# Utility

**Plan, Build, Operate**

Technical Manual

Piping Systems in Utilities

# Technical Manual

## Piping Systems in Utilities

Schaffhausen, November 2018

# Technical Manual

## Piping Systems in Utilities

# Content

# Preface

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

The scope of these planning fundamentals is to offer a valuable support in planning and 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.

We hope that, in this handbook, you will find the qualified support that you need for your daily work. In case of special applications our worldwide technical engineers will be glad to assist you.

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

Schaffhausen, November 2018

# How to Use

## Content

# 1 How to use

This handbook describes and explains the basic fundamentals for planning, product selection, processing and installation of pressure pipes 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 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 aids 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 properties |
|  | Combustion behavior |  | Mechanical characteristics |
|  | Chemical resistance |  | Physiological properties |
|  | High-purity properties |  | UV and weather resistance |
|  | Application limits | | |

# 2 List of abbreviations

| Abbrevia-tions | 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 | Crosslinked 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 |

# Introduction

## Content

# 1 GF Piping Systems

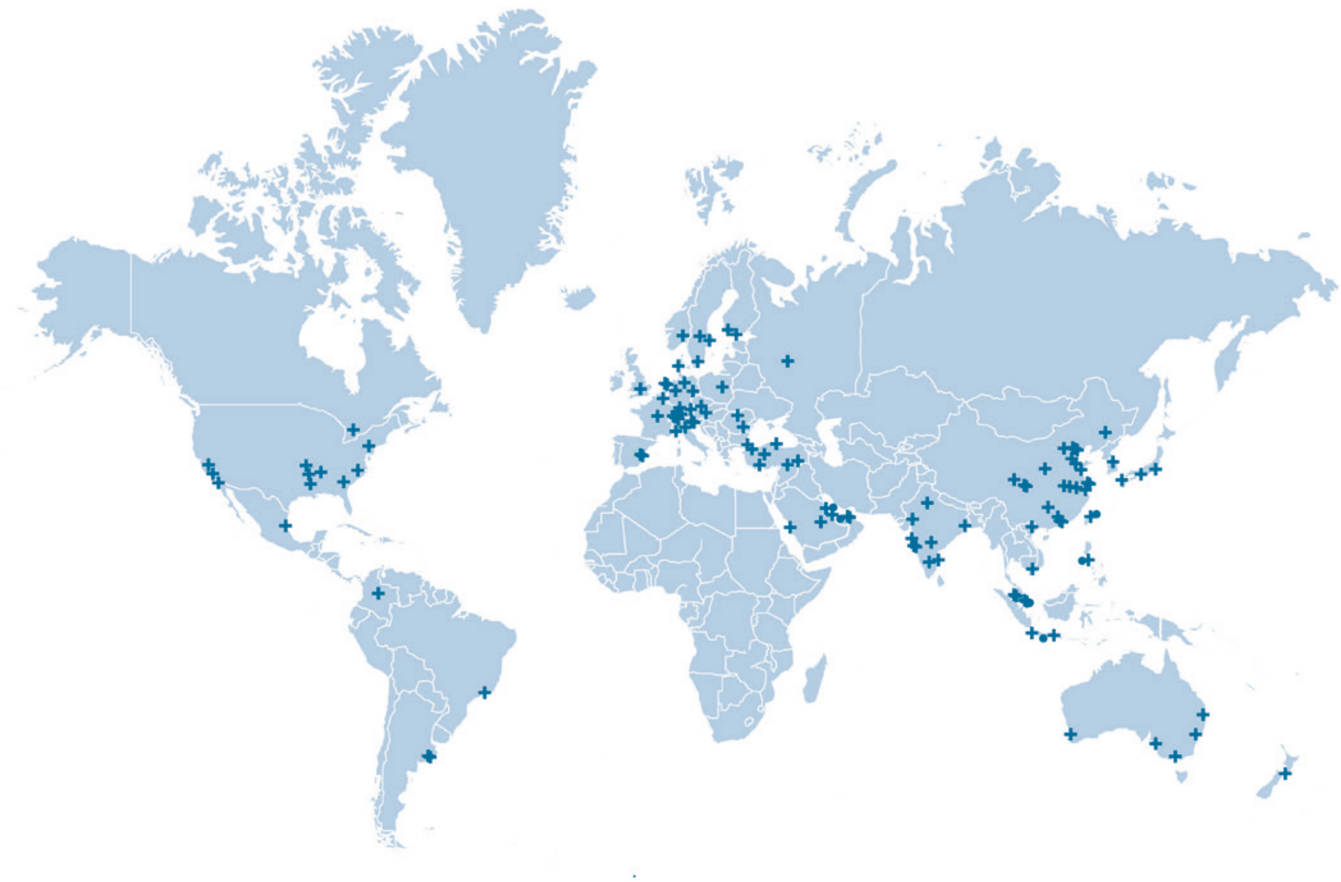
### Global presence

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

### Complete solutions provider

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

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



# 2 Services

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

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

### 1 Chemical resistance

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

### 2 CAD library

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

### 3 Technical support

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

### 4 Online and mobile calculation tools

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

### 5 On-site training

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

### 6 Customizing

The customizing teams at GF Piping Systems work closely together around the globe. The focus of our teams is on the production of custom-made special parts to complete installations. In addition, a wide variety of special solutions can be produced in small series. Standardized processes guarantee our customers the highest quality, even for individual solutions.

## 7 Rental pool

In many countries, GF Piping Systems provides machines and tools to rent for various joining techniques such as butt welding, electrofusion and mechanical connections.

## 8 Training courses

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

## 9 Fit for Service NDT

Using ultrasound technology, we are able to provide our customers with top-quality non-destructive testing (NDT) for ecoFIT (PE), PROGEF (PP) butt welds and ELGEF (PE) electrofusion welds. Important projects across the globe rely on NDT technology to ensure the greatest security and quality of welded joints on metallic pipes. GF Piping Systems' approach to holistic quality management has resulted in the world's first NDT service for butt welds and electrofusion welds on ecoFIT (PE), PROGEF (PP) and ELGEF (PE) with an operational fitness report (pass/fail). Once an item has passed, we provide a ten-year guarantee.

Our unique NDT solution guarantees your weld quality with a pass/fail report.

## 10 Track and Trace

Track and Trace is a complete management package that takes care of preparation, data entry and data archiving at all critical phases on a construction site. State-of-the-art apps, Internet platforms, online clouds, mobile devices and GPS hardware are used for this. The service is available as an annual licence and contains all the required elements to plan, manage and implement installations in an intelligent, quality-driven and smooth process.

## 11 Advanced Engineering Services

In order to support key projects across all project phases, we provide advanced engineering services for the design, installation and verification of systems. Advanced engineering services provide support for every customer requirement:

- Modification of parts
- Material selection
- Design reviews
- Detailing of standards
- Hydraulic modeling
- Dynamic-mechanical tension analysis
- Calculation of static analyses
- FEA/FEM

To guarantee safe, high performance plastic piping systems, all involved calculations are performed using professional programs such as ROHR2.

# 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 sustained success. The fundamental importance of quality determines our actions, shapes our understanding of quality, and is reflected in our own claim to quality.

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

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

## 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 Piping Systems are certified in accordance with the ISO 9001 quality management system. Furthermore, all of our production sites are certified in accordance with ISO 14001. The standard defines criteria that are applicable throughout the world for efficient environmental management systems and, as a result, is considered to be the basis for optimizing environmentally relevant processes.

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

## 3.3 Accredited test center

The test center of GF Piping Systems is a test center accredited in accordance with ISO/IEC 17025 for components of piping systems. It inspects all types of pipes, 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.

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

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

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

The SAS, which is responsible for 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 pipes
- Crush tests (ISO 9853)
- Impact resistance tests (ISO 13957)
- Decohesion test (ISO 13955, ISO 13956)
- Peeling test (ISO 13954)
- Tensile strength and failure mode on butt-fused test specimens (ISO 13953)
- Pressure drop test (EN 12117)
- Determination of density (EN ISO 1183)
- Melt flow rate MFR (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 Piping Systems, our own environmental responsibility is an integral aspect in all of our business activities. Because we regard environmental awareness as one of the most important values of our company, all internal structures and processes are oriented towards sustainability. We strive to save natural resources and work relentlessly on optimizing the eco-friendliness of our products and their applications. Outstanding material properties and innovative technologies form the basis of our environmentally friendly and energy-saving solutions. By supplying our customers with complete piping systems, we support and promote ecological and cost-efficient operating processes in many industries and in daily routine. To obtain detailed information about the environmental compatibility of our products, we monitor all phases of the product life cycle in detail, which also allows us ultimately to improve the life cycle assessment of our products.

## 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 Piping Systems operates with this responsibility as its premise. With locations in over 30 countries, GF Piping Systems views the multitude of cultures, religions, nationalities, genders and age groups as a valuable source for talent, creativity and experience. This makes possible the extraordinary services performed by approximately 16,000 staff members employed by GF Piping Systems throughout the world.

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

# 5 Training

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

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

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

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

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

# Application Solutions

## for Supply

## Content



II

# 1 Water Utilities

## 1.1 Overview

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


### 1 Water transportation lines

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

### 2 Water distribution lines

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

### 3 Water service lines and house connections

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

## 4 Pressure sewage lines

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

## 5 Irrigation

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

## 1.2 Leading Systems (Samples)

| ELGEF Plus | MULTI/JOINT | iJOINT | Machines | Tools |
|---|---|---|---|---|
|  |  |  |  |  |
| d160 – d2000 mm, PN10<br>d20 – d1200 mm, PN16 | DN50 – DN600 mm | d16 – d110 mm | **Butt fusion**<br>d40 mm – d1600 mm<br>(with CNC technology up to d630 mm) | d20 – d2000 mm |
| Electro fusion fittings, spigot fittings, seamless bends and segmented fittings and pipes | Wide range restraint couplings, reduction couplings, wide-range flanges, curves, end caps PE adapters, foot bends | Couplings, tees, bends, reducers and saddles, transition fittings, universal fittings | **Electrofusion**<br>MSA 125, 230, 330, 340 (Transformer)<br><br>MSA 2.0, 2.1, 4.0, 4.1, 2.0 MULTI<br>(Inverter technology) | Rotation peelers, clamping devices, top-load tools, cutting tools, re-rounding tools, squeeze-off tools, tapping devices |

# 2 Gas Utilities

## 2.1 Overview

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

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


### 1 Gas transportation lines

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

### 2 Gas distribution lines

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

### 3 Gas service lines and house connections

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

## 2.2 Leading Systems (Samples)

| ELGEF | Valves | MULTI/JOINT | Machines | Tools |
|---|---|---|---|---|
|  |  |  |  |  |
| d160 – d2000 mm, PN10<br>d20 – d1200 mm, PN16 | PE-ball valves up to d225 mm | DN50 – DN600 mm | **Butt fusion**<br>d40 – d1600 mm<br>(with CNC technology up to d630 mm) | d20 – d2000 mm |
| Electro fusion fittings, spigot fittings, seamless bends and segmented fittings and pipes | Pressure Tapping Valves up to d63 mm outlet , mains up to d400 mm | Wide range restraint couplings, reduction couplings, wide-range flanges, curves, end caps<br>PE adapters, foot bends | **Electrofusion**<br>MSA 125, 230, 330, 340 (Transformer)<br><br>MSA 2.0, 2.1, 4.0, 4.1, 2.0 MULTI (Inverter technology) | Rotation peelers, clamping devices, top-load tools, cutting tools, re-rounding tools, squeeze-off tools, tapping devices |

# 3 Automation

## 3.1 Overview

PE piping systems are not just used for supplying gas and water, but increasingly also in industrial applications.

Be it for measurement, control or propulsion, our technologies are not only fully compatible with one another, but – regardless of their dimensions – can also be seamlessly integrated into your piping systems using suitable system components from GF Piping Systems.

## 3.2 Measurement

**Product categories**

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

## 3.3 Control

### Precise control

Intelligent design makes life easier. All our sensors can be connected to the same transmitter. Our 9900 single-channel, multi-parameter controller ensures secure and efficient operation of your entire control circuit. Thanks to its modular design, additional functions such as batch control or communication technologies can be added at any time without any problems. The parameters of the currently connected sensors are displayed at a glance on the large, well-lit display.

### Reliable drive technology for fittings

The modular design of our drive range allows you the greatest flexibility for your configuration. Valves and drive elements can be combined flexibly and additional functions such as position control or monitoring systems can be added as options. Depending on your requirements, you can choose between electric, magnetic or pneumatic drives. Made entirely from plastic, our whole drive range is designed for the toughest environmental conditions and is resistant to aggressive chemicals and seawater.

- Easy to install: clamp-on flow rate meters can be directly attached to the outside of the pipe while the system is running.
- Easy to operate: an intuitive menu structure and the clear parameter display are integral components of our user-friendly control technology.
- Easy to combine and retrofit: the fast and easy configuration is a key benefit that proves that the flexibility of our automation solutions know no limits.

# Plastic Piping Materials

## Content



III

# 1 Properties of Plastic Piping Materials

## 1.1 Polyethylene (PE)

### PE properties (reference values)

| Property | PE 80 Value[1] | PE100 / PE100 RC Value[1] | Units | Test standard |
|---|---|---|---|---|
| Density | 0.93 | 0.95 | g/cm³ | EN ISO 1183-1 |
| Yield stress at 23 °C | 18 | 25 | N/mm² | EN ISO 527-1 |
| Tensile e-modulus at 23 °C | 700 | 900 | N/mm² | EN ISO 527-1 |
| Charpy notched impact strength at 23 °C | 110 | 83 | kJ/m² | EN ISO 179-1/1eA |
| Charpy notched impact strength at -40 °C | 7 | 13 | kJ/m² | EN ISO 179-1/1eA |
| Crystallite melting point | 131 | 130 | °C | DIN 51007 |
| Thermal conductivity at 23 °C | 0.43 | 0.38 | W/m K | EN 12664 |
| Water absorption at 23 °C | 0.01 - 0.04 | 0.01 - 0.04 | % | EN ISO 62 |
| Color | 9005 | 9005 | RAL | |
| Limiting oxygen index (LOI) | 17.4 | 17.4 | % | ISO 4589-1 |

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

### General

Polymers which consist of hydrocarbons with formula $C_nH_{2n}$ with a double bond (ethylene, propylene, butene-1, isobutene) are collectively referred as polyolefin. 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 pipes 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.

Alternative, trenchless installation methods such as relining, trench cutting and flush drilling require new materials: PE100 RC (raised crack resistance) made from modified PE100 has a greater resistance to slow crack growth and stress cracks. The advantage of PE100 RC as a material is that notches and grooves in the pipe have less of an impact on the lifetime in the long term. For this reason, this material is often used for trenchless pipe installation. The requirements for pipes made from polyethylene for alternative installation techniques are specified in PAS 1075.

**Advantages of PE**

- Low weight
- Excellent flexibility during storage and installation as well as resistance to earth movements
- Good abrasion resistance (abrasion resistance)
- Corrosion resistance, no additional measures required
- High impact strength even at low temperatures
- Good chemical resistance
- Smooth pipe surface resulting in higher flow rate, less incrustation and lower energy costs
- Suitable for trenchless installation techniques

## UV and weather resistance

Because of the black pigments used, black 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. Studies by independent institutes have shown that the expected lifetime of PE pipes, even under extreme conditions, exceeds the lifetime required by standards. For detailed information, observe the list of chemical resistance from GF Piping Systems or contact the responsible GF Piping Systems representative.

## Abrasion resistance

PE shows excellent resistance to abrasive stress. Depending on the size, geometry and speed of the solids being transported, PE has great advantages, in particular over metallic materials. PE piping systems are thus used in many applications for transporting media with solid contents.

## 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.

The following classifications in accordance with different combustion standards are used:

- According to UL94, PE is classified as HB (horizontal burning) and according to DIN 53438-1 as K2.
- According to DIN 4102-1 and EN 13501-1, PE is listed as B2 (normal flammable).

In the French classification of building materials, polyethylene corresponds to M3 (of average flammability rating). The self-ignition temperature is 350 °C. Suitable fire-fighting agents are water, foam, carbon dioxide or powder.

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

## 1.2 Sustainability

The world is facing major challenges in the energy sector. This includes the increasing consumption of energy, the finite nature of fossil resources, the increasing prices for energy and climate change. In order to satisfy the needs of today's as well as future generations, sustainable development is needed. Plastics contribute to mastering these challenges.

The products of GF Piping Systems have been in use at customers for many years, in some cases even decades. Even minor increases in efficiency – such as those achieved by a suitable design – can significantly influence the environmental balance. For this reason, GF Piping Systems pursues a comprehensive approach in the development of piping systems. Sustainable solutions are possible only if the entire life of the applications and products is considered.

### Plastics save energy

Besides their generally known technical advantages, such as corrosion resistance, plastics also present ecological benefits. With their light weight and insulating effect, plastics are suitable for a number of energy-efficient applications: in vehicles, for packaging, in insulations and for piping systems. Plastics are produced primarily out of crude oil. Roughly four percent of the crude oil produced worldwide is processed into plastics. Efforts to reduce the consumption of crude oil and other fossil fuels do not, however, mean an abandonment of plastics – on the contrary: Energy is saved by using plastics!

