-			
ECTFE	++	++	++	++	0	-	
EPDM	-						
FKM	++	++	++	0	0	-	

Jointing of PVC	20 °C	40 °C	60 °C	80 °C	100 °C	120 °C	140 °C
Tangit PVC-U	-						
Tangit PVC-C	-						

1.2.5 CONTAIN-IT Plus delivery program – Containment pipe

The containment pipe of the CONTAIN-IT Plus system can be designed with a pressure-resistant PE and a pressureless PVC-U (transparent) pipe from Georg Fischer Piping Systems. The outer fittings of the CONTAIN-IT Plus system are always made of PE100.

The prime considerations for selecting the containment pipe material are the installation and operating conditions like temperatures, pressures, impact, notch rupture strength, UV resistance, etc. The chemical resistance of both materials is sufficient, due to the fact that the containment pipe is just in contact with the medium under full load in case of leakage and hence only for a max. period of 72 h.



1 Variant 1: PE containment pipe
- Tensile-tight and pressure-resistant system
- Installation underground/above ground/inside/outside of buildings
- UV-resistant system
- Good impact and notching resistance

2 Variant 2: PVC-U (transparent) containment pipe
- Non-tensile-tight and non-pressure-resistant system
- Installation in buildings
- Simple visual leakage detection

Containment pipe variants: System overview

	Variant 1: PE100	Variant 2: PVC-U (transparent)
Connection technology	Electrofusion coupler (ELGEF Plus)	EPDM couplers and cementing sockets
		 
Tensile-tight connection	Yes	No
Containment pipe dimension	50mm – 315mm	50mm – 160mm
Nominal pressure	PN6*/PN10*/PN16*	PN1

*The nominal pressure of the inner and containment pipe is based on the component with the lowest nominal pressure. Pressure decreasing containment pipe components are, among others, mechanical connections, as well as ball valves with a nominal pressure of PN6 (housing).

Variant 1: Pressurized PE containment pipe

The containment pipe designed to encapsulate the medium-carrying inner pipe is made from polyethylene PE100. This material is characterized by good chemical resistance to acids, alkalis and salts, as well as numerous organic and inorganic solvents.

The advantages of PE100 are clear:

- High UV resistance thanks to black (stabilized with black carbon) polyethylene.
- Insusceptibility to notching
- Flexibility and impact strength even at temperatures down to -50°C.

Consequently, PE100 is ideally suited as a containment pipe material for installations indoor, outdoors and underground.

i The code numbers and wall thicknesses of the containment pipes – PE100 – are provided in the CONTAIN-IT Plus product catalog.

Connection technology:

The containment pipe out of PE100 is welded pressure-tight with the ELGEF Plus electrofusion couplers.

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.

Variant 2: Splash protection PVC-U (transparent) containment pipe

The external protective pipe designed to encapsulate the medium-carrying internal pipe is made from PVC-U (transparent). The splash protection system differs from the pressure-tight system in usage of an EPDM rubber collar with a V2A metal band for connecting the containment pipe. This connection is neither tensile-tight nor pressure-tight, and is therefore used almost exclusively inside buildings under constant operating and ambient conditions.

i The code numbers and wall thicknesses of the containment pipes – PVC-U (transparent) – are provided in the CONTAIN-IT Plus product catalog.

Connection technology

EPDM sleeves are used at every transition from PVC-U (transparent) containment pipe to the PE molded parts. The containment pipe materials offered by Georg Fischer Piping Systems can be connected to one another quickly and easily using the EPDM sleeves. The procedure for connecting the fittings is the same as for the pressure-resistant system.

For pipe-to-pipe connections, standard cemented connections (socket cementing) are used.

Containment pipe variants: wall thicknesses

Inner pipe	Containment pipe			
		Variant 1	Variant 2*	
Dimension [mm]	Dimension [mm]	PE100	PVC-U	PVC-U transparent
20	50	SDR 11	SDR 13.6	SDR 13.6
25	50	SDR 11	SDR 13.6	SDR 13.6
32	63	SDR 11	SDR 13.6	SDR 13.6
40	75	SDR 11	SDR 21	SDR 21
50	90	SDR 17.6	SDR 21	SDR 21
63	110	SDR 17.6	SDR 21	SDR 21
75	125	SDR 17.6	SDR 34.4	
90	140	SDR 17.6	On request	
110	160	SDR 17.6	On request	
125	180	SDR 17.6		
140	200	SDR 17.6		
160	225	SDR 17.6		
200	280	SDR 17.6		
225	315	SDR 17.6		

*Spacer PVC-U (transparent): Spacers can be adjusted for thin-walled pipes (on request)!

1.2.6 CONTAIN-IT Plus product range – Fittings

The CONTAIN-IT Plus double containment system is available in a wide range of different materials, dimensions, connection technologies and components.

Materials, dimensions, connection technology

The choice of materials from various plastics for the inner pipe allows the pipe material to be optimally adapted to meet the physical and chemical requirements: PVC-U, PVC-C, PP-H, PE, PVDF, ECTFE and PFA.

The containment fittings are always out of PE100 and are therefore completely independent of the inner pipe material and the inner pipe connection technology.



Dimension (mm)	Inner pipe												
	Socket cementing				Socket fusion			Butt welding				IR welding	
	PVC-U Tangit	PVC-U DTX	PVC-C Tangit	PVC-C DTX	PP-H	PE80	PVDF	PP-H SDR11	PE100 SDR11	PVDF SDR21	PVDF SDR33	PVC-U SDR13.6	ECTFE SDR21
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 welding (IR)

Other combinations such as WNF welding connection (free of beads and crevices) on request.

The factory-welded connections on the fitting are made with infrared fusion wherever possible. The infrared fusions are logged internally (fusion log) and each connection is provided with a label.

Components and their layout

The individual fittings for the inner and containment pipe are injection molded using the latest quality assured procedures. Fittings are factory-made and supplied ready to install. With the CONTAIN-IT Plus system, the containment fitting – consisting of polyethylene (PE100) – is loosely centered on the inner fitting at the factory.

90° elbow	45° elbow	T90°	End 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. End fittings have two EPDM O-rings or lip seals in series, which are required at the transition from double containment pipe to single pipe to seal the monitoring space in case of a leakage. 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.

Customized designs such as T45°, fixed point fittings inner and containment pipe (see chapter "Questionnaire for static evidence and stress calculation") are possible on request!

1.2.7 CONTAIN-IT Plus product range – Valves and mechanical connections

The CONTAIN-IT Plus Double Containment System is supplied in a wide range of different materials, dimensions, connection technologies and components.

Components and design

Double containment ball valves and mech. connections are factory-made and can be integrated into the double containment system in the same way as the fittings. Valves can be operated manually/automated from outside and can be opened radially for maintenance purposes and for pressure testing of the inner piping system. In addition, the monitoring room is continuous, so that leaks can spread easily. All fittings have Rp½ connections for the simple and flexible integration of leakage detection solutions into the monitoring room.

Ball valve Inner pipe: d20-d63	Mechanical connection Inner pipe: d20-d63



Larger, pressure-resistant ball valves (d75, d90, d110) available on request!

Seals: For the construction of the inner pipe, the sealing material must be selected according to the given operating conditions. EPDM, FKM and additionally FFKM (on request) are available for the ball valves (Valves with actuators on request).

Automation

Thanks to their modular design, double containment ball valves can be supplied from the factory with electric or pneumatic actuators or retrofitted with an actuator by adding an adapter set. Please contact your local sales office.

Electric actuators Type EA	Pneumatic actuators Type PA	Ball valve adapter set Type 546 Pro
		

1.2.8 CONTAIN-IT Plus delivery program – Leakage detection

For leakage detection, both manual and automatic solution are available. If further project-specific solutions are required (leakage location cables, vacuum or overpressure), Georg Fischer Piping Systems has the corresponding partner companies. Further information on leakage detection relevant to planning and installation can be found in the following chapters.

Manual leakage detection	Automatic leakage detection
	

Connection clamps/saddles

Depending on the isometry and local conditions, connection clamps are required for leakage detection and must be selected on the basis of the selected containment pipe variant/dimension.

PP connection clamp with NBR seal (PE/PVC-U containment pipe = d50) (Mechanical connection)	PE connection saddle (PE containment pipe ≥ d63) (Electrofusion)	PE adapter for saddle connector (For connecting the leakage detection system)
		

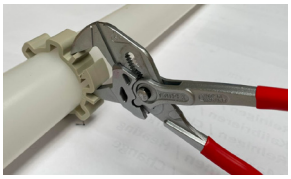
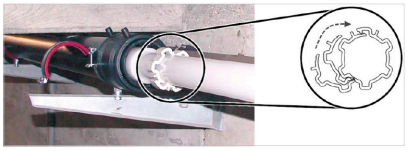
For d50 containment piping:
753 211 610
with reducer (63/50):
753 901 658

Connection clamps/saddles that can be retrofitted to the containment pipe enables flushing of the monitoring room, venting at the highest point of the pipeline, or can be used as a spigot for the pressure test of the containment pipe

1.2.9 CONTAIN-IT Plus product range – Spacers and snap rings

Spacers

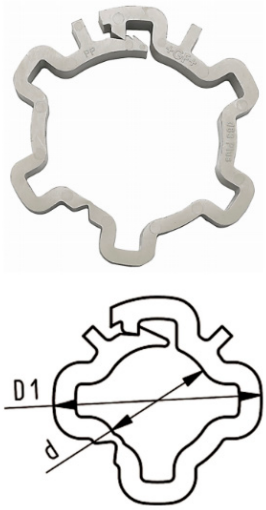
Spacers (PP-H) are a necessary component of a double containment system. Spacers prevent the inner pipeline from buckling in the outer pipeline due to thermal effects, for example, and contribute to an extended service life of the overall system. The number of spacers required or the distance between two spacers must be checked on the basis of the results of the "Questionnaire for static evidence and stress calculation".

Description	Spacers
"Click system" spacers are clamped to the inner pipe, which is then pushed into the outer pipe – double containment pipes are not pre-fabricated. The pipes can also be used as standard single pipes.	
	

Containment pipes with the appropriate wall thickness must be used so that the spacers fit as closely as possible to the containment pipe. This prevents the internal pipe from hanging through. With thin- walled PVC-U (transparent) pipes, the inner pipe may hang through in the containment pipe. Special spacers can be supplied on request.

Spacer dimensions

Inner pipe diameter d [mm]	Containment pipe diameter D1 [mm]
20	38
25	38
32	48
40	57
50	76
63	94
75	104
90	118
110	138
125	152
140	173
160	195
200	238
225	267



Snap rings

The CONTAIN-IT Plus double containment system is characterized by a staggered connection between the inner and containment pipe. This connection technology ensures a 100% visual inspection of the inner pipe connection. The 30 mm wide control gap in the containment pipe, which is needed for the visual inspection, is closed by a snap ring once the internal pipe connection has been successfully inspected.



1.2.10 CONTAIN-IT Plus – Bill of material

The calculation table below provides an overview of the required sockets, snap rings, ELGEF Plus electrofusion coupler and EPDM collars.

Material requirement checklist

Inner piping connection: Socket fusion or cementing

Quantity required per item	Pressure-tight solution ELGEF Plus Socket	Splash protection solution EPDM collars	Socket Equal	Snap ring
Connection technology	Electrofusion	Mechanical		
Containment piping material	PE	PVC-U (Transparent)		
90° elbow	2	2	1	2
45° elbow	2	2	1	2
T-90° equivalent	3	3	2	3
End fitting	1	1	0	1
Segmentation fitting	2	2	1	2
Inner pipe	0	0	*	0
Containment pipe (PE)	*	0	0	*
Containment pipe (PVC-U)	0	0	**	0

Inner pipe connection: Butt fusion

Quantity required per item	Pressure-resistant solution ELGEF Plus Coupler	Splash protection solution EPDM collars	Socket Equal	Snap ring
Connection technology	Electrofusion	Mechanical		
Containment piping material	PE	PVC-U (Transparent)		
90° elbow	2	2	0	2
45° elbow	2	2	0	2
T-90° equivalent	3	3	0	3
End fitting	1	1	0	1
Segmentation fitting	2	2	0	2
Inner pipe	0	0	0	0
Containment pipe (PE)	*	0	0	*
Containment pipe (PVC-U)	0	0	**	0

* For segmenting the monitoring room into monitoring sections

** 1 item per pipe rod to be processed

1.3 Planning instructions

1.3.1 Critera for a safe system

DVS Guideline 2210-2 (German Association of Welding Technology) must be taken into account for the project planning, design and installation of a double containment piping system.

This includes the following topics, among others, which contribute to safe operation:

Planning and installation

- Inner pipe: 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 pipes have to be DIBt-approved.
- Connections: 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.
- Static evidence and installation: Due to different operation conditions (temperatures, pressure ratings, etc.) between inner and containment pipe, as well as the use of different materials with different expansion coefficients for inner and containment pipe, high stresses can be caused by inhibited longitudinal expansion between inner and containment pipe, depending on the application. Georg Fischer Piping Systems calculates these stresses and other fundamental installation parameters, which are relevant to planning and installation for a straight pipe section (based on your project specific information in the "Questionnaire for static evidence and stress calculation") and provides the results to the planner and installer free of charge.
- Staff training: Only persons trained and authorized by Georg Fischer Piping Systems are allowed to install the CONTAIN-IT Plus double containment systems.
- Quality control and assessment: "Blind connections" cannot be tolerated in double containment systems. Especially the visual inspection of the inner pipe connection during the jointing process is an important quality feature. A successful pressure test of the inner pipe must be guaranteed before the containment pipe is sealed. A successful and recorded pressure test of the containment pipe represents the end of the installation work and is an integral part of the installation.
- Leakage detection: Manual or automated leakage detection solutions must be taken into account for double containment systems. These must be taken into account by the operator in the supervision and maintenance plan, among other things.
- Advanced planning service: Georg Fischer Piping Systems recommends the use of the advanced engineering service, especially in the case of complex isometrics. This service analyzes the entire isometry, which can then be used as a basis for cost optimization proposals to the customer (support clamp distances, etc.).

Operation

- Maintenance: For maintenance purposes, subsequent extensions, and for repair cases, the Georg Fischer Piping Systems product range includes mechanical and radially expandable separators.
- Operators: Operators of double containment systems must hold operating instructions, including all relevant documents such as a supervision and maintenance plan, an emergency plan and immediate measures to be taken into account in case of a leakage.

1.3.2 Selecting the material of the medium-carrying 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 lifetime of the system.

The decisive factors are the following:

- Operating pressure
- Operating temperature
- Conveyed medium
- Time of operation

A preselection can be done by using the list of chemical resistances and the material-related pressure and temperature diagrams.

i The ChemRes PLUS tool is available on https://www.gfps.com/com/de/downloads-tools/online-tools/chemical-resistance.html

1.3.3 Selecting the material of containment pipe

In case of a leak, both containment systems (PVC-U and PE100) provide sufficient chemical resistance to contain the escaping medium for at least 72 h in the monitoring room. However, it should be noted that the pressure rating of the containment piping system depends on the component with the lowest pressure rating

Variant 1: PE containment pipe

The pressure rating of the PE containment piping system (PN10/PN16, with fittings PN6) must be at least equal to the operating pressure rating of the inner piping system until the incident is fixed. The PE system is suitable for underground applications due to excellent impact resistance. Moreover, thanks to the wide temperature range (-50 ... +60°C) and excellent UV resistance, it can be used in harsh environments, especially for above-ground installations outside buildings. Due to its excellent properties, the PE system can be used in almost all applications.

Variant 2: PVC containment pipe (transparent)

The pressure rating of the PVC-U containment piping system (PN1) must be at least equal to the operating pressure of the inner piping system until the incident is fixed. In the event of a leak, no higher pressure (including static pressure) than PN1 is allowed in the containment pipe, including at the lowest point of the monitoring section. Due to the limited temperature range of PVC-U (0°C ... 60°C) and the mechanical connections (EPDM-Collars) of the outer pipe, which is not a tensile-tight connection, the PVC-U (transparent) system can only be installed indoors under constant operation conditions.

Combination of variants 1 and 2:

Depending on the isometric drawings, a combination of the two containment piping materials may also be suitable. At well-accessible short pipe sections (1-2m) - at the lowest point of the monitoring room - a PVC-U (transparent) containment piping system can be used for visual leak detection. However, when using a PVC-U (transparent) system, the limited pressure rating of the containment piping system to PN1 must be considered.

i A leakage of the inner pipe usually does not require an immediate shutdown of the double containment system, which means that production processes may still be completed. However, Georg Fischer Piping Systems recommends that operators define appropriate immediate measures in the event of a leakage and carry out a risk assessment before commissioning the double containment system. Depending on the installation conditions, a short-term shutdown may be necessary to ensure that the containment pipe is undamaged and that the leakage only affects the medium-carrying inner pipe.

1.3.4 Inner pipe 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.

1.3.5 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.

1.3.6 Questionnaire for static evidence and stress calculation

The questionnaire for the static evidence is a mandatory document. The results and recommendations must be taken into account during planning and installation phase. Within the scope of the standard service provided free of charge by Georg Fischer Piping Systems, a straight double containment section is considered. The entire isometric drawing is not analyzed, but only one straight pipe section. This calculation is informative enough for a standard installation.

The static evidence offers the following advantages:

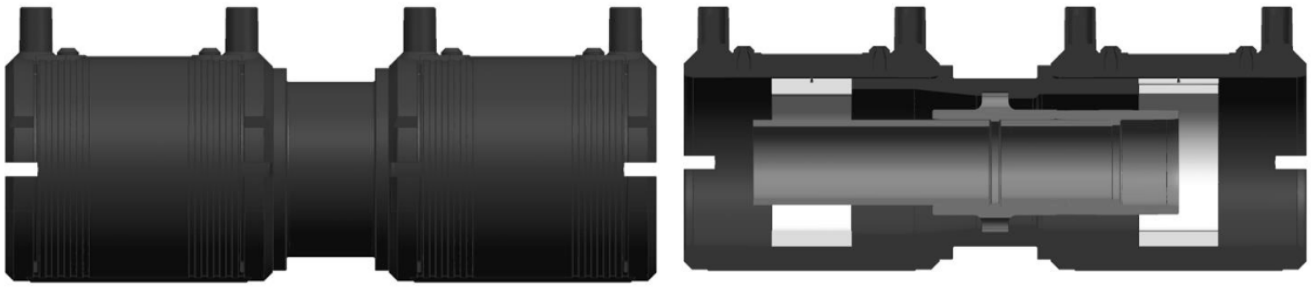
1. Material check: Based on the questionnaire for static evidence and stress calculation, Georg Fischer Piping Systems checks if the selected inner pipe material is suitable under the specified operating conditions.

2. Steel structure dimensioning: For fixed point installation - prevented linear expansion of the containment pipe - the resulting stresses and forces applied to the fittings are calculated. These stresses and forces must be absorbed by the fixed pipe clamps at every change of direction. Additional support clamps must be installed between the fixed points, due to the pipe deflection or due to a pipe routing that is not exactly aligned. The support clamps must be designed for lateral forces of approx. 10-15% of the axial forces applied to the fixed points. The support clamps are to be designed for lateral forces amounting to approx. 10-15% of the axial forces acting on the fixed points. The results of the static verification take into account the axial forces acting on the fixed points, the lateral forces acting on the support clamps, both in the operating case and in the leakage case, and the support clamps distances.

i The expansion of the containment pipe in the pipeline run does not have to be taken into account thanks to the fixed point installation, so that no additional expansion bends are necessary.

3. Expected system stresses: If the calculated stresses in the changes of direction become too large, the operating conditions or the material must be changed. Alternatively, an axial connection in the form of a fixed joint between the inner and outer piping ("fixed point fitting") must be considered to absorb the stresses before the change in direction. Experts at Georg Fischer Piping Systems will recommend a fixed point fitting based on your information in the "Questionnaire for Determination of Static Proof and Stress Calculation" if required.
   In particular, straight pipe lengths of more than 10m and significant delta T need to be checked for the necessity of fixed point fittings.
   In addition, there are various other options, such as trace heating cables with insulation, to overcome this behavior.

Example of a fixed point: Cementing variant



The described fixed point design has a pass-through, so that leakage can spread easily.

4. Spacer distances: Spacer distances must be calculated individually for each application. Spacers prevent buckling and hence excessive expansion of the inner pipe (own weight) in the containment pipe. The calculation results of the static evidence also includes a calculation of the spacer distances based on the project specific information provided in the questionnaire.

GF Piping Systems

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/cm³)		
MSDS (Material Safety Data Sheet) attached?	☐ Yes	☐ No

Operation conditions

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)			
Expected connection technology			

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 ☐ Underpressure	[mbar]	☐ No pressure	

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). GF makes its recommendations on the basis of information provided by the customer. GF does not check this information for completeness or correctness. Any liability due to incorrect or incomplete information provided by the customer is herewith excluded.

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1.3.7 Results of static evidence and stress calculation

Various materials and operating conditions require measures to ensure the expected service life time and safe operation of a double containment system.

Explanation

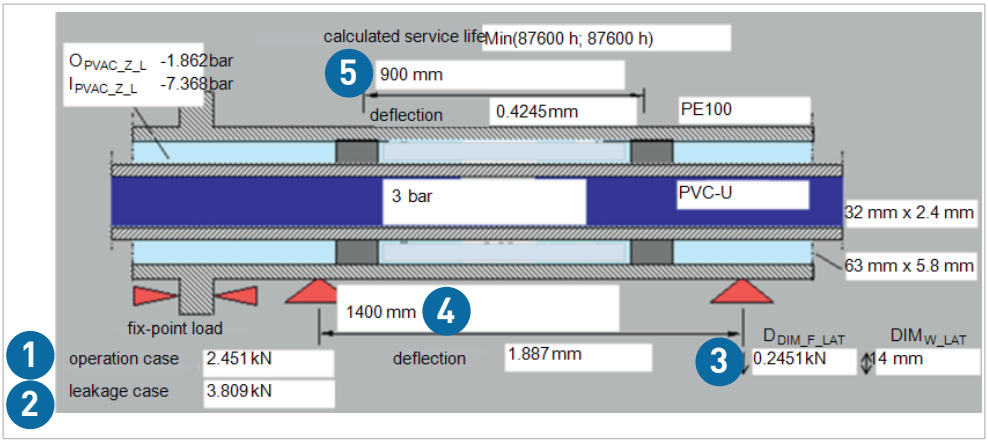
Double containment piping systems must be designed as fixed point installations due to diverse process conditions. The containment pipe must therefore be fixed to the steel structure at every change of direction to prevent thermal expansion/contraction. Inner piping materials such as PVC-C, PVC-U, ECTFE, PVDF, PP, PE, as well as outer piping materials such as PE, PVC-U (transparent) are exposed to different operating conditions. Depending on the combination, they have different expansion coefficients and thus, among other things, lead to different changes in length. Georg Fischer Piping Systems calculates the expected stress for a straight pipe section based on the project-specific information provided in the questionnaire. In this respect, it is also important, among other things, that filling lines in particular are taken into account in the questionnaire, as these are only occasionally operated under process conditions (temperature, etc.).

Material	Temperature range (°C)	α Expansion coefficient (mm/mxK)	L Pipe length (m)	ΔT Temperature change (K)	ΔL Length change (mm)
Steel		0.012	100	10	12
PVC-C	20...80	0.06...0.07	100	10	60...70
PVC-U	20...60	0.07...0.08	100	10	70...80
ECTFE	20...80	0.08...0.14	100	10	80...140
PVDF*	20...120	0.12...0.18	100	10	150...180
PP	20...80	0.16...0.18	100	10	160...180
PE	20...60	0.15...0.20	100	10	150...200

*The linear expansion coefficient increases in line with temperature.

Steel structure forces

The expected forces on the steel construction can be extracted from the result of the static evidence and must be taken into account during planning and installation phase, in particular for the pipe routing and the selection of pipe clamps, see extract from an example project:



1 Axial load at fixed point during operation [kN]
2 Axial load at fixed point in case of a leak [kN]
3 Lateral load at guide bearings [kN]
4 Guide bearing distances [mm]
5 Spacer distances [mm]

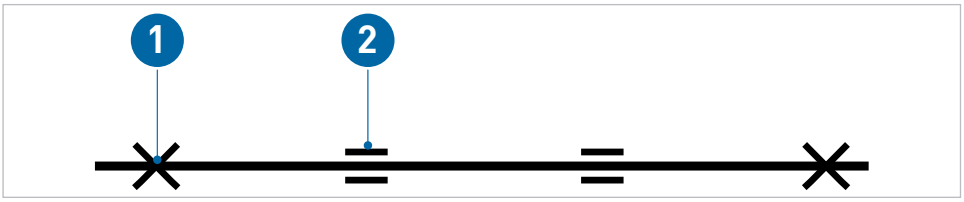
Determining the layout

The cable routing should be protected from mechanical and thermal effects. In addition, the required minimum distance from walls and ceilings must be observed.

In the case of high fixed point forces, the possibility of fastening to the building structure should be checked. If structural components cannot absorb the calculated fixed point force (e.g. trapezoidal sheet metal roofs), the forces must be absorbed by means of stable mounting rails that run with the structure.

Fixed point installation

Double containment systems must be installed as a fixed point installation due to a wide range of process conditions. Thanks to this installation technique, among other things, a meaningful service life time of the double containment system can also be calculated (see result static evidence "calculated service life time").



1 Fixed point
2 Guide bearings

Selecting the fixed point/support clamps

The appropriate load class must be taken into account when selecting the pipe supports.

Georg Fischer Piping Systems offers "Georg Fischer Stress Less" support types suitable for plastics in accordance with static proof.

https://www.gfps.com/en-us/products-solutions/systems/stress-less.html

1.3.8 Determining the leakage detection

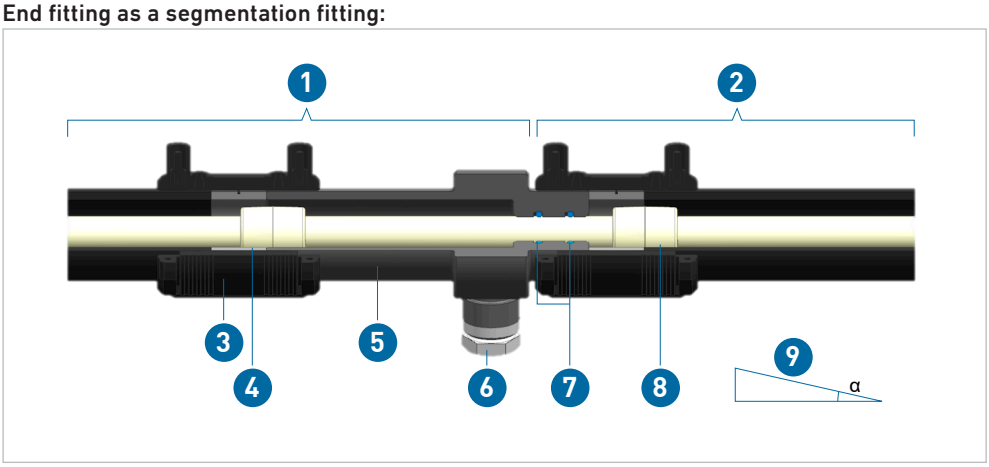
The design of the leakage monitoring is a central requirement of all double containment systems. Solutions for leakage monitoring must already be taken into account in the planning phase. In order to ensure that the double containment pipe does not become a single pipeline unnoticed in the event of a leak of the inner pipe, it must be ensured that leaks are detected within 72 hours. Various leakage monitoring solutions are available for monitoring the pipe or the monitoring room.

In addition, there are other possibilities in the design of the system available, which contribute to a fast leak localization and a quick recommissioning in case of a leak.

System segmentation: fast leakage localization and recommissioning

For rapid leakage localization and recommissioning of the double containment system in the event of a leakage, it is recommended to divide the interstitial space into smaller, freely selectable interstitial sections. This allows the leaking medium to spread only in a small monitoring section.

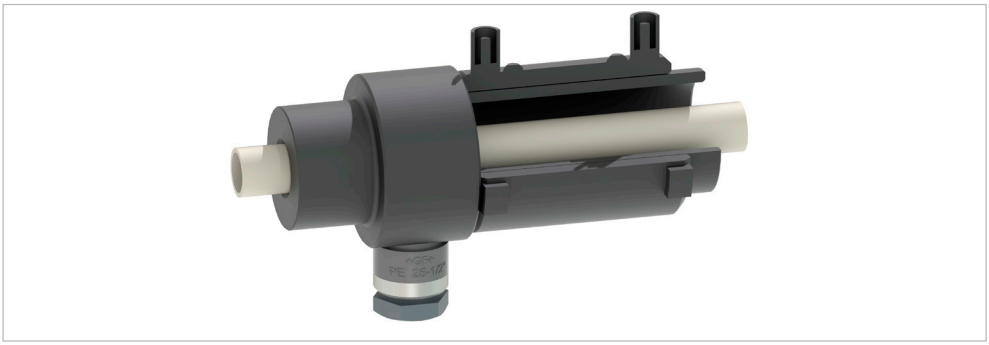
End fitting as a segmentation fitting:



1 Section 1 - Monitoring section
2 Section 2 - Monitoring section
3 Electric welding socket
4 Snap ring
5 PE support of end fitting
6 Leackage detection connection
7 EPDM seals (2x)
8 Inner pipe with socket connection
9 Gradient to be observed

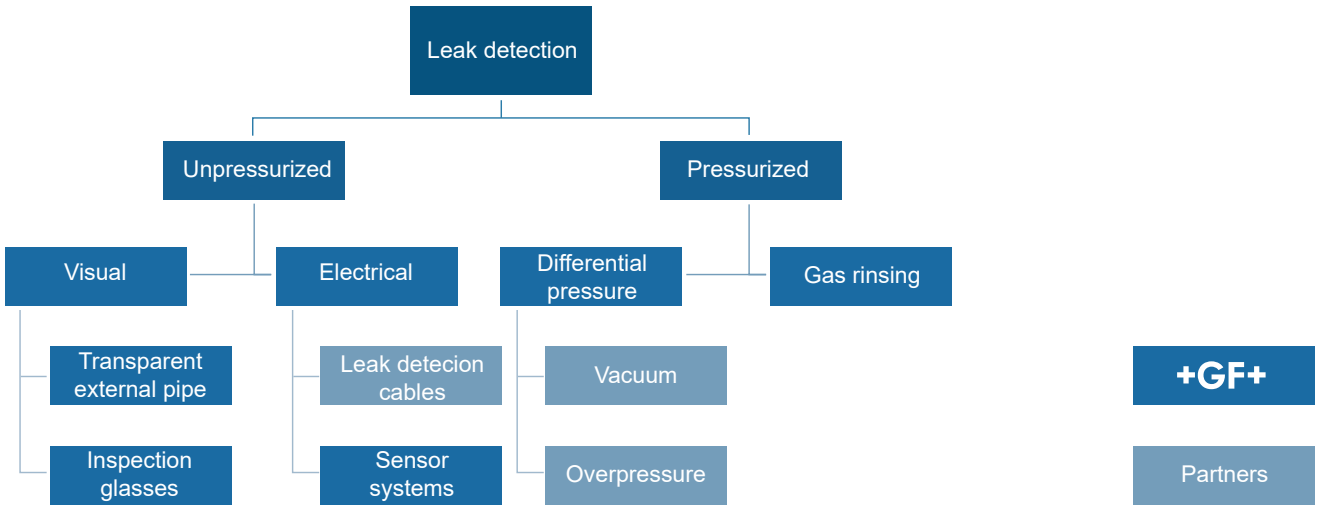
To ensure that the leakage can be reliably detected at the lowest point, it is very important to consider the installation position of the end fitting as a subdivision fitting (see illustration).

Standardized Georg Fischer Piping Systems end fittings can be used for the system segmentation (see illustration). The end fittings have two EPDM O-rings in series or a EPDM lip sealing, which ensure sufficient protection in case of a leakage and separate the monitoring rooms from each other. According to DVS- 2210-2 and based on internal experience, monitoring sections of 20m to 50m are well established.



Leakage monitoring solutions

Georg Fischer Piping Systems provides three possibilites for pressureless leakage detection. A leakage monitoring solution is required for each monitoring system segmentation.



Further information can be found in the chapter "Leakage detection and containment".

Pipe routing: Low point leakage solutions

When using low-point solutions, such as inspection glasses and sensor systems, a slight slope of the containment pipe should be taken into account. As a result, even creeping leaks are detected at an early stage and are always led to the lowest point of the monitoring section.

Monitoring room: Accessibility

Georg Fischer Piping Systems offers a wide range of flexible possibilities to get access into the monitoring room. Many standardized components such as end fittings, ball valves and mechanical connections are equipped with an Rp ½" connection to get access into the monitoring room in their standard version. In addition, it is possible to use connection clamps or saddles (PE and PP), which also allow access to the monitoring room after installation (see chapter "1.2.8 CONTAIN-IT Plus delivery program – Leakage detection").

1.4 Installation instructions

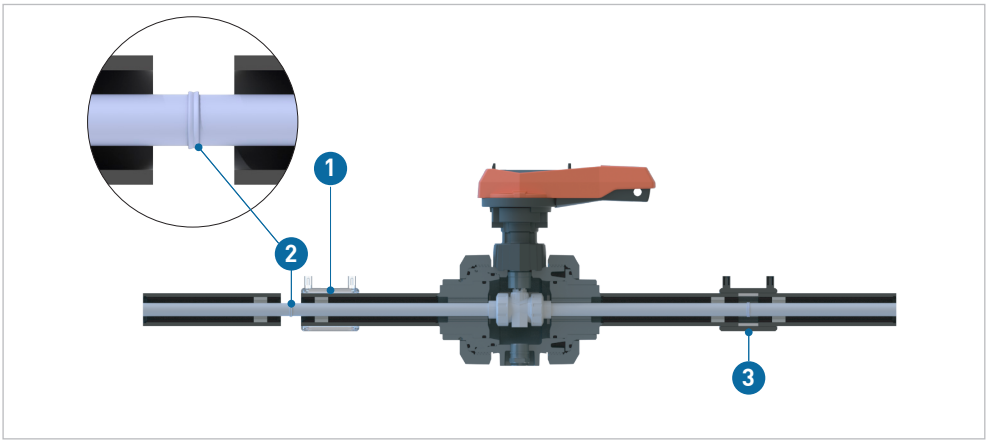
1.4.1 Authorization of installation personnel

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 Georg Fischer 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 Georg Fischer Piping Systems.

1.4.2 Introduction – double containment connection technology

The patented double containment piping connection technology allows a double containment pipe to be connected in the same way as a single pipe by using the established and proven connection technologies in accordance with DVS guidelines 2210-2. In the CONTAIN-IT Plus system, the inner pipe and containment pipe sections are connected with a staggered connection. This unique connection technology allows a visual inspection of each inner pipe connection and pressure testing of the inner pipe before closing the containment pipe. So-called "last connections", which occur with every change of direction in other systems and then usually have to be executed "blindly", are thus eliminated.

Connection Plus – Highest quality



1 ELGEF electrofusion coupler; alternative: EPDM coupler
2 Visual inspection of inner pipe connection and pressure test of inner pipe
3 Centering of the snap ring in the ELGEF electrofusion coupler (gray) and closing of the containment pipe

Explanation on connection technology

1. Step: The inner pipe connection is realized by using proven and quality-assured connection technologies based on the selected material.
2. Step: A small gap in the containment pipe enables a visual inspection of the inner pipe connection.
3. Step: The initial pressure test of the inner pipe can be executed while the outer pipe is open, so that possible leaks in the inner pipe can be quickly located and repaired.
4. Step: After the pressure test of the inner piping system has been successfully completed, a PE snap ring (cutted PE pipe) is inserted to close the containment pipe.
5. Step: The electrofusion coupler (ELGEF Plus) is centered over the snap ring and afterwards welded.
6. Step: Pressure test of the containment pipe

1.4.3 Introduction – double containment installation steps

The essential processes for installing a double containment system are explained briefly below. Detailed explanations can be found in the corresponding sub-chapters.

Overview of the key installations steps

1. **Step: Cutting length calculation**
   The dimensions between axes (Z-dimension) for the 90° angle, the 45° angle and T-pieces are always identical and indicated on the bag labels of the fittings. The external pipe has a different length dimension to the internal pipe. The two pipes must be calculated sepa- rately and is based on the internal pipe connection technology (welding losses among others, etc.) and material. Detailed information on calculating the cutting length can be found in the chapter "Calculating the cutting length of the internal and external piping".

2. **Step: Preparation pipes**
   Before the internal pipe is joined, it is necessary to ensure that the spacers are mounted on the internal pipe according to the results of the static evidence (spacer distances) and that the protective pipe has been pulled over the internal pipe. The ELGEF sockets or EPDM sleeves must be pulled onto the external pipe or the long fitting side before the internal pipe is connected. Detailed information on preparing the pipes can be found in the chapter "Preparing the internal and external piping".

3. **Step: Connection inner pipe**
   Proven and well-known standard connections have been taken into account for the connections of the inner pipeline. Depending on the material and dimensions, the following are available: Solvent cementing, socket fusion, butt fusion and the infrared fusion. The selection is based on suitability based on operating conditions. PVDF BCF welded joints (bead- and crevice-free) can be performed on request.
   Cemented connection (PVC-U and PVC-C)
   A quick jointing method that is carried out without extensive use of tools or machinery.
   Heating element socket fusion (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.
   Heating element butt fusion (PP, PE and PVDF)
   In pressurized pipe systems, all butt fusion joints must be executed with a butt fusion machine and not by hand.
   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 welding process allows smaller weld beads and reduces the risk of contamination due to the non-contact process.
   For detailed information on connecting the innerl pipe, see chapter "Connecting the inner pipe".

4. **Step: Pressure test and visual inspection of the inner pipe**
   Once the inner pipe is connected, a 30 mm gap remains in the containment pipe.
   This gap allows the inner pipe connection to be visually inspected and assessed. The pressure test of the inner pipe has to be performed before the containment pipe is closed so that leaking inner pipe connections can be quickly localized and rectified.

   The pressure test of the inner pipe requires that the inner pipe sections are ready for operation. Georg Fischer Piping Systems recommends a section-by-section pressure test, especially for long double containment piping systems and in tight locations. For further information on how to carry out the pressure test, please refer to the chapter "Instructions for internal and external pressure testing".

5. Step: Connecting containment pipe

After successful verification of the inner piping system, the containment pipe can be closed (see chapter "Connection containment pipe").

A pressure-resistant version with electrofusion coupler (ELGEF Plus) and a splash protection version with EPDM sleeve is available. Before closing the containment pipe, make sure that the 30mm gap in the containment pipe is closed by the 30mm wide snap ring (cutted PE pipe). The insertion depth of the sleeve/collar must be determined precisely so that the snap ring is centered in the sleeve/collar.

After welding the ELGEF Plus electrofusion coupler or tightening the EPDM sleeve, the pressure test of the containment pipe can be carried out.

6. Step: Pressure test containment pipe

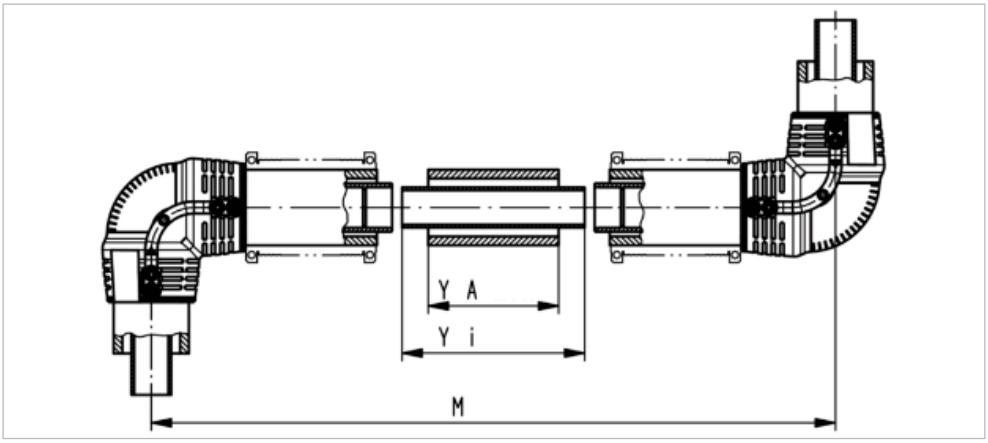
The containment pipe is pressure tested when the inner pipe is completely filled and under internal pressure (the internal pressure of the inner pipe should be at least equal to or higher than the internal pressure of the containment pipe) in order to prevent the inner pipe being exposed to external overpressure. Further information on performing the pressure test can be found in the chapter "Instructions for internal and external pressure test".

Once the pressure test of the outer pipe has been successfully completed and the connections to the interstitial space (flushing connections, pressure test connections, etc.) have finally been closed and the leakage detection units have been functionally tested, the double containment system is ready for operation from a technical point of view.

1.4.4 Cutting length calculation of internal and containment pipes

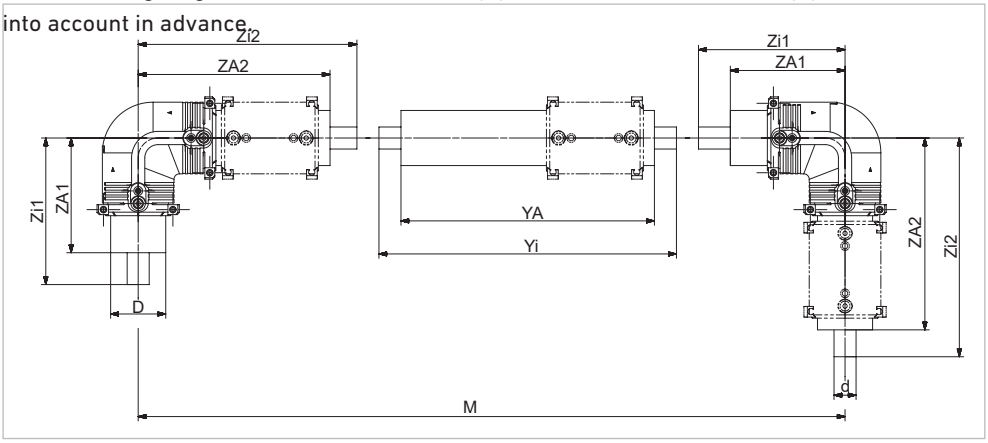
Definitions

The required axial measurement "M" can be taken from the isometric drawing or determined by precise measurement.



M ≈ Length between axes
YA ≈ cutting length
Containment pipe
Yi ≈ Cutting length
Inner pipe

For the cutting length calculation of the inner pipe "Yi" and the containment pipe "YA", the Z measures of the fittings must be taken into account in advance.

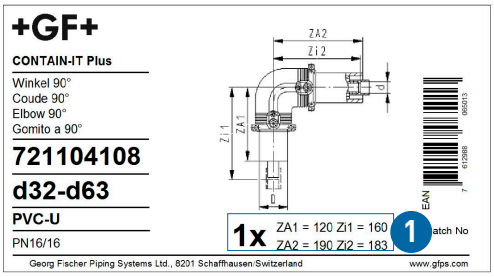


Z-dimensions of fittings

Every item of the double containment system is packaged in a bag in the factory and delivered with a bag label. The label includes all relevant Z-dimensions for calculating the cutting lengths of the inner and containment pipe.

1 Z-dimension

Labeling	Packaging with label



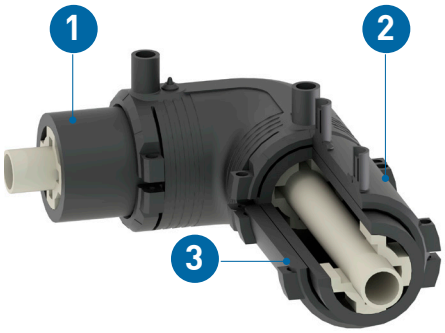


The Z-dimensions for the 90° elbow, the 45° elbow and T-pieces are identical.

Explanation of the Z-dimension

Each item of the double containment system has a short and a long side (see illustration). The shortest axial measurement can be achieved by combining the short fitting side with the long fitting side, in order to apply the ELGEF sleeve or the EPDM coupler.

Fitting-Butt Fusion	Fitting-Socket fusion/cementing

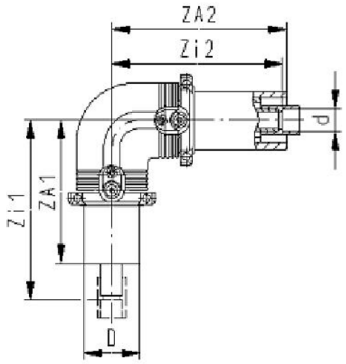




1 Short side (S)
2 Long side (L)
3 ELGEF electrofusion coupler or EPDM sleeve

CAD files (https://bim.gfps.com): AUTODESK REVIT, AVEVA

Designation	Explanation	Side
ZA1	Z-dimension of containment pipe	Short side
Zi1	Z-dimension of inner pipe	Short side
ZA2	Z-dimension of containment pipe	Long side
Zi2	Z-dimension of inner pipe	Long side

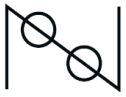


Legend

Abbreviation	Designation	Symbol	Example of 90° elbow
S	Short fitting side		
L	Long fitting side		
E	End fitting		

Case assessment

Before calculating the cutting lengths (Yi, YA), it is mandatory to consider the isometry and the corresponding installation case. The cases differ depending on the arrangement of the fittings. The following case scenarios may occur (see table). GF strongly recommends to always consider the combination "Short fitting side - Pipe - Long fitting side" for the connection.

Abbreviation	Designation	Symbol
S – P – L	**S**hort fitting side – **P**ipe – **L**ong fitting side	
S – P – S	**S**hort fitting side – **P**ipe – **S**hort fitting side	
S – L	**S**hort fitting side – **L**ong fitting side	
L – P – L	**L**ong fitting side – **P**ipe – **L**ong fitting side	
S – E	**S**hort fitting side – **E**nd fitting	
S – P – E	**S**hort fitting side – **P**ipe – **E**nd fitting	
L – P – E	**L**ong fitting side – **P**ipe – **E**nd fitting	

Depending on the isometry, the Z measures of the fittings must be selected accordingly, i.e. Zi1 and ZA1 or Zi2 and ZA2 or ZA and Zie.