In a study[1], Plastics Europe quantified what type of effect energy consumption and greenhouse emissions have when plastic products were to be replaced by other materials.

**The results of the study**

- Products made of plastic enable significant savings in energy and greenhouse emissions.
- In most cases, replacing plastic products with other materials leads to an increase of energy consumption and greenhouse emissions.

If as many plastic products as possible were to be replaced with other materials, more than 50 % more energy would be required than the energy currently being consumed during the entire life cycle of all plastic products. In other words: The plastic products that are currently on the market have enabled an energy savings of 2,400 million GJ per year. This is the equivalent of an amount of 50 million tons of crude oil that could be distributed onto 200 very large oil tankers.

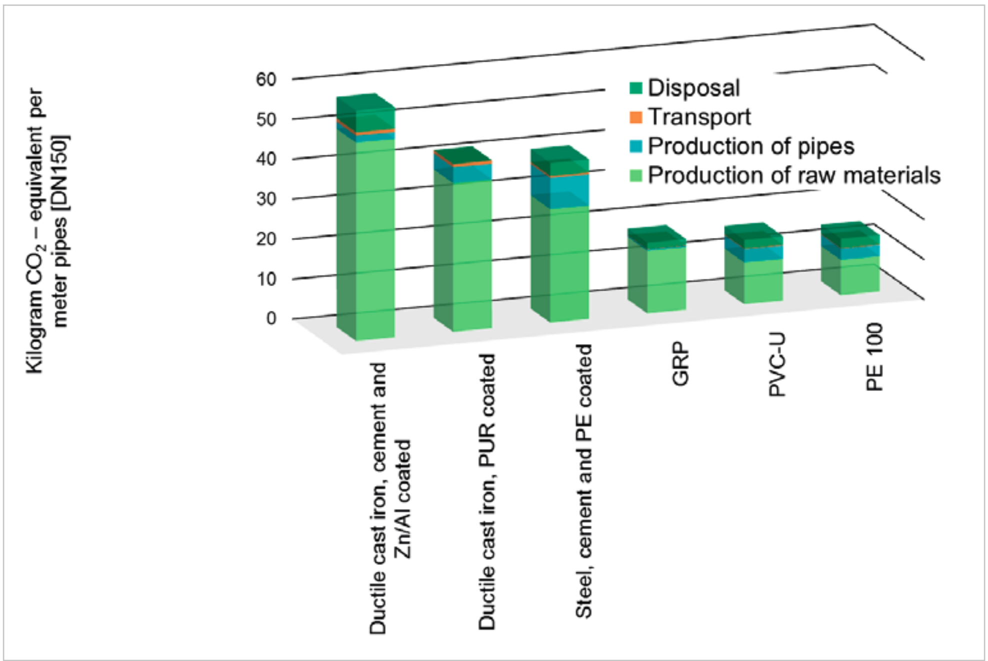
[1] Pilz, H., Brandt, B., Fehringer, R. (2010): The impact of plastics on life cycle energy consumption and greenhouse gas emissions in Europe Denkstatt GmbH under the authority of Plastics Europe, Brussels, Belgium.

## Life cycle assessment of pipes

GF Piping Systems had a life cycle assessment[2] commissioned of pipes for building technology, industry and utilities. In this assessment, the environmental effects of one meter of pipe each are compared for the plastics used by GF Piping Systems and their most important competing materials (for DN25, DN80, DN150 and DN400). The study was calculated by independent Swiss life cycle assessment experts and is based on the internationally leading life cycle assessment database „Ecoinvent".

The result is that plastic pipes in the applications and dimensions delivered by GF Piping Systems almost always show better results than the competing materials. For example, the $CO_2$ footprint, i.e. that is the added greenhouse emissions during manufacturing, transport and disposal of one meter of PE pipe of dimension DN80 is roughly five times lower than for a pipe made of stainless steel. Decisive factors for the life cycle assessment of pipes are the type and quantity of the material used. For every kilogram of material, many plastics and also copper and stainless steel show a similar high energy demand. Low-alloyed steel and cast iron with an average share of regrinds are significantly lower per kilogram. The results differ when referenced to one meter pipe. Based on the significantly lower weight, plastic pipes fare very well compared to metals, particularly for the small and medium dimensions.

[2] Büsser, S., Frischknecht, R. (2008): Life cycle assessment of pipes - comparison of different piping materials for building services, industry and utilities. ESU-Services Ltd. on behalf of Georg Fischer Piping Systems, Uster and Schaffhausen.




**G3.1 Life cycle assessment of plastic pipes**

Plastic pipes made of PE show a significantly better life cycle assessment than metal pipes.

Reducing material demand is at the center of further improvement of the life cycle assessment of plastic pipes. This applies to product development as well as to users and planners:

- Reduce material demand further
- Use of regrinds for parts with low loads
- No overdimensioning during planning (e.g. diameter, pressure level)

## Comparative life cycle assessments of GF Piping Systems industrial systems

In collaboration with the independent Belgian institute VITO, the Global Quality & Sustainability department of GF Piping Systems calculated the life cycle assessments for four selected GF-specific industrial piping systems and compared each one with a system from the competition of the same application.

GF Piping Systems and VITO analyzed the environmental impacts of the systems over the entire life cycle – from cradle to grave. The calculation of the environmental impacts of the plastic systems is based on specific data of GF Piping Systems.

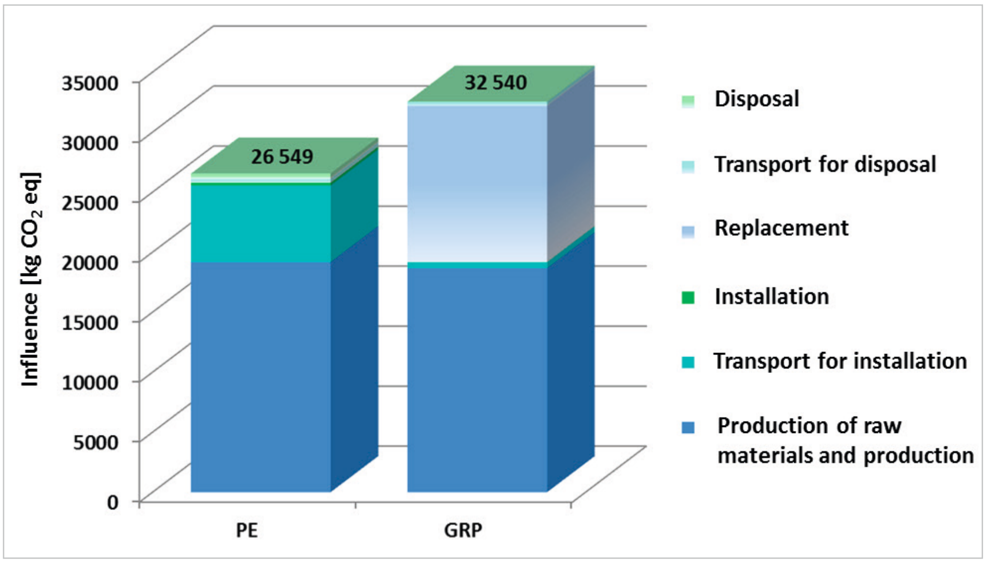
The following materials and applications were compared:

**T3.1 Comparison of materials and applications**

| Plastic | Comparative material | Anwendung |
|---|---|---|
| PP | Stainless steel | Transport of chemicals |
| PVC-U | Stainless steel | Dosing |
| PE | Glass fiber reinforced plastic (GRP) | Cooling water transport to a power plant |
| PB | Copper | Water distribution on a ship |

Based on the comparison materials, the industrial piping systems from GF Piping Systems are given a lower environmental impact than the systems from the competition. The conducted life cycle assessments confirm the results from other investigations and underscore the important significance of plastics in ecologically conscious piping system construction.

The following graphics shows the results in the impact category „global warming“ (excluding the utilization phase):




**G3.2 Results of "global warming" for PE**

The $CO_2$ savings of 5 991 kg correspond to the emissions that are caused by driving a car for 37 500 km or 1 times around the equator.

# 2 Approvals and Standards

## 2.1 Approvals of products

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

**T3.2 Abbreviations of approvals (edition: June 2016)**

| Abbreviation | Approval authority | Approved product range | Material |
|---|---|---|---|
| ABS | American Bureau of Shipping | Pipes, fittings, valves | ABS, PE, PVC-U, PVC-C |
| ACS | Attestation de Conformité Sanitaire | Fittings | PE |
| BSI<br>BSI GIS | BSI Assurance UK Limited | Fittings | PE, malleable cast iron |
| BULGARKONTROLLA | Bulgarkontrola S.A., | Fittings | PE |
| BV | Bureau Veritas | Pipes, fittings, valves | ABS, PE, PP-H, PVC-C, PVC-U |
| NF | CERTIgaz | Fittings | PE |
| DIBt | Deutsches Institut für Bautechnik | Pipes, fittings, valves | PVC-U, PP-H, PVDF, PE (Fittings) |
| DNV | Det Norske Veritas | Pipes, fittings, valves | ABS, PE, PP-H, PVC-C, PVC-U |
| DVGW | Deutscher Verein des Gas- und Wasserfaches | Gaskets | EPDM, NBR |
| | | Pipes, fittings, valves | PE, PP-H, PVC-C, PVC-U, malleable cast iron |
| EANDIS | Eandis cvba | Fittings | PE |
| ETI | Estonia Technical Inspectorate | Fittings, valves | PE |
| FM | FM Approvals | Pipes, fittings | PE |
| GAS | GAS s.r.o. | Fittings | PE |
| GL | Germanischer Lloyd | Pipes, fittings, valves | ABS, PE, PP-H, PVC-C, PVC-U |
| Global Mark | Global Mark | Fittings | PE |
| GOST-R | Rosstandart | Pipes, fittings, valves | ABS, PB, PE, PP, PVC-C, PVC-U, PVDF |
| GRDF | Gaz Réseau Distribution France | Fittings | PE |
| IGH | Institut IGH d.d. | Fittings | PE |
| IKRAM | Ikram QA Services SDN BHD | Fittings | PE |
| IIP | Instituto Italiano dei Plastici | Fittings | PE, PVC-U |
| INSTA-CERT | Dancert S/A | Fittings | PE |
| ITC | Institut pro testováni a certifikaci | Fittings | PE |
| KCW | Korea Water and Wastewater Works Association | Fittings | PE |
| KIWA<br>KIWA Gastec | Keuringsinstituut voor Waterleidingsartikelen | Fittings | PE, PVC-U<br>PE, malleable cast iron |
| KTW / W270 | Kunststoff-Trinkwasser-Empfehlungen | Dichtungen | EPDM, NBR |
| | | Fittings | PE, PVC-U |
| LR | Lloyd's Register of Shipping | Pipes, fittings, valvese | ABS, PE, PVC-U, PVC-C, PP-H |
| NK | Nippon Kaiji Kyokai | Pipes, fittings, valves | ABS, PB, PE, PP, PVC-C, PVC-U |
| NIGC | National Iranian Gas Co. | Fittings | PE |
| NSF | National Sanitary Foundation | Fittings | PE |
| ON | Österreichisches Normungsinstitut | Fittings | PE |

III

| Abbreviation | Approval authority | Approved product range | Material |
|---|---|---|---|
| ÖVGW | Österreichische Vereinigung für das Gas- und Wasserfach | Gaskets | EPDM, NBR |
| | | Pipes, fittings, valves | PE, PP, PVDF, malleable cast iron |
| PAEW | Public Authority for Electricity and Water Oman | Fittings, machines | PE |
| PROM | Promatomnadzor Weissruss-land | Fittings, machines | PE |
| PROMNAZOR | Promnazor, Kazakhstan | Fittings, machines | PE |
| RINA | Registro Italiano Navale | Pipes, fittings, valves | ABS, PE, PP-H, PVC-C, PVC-U |
| RMROS | Russian Maritime Register of Shipping | Pipes, fittings, valves | ABS, PE, PVC-C, PVC-U |
| RTN | ROSTECHNADZOR | Pipes, fittings, valves, machines | ABS, PB, PE, PP, PVC-C, PVC-U, PVDF |
| SEPRO | Niko Sepro OS, Ukraine | Fittings, Valves | PE |
| SVGW | Schweizerischer Verein des Gas- und Wasserfaches | Gaskets | EPDM, NBR |
| | | Fittings, valves | PB, PE, PP, malleable cast iron |
| TSSA | Technical Standards & Safety Authority | Pipes, fittings, valves | PVC-U, PVC-C, PP-H |
| VUSAPL | Vusapl, Slowakia | Fittings | PE |
| VUZ | Vyskumny Ustav Zvaracsky, Slowakia | Machines | - |
| WRAS | Water Regulations Advisory Scheme Water Byelaws Scheme | Gaskets | EPDM, NBR |
| | | Pipes, fittings | ABS, PE, PVC-U, PVC-C |

## 2.2 Standards and guidelines

### 2.2.1 Relevant standards and guidelines for pipes and fittings of PE

**T3.3 Standard and guidelines for pipes and fittings of PE (edition: June 2016)**

| Standard | Name |
|---|---|
| ISO 4427-1 | Plastics piping systems – Polyethylene (PE) pipes and fittings for water supply – Part 1: General |
| ISO 4427-2 | Plastics piping systems – Polyethylene (PE) pipes and fittings for water supply – Part 1: General |
| ISO 4427-3 | Plastics piping systems – Polyethylene (PE) pipes and fittings for water supply – Part 3: Fittings |
| ISO 4427-5 | Plastics piping systems – Polyethylene (PE) pipes and fittings for water supply – Part 5: Fitness for purpose of the system |
| 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 4437-5 | 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 pipes for fluids under pressure - Design lengths and size of threads - Metric series |
| ISO 17885 | Plastics piping systems – Mechanical fittings for pressure piping systems – Specifi-cations |
| 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 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 1555-5 | Plastics piping systems for the supply of gaseous fuels - Polyethylene (PE) - Part 5: Fitness for purpose of the system |
| CEN/TS 1555-7 | Plastics piping systems for the supply of gaseous fuels - Polyethylene (PE) - Part 7: Guidance for assessment of conformity |
| 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 12201-5 | Plastics piping systems for water supply, and for drainage and sewerage under pressure - Polyethylene (PE) - Part 5: Fitness for purpose of the system |
| 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 |
| AS/NZS 4129 | Fittings for polyethylene (PE) pipes for pressure applications |

## 2.2.2 Relevant standards and guidelines for processing

**T3.4 Relevant standards and guidelines for processing (edition: June 2016)**

| Standard | Name |
|---|---|
| ISO/TS 10839 | Polyethylene pipes and fittings for the supply of gaseous fuels - Code of practice for design, handling and installation |
| ISO 12176-1 | Plastics pipes and fittings – Equipment for fusion jointing polyethylene systems – Part 1: Butt fusion |
| ISO 12176-2 | Plastics pipes and fittings – Equipment for fusion jointing polyethylene systems – Part 2: Electrofusion |
| ISO 12176-3 | Plastics pipes and fittings - Equipment for fusion jointing polyethylene systems - Part 3: Operator's badge |
| ISO 12176-4 | Plastics pipes and fittings – Equipment for fusion jointing polyethylene systems – Part 4: Traceability coding |
| EN 12007-2 | Gas infrastructure - Pipelines for maximum operating pressure up to and including 16 bar - Part 1: General functional requirements; German version EN 12007-1:2012 |
| PAS 1075 | Pipes made from Polyethylene for alternative installation techniques – Dimensions, technical requirements and testing |
| DVS 2202 | Evaluation of joints between thermoplastics on piping parts and panels - Characteristics, description, evaluation |
| DVS 2202 Supplement-1 | Evaluation of imperfections in joints of thermoplastic materials to piping parts and panels. – heated plate welding (HS, IR) |
| DVS 2202 Supplement-2 | Evaluation of joints between thermoplastics on piping parts and panels - Sleeve welding with an incorporated heating element (HM) |
| 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 pipes, pipeline compo-nents and sheets made of PE |
| DVS 2210-1 | Industrial pipelines made of thermoplastics - Planning and execution - Abo-ve-ground pipe systems |
| DVS 2210-1 Supplement 1 | Industrial piping made of thermoplastics - Design and execution - Abo-ve-ground pipe systems - Calculation example |
| DVS 2210-1 Supplement 2 | Industrial piping made of thermoplastics - Design and execution - Abo-ve-ground pipe systems - Recommendations for the internal pressure and leak tests |
| DVS 2210-1 Supplement 3 | Industrial piping made of thermoplastics -Design and execution - Abo-ve-ground pipe systems - Flange connections: Description, requirements and assembly |
| DVS 2210-2 | Industrial Piping made of Thermoplastics - Design, Structure and Installa-tion of Two-pipe Systems |