30° allowance sheet - Z-Measure method

Before calculating the cutting length, the isometric drawing must be taken into account to define how the fittings should be installed in the most practical case. With the combination of "short fitting side" to "long fitting side", the shortest axial measurement M can be realized.

GF Piping Systems

Double Containment system CONTAIN-IT Plus

Date: _____ Client: _____

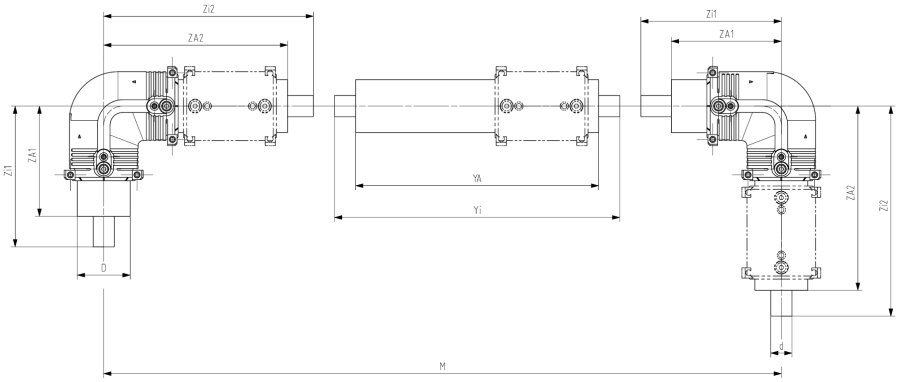
Sheet No./Number: _____/_____ Construction object: _____

Material of inner pipe:		Dimension of inner pipe:	
☐ Cementing	☐ Sockets	☐ Conventional butt	☐ Infrared butt

Legend		
Short fitting side (S)	Long fitting side (L)	Endfitting (E)
		

Z-Mass Method

Case study: Long fitting side – Pipe – Short fitting side



☐ Conventional butt & IR fusion joint

Z-Mass 90°/45°/T90°



Short fitting side:
ZA1 : _____
Zi1 : _____
Long fitting side:
ZA2 : _____
Zi2 : _____

ZA : _____
Zi : _____

Calculation – "Short-Pipe-Long":

- **Yi Cutting length inner pipe**
  M - Fitting1 Zi1 - Fitting2 Zi2 + (material loss x (number of inner pipe connections))
- **YA Cutting length outer pipe**
  M - Fitting1 ZA1 - Fitting2 ZA2 - (30mm x number of snap rings)

Material loss butt/infrared fusion [mm]:

_____

The material losses must be taken into account in the cutting length calculation for pipe-to-pipe connections.

☐ Cementing & socket connections

Z-Mass 90°/45°/T90°



Short fitting side:
ZA1 : _____
Zi1 : _____
Long fitting side:
ZA2 : _____
Zi2 : _____

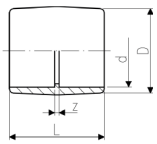
ZA : _____
Zi : _____

Calculation – "Short-Pipe-Long":

- **Yi Cutting length inner pipe**
  M - Fitting 1 Zi1 - Fitting2 Zi2 - (joint width z x number of pipe-to-pipe connections)
- **YA Cutting length outer pipe**
  M - Fitting1 ZA1 - Fitting2 ZA2 - (30mm x number of snap rings)

Z-Value of welding/solvent cement socket [mm]:

_____



The Z-Value must be taken into account when calculating the cutting length for pipe-to-pipe connections.

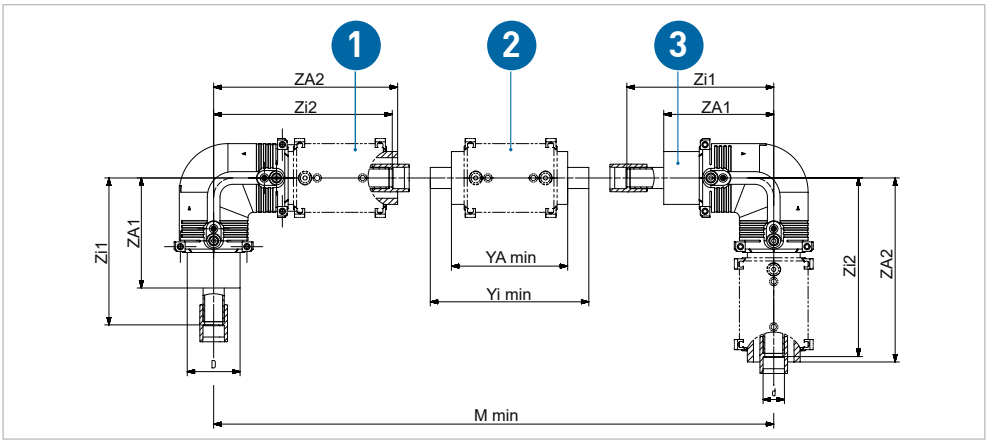
Cutting length calculation

Pipe Section No.: _____ Case: _____ M: _____ Yi: _____ YA: _____	Pipe Section No.: _____ Case: _____ M: _____ Yi: _____ YA: _____	Pipe Section No.: _____ Case: _____ M: _____ Yi: _____ YA: _____	Pipe Section No.: _____ Case: _____ M: _____ Yi: _____ YA: _____
Pipe Section No.: _____ Case: _____ M: _____ Yi: _____ YA: _____	Pipe Section No.: _____ Case: _____ M: _____ Yi: _____ YA: _____	Pipe Section No.: _____ Case: _____ M: _____ Yi: _____ YA: _____	Pipe Section No.: _____ Case: _____ M: _____ Yi: _____ YA: _____
Pipe Section No.: _____ Case: _____ M: _____ Yi: _____ YA: _____	Pipe Section No.: _____ Case: _____ M: _____ Yi: _____ YA: _____	Pipe Section No.: _____ Case: _____ M: _____ Yi: _____ YA: _____	Pipe Section No.: _____ Case: _____ M: _____ Yi: _____ YA: _____
Pipe Section No.: _____ Case: _____ M: _____ Yi: _____ YA: _____	Pipe Section No.: _____ Case: _____ M: _____ Yi: _____ YA: _____	Pipe Section No.: _____ Case: _____ M: _____ Yi: _____ YA: _____	Pipe Section No.: _____ Case: _____ M: _____ Yi: _____ YA: _____

Minimum meassures between axes M min. (Case: S – P - L)

If a very short pipe is required between two fittings, the minimum measurement between the axes must be taken into account. The shortest possible axis measurement - except for the direct fitting-to-fitting connection - can be realized by combining "Short fitting side" to "Long fitting side" (see illustration).

A sleeve/coupler can still be pushed onto the long fitting side. The second sleeve/coupler, however, has to be pushed onto the containment pipe. This leads to the fact that the outer pipe must have at least the length of the sleeve/coupler.



1 Long side
2 Coupler on containment pipe
3 Short side

General formula:

M min = 2* snap ring width + Fitting 1 ZA 1 + Fitting 2 ZA 2 + coupler length

Explanation:

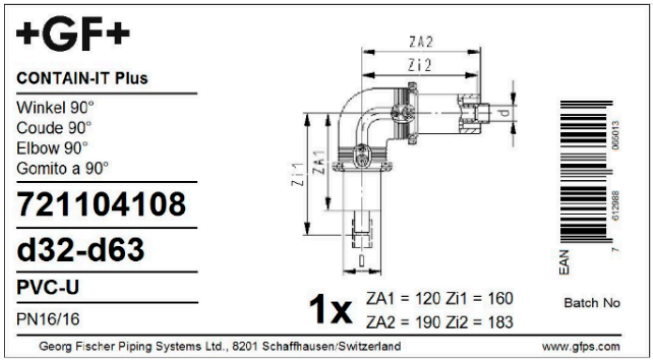
- Snap rings: Two snap rings are always required, which leads to a control gap of 30 mm for each outer pipe connection.
- Coupler length: Choice to be made between EPDM sleeves and ELGEF Plus electrofusion coupler.

Overview of socket lengths:

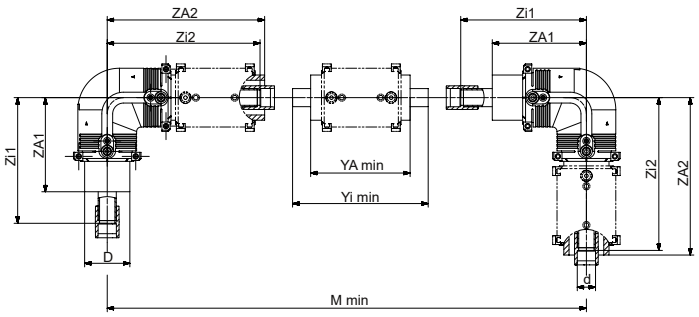
Dimension of containment pipe d [mm]	ELGEF Plus coupler (SDR11) L [mm]	EPDM sleeve L [mm]
50	88 (SDR11)	90
63	96 (SDR11)	90
75	96 (SDR11)	110
90	113 (SDR11)	100
110	138 (SDR11)	120
125	154 (SDR11)	120
140	172 (SDR11)	120
160	180 (SDR17)	120
180	192 (SDR17)	
200	206 (SDR17)	
225	225 (SDR17)	
280	252 (SDR17)	
315	267 (SDR17)	

Example for determining the minimuM dimensions between axes M min:
Long fitting side – Pipe – Short fitting side

Labeling



Measures



M min = 2*30 mm + Fitting 1 ZA1 + Fitting 2 ZA2 + Coupler length (d63 ELGEF Plus electrofusion coupler)

M min = 60 mm + 120 mm + 190 mm + (1 x 96 mm) = 466 mm

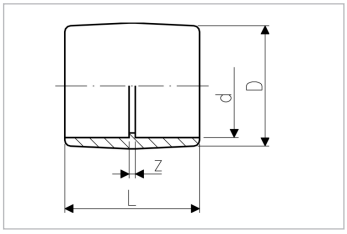
1.4.5 Cutting length calculation – Cementing

Relevant information before the calculation:

- **M dimension between axes:** This dimension either has to be measured on-site or taken from the isometric drawing.
- **Case assessment:** The case assessment is required to ensure that the correct Z-dimensions are considered for the calculation.
- **Z-dimension of double containment item:** The Z-dimensions must be gathered from the bag labels.

i To ensure a proper calculation, the use of the pipe layout chart 30° sheet is recommended.

Calculation with case example (short-pipe-long):

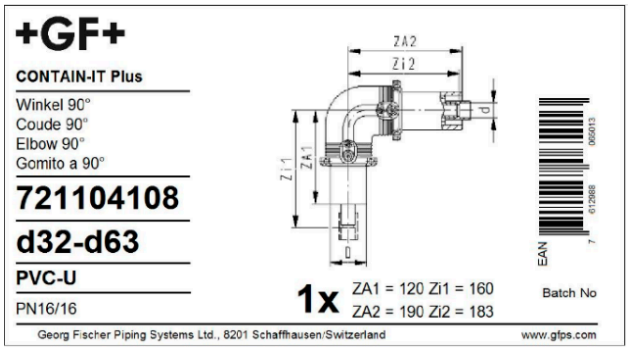


- **Yi** cutting length of inner pipe = M – Fitting 1 Zi1 – Fitting 2 Zi2 – (Z-Value z x number of pipe-to-pipe connections)
  The Z-dimensions have to be adapted in line with the isometry (case)!
- **YA** cutting length of containment pipe = M – Fitting 1 ZA1 – Fitting 2 ZA2 – (30mm x quantity of snap rings)
  The Z-dimensions have to be adapted in line with the isometry (case)!

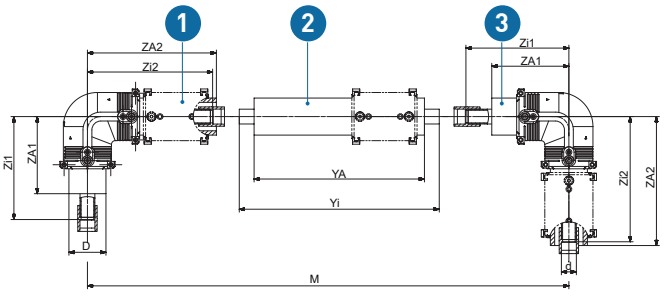
i It is essential to consider the width of the pipe stop "z" of the sockets for pipe-to-pipe connections (see illustration).

Example:

Fitting labels



Case assessment: Long side – Pipe – Short side



Case assessment: Long – Pipe – Short

M = Measure between axes = 1000 mm

1 Long side
2 Pipe
3 Short side

Yi = M – Fitting 1 Zi1 – Fitting 2 Zi2 – (Z-Value x number of pipe-to-pipe connections) = (1000 – 160 – 183) – (3 x 0) = 657 mm

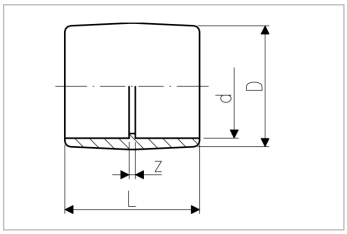
YA = M – Fitting 1 ZA1 – Fitting 2 ZA2 – (30mm x number of snap rings) = 1000 – 120 – 190 – (30 x 2) = 630 mm

1.4.6 Cutting length calculation – Socket fusion

Relevant information before the calculation:

- **M dimensions between axes:** This dimension either has to be measured on-site or taken from the isometric drawing.
- **Case assessment:** The case assessment is required to ensure that the correct Z-dimensions are considered for the calculation.
- **Z-dimension of double containment item:** The Z-dimensions must be gathered from the bag labels.

It is essential to consider the width of the pipe stop "z" of the sockets for pipe-to-pipe connections (see illustration).



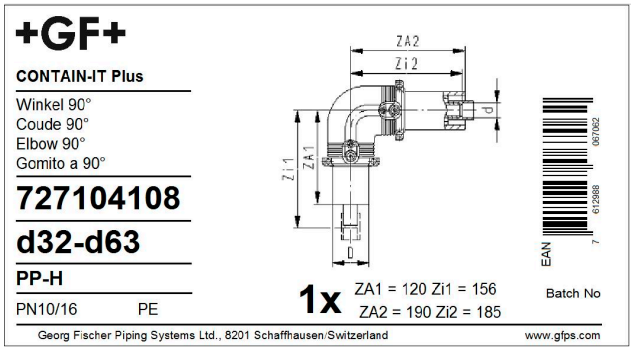
Calculation with case example (short-pipe-long):

- **Yi** cutting length of inner pipe = M – Fitting 1 Zi1 – Fitting 2 Zi2 – (Z-Value x number of pipe-to-pipe connections)
  The Z-dimensions have to be adapted in line with the isometry (case)!
- **YA** cutting length of containment pipe = M – Fitting 1 ZA1 – Fitting 2 ZA2 – (30mm x quantity of snap rings)
  The Z-dimensions have to be adapted in line with the isometry (case)!

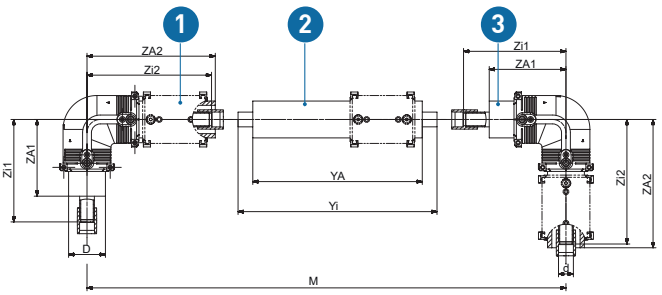
It is essential to consider the Z-Value of the sockets for pipe-to-pipe connections, see illustration.

Example:

Fitting labels



Case assessment: Long side – Pipe – Short side



Case: Long – Pipe – Short

M = Measure between axes = 1000 mm

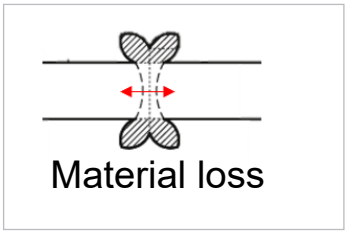
1 Long side
2 Pipe
3 Short side

Yi = M – Fitting 1 Zi1 – Fitting 2 Zi2 – (Z-Value x number of pipe-to-pipe connections) = 1000 – 156 – 185 – (3 x 0) = 659mm

YA = M – Fitting 1 ZA1 – Fitting 2 ZA2 – (30mm x number of snap rings) = 1000 – 120 – 190 – (30 x 2) = 630 mm

1.4.7 Cutting length calculation – Conventional butt fusion

Relevant information before the calculation:



- **M dimensions between axes:** This dimension either has to be measured on-site or taken from the isometric drawing.
- **Case assessment:** The case assessment is required to ensure that the correct Z-dimensions are considered for the calculation.
- **Z-dimensions of double containment item:** The Z-dimensions must be gathered from the bag labels.
- **Material loss, planing loss and welding loss:** Test welds per installer are suitable for determining the material loss, since the material loss depends on the variable planing dimension.

i To ensure a proper calculation, the use of the pipe layout chart 30° is recommended.

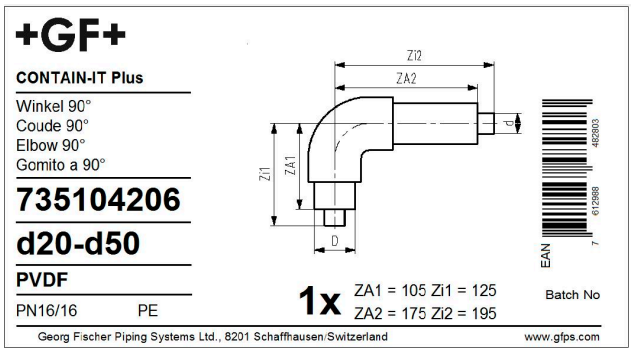
Calculation with case example (Short-Pipe-Long):

- **Yi** cutting length of inner pipe = M – Fitting 1 Zi1 – Fitting 2 Zi2 + (material loss x (number of inner pipe connections))
- **YA** cutting length of containment pipe = M – Fitting 1 ZA1 – Fitting 2 ZA2 – (30mm x quantity of snap rings)

i Material losses must be taken into account for inner pipe connections.

Example:

Fitting labels

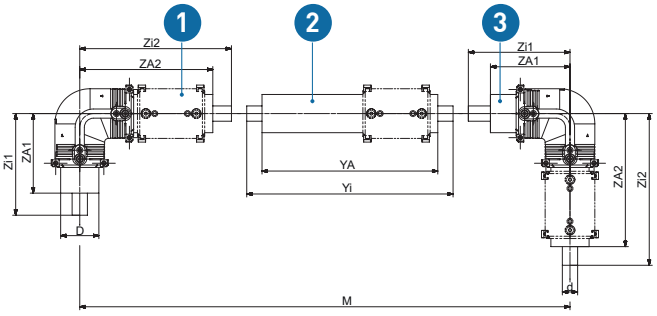


Case: Long – Pipe – Short , material PVDF

M = Measure between axes = 1000 mm

Material loss of test weld = 4.5 mm

Case assessment: Long side – Pipe – Short side



1 Long side
2 Pipe
3 Short side

Yi = M - Fitting 1 Zi1 - Fitting 2 Zi2 + (material loss x (number of inner pipe connections)) = 1000 – 125 – 195 + (4.5 x 2) = 689 mm

YA = M - Fitting 1 ZA1 - Fitting 2 ZA2 - (30mm x number of snap rings) = 1000 – 105 – 175 – (30 x 2) = 660 mm

1.4.8 Cutting length calculation – infrared fusion

Relevant information before the calculation:

- **M dimensions between axes:** This dimension either has to be measured on-site or taken from the isometric drawing.
- **Case assessment:** The case assessment is required to ensure that the correct Z-dimensions are considered for the calculation.
- **Z-dimension of double containment item:** The Z-dimensions must be gathered from the bag labels.
- **Material losses, planing loss and welding loss:** With IR fusion, the material losses depend on the machine, material and dimensions. The expected material losses are shown in the tables below.

Material losses for infrared fusion machine IR-63 M



d (mm)	PE100 (SDR11) (mm)	PP-H (SDR11) (mm)	PVDF (mm)	ECTFE (mm)	PFA (mm)	PVC-U (SDR13.6) (mm)
20	5.5	5.0	4.5	4.5	4.5	4.5
25	5.5	5.0	4.5	4.5	4.5	4.5

Material losses for infrared fusion machine IR-63 Plus*



d (mm)	PE100 (SDR11) (mm)	PP-H (SDR11) (mm)	PVDF (mm)	ECTFE (mm)	PFA (mm)	PVC-U (SDR13.6) (mm)
20	5.5	5.0	4.5	4.5	4.5	4.5
25	5.5	5.0	4.5	4.5	4.5	4.5
32	5.5	5.0	4.5	4.5	4.5	4.5
40	6.0	5.0	4.5	4.5	4.5	4.5

* Rental Pool only

Material losses for infrared fusion machine IR-110 Plus



d (mm)	PE100 (SDR11) (mm)	PP-H (SDR11) (mm)	PVDF (mm)	ECTFE (mm)	PFA (mm)
20	5.5	5.0	4.5	5.0	4.5
25	5.5	5.0	4.5	5.0	4.5
32	5.5	5.0	4.5	5.0	4.5
40	5.5	5.0	4.5	5.0	4.5
50	5.5	5.0	5.0	5.0	4.5

Material losses for infrared fusion machine IR-225 M and infrared fusion machine IR-225 Plus*



d (mm)	PE100 (SDR11) (mm)	PP-H (SDR11) (mm)	PVDF (mm)	PVC-U (SDR13.6) (mm)
63	6.5	6.0	4.5	5.0
75	6.5	6.0	4.5	
90	6.5	6.0	5.0	
110	6.5	6.0	5.0	
125	6.5	6.0	5.0	

* Rental Pool only

To ensure a proper calculation, the use of the pipe layout chart 30° sheet is recommended.

Calculation with case example (Short-Pipe-Long):

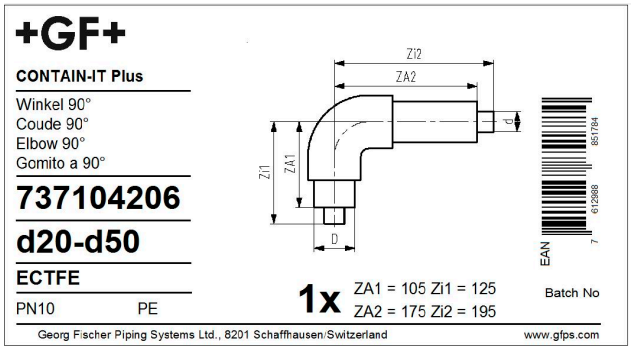
Cutting length calculation – infrared fusion

- **Yi** cutting length of inner pipe = M – Fitting 1 Zi1 – Fitting 2 Zi2 + (material loss x (number of inner pipe connections))
- **YA** cutting length of containment pipe = M – Fitting 1 ZA1 – Fitting 2 ZA2 – (30mm x number of snap rings)

Material losses must be taken into account for inner pipe connections.

Example:

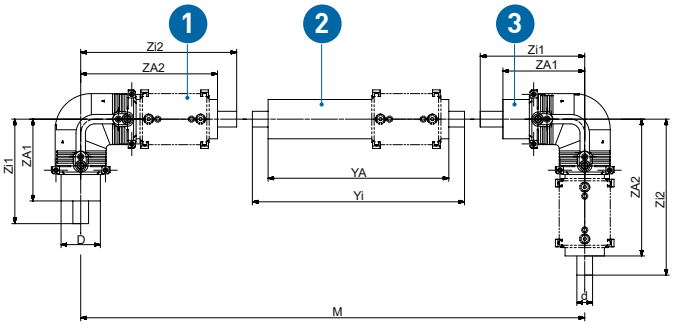
Fitting labels



Case: Long – Pipe – Short , material ECTFE

M = Measures between axes = 1000 mm

Case assessment: Long side – Pipe – Short side



1 Long side
2 Pipe
3 Short side

Yi = M - Fitting 1 Zi1 – Fitting 2 Zi2 + (material loss x (number of inner pipe connections)) = 1000 – 125 – 195 + (4.5 x 2) = 689 mm

YA = M - Fitting 1 ZA1 – Fitting 2 ZA2 – (30mm x number of snap rings) = (1000 – 105 – 175 – (30 x 2) = 660 mm

The spigots of the double containment components are supplied slightly longer and more or less consider the material losses of a mandatory weld (welder-dependent)

1.4.9 Preparations for inner piping system and containment piping system

Cutting the pipes

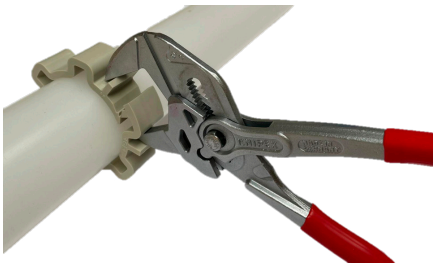


After calculating the cutting lengths, the inner and containment pipes must be cutted precisely and in a right angle according to the calculation. In addition, the pipes must be cleaned from coarse dirt to prepare them for the fusion process. It is recommended to number the cuttled pipes.

Spacers on inner pipe

The spacers must be carefully mounted/clipped onto the inner pipe by hand or with a pipe wrench. The spacer distances are specified in the results of the static evidence and stress calculation provided by Georg Fischer Piping Systems.







Variant 1: Preparing PE containment pipe

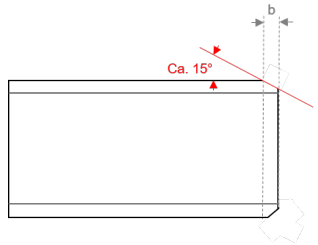


The PE containment pipe must be peeled with a rotary peeler. The peeling length on the pipe must be determined according to the type of the ELGEF Plus electrofusion coupler, half or full socket length. New fittings, which are taken out of the packaging just before processing do not have to be peeled. The pipe ends should be cleaned/degreased with TANGIT KS Cleaner and absorbent, clean paper.

d (mm)	Min. chip thickness (mm)	Permissible minimum pipe outer 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

Variant 2: Preparing PVC-U containment pipe

The PVC-U (transparent) containment pipe must be chamfered and deburred for pipe-to-pipe connections. This allows the pipe to be easily centered in the socket and does not shift the adhesive. Chamfering and deburring has also proven effective for pipe-fitting connections for easy sliding on of the EPDM sleeve and prevents surface damage to the sealing material.



d (mm)	b (mm)
6-16	1-2
10-55	2-3
63-160	3-6

Overview

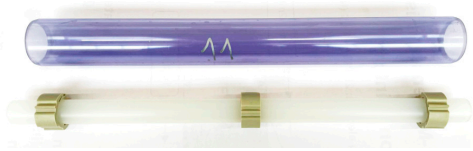
Variant 1: PE Containment pipe	Variant 2: PVC-U (transparent) Containment pipe

1. The cleaned containment pipe has a different length compared to the inner pipe (gray/white, with clipped-on spacers).

Peeled and cleaned welding surfaces



Chamfered and deburred pipe ends



2. The inner pipe is pushed into the containment pipe. Thanks to the spacer, the inner pipe is centered in the outer pipe.
3. ELGEF Plus couplers or EPDM couplers must be mounted on the containment pipes or the long fitting sides before the connection of the inner pipe.

Immediately before use, remove the ELGEF Plus electrofusion coupler from the bag without contaminating it. The center stop must be removed and the coupler must be pushed completely over the peeled pipe end. Especially in the case of outdoor installations, a PE stretch foil is strongly recommended to protect the welding areas from contamination or moisture.





The pipe ends and long fitting sides must be be cleaned/degreased with TANGIT KS Cleaner and absorbent paper. Finally the EPDM sleeves must be pushed on it.





In the next step, the inner pipe connection can be realized.

1.4.10 Connection the inner pipe

The welding directives of the DVS (German Welding Society) and the cementing instructions of the KRV (Kunststoffrohrverband e.V.) are applicable without restriction to both the containment and inner pipe connections. The following chapter deals with the special features of the double containment pipe system. Detailed information on the connection technology of the inner- and containment pipes are provided in the relevant chapters of the Planning Fundamentals.

Overview of the inner pipe connection technologies

Dimension (mm)	Inner pipe												
	Socket cementing				Socket fusion			Butt welding				IR fusion	
	PVC-U Tangit	PVC-U DTX	PVC-C Tangit	PVC-C DTX	PP-H SDR11	PE80 SDR11	PVDF SDR21	PP-H SDR11	PE100 SDR11	PVDF SDR21	PVDF SDR33	PVC-U SDR13.6	ECTFE SDR21
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 fusion (IR)

1.4.11 Inner pipe – Socket cementing

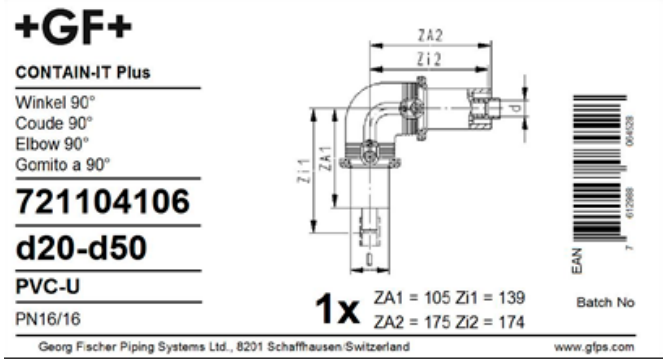
Detailed information on the connection technology for the inner pipe is provided in the Planning Fundamentals and/or the cementing instructions (KRV) and are valid without any limitation.

Fitting design

Since the axial dimension (Z-dimension) is the same for 90° angle, 45° angle and T-piece, only the 90° angles are listed here. However, this only applies to fittings made of the same material and using the same jointing method.

Double containment fittings are provided with a socket on the long fitting side at the factory. This allows direct "fitting to fitting" connections with the shortest possible axial dimension, ("fitting side long" directly to "fitting side short"). The Z-dimensions are noted on the bag label, (see illustration).

Fittings - PVC-U/PVC-C (cementing)





ELGEF Plus sockets and EPDM couplers must be ordered separately.

Final inspection before cementing

ELGEF Plus sockets or EPDM couplers must be pushed onto the containment pipe ends or the long fitting sides before the inner pipe connection is done.

1.4.12 Inner pipe – Socket fusion

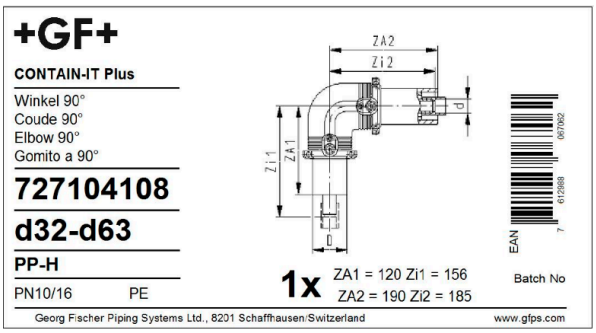
Due to the fact that the axis dimensions (Z-dimensions) are the same for angle 90°, angle 45° and T-piece, only the 90° angles are listed here. This applies only to fittings made of the same material and the same connection method.

Fitting design

Since the axial dimension (Z-dimension) is the same for 90° angle, 45° angle and T-piece, only the 90° angles are listed here. However, this only applies to fittings made of the same material and using the same jointing method.

Double containment fittings are provided with a socket on the long fitting side at the factory. This allows direct "fitting to fitting" connections with the shortest possible axial dimension, "fitting side long" directly to "fitting side short". The Z-dimensions are noted on the bag label (see illustration).

Fittings - PP-H (Socket fusion)





ELGEF Plus sockets and EPDM couplers must be ordered separately.

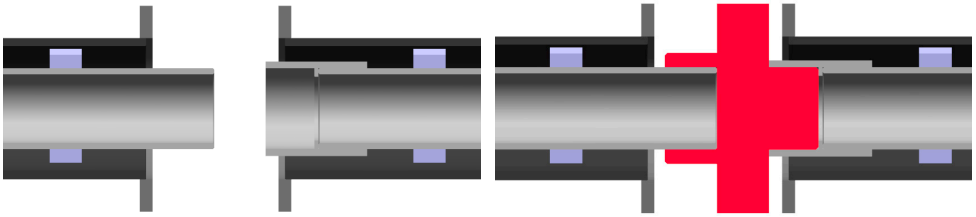
Final inspection before welding

ELGEF Plus couplers or EPDM couplers must be pushed onto the containment pipe ends or the long fitting sides before the inner pipe connection is done.

Fusion machines – Overview

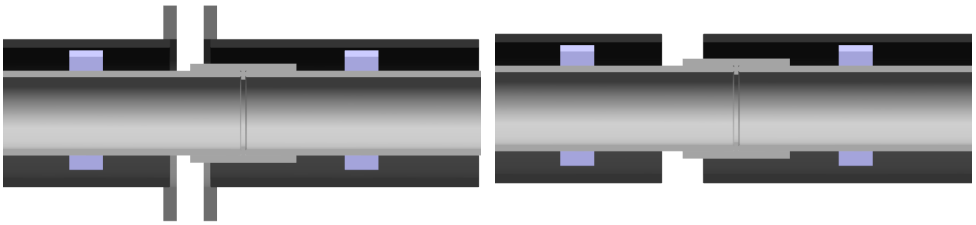
Dimension		SG 160	
			
Inner pipe	Containment pipe	Fitting – Fitting	Fitting – Pipe
d20	D50	✓ (*)	✓
d25	D50	✓ (*)	✓
d32	D63	✓ (*)	✓
d40	D75	✓ (*)	✓
d50	D90	✓ (*)	✓
d63	D110	✓ (*)	✓
d75	D125	✓ (*)	✓
d90	D140	✓ (*)	✓
d110	D160	✓ (*)	✓ (*)
d125	D180		
d140	D200		
d160	D225		
d200	D280		
d225	D315		
*Notes:		Adjusting the machine stop (pipe dependent)!	Unscrew the sheet metal of the prism!

Socket fusion – Procedure



1. **Clamping:**
   Clamping collars shell inner pipe and/or socket

2. **Standard Heating element socket fusion:**
   Inner pipe and socket are heated up simultaneously

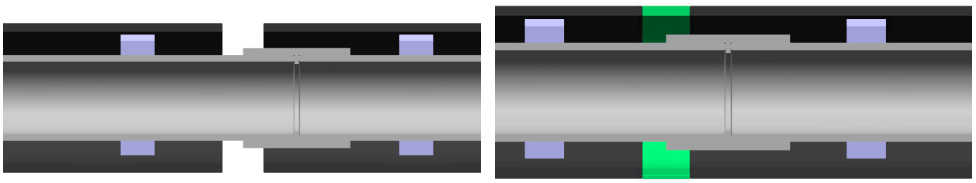


3. **Fusion:**
   Inner pipe and socket are overlapped together

4. **Cooling time and unclamping:**
   Waiting for cooling time, unclamping, control gap remains in outer tube (30mm)

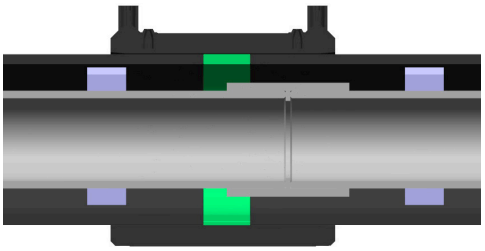
Next steps

For a detailed description, see chapters "Pressure test and visual inspection of the inner pipe", "Sealing the containment pipe" and "Instructions for internal and external pressure test"



5. **Visual inspection of inner pipe connection:**
   Visual inspection and evaluation of the inner pipe connection, followed by a pressure test

6. **Snap ring in control gap:**
   Place a snap ring (30 mm) between the ends of the containment pipe



7. **Sealing containment pipe and pressure test:**
   ELGEF Plus electrofusion coupler creates a pressure-resistant seal on the containment pipe or the EPDM coupler provides splash protection, followed by a pressure test of the containment pipe

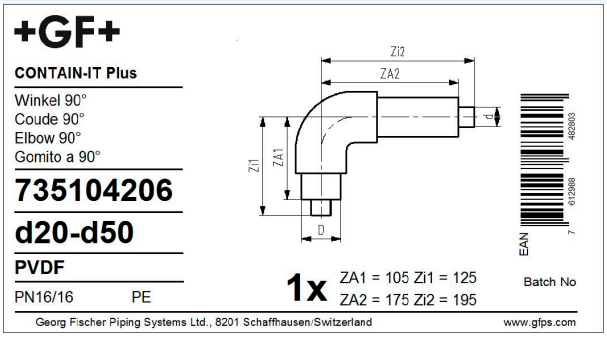
1.4.13 Inner pipe – conventional butt welding

Detailed information on the connection technology for the inner pipe is provided in the Planning Fundamentals and/or the cementing instructions issued by the DVS and are valid without any limitation.

Fitting design

From the central axis to the leading edge/spigot end, all fitting types have the same Z-dimensions (i.e. same axis mass). This only applies to fittings made of the same material and using the same joining method!
The Z-dimensions are noted on the bag label, see illustration.

Fitting - PVDF (Butt Fusion)



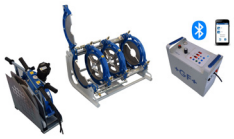
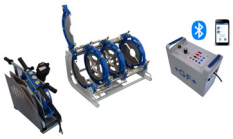


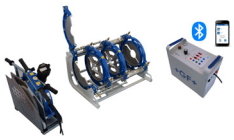
ELGEF Plus sockets and EPDM couplers must be ordered separately.

Final inspection before welding

ELGEF Plus couplers or EPDM couplers must be pushed onto the containment pipe ends or the long fitting sides before the inner pipe connection is done.

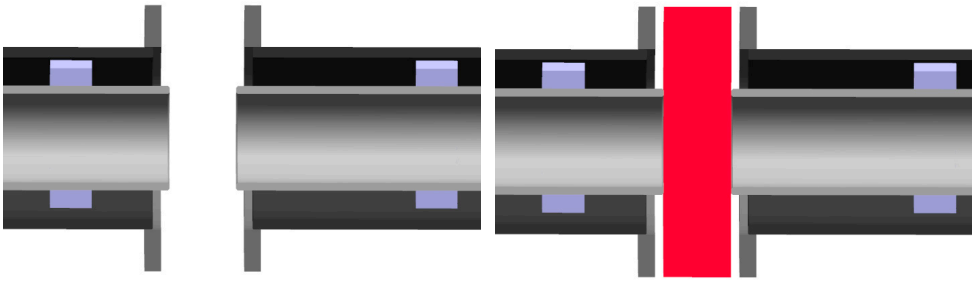
Welding machines – Overview

Dimension		SG 160		TM 160		TM 250		TM 315 RU 315	
									
Inner pipe	Containment pipe	Fitting – Fitting	Fitting – Pipe	Fitting – Fitting	Fitting – Pipe	Fitting – Fitting	Fitting – Pipe	Fitting – Fitting	Fitting – Pipe
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								
*Notes:			Rake from machine	Finger protection!	Rake off machine!	Finger protection	Rake off machine!	Finger protection!	

Dimension		GF 400		IM 160		IM 315		MC 110	
									
Inner pipe	Containment pipe	Fitting – Fitting	Fitting – Pipe	Fitting – Fitting	Fitting – Pipe	Fitting – Fitting	Fitting – Pipe	Fitting – Fitting	Fitting – Pipe
d20	D50		Tested Q2/22					✓ (*)	✓ (*)
d25	D50		Tested Q2/22					✓ (*)	✓ (*)
d32	D63		Tested Q2/22	✓	✓			✓	✓
d40	D75		Tested Q2/22	✓	✓			✓	✓
d50	D90		Tested Q2/22	✓	✓			✓	✓
d63	D110		Tested Q2/22	✓	✓				✓
d75	D125		Tested Q2/22	✓	✓				
d90	D140		Tested Q2/22	✓	✓	✓	✓		
d110	D160		Tested Q2/22	✓	✓	✓	✓		
d125	D180		Tested Q2/22			✓	✓		
d140	D200		Tested Q2/22			✓	✓		
d160	D225		Tested Q2/22			✓	✓		
d200	D280		Tested Q2/22			✓	✓		
d225	D315		Tested Q2/22			✓	✓		
*Notes:		Finger protection!						IR Plus preferred due to weld bead size	

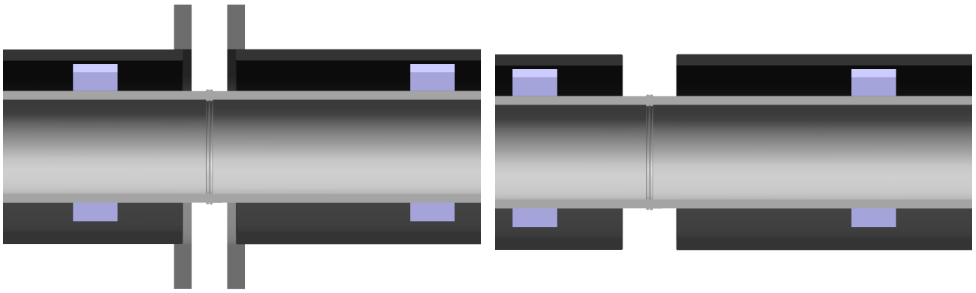
Dimension		MD 160	
			
Inner pipe	Containment pipe	Fitting – Fitting	Fitting – Pipe
d20	D50		
d25	D50		
d32	D63		
d40	D75		
d50	D90	✓	✓
d63	D110	✓	✓
d75	D125	✓	✓
d90	D140	✓	✓
d110	D160	✓	✓
d125	D180		
d140	D200		
d160	D225		
d200	D280		
d225	D315		
*Notes:			

Conventional butt weld – procedure



1. **Clamping:**
   Clamping collars hold inner pipe and/or internal fitting

2. **Heating element butt welding:**
   Inner pipe and fitting are heated up at the same time

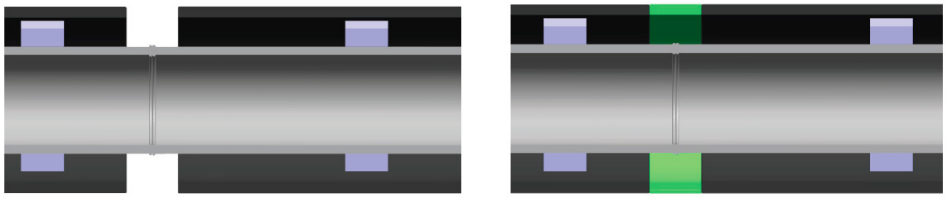


3. **Joining:**
   Inner pipe and fitting are welded together

4. **Cooling down time and unclamping:**
   Wait for the cooling down time to end before unclamping, safety gap remains in containment pipe (30 mm)

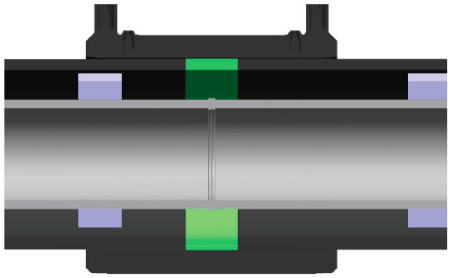
Next steps

For a detailed description, see chapters "Pressure test and visual inspection of the inner pipe", "Sealing the containment pipe" and "Instructions for internal and external pressure test"



5. **Visual inspection of inner pipe connection:**
   Visual inspection and assessment of the inner pipe connection, followed by a pressure test

6. **Snap ring in safety gap:**
   Place a snap ring (30 mm) between the ends of the containment pipe



7. **Sealing containment pipe and pressure test:**
   ELGEF Plus electrofusion coupler creates a pressure-resistant seal on the containment pipe or the EPDM coupler provides splash protection, followed by a pressure test of the containment pipe

1.4.14 Inner pipe – infrared butt fusion

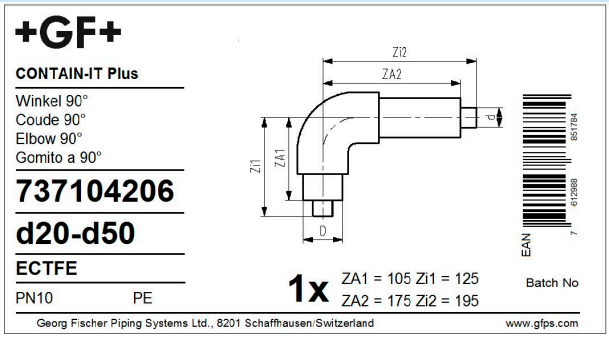
Detailed information on the connection technology for the inner pipe is provided in the Planning Fundamentals and/or the cementing instructions issued by the DVS and are valid without any limitation.

Fitting design

From the center axis to the front edge/spigot end, all fitting types have the same Z-dimensions (i.e. same dimension between axes). This applies only to fittings made from the same material using the same jointing method.

The Z-dimensions are noted on the bag label (see figure).

Fitting - ECTFE (IR-Fusion)





ELGEF Plus sockets and EPDM couplers must be ordered separately.

Final inspection before welding

Before the inner pipe connection is made, ELGEF Plus couplers or EPDM couplers must be pushed onto the containment pipe ends or onto the long fitting sides.