## 2.2.3 Relevant standards and standards met for valves

**T3.5 Standards and guidelines for valves (edition: June 2016)**

| Standard | Name |
|---|---|
| EN 1555-4 | Plastics piping systems for the supply of gaseous fuels - Polyethylene (PE) - Part 4: Valves |
| EN 12201-4 | Plastics piping systems for water supply - Polyethylene (PE) - Part 4: Valves |
| EN 593 | Industrial valves - Metallic butterfly valves |
| 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 16139 | Industrial valves - Gate valves of thermoplastic materials |
| EN ISO 21787 | Industrial valves - Valves of thermoplastic materials |
| ISO 4437-4 | Plastics piping systems for the supply of gaseous fuels - Polyethylene (PE) - Part 4: Valves |

## 2.2.4 Relevant standards and guidelines for flanges and gaskets

**T3.6 Standards and guidelines for flanges (edition: June 2016)**

| Standard | Name |
|---|---|
| EN 681-1 | Elastomeric seals - Material requirements for pipe joint seals used in water and drainage applications - Part 1: Vulcanized rubber |
| EN 681-2 | Elastomeric seals - Material requirements for pipe joint seals used in water and drainage applications - Part 2: Thermoplastic elastomers |
| ISO 7005-1 | Pipe flanges - Part 1: Steel flanges for industrial and general service piping systems |
| ISO 7005-2 | Metallic flanges - Part 2: Cast iron flanges |
| ISO 7005-3 | Metallic flanges - Part 3: Copper alloy and composite flanges |
| 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 9624 | Thermoplastics pipes for fluids under pressure - Mating dimensions of flange adapters and loose backing flanges |
| 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 pipes, valves, fittings and accessories, PN designated – Part 1: Steel flanges |
| EN 1092-2 | Flanges and their joints - Circular flanges for pipes, 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 |
| ASME B16.5 | Pipe Flanges and Flanged Fittings: NPS 1/2 through NPS 24 Metric/Inch Standard |
| BS 10:2009 | Specification for flanges and bolting for pipes, valves and fittings |
| 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 |

## 2.2.5 Relevant standards and guidelines for threads

**T3.7 Standard and guidelines for threads (edition: June 2016)**

| Standard | Name |
|---|---|
| EN ISO 228-1 | Pipe threads where pressure-tight joints are not made on the threads - Part 1: Dimensions, tolerances and designation |
| 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 10226-2 | Pipe threads where pressure tight joints are made on the threads – Part 2: Taper external threads and taper internal threads – Dimensions, tolerances and designation |

## 2.2.6 Relevant standards and guidelines for malleable cast iron connectors

| Norm | Bezeichnung |
|---|---|
| ISO 17885 | Plastics piping systems. Mechanical fittings for pressure piping systems. Specifications |
| EN 10284 | Malleable cast iron fittings with compression ends for polyethylene (PE) piping systems |
| EN 10344 | Malleable cast iron fittings with compression ends for steel pipes |

# Design and Laying

## Content



IV

# 1 Basic knowledge

## 1.1 Metric and British system of units

The essential difference between the metric and the British system of units lies in the fact that one is based on the nominal diameter and the other on the outside diameter. The metric system of units utilizes the outside diameter and the values are given in mm. The British system utilizes the nominal diameter of the pipe and uses the inch system of units and fractions thereof.

### Conversions of metric and British system of units

| Metric sizes | | Inch sizes | |
|---|---|---|---|
| Pipe outer diameter $d_n$ (mm) | Nominal diameter DN (mm) | Nominal diameter DN (inch) | Pipe outer diameter $d_n$ (mm) |
| 10 | 6 | ⅛ | 10.2 |
| 12 | 8 | ¼ | 13.5 |
| 16 | 10 | ⅜ | 17.2 |
| 20 | 15 | ½ | 21.3 |
| 25 | 20 | ¾ | 26.9 |
| 32 | 25 | 1 | 33.7 |
| 40 | 32 | 1¼ | 42.4 |
| 50 | 40 | 1½ | 48.3 |
| 63 | 50 | 2 | 60.3 |
| 75 | 65 | 2½ | 75.3 |
| 90 | 80 | 3 | 88.9 |
| - | - | 3½ | 101.6 |
| 110 | 100 | 4 | 114.3 |
| 125 | 100 | - | - |
| 140 | 125 | 5 | 140.3 |
| 160 | 150 | 6 | 168.3 |
| 180 | 150 | - | - |
| 200 | 200 | 8 | 219.1 |
| 225 | 200 | 8 | 219.1 |
| 250 | 250 | 9 | 244.5 |
| 280 | 250 | 10 | 273.0 |
| 315 | 300 | 12 | 323.9 |
| 355 | 350 | 14 | 355.6 |
| 400 | 400 | 16 | 406.4 |
| 450 | 450 | 18 | 457.2 |
| 450 | 500 | 20 | 508.0 |
| 500 | 500 | 20 | 508.0 |
| 560 | 600 | 22 | 558.2 |
| 630 | 600 | 24 | 609.6 |
| - | - | 26 | 660.4 |
| 710 | 700 | 28 | 711.2 |
| - | - | 30 | 762.0 |
| 800 | 800 | 32 | 812.8 |
| - | - | 34 | 863.6 |
| 900 | 900 | 36 | 914.4 |
| 1000 | 1000 | 40 | 1016.0 |
| 1200 | 1200 | 48 | 1219.2 |
| 1400 | 1400 | 56 | 1422.4 |
| 1600 | 1600 | 64 | 1625.6 |
| 2000 | 2000 | 80 | 2032.0 |

# 1.2 Abbreviations and units of measure

## 1.2.1 Abbreviations for materials

| Abbreviation | Name |
|---|---|
| ABS | Acrylonitrile-butadiene-styrene |
| CR | Chloroprene rubber, e.g. neoprene |
| EPDM | Ethylene propylene rubber |
| FKM | Fluororubber |
| GFK | Glass-fiber reinforced plastics |
| Ms | Brass |
| NBR | Nitrile rubber |
| NR | Natural rubber |
| PB | Polybutylene |
| PE | Polyethylene |
| PE-X | Crosslinked polyethylene |
| PP | Polypropylene |
| PTFE | Polytetrafluorethylene |
| PVC | Polyvinylchloride |
| PVC-C | Polyvinylchloride postchlorinated (increased chlorine content |
| PVC-U | Polyvinylchloride plasticizer-free |
| PVDF | Polyvinylidenefluoride |
| TG | Malleable cast iron |
| UP-GF | Unsaturated polyester resin, fiberglass-reinforced |
| POM | Polyoxymethylene (Polyacetal) |

## 1.2.2 Abbreviations for procedures

| Abkürzung | Bezeichnung | |
|---|---|---|
| C | Design factor | Coefficient with a value greater than one, which takes account of both the operating conditions and the properties of the components of a pipeline system not yet recorded in the lower confidence limit. |
| S | Pipe series | Dimensionless key figure for designating pipes; S = (SDR-1)/2 |
| SDR | Standard dimension ratio | Whole-number numeric key figure for a pipe series that approximately corresponds to the ratio between the nominal outside diameter of a pipe and its nominal wall thickness |
| MFR | Melt mass-flow rate | Value that relates to the viscosity of a melted mass that is pressed through a die with a particular weight at a predefined temperature |
| MRS | Minimum required strength | Value of $\sigma$LCL (lower confidence limit of the predicted resistance to internal pressure) at 20 °C and 50 years |

### 1.2.3 Abbreviations for Dimensions and units

| Abkürzung | Bezeichnung |
|---|---|
| d, d1, d2, d3, d4 | Outer diameter |
| DN | Nominal diameter |
| $d_n$ | Nominal outer diameter (EN1555/EN12201) |
| SC | Size of hexagon head bolts |
| AL | Number of bolt holes |
| s | Wrench size |
| g | Weight in grams |
| e | Wall thickness of pipe |
| PN | Nominal pressure at 20 °C, water |
| 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$^2$<br>= 0.1 MPa<br>= 14.504 psi |

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

## 1.3 SI-units

### 1.3.1 SI base units

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

### 1.3.2 Internationally defined prefixes

| | Prefix | | Factor as | |
|---|---|---|---|---|
| Meaning | Name | Sign | 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 | deca | da | $10^{1}$ | = 10 |
| Tenth | deci | d | $10^{-1}$ | = 0.1 |
| Hundredth | centi | c | $10^{-2}$ | = 0.01 |
| Thousandth | milli | m | $10^{-3}$ | = 0.001 |
| Millionth | micro | µ | $10^{-6}$ | = 0.000 001 |
| Billionth | nano | n | $10^{-9}$ | = 0.000 000 001 |
| Trillionth | pico | p | $10^{-12}$ | = 0.000 000 000 001 |
| Quadrillionth | femto | f | $10^{-15}$ | = 0.000 000 000 000 001 |
| Quintillionth | atto | a | $10^{-18}$ | = 0.000 000 000 000 000 001 |

## 1.3.3 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<br>1 Sm = 1852 m |
| Area | A | $m^2$ | | | 1 b = $10^{-28}$ $m^2$<br>1 a = $10^2$ $m^2$<br>1 ha = $10^4$ $m^2$<br>sqm, sqdm, sqcm |
| 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<br>1 g = 2.467 • $10^{-4}$ sr |
| Time | t | s | min<br>h<br>d | 1 min = 60 s<br>1 h = 3600 s<br>1 d = 86 400 s | |
| Frequency | f | Hz | | 1 Hz = 1/s | |
| Speed,<br>rotational frequency | n | $s^{-1}$ | $min^{-1}$<br>U/min | 1 $min^{-1}$ (1/60) $s^{-1}$<br>1 U/min = 1 (1/min) | |
| Velocity | v | m/s | km/h | 1 km/h = (1/3.6) m/s | |
| Acceleration | g | $m/s^2$ | | Standard gravitational acceleration<br>$g_n$ = 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 | $kg/m^3$ | $t/m^3$<br>kg/l | 1 $t/m^3$ = 1000 $kg/m^3$<br>1 kg/l = 1000 $kg/m^3$ | |
| Moment of inertia | J | kg • $m^2$ | | | 1 kp • m $s^2$ = 9.81 kg • $m^2$ |
| Force | F | N | | 1 N = 1 kg • $m/s^2$ | 1 dyn = $10^{-5}$ N<br>1 p = 9.80665 • $10^{-3}$ N<br>1 kp = 9.80665 N |
| Torque | M | N • m | | | 1 kpm = 9.80665 Nm<br>1 Nm = 0.7375 lb-ft |
| Pressure | p | Pa | bar | 1 Pa = 1 $N/m^2$<br>1 bar = $10^5$ Pa | 1 atm = 1.01325 bar<br>1 at = 0.980665 bar<br>1 Torr = 1.333224 • $10^{-3}$ bar<br>1 m WS = 98.0665 • $10^{-3}$ bar<br>1 mm Hg = 1.333224 • $10^{-3}$bar |
| Stress | σ | $N/m^2$<br>Pa | | 1 $N/m^2$ = 1 Pa | 1 $kp/m^2$ = 9.80665 $N/m^2$<br>1 $kp/cm^2$ = 98.0665 $10^{-3}$ $N/m^2$<br>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<br>E | J | eV<br>W • h | 1 J = 1 Nm = 1 WS<br>1 W • h = 3.6 KJ | 1 cal = 4.1868 J<br>1 kpm = 9.80665 J<br>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<br>1 W = 1 V • A | 1 PS = 735.498 W<br>1 kcal/h = 1.163 W<br>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<br>0 °C = 273.15 K | |
| Celsius temperature | t, δ | °C | | Δ 1 °C = Δ 1 K<br>0 K = -273.15 °C | |
| Thermal capacity | C | J/K | | | 1 Kcl/grad = 4.1868 $10^{-3}$ J/K<br>1 Cl = 4.1868 J/K |

# 1.4 Conversion tables

## 1.4.1 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 m²/s |
|---|---|---|---|---|---|---|---|---|---|---|
| 1.0 | 1.0 | 1.0 | 31 | 29 | - | - | - | - | 0.01 | $1.0 \times 10^{-6}$ |
| 2.0 | 2.0 | 1.1 | 34 | 30 | - | - | 3640 | - | 0.02 | $2.0 \times 10^{-6}$ |
| 3.0 | 3.0 | 1.2 | 35 | 33 | - | - | 2426 | - | 0.03 | $3.0 \times 10^{-6}$ |
| 4.0 | 4.0 | 1.3 | 37 | 35 | - | - | 1820 | - | - | $4.0 \times 10^{-6}$ |
| 5.0 | 5.0 | 1.39 | 42 | 38 | - | - | 1300 | - | 0.05 | $5.0 \times 10^{-6}$ |
| 6.0 | 6.0 | 1.48 | 45.5 | 40.5 | - | - | 1085 | - | 0.06 | $6.0 \times 10^{-6}$ |
| 7.0 | 7.0 | 1.57 | 48.5 | 43 | - | - | 930 | - | 0.07 | $7.0 \times 10^{-6}$ |
| 8.0 | 8.0 | 1.65 | 53 | 46 | - | - | 814 | - | 0.08 | $8.0 \times 10^{-6}$ |
| 9.0 | 9.0 | 1.74 | 55 | 48.5 | - | - | 723 | - | 0.09 | $9.0 \times 10^{-6}$ |
| 10 | 10 | 1.84 | 59 | 52 | - | - | 650 | - | 0.10 | $1.0 \times 10^{-5}$ |
| 20 | 20 | 2.9 | 97 | 85 | 15 | - | 320 | - | 0.2 | $2.0 \times 10^{-5}$ |
| 40 | 40 | 5.3 | 185 | 163 | 21 | - | 159 | - | 0.4 | $4.0 \times 10^{-5}$ |
| 60 | 60 | 7.9 | 280 | 245 | 30 | 18.7 | 106 | 5.6 | 0.6 | $6.0 \times 10^{-5}$ |
| 80 | 80 | 10.5 | 370 | 322 | 38 | 25.9 | 79 | 6.7 | 0.8 | $8.0 \times 10^{-5}$ |
| 100 | 100 | 13.2 | 472 | 408 | 47 | 32 | 65 | 7.4 | 1.0 | $1.0 \times 10^{-4}$ |
| 200 | 200 | 26.4 | 944 | 816 | 92 | 60 | 32.5 | 11.2 | 2.0 | $2.0 \times 10^{-4}$ |
| 400 | 400 | 52.8 | 1888 | 1632 | 184 | 111 | 15.9 | 18.4 | 4.0 | $4.0 \times 10^{-4}$ |
| 600 | 600 | 79.2 | 2832 | 2448 | 276 | 162 | 10.6 | 26.9 | 6.0 | $6.0 \times 10^{-4}$ |
| 800 | 800 | 106 | 3776 | 3264 | 368 | 217 | 8.1 | 35 | 8.0 | $8.0 \times 10^{-4}$ |
| 1000 | 1000 | 132 | 7080 | 4080 | 460 | 415 | 6.6 | 68 | 10 | $1.0 \times 10^{-3}$ |
| 5000 | 5000 | 660 | 23 600 | 20 400 | 2300 | 1356 | 1.23 | 240 | 50 | $5.0 \times 10^{-3}$ |
| 10 000 | 10 000 | 1320 | 47 200 | 40 800 | 4600 | 2713 | - | 481 | 100 | $1.0 \times 10^{-2}$ |
| 50 000 | 50 000 | 6600 | 236 000 | 204 000 | 23 000 | 13 560 | - | 2403 | 500 | $5.0 \times 10^{-2}$ |

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

## 1.4.2 Flow volume

| m³/h | l/min | l/s | m³/s | Imp. gal/min | US gal/min | cu. ft./h | cu. ft./s |
|---|---|---|---|---|---|---|---|
| 1.0 | 16.67 | 0.278 | $2.78 \cdot 10^{-4}$ | 3.667 | 4.404 | 35.311 | $9.81 \cdot 10^{-3}$ |
| 0.06 | 1.0 | 0.017 | $1.67 \cdot 10^{-5}$ | 0.220 | 0.264 | 2.119 | $5.89 \cdot 10^{-4}$ |
| 3.6 | 60 | 1.0 | $1.00 \cdot 10^{-3}$ | 13.20 | 15.853 | 127.12 | $3.53 \cdot 10^{-2}$ |
| 3 600 | 60 000 | 1000 | 1.0 | 13 200 | 15 838 | 127 118 | 35.311 |
| 0.2727 | 4.55 | 0.076 | $7.58 \cdot 10^{-5}$ | 1.0 | 1.201 | 9.629 | $2.67 \cdot 10^{-3}$ |
| 0.2272 | 3.79 | 0.063 | $6.31 \cdot 10^{-5}$ | 0.833 | 1.0 | 8.0238 | $2.23 \cdot 10^{-3}$ |
| 0.0283 | 0.47 | 0.008 | $7.86 \cdot 10^{-6}$ | 0.104 | 0.125 | 1.0 | $2.78 \cdot 10^{-4}$ |
| 101.94 | 1 699 | 28.32 | $2.83 \cdot 10^{-2}$ | 373.77 | 448.8 | 3 600 | 1.0 |

## 1.4.3 Pressure and 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 |
| $13.3 \cdot 10^{-4}$ | 0.0014 | 0.0193 | $13.2 \cdot 10^{-4}$ | 0.0446 | 0.0136 | 1.0 | 0.0394 | 0.133 |
| 0.0339 | 0.0345 | 0.4912 | 0.0334 | 1.1329 | 0.3453 | 25.40 | 1.0 | 3.39 |
| $1.0 \cdot 10^{-5}$ | $10.2 \cdot 10^{-6}$ | $14.5 \cdot 10^{-5}$ | $9.87 \cdot 10^{-6}$ | $3.34 \cdot 10^{-4}$ | $10.2 \cdot 10^{-5}$ | $75.0 \cdot 10^{-4}$ | $29.5 \cdot 10^{-5}$ | 1.0 |

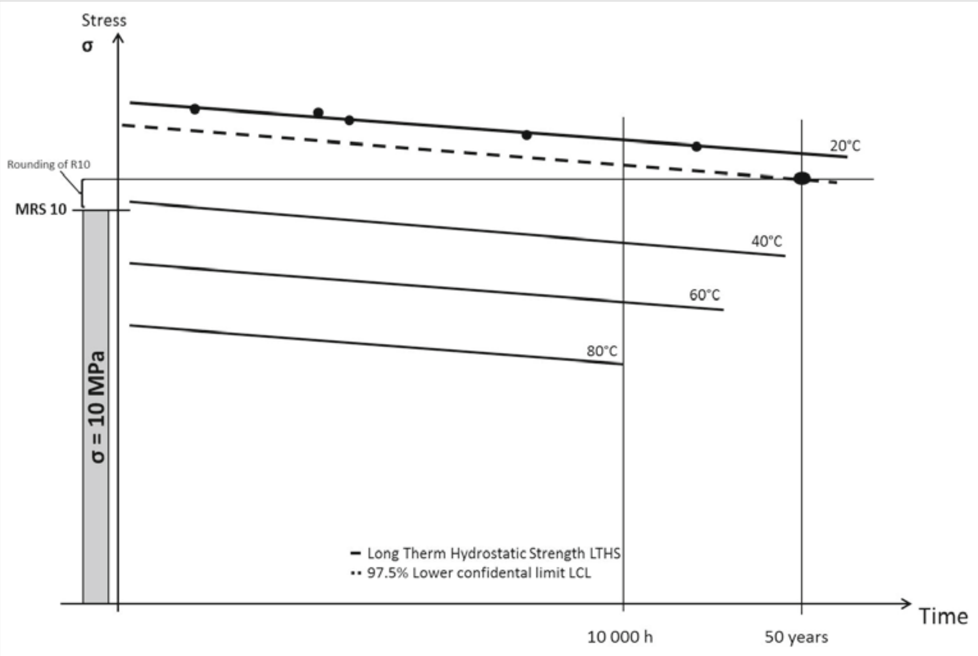
atm International standard atmosphere
kg/cm² Metric atmosphere

# 2 Design

## 2.1 Long-term behavior of thermoplastic materials

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

### 2.1.1 MRS-values




We differentiate between the properties relating to the creep behavior of the pressure pipe plastics using a standardized classification system. The starting point for classification is the determination of the charts for long-term failure under internal hydrostatic pressure and the evaluation of these charts based on standard extrapolation methods. The maximum stress over time at constant temperature is determined. The LTHS (long-term hydrostatic strength) expected value forms the theoretical curve for the determined test values. The stress determined in this way at 50 years (rounded to the next-lowest standard preferred number) forms the MRS (minimum required strength) value – the material-specific minimum strength.

Classification of PE materials:

| Material | MRS-Wert (MPa) | σLCL |
|---|---|---|
| PE63 | 6 | 6.3-7.99 |
| PE80 | 8 | 8.0-9.99 |
| PE100 / PE100 RC | 10 | 10.0-11.19 |

## 2.1.2 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 pressure-temperature diagram that we provide for pipes 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.

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**

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

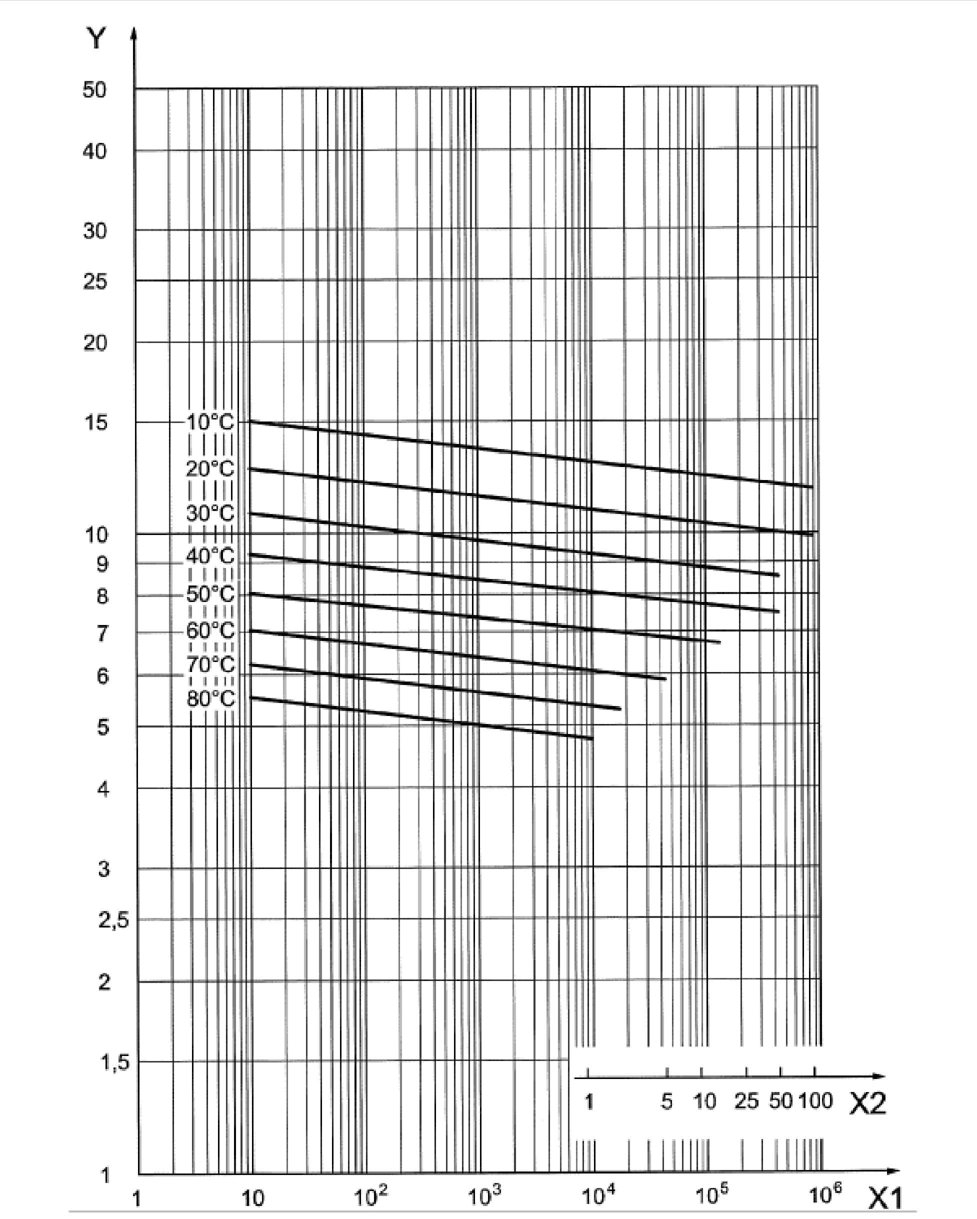
**PE80**

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

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

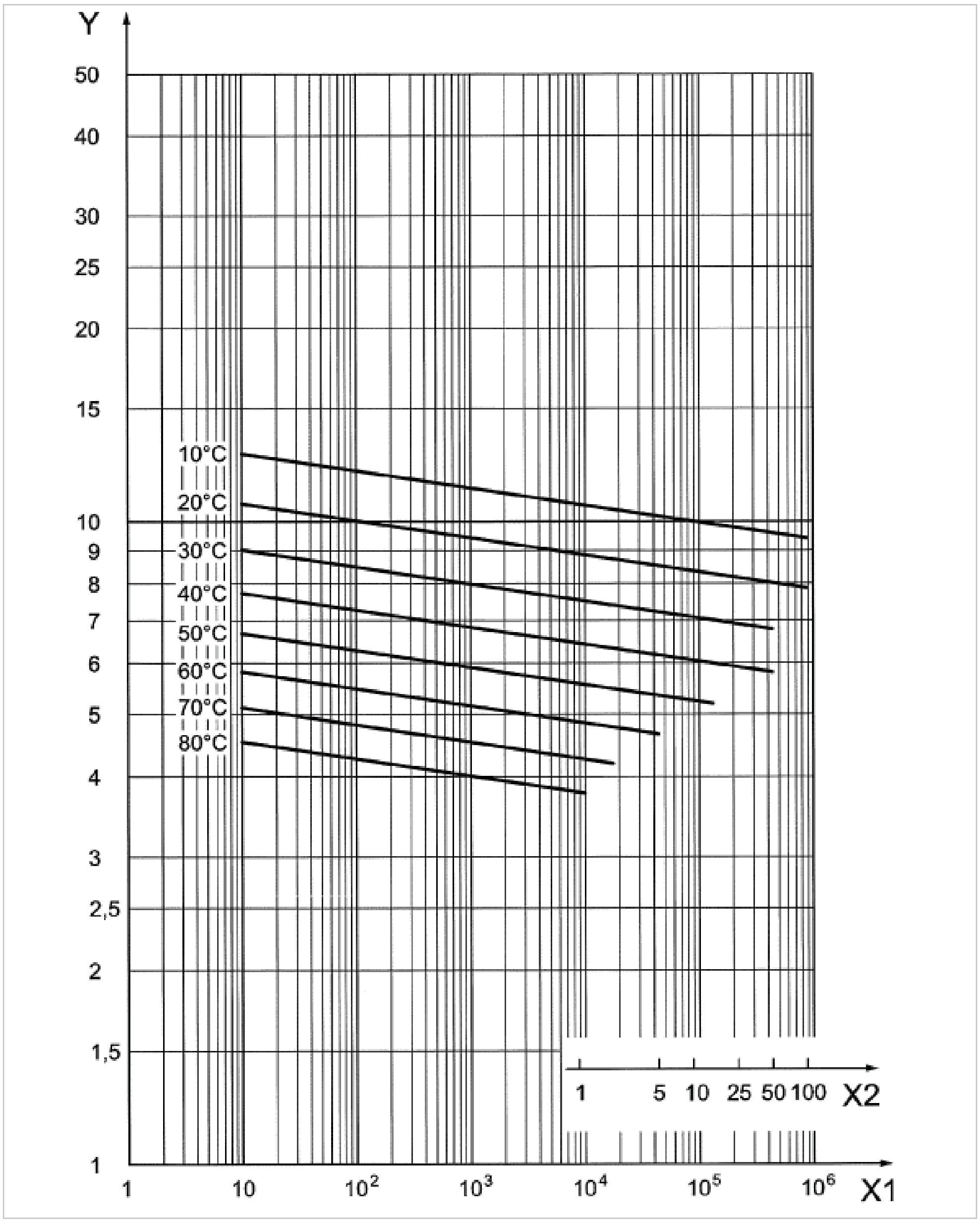
IV

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




$X_1$ Time to failure, in hours (h)
$X_2$ Time to failure, in years
Y Hoop stress (MPa)
(1 MPa = 1 $N/mm^2$)

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




$X_1$ Time to failure, in hours (h)
$X_2$ Time to failure, in years
Y Hoop stress (MPa)
(1 MPa = 1 N/mm$^2$)

## 2.2 Range of applications for pipes and fittings

### 2.2.1 In general

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

The decisive influencing factors are the following:

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

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

### 2.2.2 Pressure-temperature diagram for PE

#### PE100

A PE system is designed based on average operating conditions taking account of the maximum values. In contrast to metal pipelines, PE pipelines are designed with the aim of a guaranteed life. The average operating conditions must be used as the basis for this.

If, for example, a line is exposed to a temperature of 40°C for one month at the hottest time, this is not the temperature used as the basis for the calculation. A more accurate value is the annual average temperature. As a result, the line is not overdimensioned and is instead designed exactly to meet the operating condition requirements. The design factors, described later, provide additional reliability.

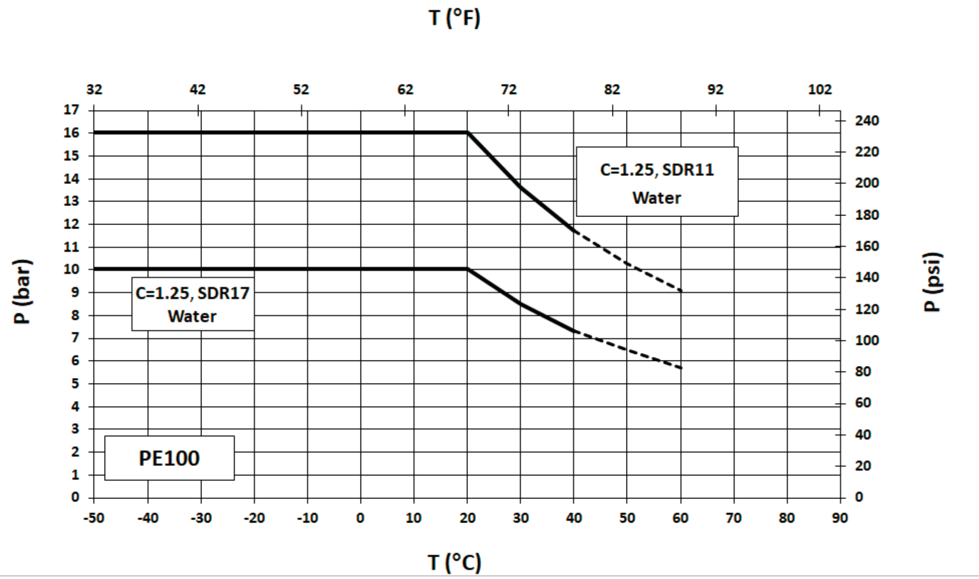
The following pressure-temperature diagram for PE100 pipes and fittings is valid for a service life of 50 years.

The design factor of 1.25 for water and 2.0 for gas has been incorporated.

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

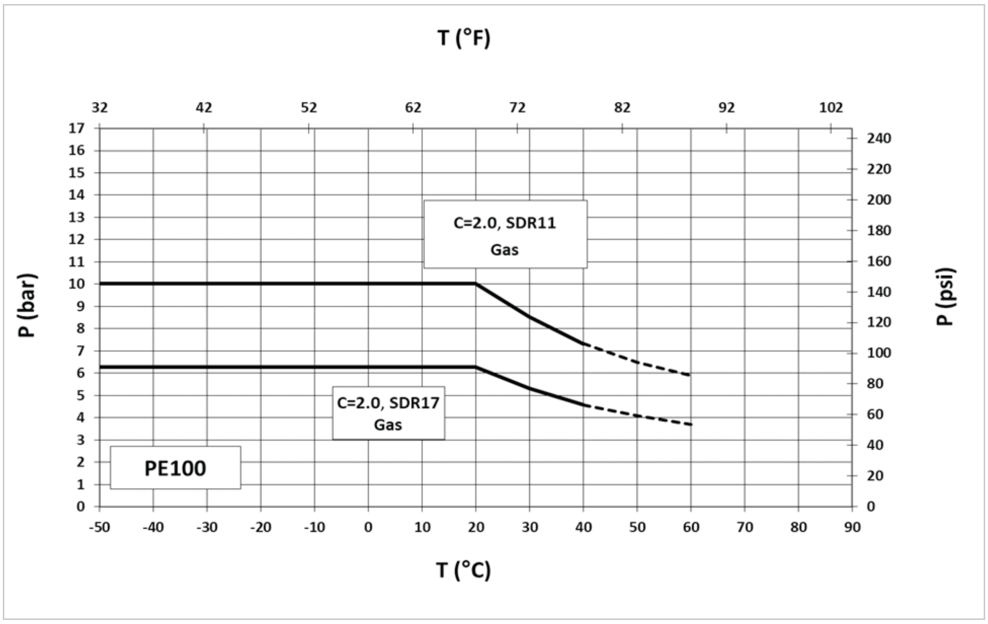
**!** **Please take into account the pressure-temperature diagrams for valves and special fittings. Because of the construction and/or sealing material used, differences are possible when compared to pipes and fittings. More information is available in the Planning Fundamentals of the relevant types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

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




### G4.3 Pressure-temperature diagram for PE100, water

1 Design factor C = 1.25, S5, SDR11 for 20 °C water, 50 years
2 Design factor C = 1.25, S8.3, SDR17.6 and S8, SDR17 for 20 °C water, 50 years
P Permissible pressure (bar, psi)
T Temperature (°C, °F)




### G4.4 Pressure-temperature diagram for PE100, gas

1 Design factor C = 2.0, S5, SDR11 fr 20 °C gas, 50 years
2 Design factor C = 2.0, S8.3, SDR17o.6 and S8, SDR17 for 20 °C gas, 50 years
P Permissible pressure (bar, psi)
T Temperature (°C, °F)

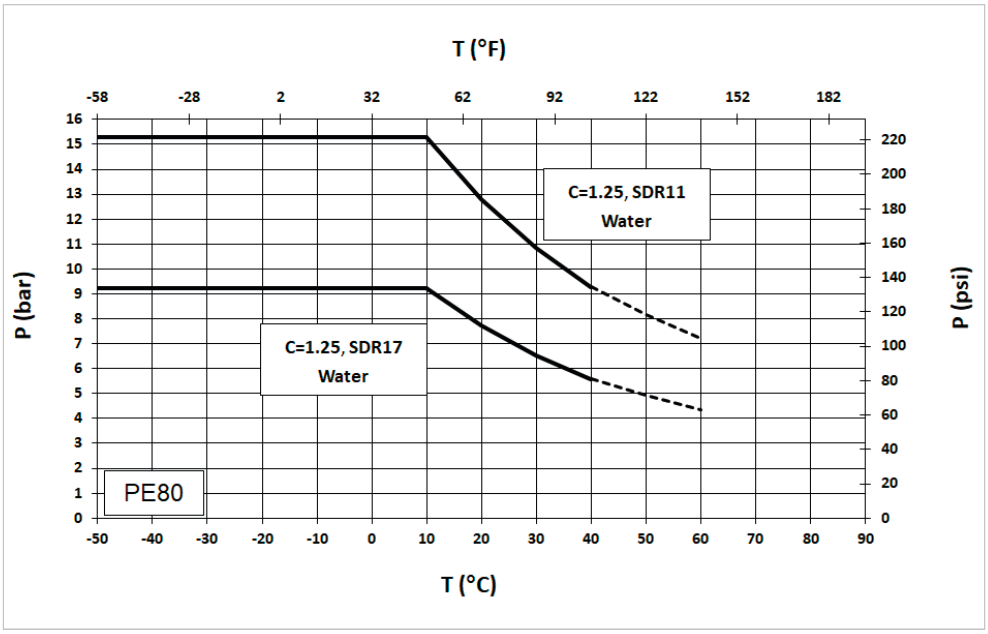
## PE80

The following pressure-temperature diagram for PE80 pipes and fittings is valid for a service life of 50 years.