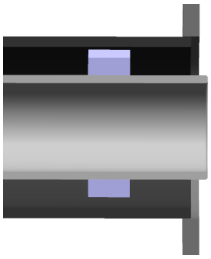
Fusion machines - overview

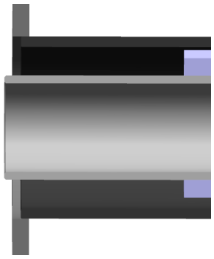
Dimension		IR-63 M		IR-63 Plus*			IR-110 Plus			IR-225 M		IR-225 Plus*		
														
Inner pipe	Containment pipe	Fitting – fitting	Fitting – pipe	Fitting – fitting	Fitting – pipe	Special half shell	Fitting – fitting	Fitting – pipe	Special half shell	Fitting – fitting	Fitting – pipe	Fitting – fitting	Fitting – pipe	Special half shell
d20	D50	✓	✓	✓	✓	790 131 090	✓	✓	790 132 190					
d25	D50	✓	✓	✓	✓	790 131 091	✓	✓	790 132 191					
d32	D63			✓	✓	790 131 092	✓	✓	790 132 192					
d40	D75			✓	✓	790 131 093	✓	✓	790 132 193					
d50	D90						✓	✓	790 132 194					
d63	D110									✓	✓	✓	✓	790 133 090
d75	D125									✓	✓	✓	✓	790 133 091
d90	D140									✓	✓	✓	✓	790 133 092
d110	D160									✓	✓	✓	✓	790 133 093
d125	D180									✓	✓	✓	✓	790 133 094
d140	D200													
d160	D225													
d200	D280													
d225	D315													

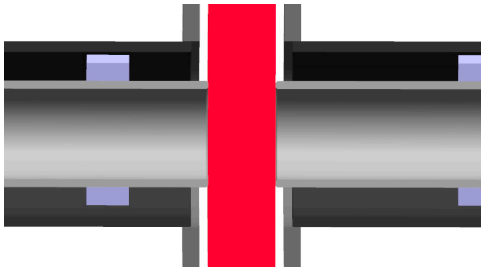
*Rental Pool only

Automated infrared fusion machines cannot be used for the CONTAIN-IT Plus system.

Infrared butt weld – procedure

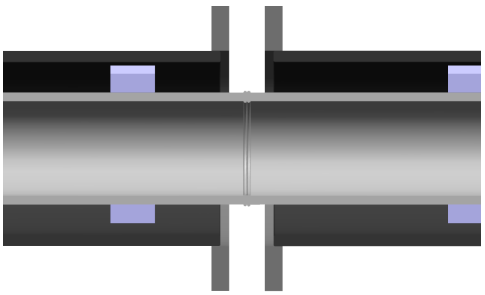


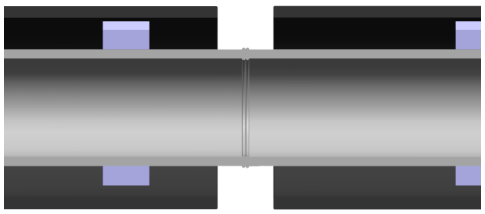




1. **Clamping:**
   Clamping collars hold inner pipe and/or internal fitting

2. **Heating element butt welding:**
   Pipe and fitting are heated up at the same time



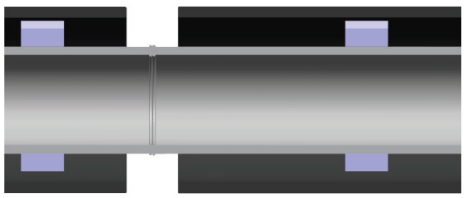


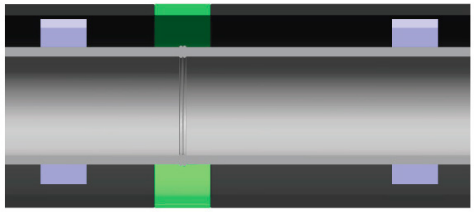
3. **Joining:**
   Inner pipe and fitting are welded together

4. **Cooling down time and unclamping:**
   Wait for the cooling down time to end before unclamping, safety gap remains in containment pipe [30 mm]

Next steps

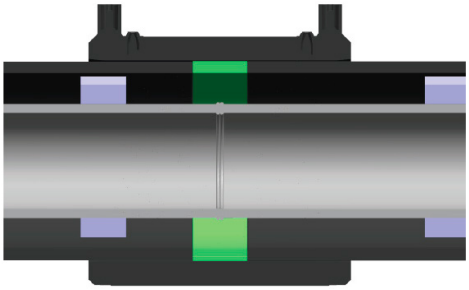
For a detailed description, see chapters "Pressure test and visual inspection of the inner pipe", "Sealing the containment pipe" and "Instructions for internal and external pressure test"





5. **Visual inspection of inner pipe connection:**
   Visual inspection and assessment of the inner pipe connection, followed by a pressure test

6. **Snap ring in safety gap:**
   Place a snap ring [30 mm] between the ends of the containment pipe

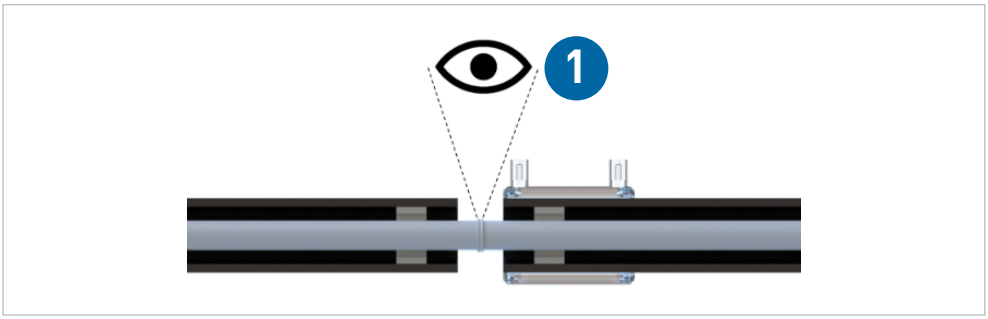


7. **Sealing containment pipe and pressure test:**
   ELGEF Plus electrofusion coupler creates a pressure-resistant seal on the containment pipe or the EPDM coupler provides splash protection, followed by a pressure test of the containment pipe

1.4.15 Visual inspection of the inner pipe and pressure test

Visual inspection of the inner pipe

Thanks to the innovative connection technology, a gap of 30 mm appears in the containment pipe and this allows a visual inspection and assessment of the inner pipe connection in accordance with DVS 2210-2 among others. As a result of this technology, there are no blind connections anywhere in the piping system.



1 Visual inspection and pressure test of the inner pipe!

Pressure test

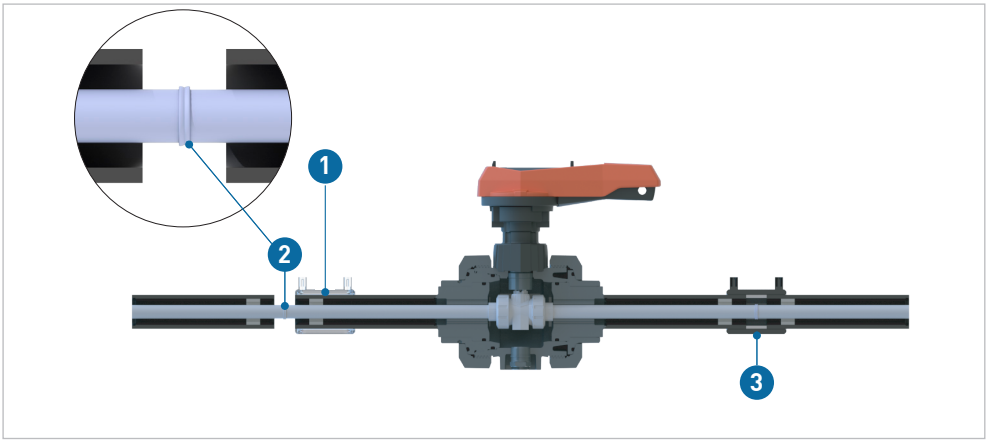
The pressure test of the inner pipe requires the pipe or pipe sections to be operational. A section-by-section pressure test is the suitable method, depending on the accessibility and length of the pipe (in-situ welding, etc.). The test pressure load ought to furnish experimental proof of operational safety. The precise procedure for the internal pressure test is described in the chapter "Pressure test of inner pipe".

1.4.16 Sealing the containment pipe

After a successful visual inspection of the inner pipe connection and a successful pressure test of the inner pipe, the containment pipe is sealed.

Various procedures are followed, depending on the containment pipe material:

- Variant 1 with PE100 System: ELGEF Plus electrofusion couplers
- Variant 2 with PVC-U (transparent) system: EPDM couplers and cementing



1 ELGEF electrofusion coupler; alternative: EPDM coupler
2 Visual inspection of inner pipe connection and pressure test of inner pipe
3 Centering of the snap ring in the ELGEF electrofusion coupler (gray) and closing of the containment pipe

Variant 1 – containment pipe material PE100

The connections in the containment pipe system are made by means of pressure-resistant and tight ELGEF Plus electrofusion couplers. The instructions for the electrofusion of sockets must be followed (clean welding zone, etc.). Holding devices are to be used wherever possible to ensure a stress-relieved welding process.



Calculating the insertion depth:

The 30 mm long gap in the containment pipe must be sealed by a PE snap ring prior to welding. This gap of 30 mm should be included in the calculation of the insertion depth and reduces the insertion depth by 15 mm on each side, see calculation.



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

Length: ELGEF Plus electrofusion couplers

d (mm)	SDR	L (mm)	Insertion depth ½L – 15 (mm)	SDR pipe
50	11	88	29.0	9.0 - 11.0
63	11	96	33.0	9.0 - 17.6
75	11	110	40.0	9.0 - 17.6
90	11	125	47.5	9.0 - 17.6
110	11	145	57.5	9.0 - 17.6
125	11	156	63.0	9.0 - 17.6
140	11	166	68.0	9.0 - 17.6
160	17	180	75.0	9.0 - 26.0
180	17	192	81.0	9.0 - 26.0
200	17	206	88.0	9.0 - 26.0
225	17	225	97.5	9.0 - 26.0
280	17	252	111.0	9.0 - 26.0
315	17	267	118.5	9.0 - 26.0

Marking

The calculated insertion depth has to be marked on both sides (pipe-pipe, pipe-fitting, etc.) two markings per connection.

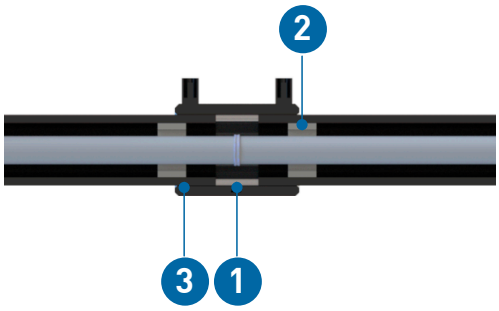
Snap ring

Next, the snap ring has to be pushed over the 30 mm wide safety gap. The containment pipe ends must be in contact with the snap ring without any gap. Generally, distances of <2mm (up to d110) per side from snap ring to pipe ends are within tolerance. This calls for a highly precise measurement and the containment pipe to be cut at right angles.



Welding process

The PE stretch foil has to be removed from the ELGEF Plus socket immediately before the containment pipe is sealed. The ELGEF Plus socket must then be pulled over the safety gap/snap ring and closed flush with the markings on both sides. If the electrofusion coupler is pulled over without a snap ring, the containment pipe can move and a reliable sealing is then no longer guaranteed. The snap ring must be located in the middle of the ELGEF Plus socket (cold zone).

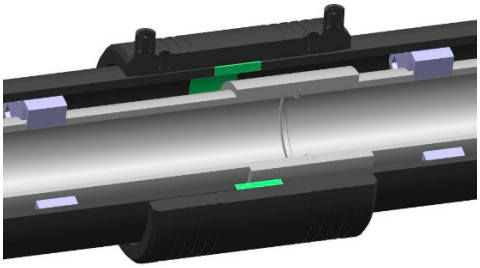


1 Snap ring
2 Spacer
3 ELGEF electrofusion coupler; alternative: EPDM coupler

Welding machine and connection

Next, stress-relieved welding must be carried out using a MSA welding tool and a holding device.

Snap ring 30 mm	MSA welding tool for ELGEF Plus socket with GPS function

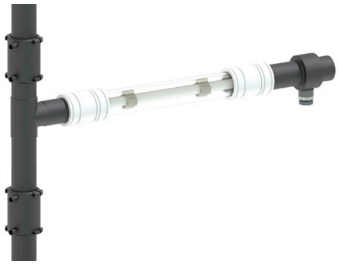




Variant 2 - containment pipe material PVC-U (transparent)

The pipes to fitting connections in the containment pipe systems are made using non-tensile-tight and splash protection EPDM couplers (PN1). The straight pipe connections (pipe-pipe) are made as a cemented connection (Tangit).

EPDM coupler





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 fitting (PE).

Cemented connection: pipe to pipe

Since the EPDM coupler does not offer tensile strength itself, Georg Fischer Piping Systems recommends cemented connections (PVC-U cementing sockets) for straight pipe runs. Information on the cementing process is provided in the chapter PVC-U (transparent) in the "Georg Fischer Planning Fundamentals" and is valid without any limitation.

Calculating the insertion depth: EPDM coupler

The 30 mm wide gap between PVC-U pipe and PE fitting needs to be sealed using a PE snap ring. The gap of 30mm must be taken into account when calculating the insertion depth and reduces the insertion depth by 15mm per side (see calculation).

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

Length: EPDM couplers

d (mm)	EPDM coupler L (mm)	Insertion depth ½L – 15 (mm)
50	90	30
63	90	30
75	110	40
90	100	35
110	120	45
125	120	45
140	120	45
160	120	45

Calculating the insertion depth: cementing sleeve

$$t = \frac{d}{2} + 6\ \text{mm}$$

t = insertion depth for pipes (mm)

d = pipe external diameter (mm)

Marking

The calculated insertion depth is marked on the pipe ends, as well as on the fitting supports. Therefore, each connection has two markings.

Snap ring

The snap ring must be located in the middle of the EPDM coupler. The containment pipe ends must be in contact with the snap ring without any gap. Snap rings must not be used for cementing sockets.

Connection

Clean the right angle cut containment pipe with a clean cloth and slide the sleeve over the safety gap/snap ring. The snap ring must be centered in the rubber sleeve. Tighten the rubber sleeve according to the torque on the label.

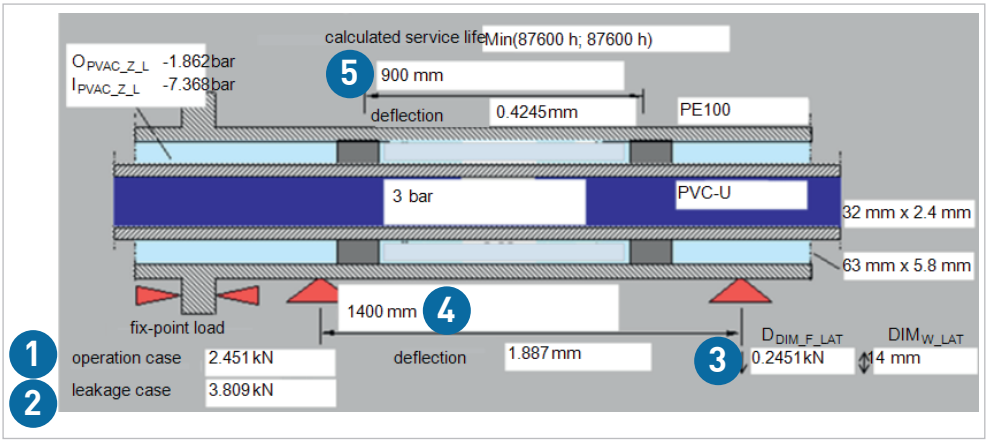




1 Snap ring: 30 mm
2 Inner pipe connection
3 PVC-U (transparent) pipe
4 CONTAIN-IT Plus components (PE containment pipe)

1.4.17 Fixed point installation

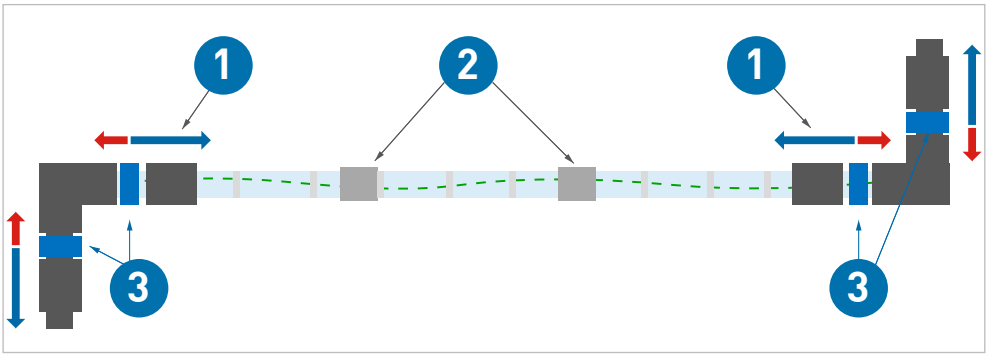
A central component of a safe installation is the result of the "Questionnaire for Static Proof and Stress Calculation". Based on this information, the steel structure (pipe clamps, guide bearing distances, etc.) must be designed.



1 Axial load at fixed point during operation [kN]
2 Axial load at fixed point in case of a leakage [kN]
3 Lateral load at support clamps [kN]
4 Suport clamp distances [mm]
5 Spacer distances [mm]

Installation technology data

Due to a variety of process conditions, double containment systems must be installed as a fixed point installation. To prevent thermal expansion/contraction, the containment pipe must be fixed to the steel structure at every change of direction.



1 Connection with EPDM coupler
2 Connection with cementing sockets
3 Fixed point to steel structure

Thanks to this connection technology, no additional expansion loops or compensators are required.

Installation example of a fixed point installation:



1.4.18 Leakage detection and containment

For the operation of a double containment system, devices for the control, indication or permanent monitoring of a leakage must be provided.

When dividing the interstitial space into monitoring sections by means of end fittings, it must be ensured that each section is equipped with a monitoring device.

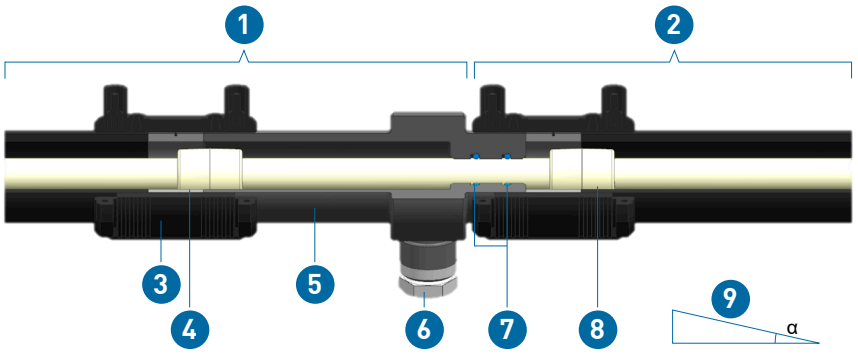
Leakage containment: Segmentation into monitoring sections

When dividing a large interstitial space into leakage monitoring sections using end fittings, the leaking medium can only spread in the pipe section or interstitial space between the installed end fittings (EPDM seals).

For more information on planning, see chapter "Determining leakage detection".

Advantages

- Fast and reliable leakage detection
- Only the identified section of the containment pipe has to be purged and cleaned
- Length of the leakage detection sections is freely selectable

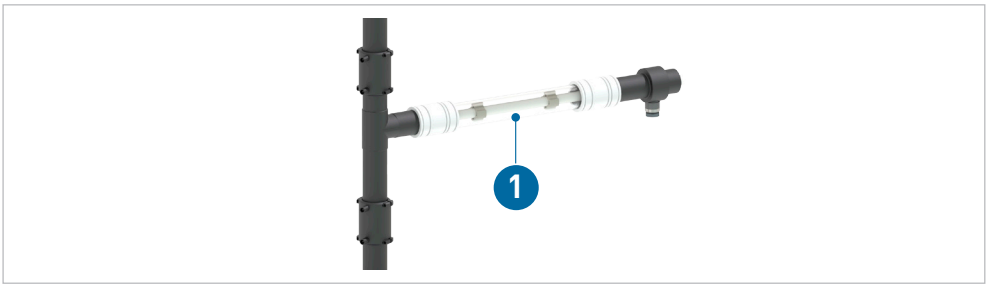


1 Section 1 - Monitoring section
2 Section 2 - Monitoring section
3 Electrofusion coupler
4 Snap ring
5 PE support of end fitting
6 Connection for leackage detection
7 EPDM seals (2x)
8 Inner pipe with socket connection
9 Gradient to be considered

Attention! If end fittings are used to connect a low point leakage detection solution, the installation direction of the end fittings should be taken into account since there is only one connection per end fitting in an monitoring room (section). In addition, the pipe should be installed on a gradient (min. 2-3°) so that creeping leakages can be detected as quickly as possible at the lowest point of the monitoring section. Further information can be found in the chapter "Defining the leakage detection solution".

Leakage detection solutions

1. Visual solution: transparent containment pipe



1 PVC-U: Transparent containment pipe

The PVC-U Transparent Splash Protection System (PN1) is an ideal solution for quick leakage localization. Due to the transparent containment pipe system, leaks on straight pipe sections can be quickly detected and repaired.

Routine checks needs to be determined by the operator according to the risk assessment and are mandatory for safe operation!

2. Inspection glass: transparent monitoring pipe

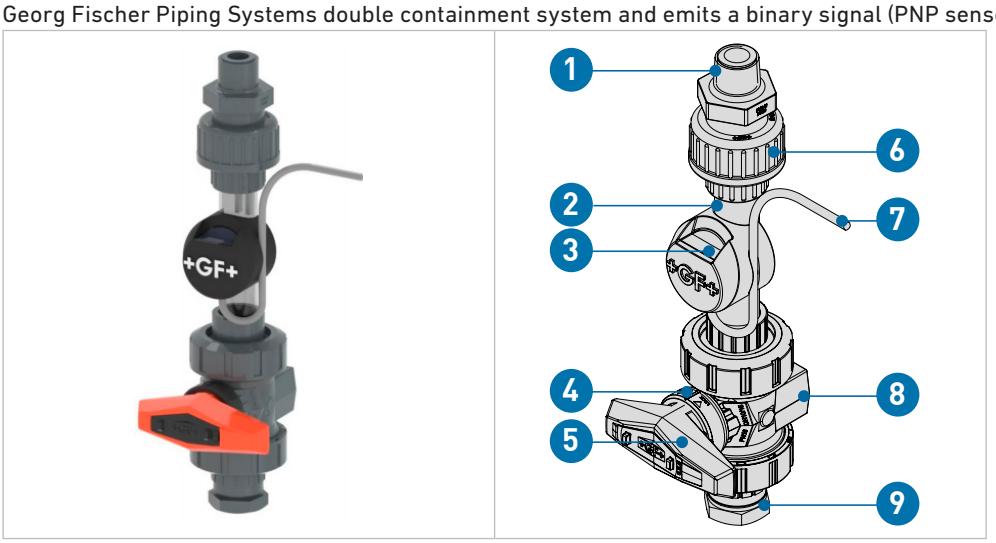


For optical leakage monitoring by means of a inspection glass, a 546 Pro ball valve (d20) with a transparent monitoring tube made of PVC-U is attached to the Rp ½" connection of the end fitting or to the connection clamp. Alternatively, the standard fittings also offer a connection option.