The design factor of 1.25 for water and 2.0 for gas has been incorporated.

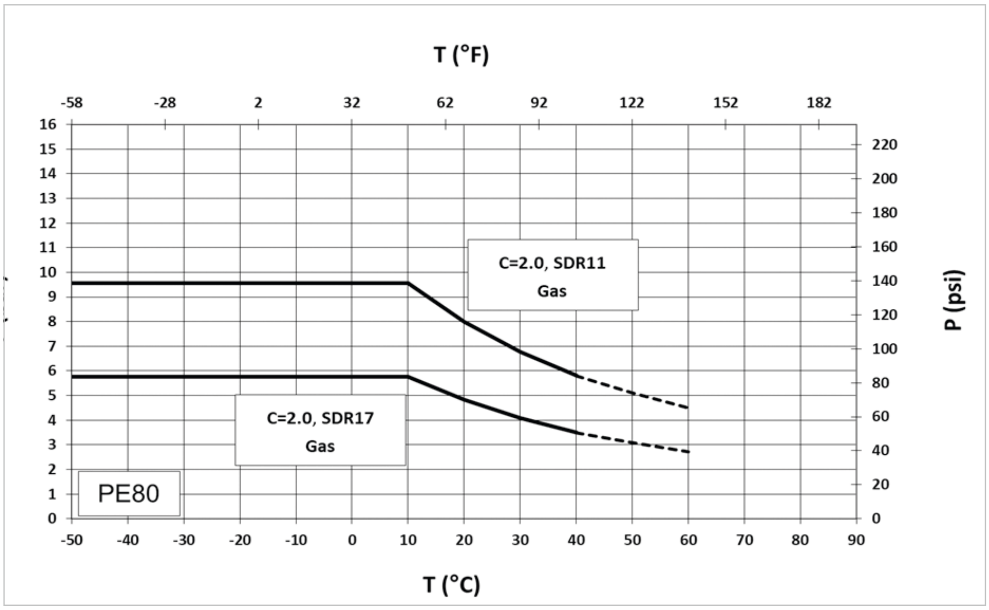
It can be used for water or media resembling water, in other words, media that have no reduction factor for chemical resistance.

> **!** **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 pipes and fittings. More information is available in the Planning Fundamentals of the relevant types of valves and special fittings.**
>
> **In case of long-term operating pressure at temperatures above 40 °C, please contact your authorized GF Piping Systems representative.**




**G4.5 Pressure-temperature diagram for PE80, water**

1 Design factor C = 1.25, S5, SDR11 for 20 °C water, 50 years
2 Design factor C = 1.25, S8.3, SDR17.6 and S8, SDR17 for 20 °C water, 50 years
P Permissible pressure (bar, psi)
T Temperature (°C, °F)




**G4.6 Pressure-temperature diagram for PE80, gas**

1 Design factor C = 2.0, S5, SDR11 for 20 °C Gas, 50 years
2 Design factor C = 2.0, S8.3, SDR17.6 and S8, SDR17 for 20 °C Gas, 50 years
P Permissible pressure (bar, psi)
T Temperature (°C, °F)

## 2.3 Calculation of allowable pressure/required wall thickness

### 2.3.1 Selecting plastic piping components

Dimensioning of thermoplastic pipes 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)
$\sigma_{zul}$ Allowable hoop stress (N/mm²)

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

ISO 4065 classifies pipes by series according to pressure rating, so that pipes 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:

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

IV

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

SDR = 2 · 5 + 1 = 11

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

### 2.3.2 Calculating the effective design factor / permissible operating pressure

To calculate the design factor and allowable operating pressure, it is necessary to know the long-term behavior of the material. Such a diagram allows the long-term creep strength to be read depending on the desired service life and operating temperature. For fittings and valves, the wall thickness is usually greater than for pipes 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 | 50 Jahre |
| Max. operating temperature | +20 °C |
| Max. operating pressure | 10 bar |
| Material | PE100 |
| Intended pressure level | PN16 bar |
| Outside diameter | 110 mm |
| Wall thickness | 10 mm |
| Hoop stress | 8.52 N/mm² |

$$C = \frac{10 \cdot 20 \cdot 10}{10 \cdot (110 - 10)} = 2.0 > 1.25$$

For the sake of clarity, the calculations are carried out using the example above, but using the usual minimum design factor for PE100.

$$p = \frac{20 \cdot 10 \cdot \left(\frac{10}{1.25}\right)}{(110 - 10)} = 16 \text{ bar}$$

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

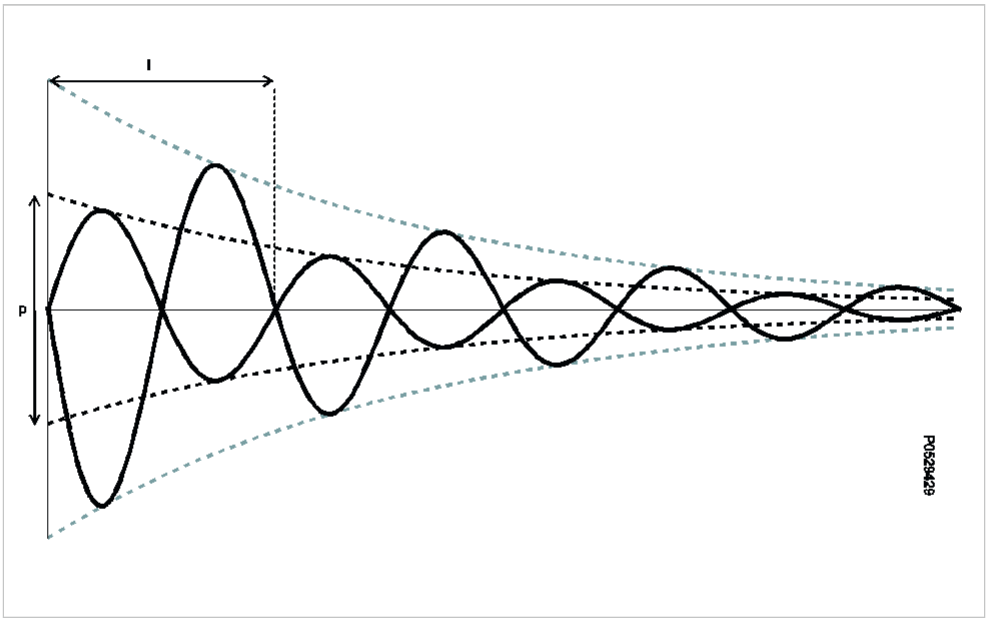
## 2.4 Water hammer

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

Water hammers may be generated by the following:

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

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




**G4.7 Damped pressure wave**

l Wave length
p Pressure change

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

## ❶ Determine the velocity of the pressure

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

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

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

## ❷ Calculate maximum pressure change due to water hammers

$$\Delta p = V_w \cdot \Delta v \cdot \rho \,/\, 10000$$

$\Delta p$ Maximum pressure change (bar)
$V_w$ Pressure wave velocity (m/s) (see step 1)
$\Delta v$ Change in fluid velocity (m/s) = (v1-v2)
v1 Velocity of fluid before change (m/s)
v2 Velocity of fluid after change (m/s)
$\rho$ Fluid density (kg/m$^3$)

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

## ❸ Calculate the maximum and minimum total pressure

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

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

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

## ❹ Calculate the effective safety factor

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

$C_{max}$ Safety factor (dimensionless)
$\sigma$ 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 ($p_{max}$) 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 $T_c$ 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 | PE100 |
| Outside diameter | 110 mm |
| Wall thickness | 10 mm |
| Nominal pressure | PN16 (SDR11) |
| Pipeline length | 500 m |
| Operating temperature | 20 °C |
| Modulus of elasticity | $E = 1320\ N/mm^2 = 1320 \times 10^6\ Pa$ |
| 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

$$V_w = \sqrt{\frac{2.05 \cdot 10^9}{10^3 \cdot \left(1 + \frac{90 \cdot 2.05 \cdot 10^9}{10 \cdot 1320 \cdot 10^6}\right)}} = 370\ m/s$$

## 2 Calculating the fluid velocity before the change

$$v_1 = \frac{\text{Volumendurchsatz}}{\text{Querschnittsfläche}}$$

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

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

**Pressure change**
$\Delta p = 370 \cdot (1.53) \cdot 1000/1000 = 5.65$ bar

## 3 Calculating the maximum pressure

$p_{max} = 16 + 5.65 = 21.65$ bar

$\Delta p$ is less then 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.

$\sigma = 13.9$ N/mm$^2$

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

$$C = \frac{20 \cdot 13.9 \cdot 10}{21.65 \cdot (110 - 10)} = 1.28$$

## 5 Calculating the maximum safety factor

The minimum safety factor for PE100 can be set to 1.25. Here, C = 1.28 > 1.2, so this piping is suitable for infrequent water hammers. However it would not be suitable if periodic water hammers occurred, because in that case we would need C > 3. Pipe dimensions or valve closing time would need to be adjusted in order to reduce water hammer.

**Calculating the critical period**

$$T_c = \frac{2 \cdot L}{V_w} = \frac{2 \cdot 500\ \text{m}}{370\ \text{m/s}} = 2.70\ \text{s}$$

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

## 2.5 Pipelines 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 pipes:

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

$P_k$ Critical buckling pressure (N/mm$^2$) (1 N/mm$^2$ = 10 bar)
$E_c$ Long-term creep modulus (N/mm$^2$)
$\mu$ Poisson's ratio
e Pipe wall thickness (mm)
r Mean pipe radius (mm)

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

(25 year values: Poisson's ratio μ = 0,4; design factor = 2)

### 2.5.1 Pipes and fittings

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

| Material | PN (bar) | SDR | Temperature (°C) |
|---|---|---|---|
| **PE80** | 10 | 11 | 50 |
| **PE100 / PE100 RC** | 16 | 11 | 60 |

### 2.5.2 Mechanical connections

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

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

## 2.5.3 Laying in industrial applications

In the classical application of "pipeline systems for utilities," pipelines are usually laid in the ground and the trenches are refilled once the pipeline construction work has been completed. As a result, the ambient temperatures are very constant and changes in length are prevented by the surrounding earth.

In contrast, when lines are laid in industrial applications, particular attention must also be paid to the following points:

- Changes in length as a result of the effects of temperature
- Deflections
- Choice of suitable connection technology

Special construction measures must be investigated and implemented to counteract this influencing factor. These can include the installation of bends, pipe brackets and compensators. Detailed documents relating to pipeline systems made of polyethylene and other materials can be found in the "Industrial Pipeline Systems" planning fundamentals.

## 2.5.4 Calculation of length changes

The change in length caused by temperature can be calculated using the following formula:

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

$\Delta L$ Temperature-related length change (mm)
$L$ Length of the pipe section (m)
$\Delta T$ Difference of temperature (K)
$\alpha$ Coefficient of linear expansion (mm/m K)

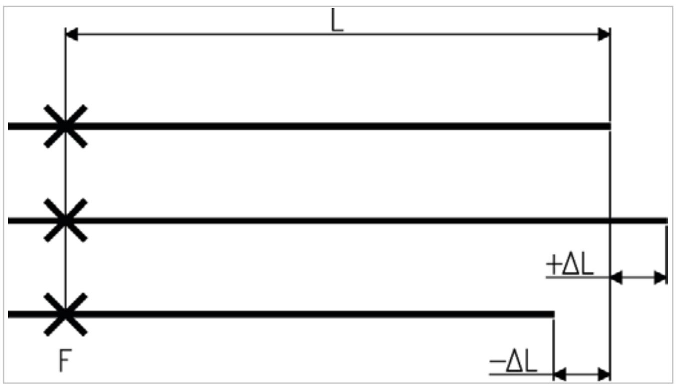
### Coefficients of linear expansion of polymers

| Material | $\alpha$ = mm/m K |
|---|---|
| PE | 0.15 – 0.20 |

Exact values can be calculated using GF Piping Systems' online tool (www.cool-fit.georgfischer.com) or requested directly from the authorized GF Piping Systems representative.

! **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.



## 2.5.5 Calculation of flexible sections

The required length of the flexible section can be calculated using the following formula:

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

| | |
|---|---|
| $L_B$ | Length of flexible section (mm) |
| $d_a$ | Pipe outer diameter (mm) |
| $\Delta L$ | Length change (mm) |
| $E_{cm}$ | Average bending creep modulus for t = 25 a (N/mm²) |
| $\sigma_b$ | Permissible bending stress for t = 25 a (N/mm²) |

**! Because $E_{cm}$ and $\sigma_b$ are dependent on time, temperature and stress, it is difficult to calculate LB. Therefore the following diagrams should be used instead of the formula.**

## 2.5.6 Pipe clamping distance and fastening of installation of pipes

### Overview

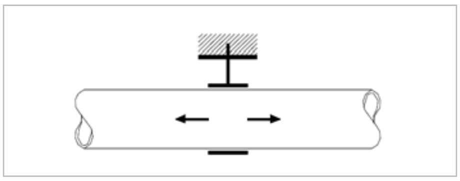
**Installation of plastic pipes**

Plastic pipes should be installed using supports designed for use with plastics and should then be installed taking care not to damage or overstress the pipe.

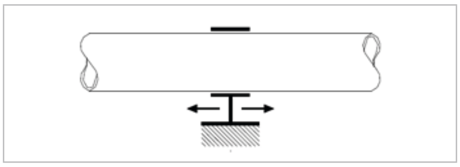
**Arranging loose brackets**

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.

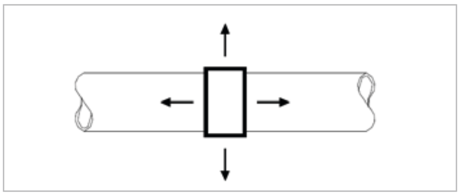
Movement of the pipe in the pipe bracket.



Pipe bracket firmly installed on the pipe, movement in the bracket suspension.



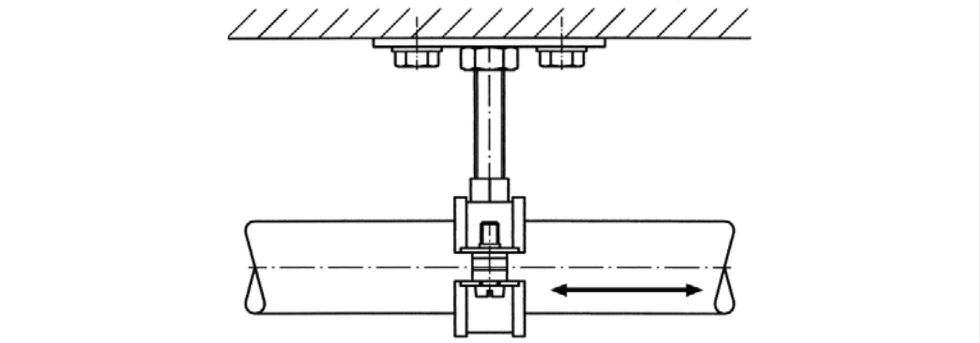
Movement of the pipe in 2 axes.



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.

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



**G4.8 Spacers prevent clamping the pipe**

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

Sliding brackets and hanging brackets permit the pipe to move in different directions. Attaching a sliding block to the base of the pipe bracket permits free movement of the pipe along a flat supporting surface. Sliding and hanging brackets are needed in situations where the pipeline changes direction and free movement of the pipe must be allowed.

**Arranging fixed points**

A fixed pipe bracket is a bracket which prevents the pipe from moving in any direction. The purpose of a fixed point is to control system stresses caused by temperature changes.

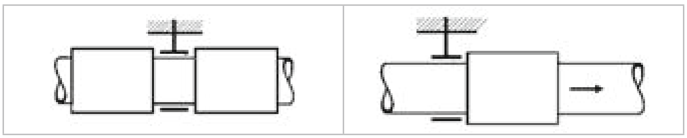
! **Fixed point design**

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

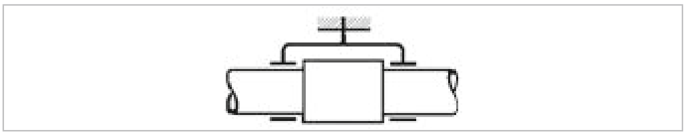
If it is necessary to restrict the length change of the pipe at both ends – as it is usually the case – then the pipe bracket should be arranged between two fittings or designed as a double bracket (two-sided fixed point).

Placing a pipe bracket immediately adjacent to a fitting restricts movement due to changes in length to one direction (one-sided fixed point).

One sided fixed point



Two sided fixed point



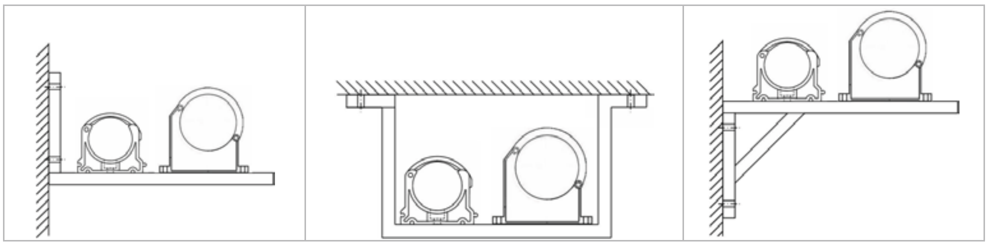
! **Pipe brackets must be robust and mounted firmly to be able to take up the forces arising from changes in length in the pipeline. Hanging brackets or KLIP-IT pipe brackets are unsuitable for use as fixed points.**

### KLIP-IT pipe brackets

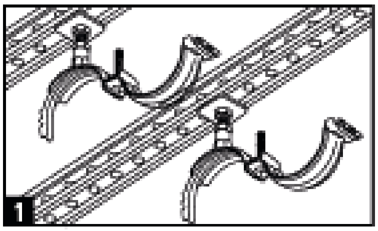
These robust plastic pipe brackets can be used not only under rigorous operating conditions, but also where the pipework is subject to aggressive media or atmospheric conditions. Pipe brackets and pipe clamps from GF Piping Systems are suitable for all pipe materials used.

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

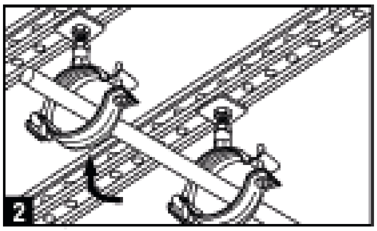
Starting from the dimension d90, the KLIP-IT brackets must be installed standing, as shown in the following assembly examples.



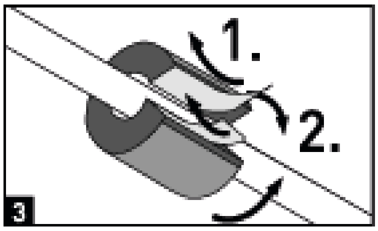
### T4.8 Pipe brackets for cold insulation MIP



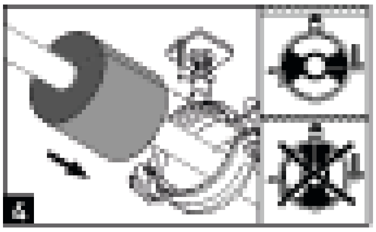

Open handle



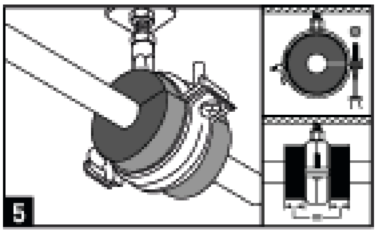

Insert pipe, close handle with quick action clamp



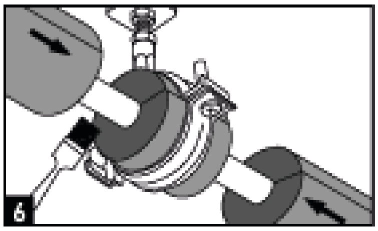

Assemble insulation
1. Peel off foil
2. Press on contact area




Push insulation into the bracket. Caution: Make sure the rigid foam is positioned correctly.




Tighten the screw

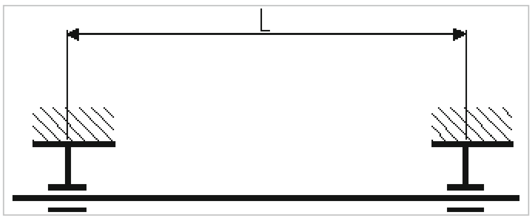



Coat contact areas with adhesive and bond the insulation

### Using information for pipe spacing

Plastic pipelines must be  supported at certain intervals depending in the material, average pipe wall temperature, density oft he flow medium, pipe diameter and pipe wall thickness. The distances between the pipe clmaps were calculated based on a particular pipe deflection (regarded as permissible) between two brackets.

Pipelines that are clamped in an axially rigid manner and permanently laid must be tested for resistance to buckling. In most cases, this test leads to a reduction of the maximum internal pressure and a reduction of the spacing between supports. Furthermore, the forces acting on the fixed points must be taken into consideration.



## Bracket spacing for PE pipes

**Liquids with a density of 1 g/cm³**

| d (mm) | Bracket spacing L for SDR11 pipes (mm) | | | | |
|---|---|---|---|---|---|
| | ≤ 20 °C | 30 °C | 40 °C | 50 °C | 60 °C |
| 16 | 500 | 450 | 450 | 400 | 350 |
| 20 | 575 | 550 | 500 | 450 | 400 |
| 25 | 650 | 600 | 550 | 550 | 500 |
| 32 | 750 | 750 | 650 | 650 | 550 |
| 40 | 900 | 850 | 750 | 750 | 650 |
| 50 | 1050 | 1000 | 900 | 850 | 750 |
| 63 | 1200 | 1150 | 1050 | 1000 | 900 |
| 75 | 1350 | 1300 | 1200 | 1100 | 1000 |
| 90 | 1500 | 1450 | 1350 | 1250 | 1150 |
| 110 | 1650 | 1600 | 1500 | 1450 | 1300 |
| 125 | 1750 | 1700 | 1600 | 1550 | 1400 |
| 140 | 1900 | 1850 | 1750 | 1650 | 1500 |
| 160 | 2050 | 1950 | 1850 | 1750 | 1600 |
| 180 | 2150 | 2050 | 1950 | 1850 | 1750 |
| 200 | 2300 | 2200 | 2100 | 2000 | 1900 |
| 225 | 2450 | 2350 | 2250 | 2150 | 2050 |
| 250 | 2600 | 2500 | 2400 | 2300 | 2100 |
| 280 | 2750 | 2650 | 2550 | 2400 | 2200 |
| 315 | 2900 | 2800 | 2700 | 2550 | 2350 |
| 355 | 3100 | 3000 | 2900 | 2750 | 2550 |
| 400 | 3300 | 3150 | 3050 | 2900 | 2700 |
| 450 | 3550 | 3400 | 3300 | 3100 | 2900 |
| 500 | 3900 | 3650 | 3500 | 3350 | 3100 |

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

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

The pipe bracket spacing given in the table may be increased by 30 % in the case of vertical pipe runs, i.e., multiply the values given by 1.3.

**Liquids with a density other than 1g/cm³**

If the liquid to be transported has a density other than 1 g/cm³, then the bracket spacings in the table above should be multiplied by the factor given in the following table to obtain different support spacings.

| Density of medium (g/cm³) | Type of medium | Factors for bracket spacing |
|---|---|---|
| 1.00 | Water | 1.00 |
| 1.25<br>1.50<br>1.75<br>2.00 | Other media | 0.96<br>0.92<br>0.88<br>0.84 |
| ≤ 0.01 | Gaseous media | 1.30 for SDR11<br>1.21 for SDR7.4 |

# 3 Hydraulic Calcuation and Pressure Losses

## 3.1 Hydraulic calculation

### 3.1.1 Required pipe diameter

#### Formulas

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

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

| | |
|---|---|
| $v$ | Flow velocity (m/s) |
| $d_i$ | Pipe inner diameter (mm) |
| $Q_1$ | Flow rate ($m^3$/h) |
| $Q_2$ | Flow rate (l/s) |
| 18.8 | Conversion factor for units Q1 ($m^3$/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 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.

**T4.9 Conversation table with units for flow rate**

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

IV

**Example for calculating the inner diameter $d_i$**

| | |
|---|---|
| PE100 pipe | SDR11 |
| Flow volume $Q_2$ | 8 l/s |
| Flow velocity | 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:

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

| | |
|---|---|
| v | Flow velocity (m/s) |
| $d_i$ | Pipe inner diameter (mm) |
| $Q_1$ | Flow rate ($m^3$/h) |
| $Q_2$ | Durchflussmenge (l/s) |
| 354 | Conversion factor for units Q1 ($m^3$/h) |
| 1275 | Conversion factor for units Q2 (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:

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

**T4.10 Correlation of outside diameter to inside diameter for SDR11 and SDR17/17.6**

| $d_i$ (mm) | SDR11 d (mm) | $d_i$ (mm) | SDR17/17.6 d (mm) |
|---|---|---|---|
| 16 | 20 | 16 | 20 |
| 20 | 25 | 21 | 25 |
| 26 | 32 | 28 | 32 |
| 33 | 40 | 35 | 40 |
| 41 | 50 | 44 | 50 |
| 52 | 63 | 56 | 63 |
| 61 | 75 | 66 | 75 |
| 74 | 90 | 79 | 90 |
| 90 | 110 | 97 | 110 |
| 102 | 125 | 110 | 125 |
| 115 | 140 | 124 | 140 |
| 131 | 160 | 141 | 160 |
| 147 | 180 | 159 | 180 |
| 164 | 200 | 176 | 200 |
| 184 | 225 | 199 | 225 |
| 205 | 250 | 221 | 250 |
| 229 | 280 | 247 | 280 |
| 258 | 315 | 278 | 315 |
| 290 | 355 | 313 | 355 |
| 327 | 400 | 353 | 400 |
| 368 | 450 | 397 | 450 |
| 409 | 500 | 441 | 500 |
| 458 | 560 | 494 | 560 |
| 515 | 630 | 556 | 630 |
| 581 | 710 | 626 | 710 |
| 655 | 800 | 705 | 800 |

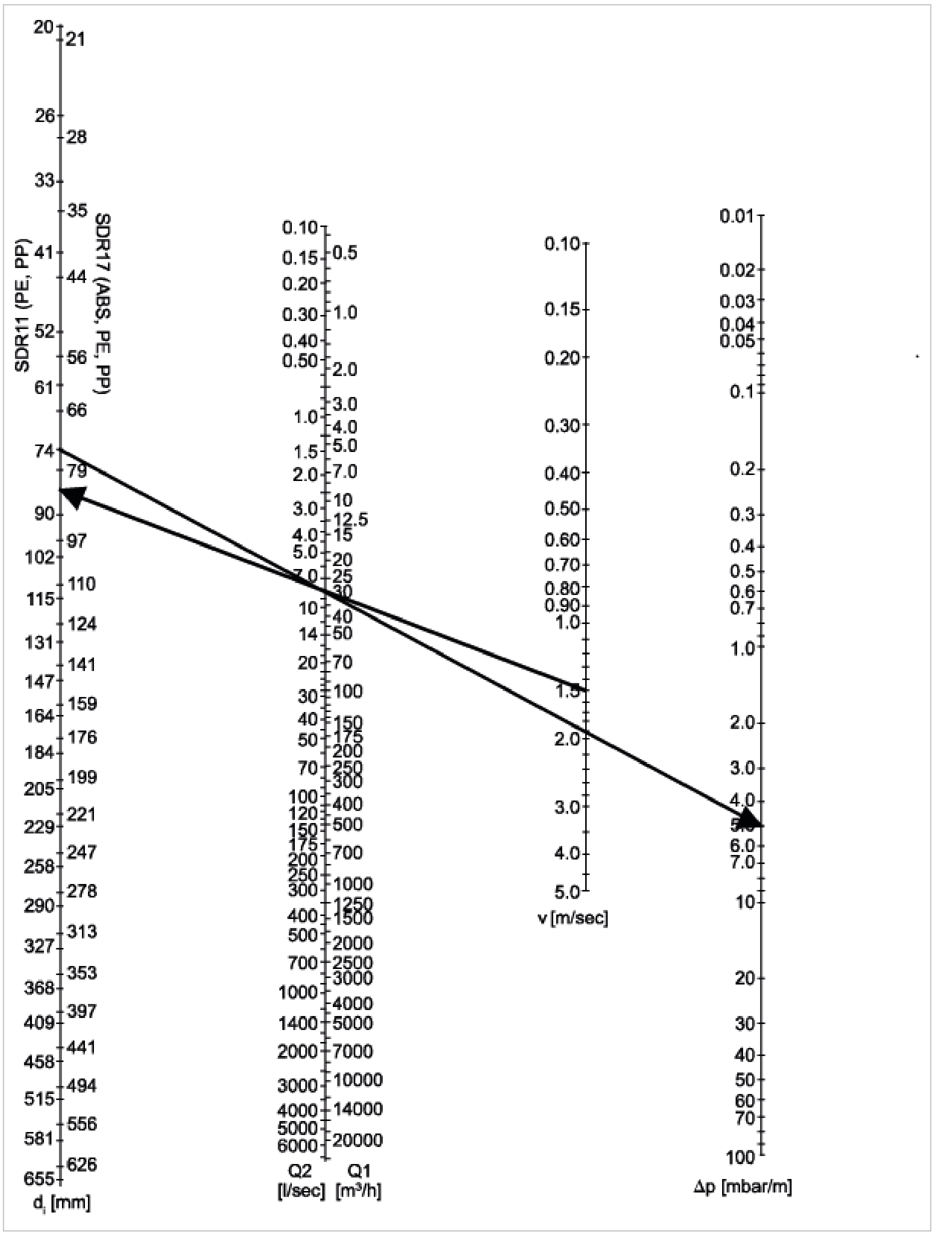
## 3.1.2 Nomogram for easy determination of diameter and pressure loss

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

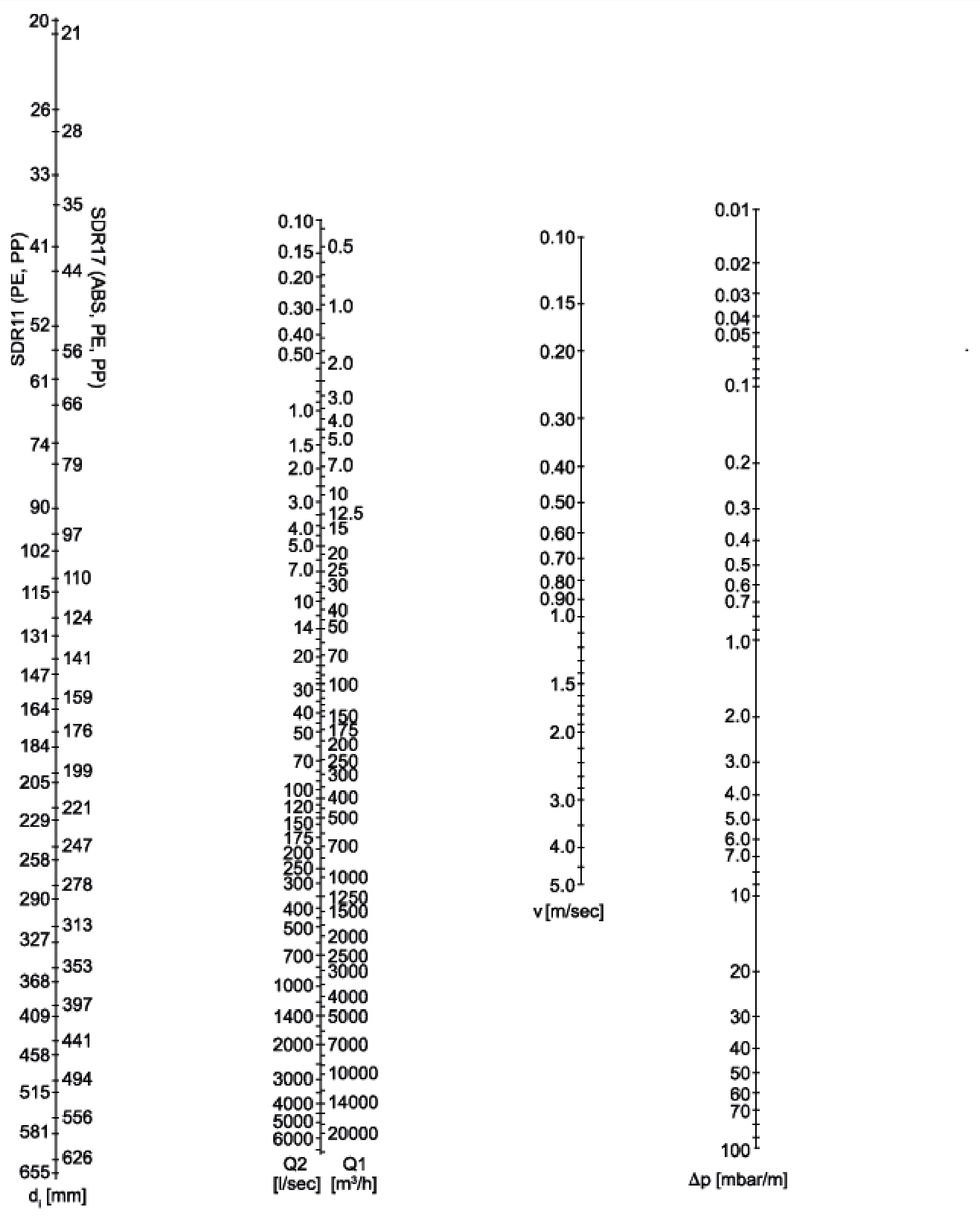
**! The determined pressure loss from the nomogram applies only to a density of the flow medium of 1,000 kg/m³, e.g. for water. Further pressure losses of fittings, valves, etc. have to be considered as shown in the following.**