To ensure that even a small amount of the escaping medium covers the measuring point in the event of a leak, the inspection glass must be mounted at the lowest point of the interstitial space. Routine checks needs to be determined by the operator according to the risk assessment and are mandatory for safe operation!

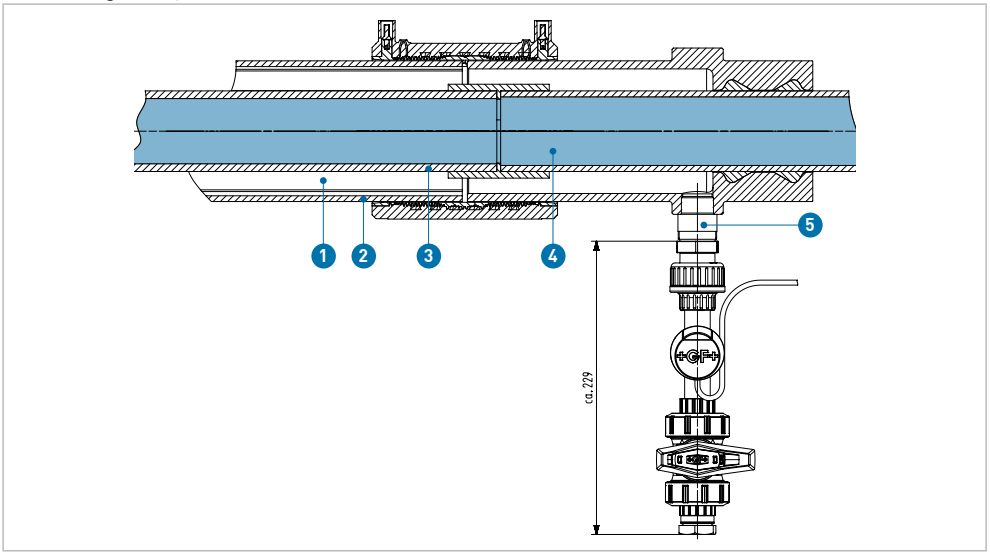
3. Electrical solutions: capacitive sensor

The double containment leakage detection sensor detects escaping fluids (dielectric constant εr > 4.0) in the monitoring room of Georg Fischer Piping Systems double containment system and emits a binary signal (PNP sensor).



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 in the event of a leakage even a small amount of the escaping medium covers the measuring point, which thus leads to a change in the dielectric permettivity, the double containment detection sensor must be mounted at the lowest point of the interstitial space. Access to the interstitial space can be realized by means of the Rp ½" connections of the end fittings or a connecting clamp.



1 Monitoring chamber
2 Outside pipe
3 Internal pipe
4 Medium in internal pipe
5 Leak connection to double containment system R ½"

Detailed information can be found in the operating instructions of the Type 2286 Leakage Sensor.

4. Leakage detection cable

Alternatively, a cable can be installed in the space between the inner and containment pipe, which reacts either to conductive liquids or to chemicals, and triggers an alarm. The installation of a leak detection cable requires special attention and represents an additional effort in production, planning and installation. The installation of a leak detection cable in Georg Fischer Piping Systems standard double containment fittings is not possible and requires a detailed consultation with the local Georg Fischer Piping Systems branch. Custom solutions may be possible on request.

Advantages	Disadvantages
• Leaking point is indicated with an accuracy of 1 m • Automatic alarm triggering	• Containment pipe is not monitored • Relatively expensive • Retrofits not possible • Containment pipe may need to have a larger external diameter, depending on the system • Susceptible to condensate

5. Differential pressure monitoring

	Overpressure monitoring	Vacuum monitoring (underpressure monitoring)
General	In differential pressure monitoring with overpressure, the interstitial space between the inner and containment pipe is pressurized with nitrogen. In the event of a pressure drop in the interstitial space, the associated alarm switchgear indicates the leakage.	In differential pressure monitoring with vacuum, a vacuum in the range of 600 to 700 mbar is generated in the space between the inner and containment pipe with the aid of a pump. In the event of a possible leak, the vacuum pump is switched on via a vacuum switch (PU). At the same time, the alarm is triggered visually by an indicator light and acoustically by a buzzer.
Advantages	• Inner and containment pipe are monitored for leak-tightness • Retrofit installation is possible • TÜV test certificate • Automatic alarm	• No pressure loading on the inner pipe • Inner and containment pipe are monitored for leak-tightness • Retrofit installation is possible • TÜV test certificate • Automatic alarm
Disadvantages	The injected nitrogen must have a higher pressure than the medium-carrying inner pipe, thus the inner pipe must be checked for collapse, taking into account 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 • If the volume of the space between the inner and outer pipe is large, the vacuum pump must be dimensioned accordingly or divided into leakage sections, each with a vacuum pump (division with end fitting, refer to chapter "End fittings - Tools for leakage localization").
Leak locating	• Containment pipe direct • Inner pipe through exploratory borehole in the containment pipe	• Containment pipe direct • Inner pipe through exploratory borehole in the containment 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

1.5 Pressure testing the inner and containment pipe

1.5.1 Pressure test of the inner pipe

General

The internal pressure test forms the conclusion of the installation work and requires a ready-to-operate pipeline or ready-to-operate test sections. The stress caused by the test pressure is intended to provide experimental proof of operational safety. The test pressure is not based on the operating pressure, but on the internal pressure load capacity, starting from the pipe wall thickness.

The following information is based on supplement 2 to DVS 2210-1. This completely replaces the information in DVS 2210-1. The reasons for these adaptations are listed below:

- The reference value "nominal pressure (PN)" for determining the test pressure (1.5 x PN or 1.3 x PN) is increasingly being dropped and replaced by SDR.
- Possible short-term overstressing up to shortening of the service life if the pipe wall temperature TR = 20 °C is exceeded by more than 5 °C during the nominal pressure-dependent internal pressure test.

Therefore, the test pressures are determined depending on the SDR and the pipe wall temperature. The value of 100 hours from the creep diagram is taken as the test stress.

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 or the permissible test pressure of the installed components, see section "Determination of 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 purpose of the pre-test is to prepare the piping system for the actual test (main test). During the pre-test, a stress-strain equilibrium is established in the piping system in conjunction with an increase in volume. This results in a material-dependent pressure drop, which necessitates repeated re-pumping to restore the test pressure and often retightening 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
PP	0.8
PE	1.2
PVDF	0.8
ECTFE	0.9

Main test

During the main inspection, a much lower pressure drop can be expected if the pipe wall temperatures remain approximately constant, so that there is no need for re-pumping. The checks can concentrate on the tightness of the flange connections and possible changes in the position of the pipeline.

If a valve is located at the end of a pipeline (end or shut-off valve), the valve, and thus the end of the pipeline, must be closed off by means of a blind flange or cap. This prevents medium from escaping or the inside of the valve from being contaminated by unintentional actuation 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?
- Waiting time after last fusion/cementing observed?

Now the piping system can be filled from the geodetic lowest point. Special attention must be paid to the venting. For this purpose, vents must be provided at all high points of the pipeline, if possible, and must be open when filling the system. The flushing speed must be at least 1 m/s.

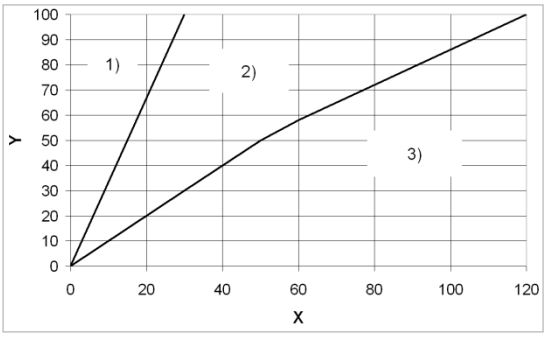
Reference values for the filling volume are given in the following table:

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

Between filling and testing the pipeline, allow sufficient time for the air in the pipeline system to escape via the vents: approx. 6 to 12 hours, depending on the pipe diameter.

1.5.2 Applying the test pressure

The test pressure is applied according to the diagram. Make sure that the pressure increase rate does not cause any impact stop!



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

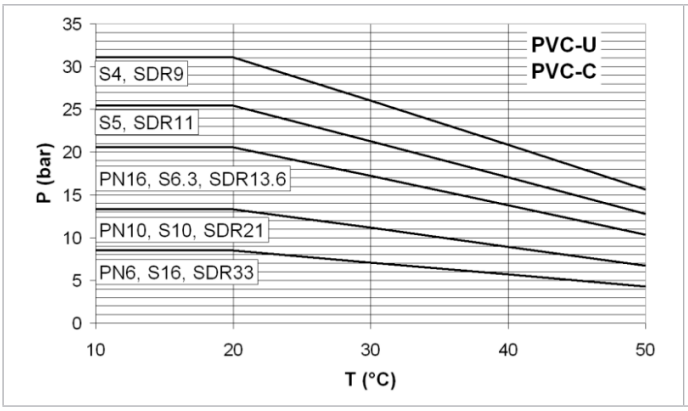
The permissible test pressure is calculated according to the following formula:

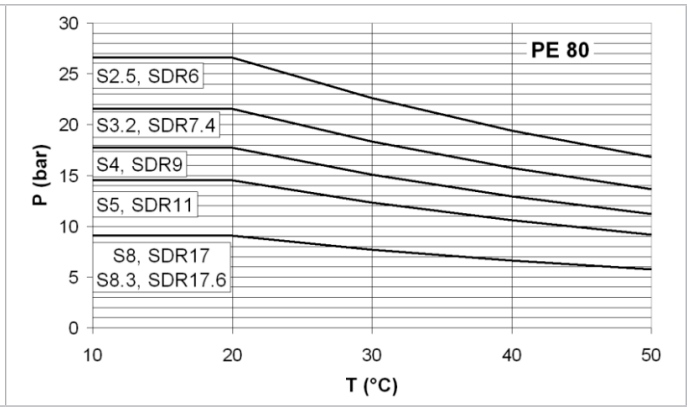
$$P_{p(zul)} = \frac{1}{SDR} \cdot \frac{20 \cdot \sigma_{v(T,\,100\,h)}}{S_p \cdot A_G}$$

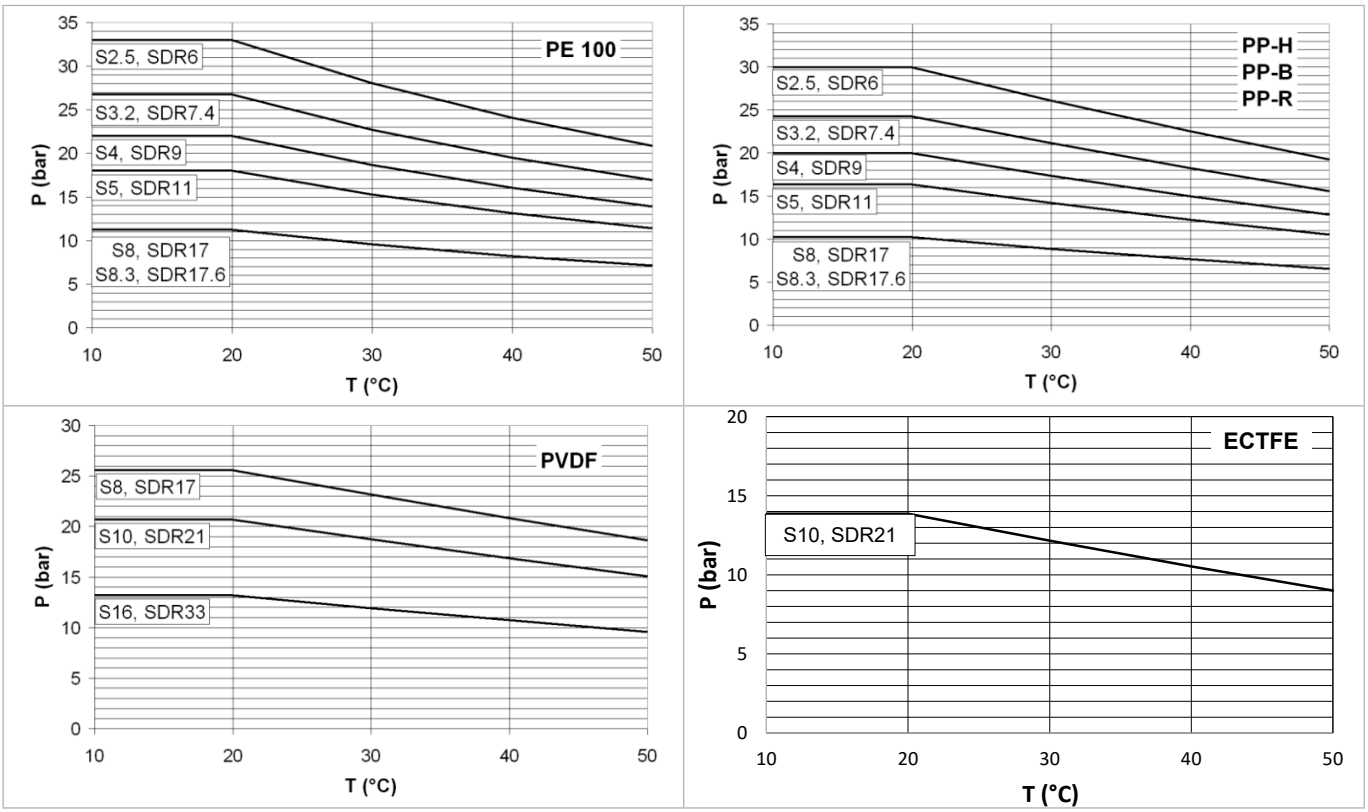
$\sigma_{v\,(T,100\,h)}$ Long-term creep strength for pipe wall temperature TP (at t = 100 h)
S_p Minimum safety factor for long-term creep strength
A_G Processing or geometry-specific factor that reduces the permissible test pressure (if the AG factor is less than zero, you need to use the reciprocal (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 permissible 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 an internal pressure test with water is not possible (e.g. keeping pipelines dry), a leak test can be carried out with slight overpressure. For safety reasons, the test pressure must then be limited to a maximum of 0.5 bar (gauge pressure).

During the leak test, all connection points must be sprayed with a foam-forming agent and checked. Since the efficiency of the leak test is significantly limited due to the slight load, it should preferably be used for systems with operating pressures of less than 0.5 bar.

1.5.3 Pressure test of the containment pipe

General

The test of the containment pipe is carried out with the inner pipe completely filled and under internal pressure (internal pressure of the inner pipe should be at least equal to or greater than the internal pressure of the containment pipe), in order to avoid loading of the inner pipe by external overpressure. Suitable filling and venting facilities must be provided on the containment pipe for carrying out the pressure test.

After the installation of the double containment piping 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 test of the space between the pipe is carried out at room temperature (20 °C).

⚠ Thin-walled inner pipes in particular can collapse due to the overpressure in the annular space. The maximum permissible test or overpressure in the annular space depends on the load capacity of the medium-carrying inner pipe, whereby it must be ensured that the internal pipe pressure load (PN stage) does not correspond to the external pipe pressure load.

Water is the preferred test medium. However, complete draining 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, various materials tend to splinter when subjected to mechanical action and internal pressure from compressed media.
- Appropriate safety precautions must be taken against the effects of a splintering break in the containment pipe, especially in the case of 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 containment pipe, pressure-resistant welded with ELGEF Plus coupler		PVC-U containment 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 test pressure until all connection parts, valves, flanges, etc. have been tested for leaks using a foaming agent. It is best to use soap solution, which can be easily removed with water.

⚠ Commercially available leak detection sprays can trigger stress cracks in plastics. If these sprays are used, residue-free removal is required after testing.

No overloading of the components

The adjustment of the test pressure at the corresponding components must be taken into account. In the case of installed valves, for example, the protective line in the flameproof system may only be pressurized to less than or equal to 6 bar.

Test medium for double containment valves	PE100 containment pipe, pressure-resistant welded with ELGEF Plus coupler		Containment pipe PVC-U splash guard with EPDM rubber sleeve (not tension-proof)	
	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

1.6 Operating and maintenance instructions

General information

In case of maintenance (sealing of ball valve, diaphragm valve, mechanical separation, etc.), leakage, or system expansion, please contact your local safety representative before opening the containment and inner pipes. Operators must maintain an operating manual with a monitoring plan, maintenance plan, emergency plan and specified immediate measures in the event of a leak.

Operation

- If the system consists of several double containment piping systems or several leakage monitoring sections, all these interstitial spaces must be equipped with leakage detection devices (manual/automatic). Leakages must be detected within 72 hours and defined countermeasures must be initiated to ensure the safe condition of the system.
- Routine checks are mandatory when using a visual leak detection solution for rapid leak detection and for initiating the defined countermeasures. When using electrical monitoring systems, regular functional checks are mandatory. These routine checks and functional tests are to be defined by the operator in accordance with a risk assessment and taking into account the existing local legislation and the operating instructions.
- Double containment piping systems must be protected against uncontrolled thermal and mechanical influences.
- In the event of a leakage, the double containment piping system becomes a single pipe. The safety measures according to section Repair must be observed.

Maintenance

- To carry out maintenance work, it is mandatory to contact the safety officer in advance.
- Before performing maintenance, appropriate precautions such as checking the leakage warning system, complete draining of the inner and containment pipe, etc. must be taken into account.

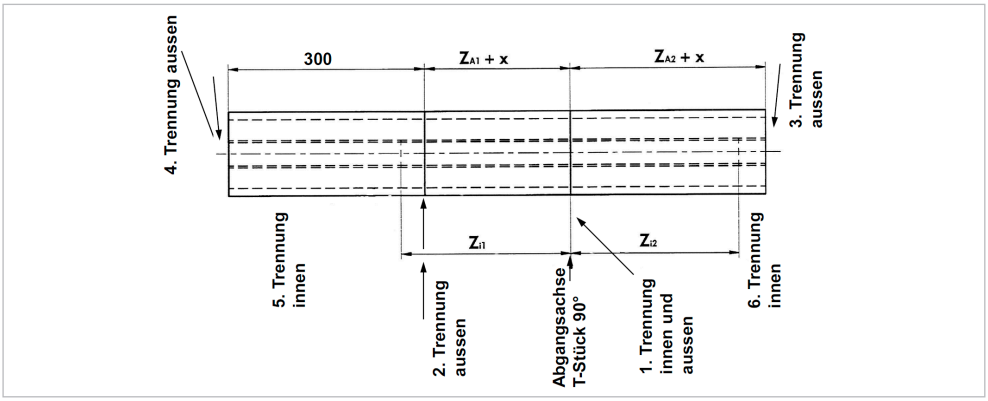
Repair – Case of a Leakage:

- The safety officer must be contacted in advance before carrying out any repair work!
- If a leakage occurs, the procedure defined in advance by the operator of the double containment system must be followed.
- Before starting any repair work, comply with the precautionary measures such as complete draining, flushing of the inner and outer pipe, prevention of dripping, protective clothing, etc... If a leak cannot be located precisely, it is helpful to proceed in sections.
- Leakage detection may only be carried out with water to protect employees, the environment and equipment.
- In order to roughly locate/limit the leakage, test holes can be carefully drilled on the underside of the containment pipe using the mechanically fixed tapping clamp with half outlet. When drilling out containment pipe, make sure that the medium-carrying inner pipe is not damaged. The clamp is later closed again with a PVC plug.
- Georg Fischer Piping Systems recommends dividing the pipeline into leakage detection sections by means of end fittings already during new construction.
- The pipeline must be replaced in compliance with the Georg Fischer Piping Systems installation instructions.

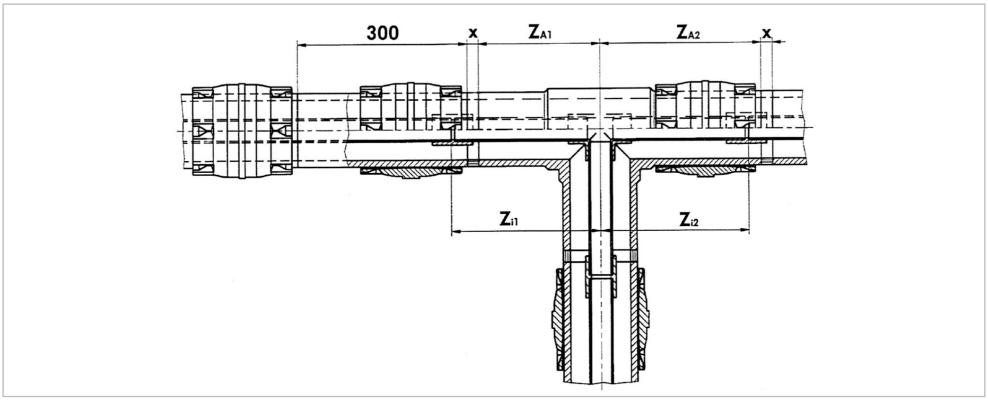
Extension of the existing piping system and subsequent installation of a T-piece

- The safety officer must be contacted in advance if extensions are to be carried out.
- Before any extension begins, appropriate precautions must be taken, such as complete draining, flushing of the inner and containment pipe, prevention of dripping, protective clothing, etc.
- The pipeline must be extended in accordance with the Georg Fischer Piping Systems installation instructions.

Explanation:



x = 30 mm



Pressure test - recommissioning

- A pressure test of the inner and containment pipe is mandatory as soon as a new connection has been made. See chapter "Pressure test for inner and containment pipe".

Safety and fire prevention measures

- Georg Fischer 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

- If the pipe is laid in the ground, it must be ensured that the regulations regarding the creation of the trench, embedding of the double containment pipe and filling of the trench, as well as the relevant guidelines of professional associations and state authorities, are observed.

1.7 Double containment – CONTAIN-IT Plus - Valves and mechanical connections

1.7.1 CONTAIN-IT Plus - Valves and mechanical connections

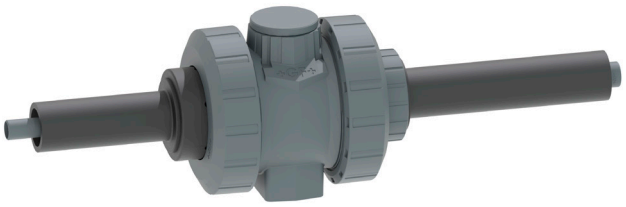
The CONTAIN-IT Plus mechanical connections are delivered as ready-to-install system units with a PVC-U PN6 protective housing.

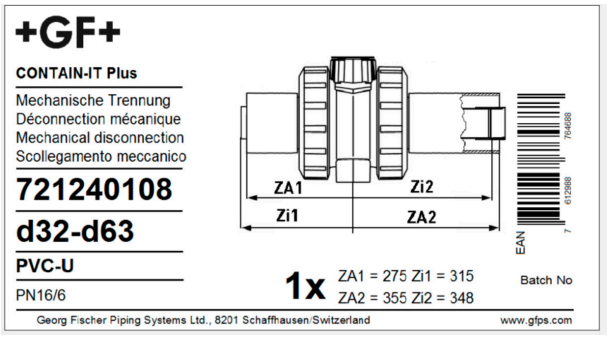
Application

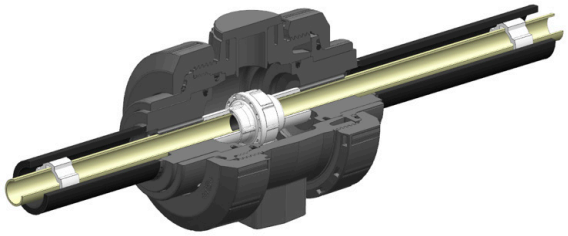
The mechanical separation finds its application primarily in hard-to-reach areas, where the use of welding machines is difficult. In addition, mechanical separation is often used for subsequent removal or repair.

Connection technology

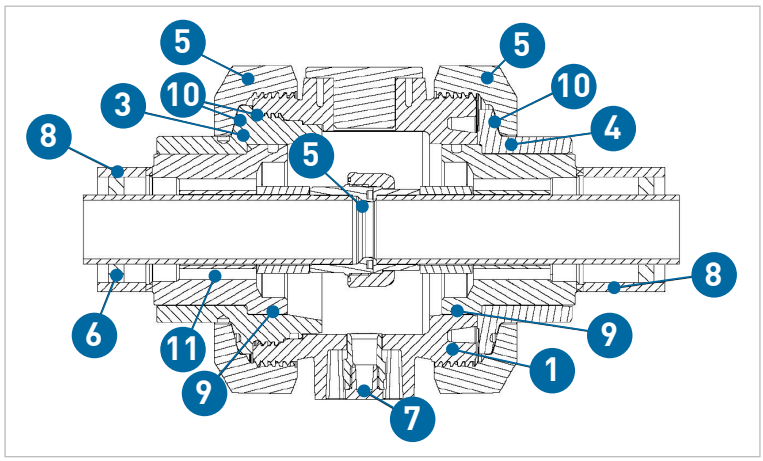
The connection technology used is analogous to the one used for double containment fittings. The double containment connection technology from Georg Fischer Piping Systems is based on the principle that the inner pipe is connected first according to the relevant connection technology. For details, see chapter "CONTAIN-IT Plus - principles of connection technology".







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

Connection technologies inner pipe

Dimension (mm)	Socket cementing		Socket fusion			Butt welding & IR fusion				
	PVC-U Tangit/ DTX	PVC-C Tangit/ DTX	PP-H	PE	PVDF	PP-H	PE	PVDF	PVC-U*	ECTFE*
d20/D50	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
d25/D50	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
d32/D63	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
d40/D75	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
d50/D90	✓	✓	✓	✓	✓	✓	✓	✓		✓
d63/D110	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

* IR fusion only

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).

Maintenance

Thanks to the possibility of a radial installation and removal, the inner pipe union can be easily maintained/replaced (O-Rings, etc.)



1.7.2 CONTAIN-IT Plus – Double containment ball valve

Double containment valves in their standard version have a PVC-U PN6 protective housing with an anti-overwinding handle.

Double containment valves from Georg Fischer Piping Systems are delivered as ready-to-install system units with a PVC-U PN6 protective housing.

Double containment ball valves are also available in the following versions on request:

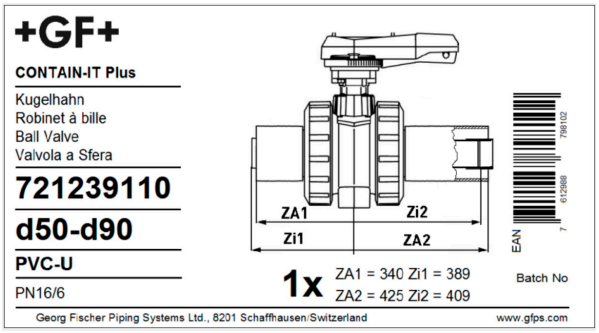
- Pneumatic actuator
- Electric actuator

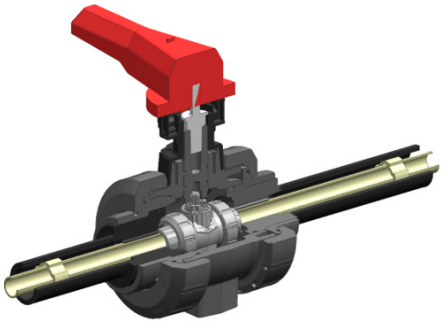
i A manual CONTAIN-IT Plus ball valve can be upgraded at any time by using an adapter set.

Connection technology

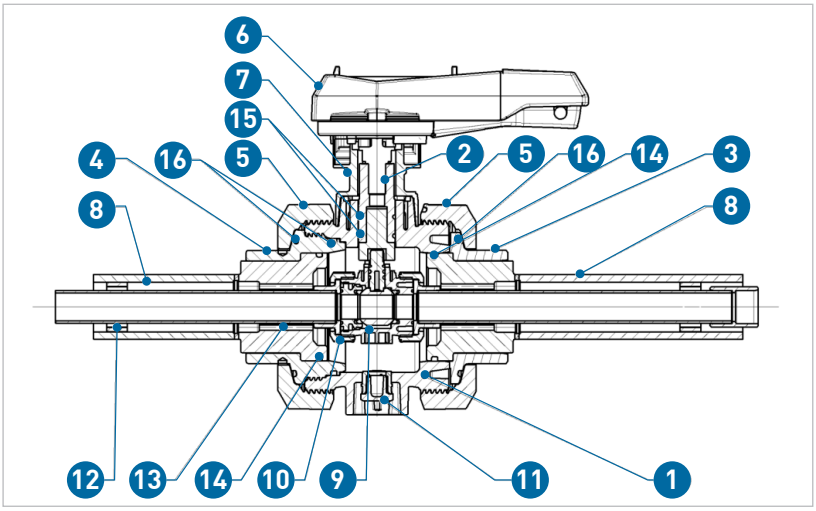
The connection technology used is analogous to the one used for double containment fittings. The principle of the double containment connection technology of Georg Fischer Piping Systems is based on the fact that first the inner pipe is connected according to the respective connection technology. For details, see chapter "CONTAIN-IT Plus - Principles of connection technology".







Design

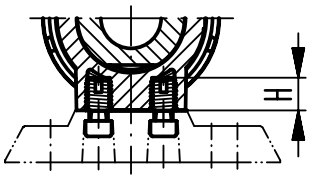


1 Protective housing
2 Stem
3 Union end
4 Union bush
5 Union nut of protective housing
6 Hand lever
7 Nuts and screws (to fix the hand lever)
8 PE supports
9 Ball valve type 546 (central part)
10 Ball valve type 546 coupling nut
11 Adaptor for ½" leak detection or PVC-U ½" plug
12 Spacer
13 Bore-hole 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

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 ball valve: When replacing an inner ball valve in the dimension d63/D110, it is mandatory to contact the Georg Fischer Piping Systems Global Service and Support Team. In this case, a slightly modified inner ball valve must be used!

Maintenance

Thanks to the option of radial installation and removal, the inner pipe ball valve is easy to maintain/replace (O-rings, etc.).



Inner pipe connection

Dimension (mm)	Socket cementing		Socket fusion			Butt welding & IR fusion				
	PVC-U Tangit/ DTX	PVC-C Tangit/ DTX	PP-H	PE	PVDF	PP-H	PE	PVDF	PVC-U*	ECTFE*
d20/D50	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
d25/D50	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
d32/D63	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
d40/D75	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
d50/D90	✓	✓	✓	✓	✓	✓	✓	✓		✓
d63/D110	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

* IR fusion only

The installation, pressure test and maintenance work must be carried out as described in the relevant installation instructions. The installation instructions are delivered with the product, see also the online product catalog at www.gfps.com.

Customizing

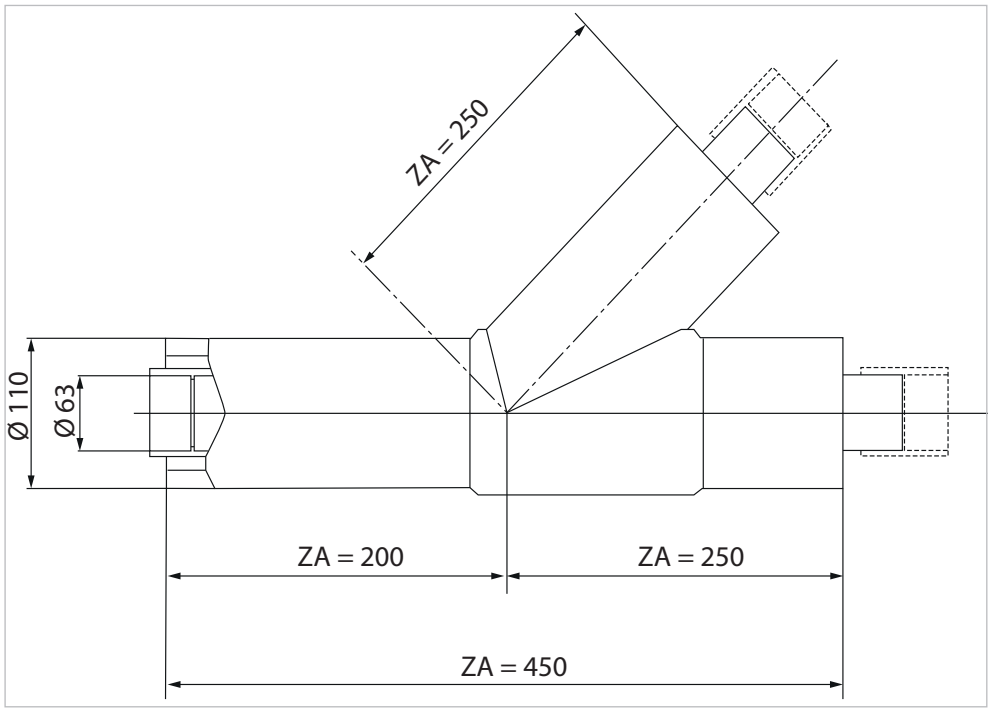
Larger dimensions are available on request. Please contact your local Georg Fischer Piping Systems branch.

1.7.3 Special components

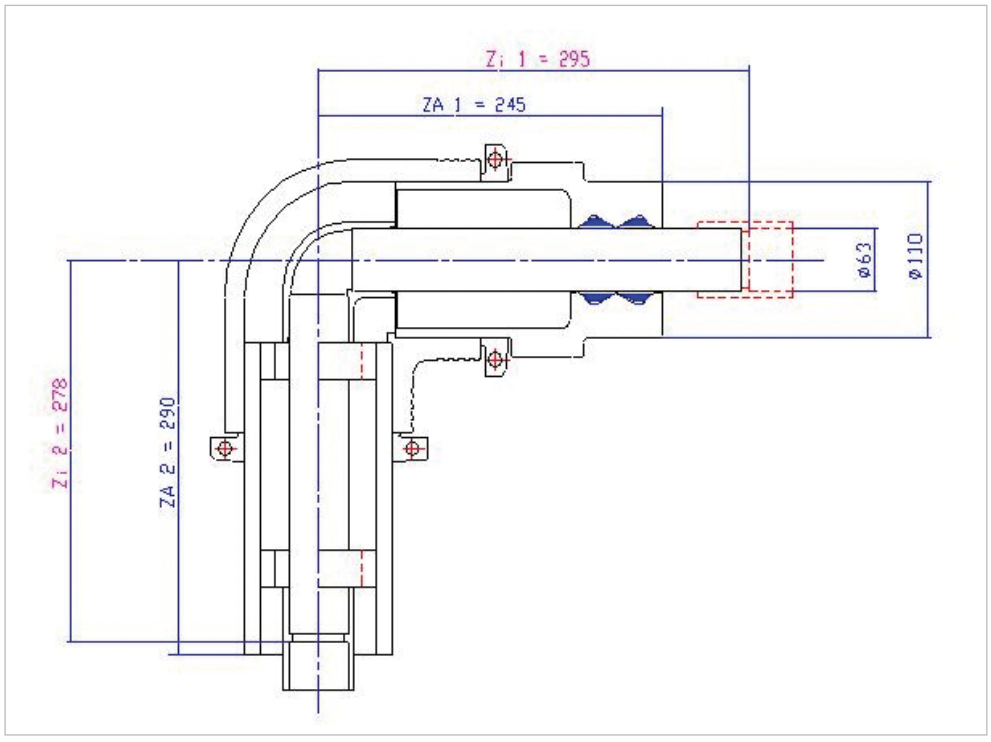
In the double containment product range, many components are manufactured according to customer requirements. Prefabricated tapping pieces, reducing T-pieces, end pieces integrated in the fitting or the prefabrication of entire assemblies can facilitate assembly on the construction site.

⚠ Customized fittings may require the inclusion of a reduction factor.
Contact your Georg Fischer Piping Systems representative for additional information.

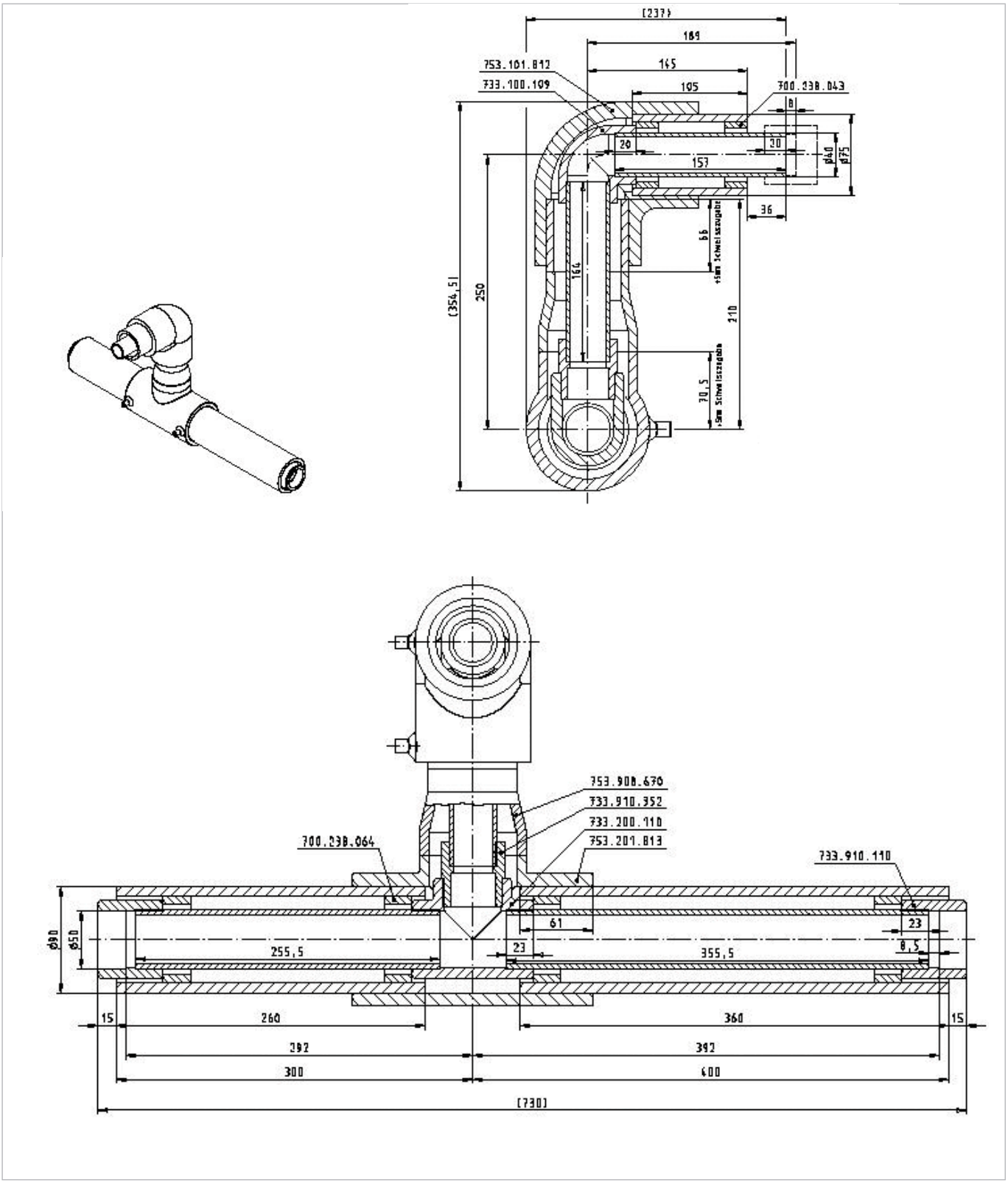
T-piece with 45° tapping point



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

Marine Solutions

HEAT-FIT

Content

HEAT-FIT – Ultimate Fire Protection 623

Marine Solutions

HEAT-FIT

Content

HEAT-FIT – Ultimate Fire Protection **623**
1.1 HEAT-FIT Product Range 625
1.2 HEAT-FIT Installation 634

HEAT-FIT – Ultimate Fire Protection

The HEAT-FIT System is designed for applications in the maritime industry and makes the thermoplastic piping system ecoFIT resistant to temperatures up to 1.000°C or 1832°F for at least 30 minutes under pressure.



HEAT-FIT PE Fire Resistant test (IMO Res. A753 fire endurance L3 Code)

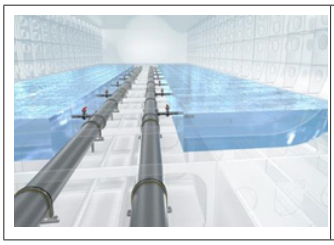
Features & Advantages

- Easy installation: No special skills required
- Up to 30% lighter than alternative materials (metal or Glass Reinforced Plastic)
- Fire Resistant code L3 according to IMO 753 – Meets the guidelines for applications of plastic pipes on ships
- Impact resistant, deformation can be absorbed
- Reliable, sustainable and long lasting solution
- 100% corrosion free
-

Most important market segments

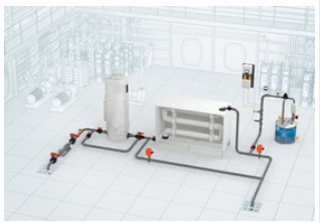
- Marine

Marine applications



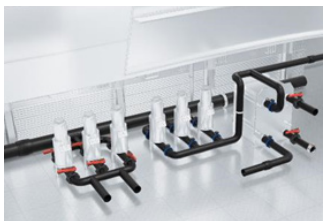
Ballast system
Ballast system ensures the stability of a vessels

- Media: Sea water
- Temperature: up to +35°C



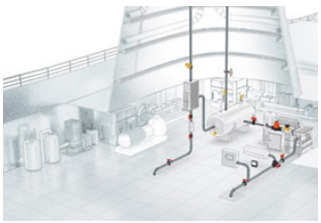
Ballast water treatment Management
Regulates the discharge

- Media: Sea water
- Temperature: up to +35°C



Seawater and freshwater cooling
Provide cooling to engine or other equipment

- Media: Sea and fresh water
- Temperature: up to +60°C



Exhaust gas scrubber
Remove Sulphur oxides from ship's exhaust gas by scrubbing it with sea water or fresh water.

- Media: Sea water - low PH and very aggressive
- Temperature: up to +60°C

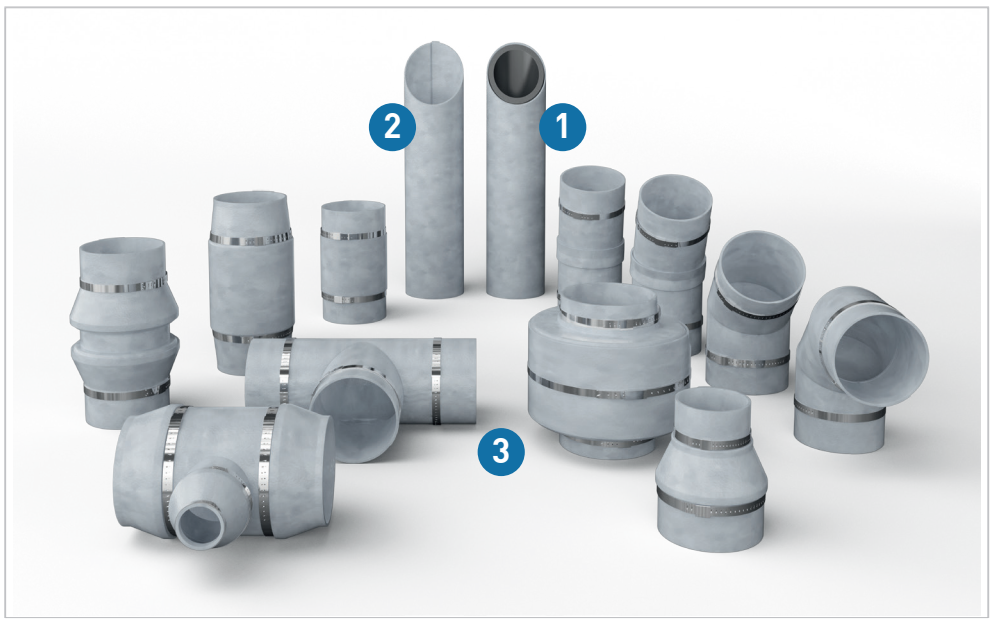
IMO 753 - Fire endurance requirements matrix

Piping Systems	Location					
	A	B	C	D	J	K
	Machinery spaces of category A	Other machinery spaces and pump rooms	Cargo pump rooms	RO/RO cargo holds	Accomendation service and control spaces	Open decks
Sea water						
Sprinkler system						
Ballast sea water (include BWT lines)	L3	L3	L3	L3	L2	L2
Cooling water, essential services	L3	L3				L2
Tank cleaning services fixed machines			L3			
Fresh water						
Cooling water, essential services	L3	L3			L3	L3
Condensate return	L3	L3	L3			
Exhaust gas cleaning effluent line	L3	L3			L3	

L2 : Fire Resistant code L2 according to IMO 753
L3 : Fire Resistant code L3 according to IMO 753
Source: IMO Publications and Documents

1.1 HEAT-FIT Product Range

Georg Fischer provides a HEAT-FIT JACKET and a HEAT-FIT PE system.