### Using the nomogram

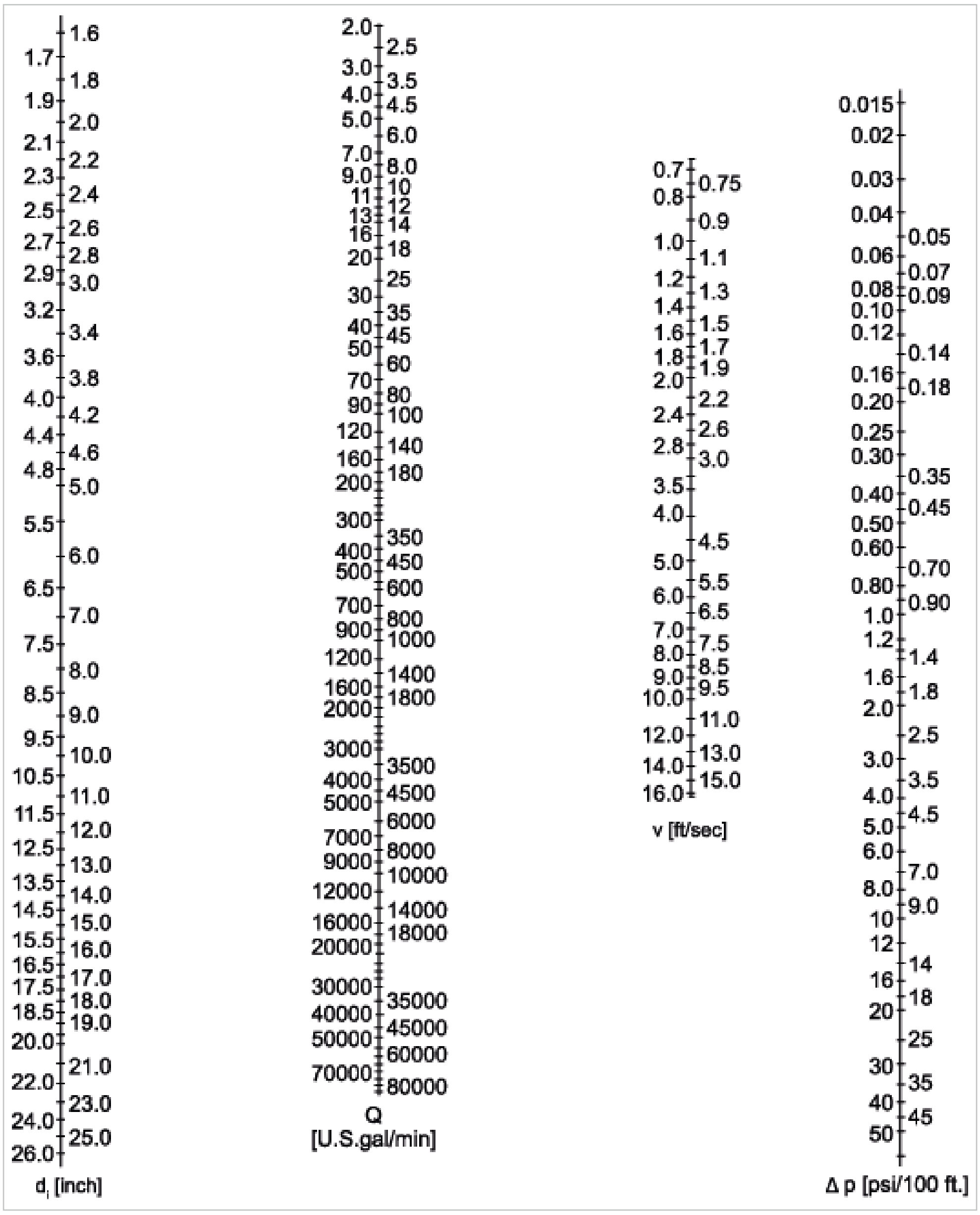
Based on a flow velocity of 1.5 m/s, a line is drawn through the desired flow rate (e.g. 30 m³/h) to the axis with an inner diameter of di (≈ 84 mm). Then select a diameter nearby (74 mm for SDR11) and draw a 2nd line through the desired flow rate up to the pressure loss axis Δp (5 mbar per meter pipe).



### Nomogram for pipes SDR11, SDR17/17.6, SDR33 using the metric system (water, $H_2O$)



## Nomogram for inch pipes



# 3.2 Pressure loss

## 3.2.1 Pressure loss in straight pipes

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 $Re_{crit}$ = 2,320.

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:

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

| | |
|---|---|
| $\Delta p_R$ | Pressure loss in a straight length of pipe (bar) |
| $\lambda$ | Pipe friction factor |
| L | Length of the straight length of pipe (m) |
| $d_i$ | Pipe inner diameter (mm) |
| $\rho$ | Density of flow media (kg/m³) (1 g/cm³ = 1000 kg/m³) |
| v | Flow velocity (m/s) |

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

## 3.2.2 Pressure loss in fittings

### Coefficient of resistance

The pressure losses depend upon the type of fitting as well as on the flow in the fitting. The so-called coefficient of resistance (ζ-value) 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 pipes) | d >90 mm: 0.1<br>20 ≤ d ≤ 90 mm: 1.0 to 0.1: | |
| | d20: 1.0 | d50: 0.6 |
| | d25: 0.9 | d63: 0.4 |
| | d32: 0.8 | d75: 0.3 |
| | d40: 0.7 | d90: 0.1 |

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

### Calculation of pressure loss

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

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

| | |
|---|---|
| $\Delta p_{Fi}$ | Pressure loss of fittings (bar) |
| $\Sigma\zeta$ | Sum of the individual losses |
| $v$ | Flow velocity (m/s) |
| $\rho$ | Density of the medium transported in $kg/m^3$ ($1\ g/cm^3 = 1000\ kg/m^3$) |

## 3.2.3 Pressure loss in valves

The $k_v$ factor is a convenient means of calculating the hydraulic flow rates for valves. It allows for all internal resistances and for practical purposes is regarded as reliable. It is defined as the flow rate of water in liters per minute with a pressure drop of 1 bar across the valve. The technical data of the GF Piping Systems valves contains the kv 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 kv value according to the following formula:

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

| | |
|---|---|
| $\Delta p_{Ar}$ | Pressure loss of valve (bar) |
| $Q$ | Flow rate ($m^3/h$) |
| $\rho$ | Density of the medium transported ($kg/m^3$) ($1\ g/cm^3 = 1000\ kg/m^3$) |
| $k_v$ | Valve flow characteristic ($m^3/h$) |

## 3.2.4 Pressure different from static pressure

If the pipeline is laid vertically, a geodetic pressure difference must also be calculated. This pressure difference is calculated as follows:

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

| | |
|---|---|
| $\Delta p_{geod}$ | Geodetic pressure difference (bar) |
| $\Delta H_{geod}$ | Difference in elevation of the pipeline (m) |
| $\rho$ | Density of media ($kg/m^3$) ($1\ g/cm^3 = 1000\ kg/m^3$) |

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### 3.2.5 Sum of pressure losses

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

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

**Example of a pressure loss calculation**

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

| | | Number of fittings |
|---|---|---|
| PE pipe | d110 mm | 12 x elbow 90° |
| SDR 11 flow rate | 10 l/s | 4 x elbow 45° |
| Medium | Wasser | 3 x tees |
| Density of medium | 1 g/cm³ | 3 x unions |
| Length of straight pipe sections | 15 m | 2 x flange connections |
| Elevation difference | 2.0 m | 1 x diaphragm valve Typ 039, 100% opened |

The wall thickness of this pipeline can be calculated as follows with the SDR:

$$e = \frac{d}{SDR} = \frac{110\ mm}{11} = 10\ mm$$

The inner diameter of the pipeline is as follows:

$$d_i = d - 2 \cdot e = d - \frac{2 \cdot d}{SDR} = 90\ mm$$

With the required flow rate of 10 l/s, the flow velocity is as follows:

$$v = 1275 \cdot \frac{Q_2}{d_i^2} = 1275 \cdot \frac{10}{90^2}\ \frac{m}{sec} = 1.57\ \frac{m}{sec}$$

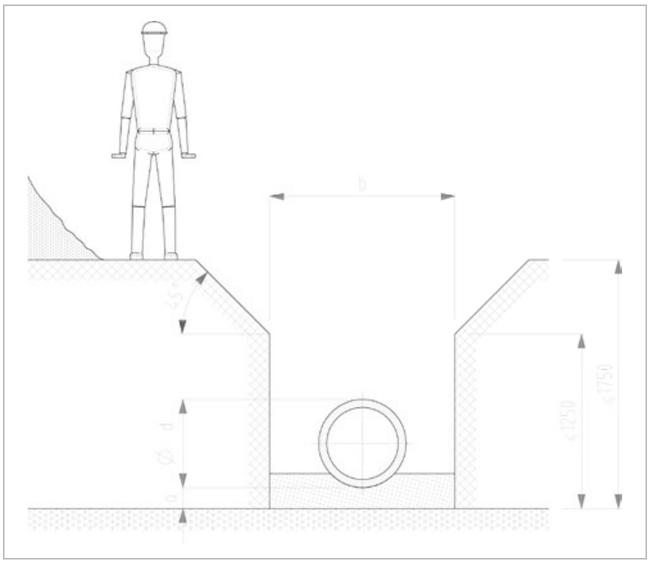
**T4.11 Formulas for calculation of pressure losses**

| Pressure loss | Formula |
|---|---|
| Pressure loss of strait pipes | $\Delta p_R = 0.02 \cdot \frac{15}{90} \cdot \frac{1000}{2\ 10^2}\ 1.57^2 = 0.04\ bar$ |
| Pressure loss of fittings and joints | $\Sigma\zeta = (12 \cdot 1.2) + (4 \cdot 0.3) + (3 \cdot 1.3) + (5 \cdot 0.1) = 20$<br>$\Delta p_{Fi} = 20 \cdot \frac{1.57^2}{2\ 10^5}\ 1000 = 0.25\ bar$ |
| Pressure loss of valve, 100 % opened. With the flow charac-teristics diagram of diaphragm valve, type 039, kv-value 702.6 l/min (flow rate 10 l/s = 36 m³/h) | $\Delta p_{Ar} = \left(\frac{36}{702.6}\right)^2 \cdot \frac{1000}{1000} = 0.0026\ bar$ |
| Pressure loss oh height difference | $\Delta p_{geod} = 2.0 \cdot 1000 \cdot 10^{-4} = 0.2\ bar$ |
| Total pressure loss of the pipeline | $\Sigma\Delta p = 0.04\ bar + 0.25\ bar + 0.0026\ bar + 0.2\ bar = 0.4917\ bar$ |

# 4 Laying

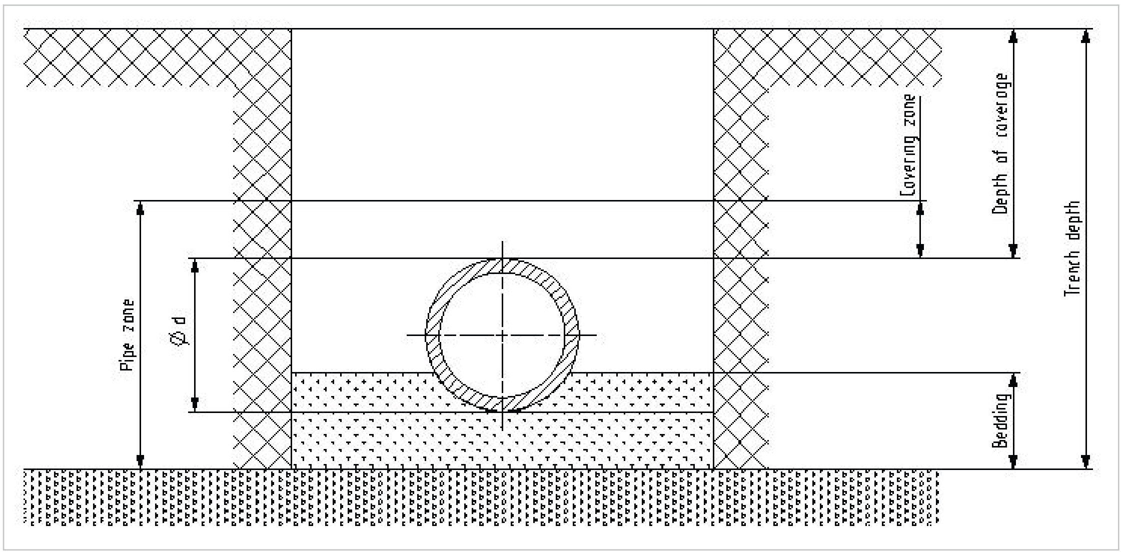
## 4.1 Pipe trenches

The relevant national and regional laying guidelines and regulations for underground pipelines apply for construction of the required pipe trench and for laying of the pipes. The pipe trench must be constructed such that all parts of the line can be laid at a frost-proof depth. The pipe coverage (coverage height) h is 0.6-1 m for gas and 1-1.8 m for water, pursuant to DVGW.



The trench base must be prepared so that the pipeline lies on it evenly. If the sub-surface is rocky or stony, the trench base must be dug out at a lower depth and the excavated material replaced by suitable ground material with a grain size that causes no damage to the pipes.

Perfect preparation of the pipeline zone is decisive for the load-carrying capacity of the PE pipes and fittings in the ground. The pipeline zone is the backfill in the region of the PE pipe and consists of the bedding, side fill and cover zone.




The pipeline zone must be created in accordance with the planning requirements and structural analysis calculation. The region between the trench base and side filling is termed "bedding". As a result of earth replacement, a load-bearing sub-surface must be ensured, i.e. for normal ground conditions, EN 1610 specifies a minimum thickness for the region of the lower bedding as a =100 mm and for rock or very hard ground as a = 150 mm. In addition to the minimum thickness, requirements are also made regarding the building materials to be used for the bedding.

No building materials should be used with components greater than:

- 22 mm at DN ≤ 200
- 40 mm at DN >200 up to DN ≤ 600

The upper layer thickness b results from the structural analysis calculation. Furthermore, it is necessary to ensure that no cavities occur under the pipe. The purpose of the pipe bedding is to reliably and evenly transfer all the loads borne by the pipe to the ground. The laid PE pipe must therefore be fully supported over the complete length. The upper limit of the pipeline zone is defined in EN1610 at 150 mm over the pipe crown or 100 mm over the pipe connection. When installing the cover and the earth layers above this, it is necessary to ensure that the pipe cannot be damaged by infilling and sealing.

## 4.2 Trenchless laying

Trenchless laying allows costs to be saved compared to an open-trench method. Potential savings are generated by the reduction in construction time and the protection of resources, such as surfaces, backfill materials and storage space. Indirect costs can be reduced by avoiding adverse effects on resisdents and the infrastructure. A further advantage of trenchless laying is the reduction in dust, noise and $CO_2$ emissions thanks to less excavation work and fewer transport journeys. Safe laying is possible by using PE pipes with protective and test properties.

There are different kinds of trenchless laying:

- Relining
- Horizontal directional drilling
- Burst lining
- Close-fit lining
- Displacement hammer (for trenchless laying of house connections)

## 4.3 Processing and handling

Successful processing starts with the handling of the components. The aim here is to bring the components to the place of processing cleanly and without damage across the complete supply chain.