1 HEAT-FIT PE
2 HEAT-FIT Jacket Sleeve
3 HEAT-FIT Jacket

Technical data

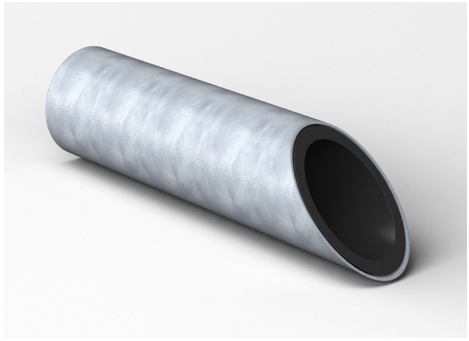
	HEAT-FIT PE		HEAT-FIT Jackets & Sleeves	
Dimensions	d110, d160, d225, d315		d110, d160, d225, d315	
SDR	11		Note: Combined with ecoFIT PE100 SDR 11 system	
PN (bar)	16		Note: Combined with ecoFIT PE100 PN 16 system	
Materials	Pipe	PE100	Base fabric	High Temp. Fiberglass
			Finished weight	3400 g/m2
			Thickness	3.5 mm
			Finishing	TPU film
	Coating	Fire Retardant (FR)	Coating	Fire Retardant (FR)
Fire resistant	At least 30 minutes up to 1.000°C / 1832° Fahrenheit		At least 30 minutes up to 1.000°C / 1832° Fahrenheit	
Density	~1.14 g/cm³ (Acc. EN ISO 1183-1)		~1.021 g/cm3 (Acc. EN ISO 1183-1)	
Impact resistance (90° RT & 0°C & RT)	No damage		No damage	
Vibration (5 Hz)	2'000'000 load cycles		2'000'000 load cycles	
Diesel Resistance (RT, 24h, immersion)	0.30%		15%	
Humidity (50 °C, 95 % r.h., 24h spray)	0.80%		20%	
NSS (35 °C, 24h immersion, 5 % NaCl, pH-value of 6.5-7.2)	0.40%		3.0%	
NaCl (23 °C, 24h immersion, 3.5 % NaCl, pH-value of 6.5-7.2)	0.20%		1.4%	
Color	Light grey		Light grey as RAL 7035	
Service life	tbd		tbd	

Approvals & Testing

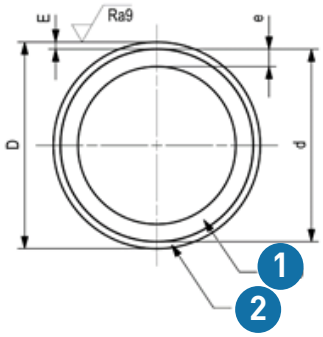
Approval/Test	HEAT-FIT PE	HEAT-FIT Jackets & Sleeves
ABS (20-1958414-1-PDA 20-4336831)	Expected Q4/2023	X
LR (LR22277454TA)	Expected Q4/2023	X
DNV (TAK00001B2)	Expected Q4/2023	X
RINA (Q4/2022)	Expected Q4/2023	X
BV (10132/F1)	Expected Q4/2023	X
Fire Resistant plastic piping systems (IMO Res. A753 fire endurance L3 Code)	X	X
Surface Flammability, Smoke and Toxicity (IMO A653 2010 FTP Code Part 5 and Part 2)	-	X
ASTM D635-22 Standard test method for rate of burning and/ or extent and time of burning of plastics in a horizontal position	X	

HEAT-FIT PE

The HEAT-FIT PE piping system is a solution designed for the maritime industry. The co-extruded pipe basically consists of a media-carrying polyethylene pipe and a fire-retardant coating with a wall thickness e of 4mm.



HEAT-FIT PE



1 PE100 pipe
2 Flame-retardant coating

Technology



The halogen-free, high-performance intumescent coating, which is applied to the pipe by a co-extrusion process, withstands the most stringent requirements. The flame-retardant coating reacts with an intumescent reaction upon contact with flames. This intumescent reaction forms a protective layer that shields the underlying piping from flames and heat.

Product range

In the following table units of measurement are indicated according to the metric system.

Products	DN (mm)	110	125	140	160	180	200	225	280	315
PE100 pipe*	d (mm)	110			160			225		315
HEAT-FIT PE**	D (mm)	118			168			233		323

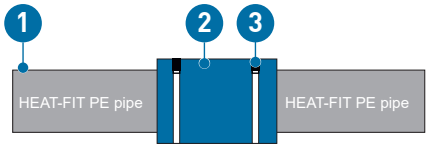
* d Outside diameter of the PE100 pipe

** D Outside diameter of the HEAT-FIT PE pipe

For further information see www.gfps.com/heat-fit

Connection technology

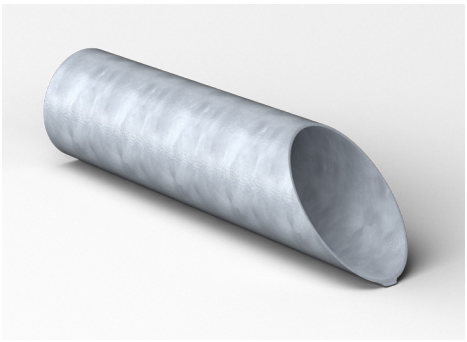
Pipe to pipe connections must be done via butt fusion. The weld bead must be covered after the succesfull pressure test with a HEAT-FIT Jacket Weld Bead Cover to ensure the flame retardant functionality.



1 HEAT-FIT PE pipe
2 HEAT-FIT Jacket Weld Bead Cover
3 Metal strap and closure coupler

HEAT-FIT Jacket Sleeves

HEAT-FIT Jacket is a flame-retardant system for ecoFIT PE100 pipes. All HEAT-FIT Jacket Sleeves are made of high temperature (HT) glass fiber fabric, intumescent coating, special adhesive and thermoplastic polyurethane (TPU).



HEAT-FIT Jacket Sleeves



ecoFIT PE100 pipes

Technology



The Halogen-free water-based high performing intumescent coating which is applied to a glass fiber fabric is more flexible, more elastic, smoother and capable of surpassing the most severe requirements. In order to protect the coating and the fiberglass fabric from external influences, they are laminated with a flame retardant thermoplastic Urethane. The coating reacts with an expanding reaction upon contact with flames. This intumescent reaction forms a protective layer that protects the underlying piping from flames and heat.

Product range

In the following table units of measurement are indicated according to the metric system.

Products	DN (mm)	110	125	140	160	180	200	225	280	315
ecoFIT PE100 pipe*	d (mm)	110			160			225		315
HEAT-FIT Jacket Sleeves**	D (mm)	122			172			237		327

* d Outside diameter of the ecoFIT PE100 pipe

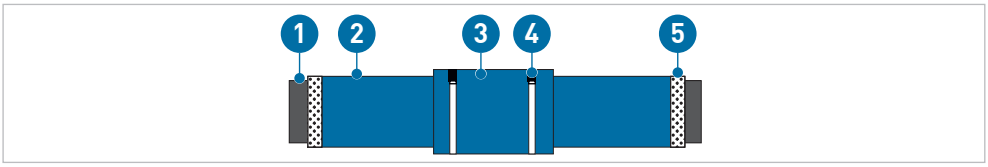
** D Outside diameter of the HEAT-FIT Jacket Sleeves

For further information see www.gfps.com/heat-fit

Connection technology

Pipe to pipe connections must be done via butt fusion or electrofusion.

To ensure the flame retardant functionality after the succesfull pressure test, the weld bead must be covered with a HEAT-FIT Jacket Weld Bead Cover, the electrofusion coupler must be covered with HEAT-FIT Jacket Electrofusion coupler.



1 ecoFIT PE100 pipe
2 HEAT-FIT Jacket Sleeve
3 HEAT-FIT Jacket Weld Bead Cover / HEAT-FIT Jacket Electrofusion coupler
4 Metal Strap
5 TPU sealing tape

HEAT-FIT Jacket

HEAT-FIT Jacket Fittings is a flame-retardant system for ecoFIT PE100 fittings. All HEAT-FIT Jacket Fittings are made of high temperature (HT) glass fiber fabric, intumescent coating, special adhesive and thermoplastic polyurethane (TPU).



HEAT-FIT
Tee 90° Equal



ecoFIT
Tee 90° Equal



HEAT-FIT Jackets
combined with ecoFIT PE100 Fitting

Technology

The Halogen-free water-based high performing intumescent coating which is applied to a glass fiber fabric is more flexible, more elastic, smoother, and capable of surpassing the most severe requirements. In order to protect the coating and the fiberglass fabric from external influences, they are laminated with a flame retardant thermoplastic Urethane. The coating reacts with an expanding reaction upon contact with flames. This intumescent reaction forms a protective layer that protects the underlying piping from flames and heat.

Product range

The following table uses metric units of measure.

Products	d (mm)	110	125	140	160	180	200	225	280	315
Jacket – 90° Bend		■			■			■		■
Jacket – 45° Elbow		■			■			■		■
Jacket – 30° Elbow Long Spigot		■			■			■		■
Jacket – 15° Elbow Long Spigot		■			■			■		■
Jacket – Tee 90° Equal		■			■			■		■
Jacket – Tee 90° Reduced		■			■			■		■
Jacket – Reducer		■			■			■		■
Jacket – Flange Connection		■			■			■		■
Jacket – Fix Point		■			■			■		■
Jacket – Branch Saddle (to d63)		■			■			■		■
Jacket – Electrofusion coupler		■			■			■		■
Jacket – Weld Bead Cover		■			■			■		■
Insert for pipe clamps		■			■			■		■

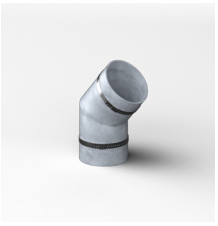
For further information see www.gfps.com/heat-fit



HEAT-FIT
15° Elbow Jacket



HEAT-FIT
30° Elbow Jacket



HEAT-FIT
45° Elbow Jacket



HEAT-FIT
90° Bend Jacket



HEAT-FIT
Branch Saddle Jacket



HEAT-FIT
Electrofusion Coupler Jacket



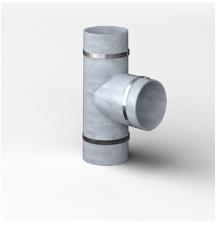
HEAT-FIT
Fix Point Jacket



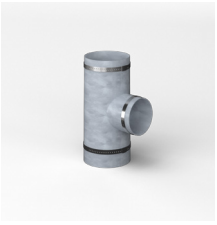
HEAT-FIT
Flange Connection Jacket



HEAT-FIT
Reducer Jacket



HEAT-FIT
Tee 90° Jacket

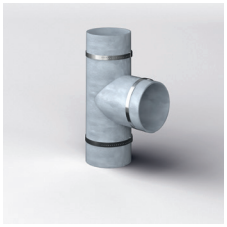


HEAT-FIT
Tee 90° Reduced Jacket



HEAT-FIT
Weld Bead Cover Jacket

HEAT-FIT Accessories

HEAT-FIT Jacket Tee 90°	HEAT-FIT Metal Strap	HEAT-FIT Metal Closure	ecoFIT Tee 90° PE100
			
756 200 114 1x	756 170 302 1x 165cm	756 170 303 3x	753 208 614 1x

Product range

The following table uses metric units of measure.

Products	d (mm)	110	125	140	160	180	200	225	280	315
Sealing Tape		■			■			■		■
Metal Strap										
Metal Closure										

Sealing Tape

The thermoplastic polyurethane (TPU) tape is delivered on a role with a total length of 25m and needed in case that the HEAT-FIT Jacket Sleeves must be shortened.

Metal Strap & Metal Closure

Stainless steel straps are delivered on a role with a total length of 30m. All metal straps must be closed via the metal closures to ensure the flame retardant functionality.

i For further information see www.gfps.com/heat-fit

Order information

All components must be ordered separately. The required information, such as the required length of metal straps, quantity of metal closures and corresponding ecoFIT inner pipe code numbers are listed in the HEAT-FIT datasheets.

Training

Planners and installer, involved with HEAT-FIT, ELGEF-Plus and ecoFIT planning and installation, must undergo training and certification from GF Industry & Infrastructure Flow Solutions prior to performing any operations on site. For further information and training please contact GF support.

1.2 HEAT-FIT Installation

Installation HEAT-FIT PE

Connection technology HEAT-FIT PE

The system is installed analogously to the standard ecoFIT piping system by means of a conventional butt fusion. For more information, see chapter "Jointing technology – Welding".

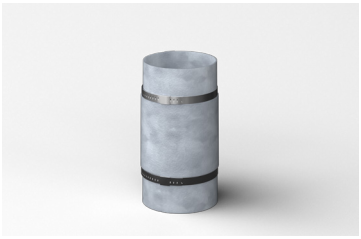
Welding parameters

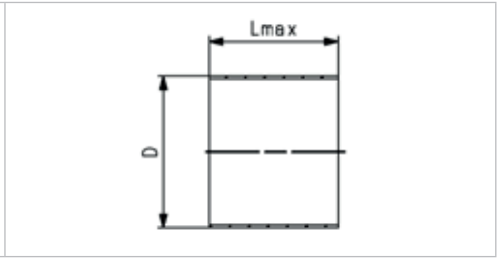
Standard welding parameters for ecoFIT PE100 / PN16 / SDR11 must be considered for all weldings.

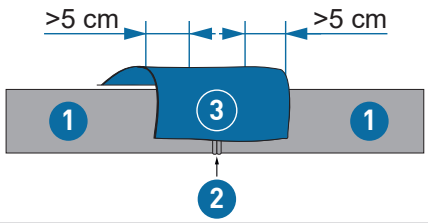
Pipe to pipe connections

Pipe-to-pipe butt-weld joints must be covered with a HEAT-FIT Jacket.

Dimension	Code
d110	756 170 334
d160	756 170 337
d225	756 170 330
d315	756 170 333

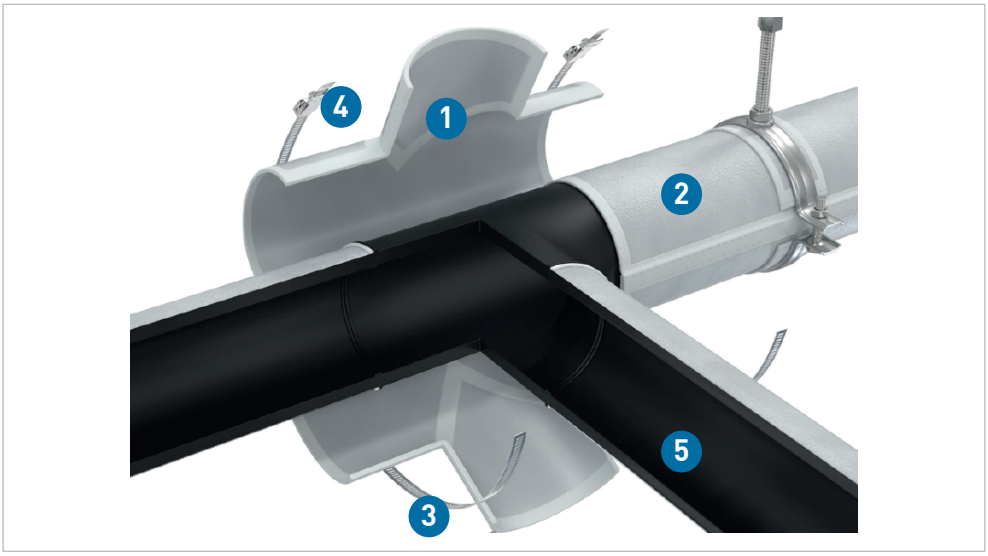






Pipe to fitting connections

Pipe to fitting connections must be covered with a HEAT-FIT Jacket. Care must be taken to ensure an overlap.



1 HEAT-FIT Jacket Tee 90° Art. Code 756 200 114
2 HEAT-FIT Jacket Art. Code 756 170 114
3 Metal Strap Art. Code 756 170 302
4 Metal Closure Art. Code 756 170 303
5 HEAT-FIT PE Pipe Art. Code 756 017 114

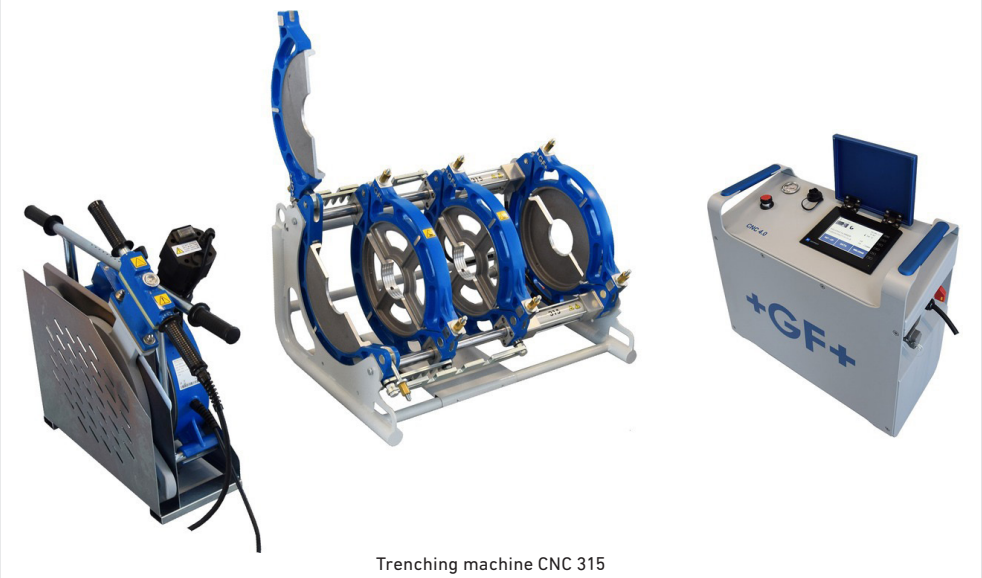
Important: Due to the larger outside diameter D (FR) of the HEAT-FIT PE pipe, special half-shells for the welding machines must be considered during installation. Please contact GF Industry & Infrastructure Flow Solutions local sales company.

Due to the flame-retardant layer of 4mm on the outer pipe the pipe dimension is slightly bigger.

Therefore please keep an eye on the relevant welding machines.

Example:

- HEAT-FIT PE d160mm/D168mm
- Possible welding machine: TM 250 / TM 315



Trenching machine CNC 315

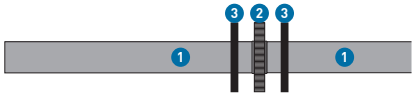
Installation HEAT-FIT PE

HEAT-FIT Jackets are hand-fitted to the ecoFIT piping system components using HEAT-FIT metal straps and HEAT-FIT fasteners after welding the ecoFIT inner pipe.

1

Fusion process

1. Carry out the butt fusion process for ecoFIT piping system according to separate instructions.



1 HEAT-FIT PE pipe
2 Special half shells
3 Heating element

2. Observe the cool down time following the welding process.



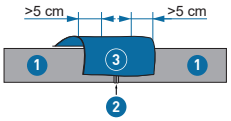
1 Weld bead

2

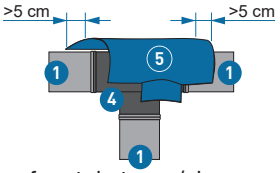
HEAT-FIT Jacket installation

1. Position HEAT-FIT Jacket on the fitting: Ensure >5cm overlap from HEAT-FIT Jacket to Pipe.

Pipe



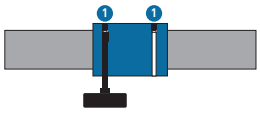
Fittings



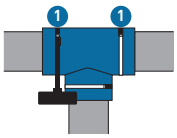
1 HEAT-FIT PE pipe
2 Weld bead
3 HEAT-FIT Jacket Weld Bead Cover
4 ecoFIT PE100 Tee 90°
5 HEAT-FIT Jacket Tee 90°

2. Refer to the product catalog for the number of metal straps/closures required and hand-tighten accordingly. It is mandatory to place the metal strap over each overlapping surface. Caution: Do not overtighten.

Pipe



Fittings



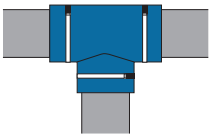
1 HEAT-FIT Metal Strap & Closures

3. Final inspection: The HEAT-FIT pipe must be completely covered with the HEAT-FIT Jackets.

Pipe



Fittings



Installation HEAT-FIT Jackets and Sleeves

HEAT-FIT Jacket Sleeves are installed on the straight pipe runs prior to welding the ecoFIT piping system components.

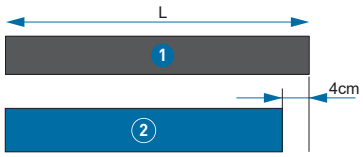
HEAT-FIT Jackets are hand-fitted to the ecoFIT piping system components using HEAT-FIT metal straps and HEAT-FIT fasteners after welding the ecoFIT inner pipe.

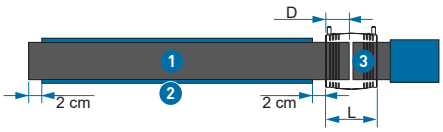
1 Cutting

Butt fusion
After cutting the ecoFIT pipe to the required length, cut the HEAT-FIT Jacket Sleeve 4 cm shorter than the ecoFIT pipe.

Electrofusion
(Pipe-pipe connections only!)
After cutting the ecoFIT pipe to the required length, cut the HEAT-FIT Jacket Sleeve according to the formula below.
Calculation HEAT-FIT Jacket Sleeve length
Jacket Sleeve Length = ecoFIT Pipe Length – (Insertion depth + 2cm). Insertion depth ELGEF Plus = L / 2

1 ecoFIT pipe
2 HEAT-FIT Jacket Sleeve
3 ELGEF Plus electrofusion coupler





2 Sealing

1. To prevent moisture penetration, apply TPU sealing tape around the cut edge of the HEAT-FIT material and press on by hand.

1 HEAT-FIT Jacket Sleeve
2 TPU sealing tape



2. Align HEAT-FIT Jacket Sleeve centered on the ecoFIT pipe.

1 HEAT-FIT Jacket Sleeve



3 Fusion process

1. Carry out the butt fusion process for ecoFIT piping system according to separate instructions. For free access to the welding point, the HEAT-FIT Jacket Sleeve must be pushed away from the welding site.

1 HEAT-FIT Jacket Sleeve
2 Half shells
3 Heating element



2. Following the welding process and after the cooling time has elapsed, the HEAT-FIT Pipel Sleeve is pushed into the center of the two welding beads.

1 HEAT-FIT Jacket Sleeve

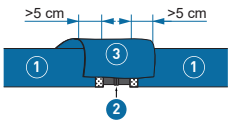


4

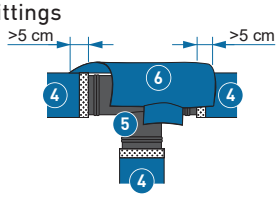
HEAT-FIT Jacket installation

1. Position HEAT-FIT Jacket on the fitting: Ensure >5cm overlap from HEAT-FIT Jacket to Jacket Sleeve according to illustration.

Pipe



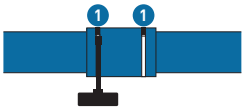
Fittings



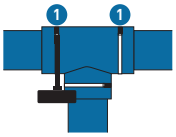
1 HEAT-FIT Jacket Sleeve
2 Weld bead
3 HEAT-FIT Jacket Weld Bead Cover
4 ecoFIT PE100 pipe & HEAT-FIT Jacket Sleeve
5 ecoFIT PE100 Tee 90°
6 HEAT-FIT Jacket Tee 90° Equal

2. Refer to the product catalog for the number of metal straps/closures required and hand-tighten accordingly. It is mandatory to place the metal strap over each overlapping surface. Caution: Do not overtighten.

Pipe



Fittings



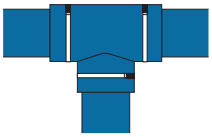
1 HEAT-FIT Metal Strap & Closures

3. Final inspection: The ecoFIT piping system must be completely covered with the HEAT-FIT.

Pipe



Fittings



Excellence in Flow

Visit our webpage to get in touch with your local specialist:
www.gfps.com/our-locations

Industry

Plan, Build, Operate



Design and Installation



Valves and Actuators



Measurement and Control

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