### 4.3.1 Oxide layer

In its melted state, the polymer is susceptible to oxidative reaction. During the extrusion process, the melt comes into contact with air and forms an oxide layer. This can adversely affect the connection quality and must be mechanically removed during processing (see chapter “5.13.2 Connection technology” on page 108).

In contrast, the fitting cools in the closed mold in the injection molding process, and there is therefore no oxidative reaction here. This is true as long as the fitting is in its original packaging (bag and box).

UV irradiation causes a change to the molecular structure on the PE surface. This also leads to the formation of an oxide layer and the connection mechanism in the welding process is restricted. Protection against direct sunlight is important to prevent the formation of an oxide layer on the surface of the components.

### 4.3.2 Packaging concept

For safe and reliable transport, the ELGEF Plus products are packed individually or in packaging units in a plastic bag and a box.

The boxes can be stacked and protect the fitting against sunlight, dirt and damage. All ELGEF Plus electrofusion components are also individually packed in bags. Air circulation in the packaging is reduced to a minimum. This prevents a reactive environment from occurring. The packaging protects against dirt.

Injection-molded ELGEF Plus products are packed in bags and boxes directly after production. PE ball valves and spigot fittings in larger dimensions (>d315 und >d280 T90° reduced) are packed in boxes.

Seamless elbows are made of PE pipe and packed on pallets without a box and plastic bag.

### 4.3.3 Storage

#### Pipes

The pipe storage surface must be level and free of stones. Pipes must be layered and stacked in a way that avoids the risk of damage or permanent deformation. Larger-diameter, thin-walled pipes 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 pipes 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 pipes 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.

Pipes 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) |
|---|---|
| PE100/ PE100 RC | 1.0 |

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### Fittings

ELGEF Plus fittings and PE ball valves must be protected against moisture and contamination throughout the entire duration of storage. The maximum recommended storage duration is ten years. In order to reach this maximum duration, the ELGEF Plus components must be stored in the original packaging (box + bag) at a temperature below +50 °C. The storage time begins on the date of production.

The PE bag film protects the ELGEF Plus fittings effectively against UV light. Storage without a box but in the undamaged bag is possible for a **maximum of up to two years**. During this time, the fittings can be welded safely. The processor is responsible for indicating the time that the fitting in the plastic bag was removed from the box.

Larger dimensions (>d315), which are usually also heavy and bulky, must be stored in the box in order to protect against damage.

Seamless elbows should be protected from direct sunlight. To avoid deformation, pallets with seamless elbows must not be stacked.

ELGEF Plus fittings must not come into contact with solvents, greases, paints, silicone, or similar substances.

## 4.3.4 Transportation

### Pipes

Vehicles used to transport pipes must be capable of accommodating the full pipe length. The pipes must be supported to prevent them bending or deforming. The area where pipes 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, pipes 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 pipes 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.

Pipes and fittings must be transported and stored so that they cannot be soiled by earth, mud, dirty water, etc. We recommend sealing pipes with protective endcaps to prevent the ingress of dirt.

### Fittings

To prevent transport damage, the fittings should be well protected during transportation. We recommend leaving the products in the original packaging until installation. If smaller quantities need to be removed, these should be transported in a box that protects them well against UV radiation and contamination.

During unpacking, care must be taken to place the products so that the plastic bags are not damaged by sharp or protruding edges, e.g. plug contacts. To avoid damage, products should not be thrown.

Seamless elbows should be transported on pallets.

We recommend only removing fittings and valves from GF Piping Systems from the packaging immediately before use.

## 4.3.5 Use on building sites

To prevent the products from becoming contaminated and damaged, they should be removed from the packaging immediately before processing.

The welded areas must be cleaned if:
- The plastic bag has been opened or damaged
- The product is not packed in a plastic bag
- The product was produced from a pipe, e.g. seamless or segment-welded elbows
- The welded area is contaminated

Peeling is required if:
- The product is not packed in a plastic bag
- The product was produced from a pip, e.g. seamless or segment-welded

## 4.3.6 Pipe bending

It is possible to take advantage of the elasticity of the pipe materials to an extent, meaning the PE pipes can be laid in a curve during installation. The specified values for the smallest permitted bending radius must not be undershot.

The permissible bending radii at different temperatures are a multiple of the pipe outside diameter:

| Pipe wall temperature | 20 °C | 10 °C | 0 °C |
|---|---|---|---|
| Minimum bending radius for PE | 20d | 35d | 50d |

Values between the temperatures can be interpolated linearly
Source: DVGW worksheet GW 321 (Table A.3)

When laying PE pipes SDR 11 and 17 in a depressurized state (20 °C), a minimum bending radius of 10d may be used for a short time.

Source: DVGW worksheet GW 320-1 (Appendix A)

# 4.4 Internal pressure and leak test

## 4.4.1 Introduction to pressure testing

### Overview of the different testing methods

| Testing method | Internal pressure test | | | Leak test | |
|---|---|---|---|---|---|
| Medium | Water | Gas* | Compressed air[1] | Gas/air (oil-free) | Gas/air (oil-free) |
| Type | Incompres-sible | Compressible | Compressible | Compressible | Compressible |
| Test pressure (overpres-sure) | $P_{p\,(perm)}$ 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 | PE | PE | All plastics | ABS |
| Informative valve | 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 | Mittel Medium |

[1] Observe the applicable safety precautions. More information is available in DVS 2210-1 addendum 2.

Various test methods for pressure and tightness tests are used depending on national and international standards and guidelines as well as local conditions. These include for example contraction methods, pressure loss methods, pressure difference methods or visual methods. They vary in the test process, test time and test pressure.

The purpose of a pressure test is:

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

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

The following comparison attempts to point out the difference between water and air as a test medium:

Water is an incompressible medium, i.e. setting a 1 m PE pipe with a diameter of d160 under a pressure of 3 bar results in an energy of approx. 1 joule. In contrast, air is a compressible medium. The same pipe with test pressure of 3 bar already stores an energy of 5,000 joule. If there were a failure during the internal pressure test, the water-filled pipe would jump up 0.02 m, the air-filled pipe 100 m.

### Fracture behavior of plastics

In case of a failure, thermoplastic materials show different behaviors. Hence, PE and PB exhibit a ductile behavior (and ABS slightly lower), so that brittle fracture cannot occur.

Nevertheless, the following safety precautions must be taken into consideration during the internal pressure test. As mentioned before, the pressure test is the first loading placed on the pipeline and is intended to uncover any existing processing faults (e.g. insufficient fusioning).

Gas leak-tightness cannot be demonstrated by a water pressure test, not even with increased test pressure!

## 4.4.2 Internal pressure test with water or a similar incompressible test medium overview

#### Overview

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

Addendum 2 of DVS 2210-1 forms the basis for the following information. This replaces the data in DVS 2210-1 entirely. The modifications became necessary because the reference value „nominal pressure (PN)“ is being used less and less to determine the test pressure (1.5 • PN, bzw. 1.3 • 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 $T_R$ = 20 °C is exceeded by more than 5 °C in the course of the internal pressure test based on the nominal pressure.

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

#### Test parameters

The following table provides recommended methods for performing the internal pressure test.

| Object | Pre-test | Main test |
|---|---|---|
| Test duration (depends on the length of the pipeline sections) | ≤ $P_{p\,(perm)}$ | ≤ 0.85 $P_{p\,(perm)}$ |
| Prüfdauer (abhängig von der Länge der Rohrleitungsabschnitte) | L ≤ 100 m: 3 h<br>100 m < L ≤ 500 m: 6 h | L ≤ 100 m: 3 h<br>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 pipes are:

| Material | Pressure drop (bar/h) |
|---|---|
| PE | 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 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.

## Filling the pipeline

Before starting with the internal pressure test, the following points must be checked:
- Was installation done according to the available plans?
- All pressure relief devices and flap traps mounted in the flow direction?
- All end valves shut?
- Valves in front of other devices are shut to protect against pressure?
- Visual inspection of all joints, pumps, measurement devices and tanks?
- Has the waiting period after the last fusion/cementing been observed?

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

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.

## Determining the test pressure

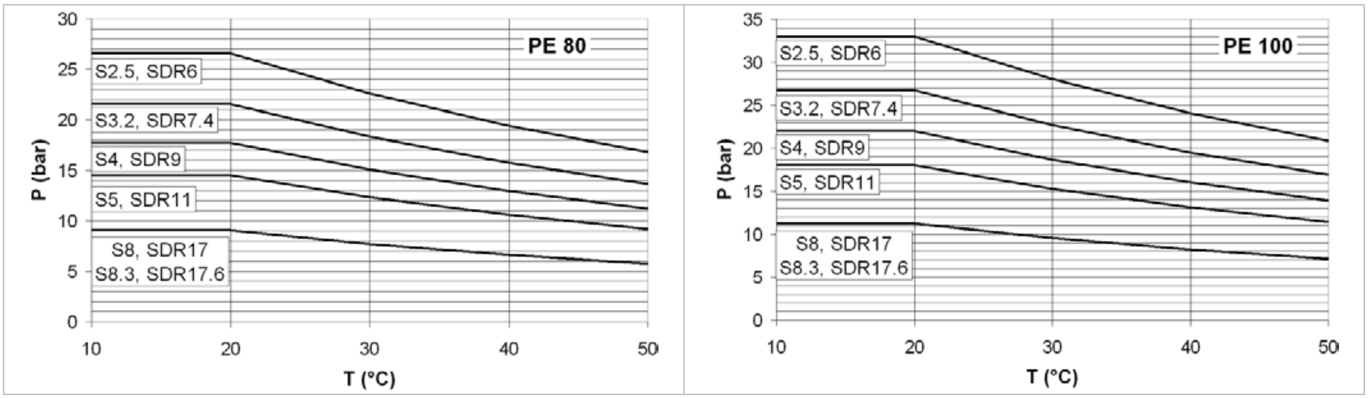
The permissible test pressure is calculated according to the following formula:

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

$\sigma_{v(T,\,100\,h)}$ Long-term creep strength for pipe wall temperature
$T_R$ (at t = 100 h)
$S_p$ Minimum safety factor for long-term creep strength
$A_G$ Processing or geometry-specific factor that reduces the allowable test pressure
$T_R$ Pipe wall temperature: average value of test medium temperature and pipe surface temperature

| Material | $S_p$ Minimum safety factor |
|---|---|
| PE80, PE100 | 1.25 |

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




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

### Checks during testing

The following measurement values must be recorded consistently during testing:

- Internal pressure at the absolute lowest point of the pipeline
- Medium and ambient temperature
- Water volume input
- Water volume output
- Pressure drop rates

## 4.5 Disinfection of pipeline systems

Disinfection measures in pipeline systems are needed if contamination is too great. This state can occur during new installations or repairs where the system was opened and basic disinfection is carried out shortly before the system is put into operation. However, a more or less long stagnation of the water phase (potable or industrial water) can also lead to an impermissibly high number of germs. In many cases, a higher number of germs also builds up over time in normal operation.

In any case, the question arises regarding the suitable disinfection process, the most important aspects of which include the right choice of disinfectant.

Most disinfectants are, by their chemical nature, aggressive to plastics and the compatibility and usability of plastic pipelines depends to a significant degree on the type of disinfectant, its concentration and the operating conditions.

The most common disinfectants are based on chlorine as gaseous chlorine or commercially available sodium hypochlorite (also chlorine bleaching lye). They are comparable in terms of their bacterial effect and potential damage to the pipe system, and their impact on pipeline materials is very well-known and foreseeable.

In numerous tests on the long-term behavior of polyolefins with respect to chlorine/hypochlorite, it could be shown, for example, that PE has a very good resistance to chlorine concentrations that are permitted in potable water. As a rule, the life of the pipe system is not restricted by the disinfectant here.

PE even demonstrates good resistance at concentrations common in swimming pools (approx. 2 ppm). However, no general statements on resistance can be made at this point because in these areas of application, regular or irregular shock chlorination is common practice, in addition to higher temperatures. An individual analysis and design are required here to ensure the life is not impacted.

If chlorine dioxide is used to disinfect water pipelines, an individual analysis must be carried out.

# 5 Jointing Technology

## 5.1 Integral connections

### Overview

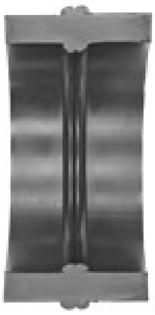
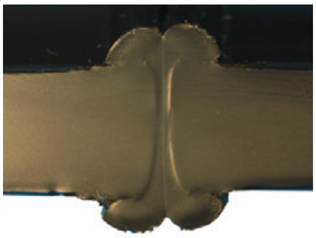
From the wide range of solutions offered by GF Piping Systems on the subject of material-to-materail connections, the methods commonly used in underground pipeline construction are described in more detail below:

| Connection type | Butt fusion | Electrofusion |
|---|---|---|
| Dimension range | d40-d1600 | d20-d1200 |

## 5.2 Butt fusion jointing (heating element fusion conventional butt fusion)

### 5.2.1 Overview

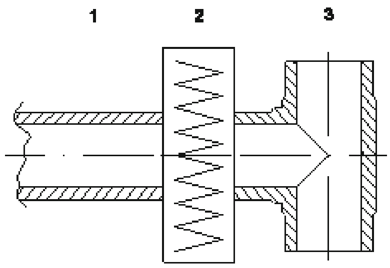
#### Material: PE

| Fusion machine | Jointing cross section | Macro view |
|---|---|---|
|  |  |  |

### 5.2.2 Fusion procedure

For heating element butt fusion (HB), the fusion areas of the parts to be joined (pipes, 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 pipelines must only be created with a fusion device that allows the jointing pressure to be regulated. When building pressure pipelines, 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.

**For additional information about using the fusion procedure for corresponding materials, see www.gfps.com**

## 5.2.3 Installation process

The following installation process is representative for all GF butt-welding machines. For detailed and specified machine handling, please see the relevant operating instructions.

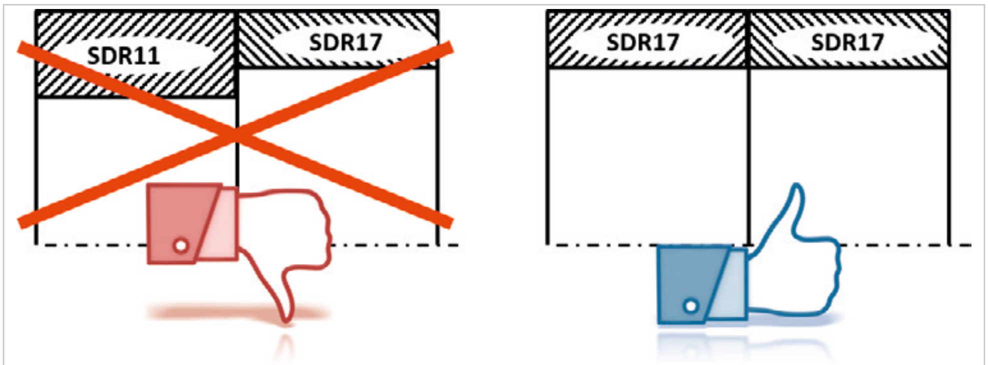
For detailed information, please see our homepage www.gfps.com or contact your regional GF sales office.

### Prerequisites

Only materials of the same kind can be welded to each other (PE to PE). For detailed information on PE type material compatibility, see section 1.2. “Area of use – suitable pipes” on page 111.

In butt welding, only pipe ends with the same wall thickness (SDR class/pipe series) can be welded to each other.

Make sure you have sufficient space in the welding area and the working environment permits professional work.



**1 Clean heating element**

Before every welding operation, clean heating element with dry, clean, lint-free paper.

- Before heating, clean with paper towels and PE cleaner.
- In warm state, clean with dry paper towels.

Caution – risk of burning

**2 Align and clamp pipes**

To minimize the displacement caused by pipe ovality, the pipes must be aligned in accordance with their signatures.

Clamp pipes/fittings securely. Clamp with two jaws on the fixed and moveable side of the welding machine.

Position and support pipe ends securely on roller blocks, this makes it easier to ensure flush alignment and secure clamping.

**3 Planing**

Check whether planer is clean and free of grease on both sides. Do not plane until immediately before welding.

Plane welding ends flat; even, uninterrupted machining at least 1-1.5 x circumference.

Make sure chips are removed effectively and remove chips continuously. Stop planing intermittently. Remove chips and check result of planing.

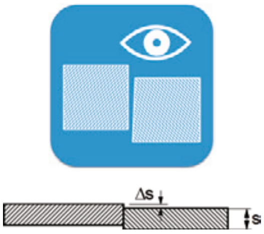
Check: same wall thickness of welding ends.

**4 Offset and gap check**

Offset check: Maximum permitted offset ≤ 10% of wall thickness

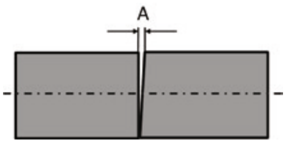
$$\Delta s \text{ max.} = 0.1 \times s$$

However, maximum of 5 mm for wall thicknesses of > 30 mm and diameters >dn630




Gap check (values as per DVS 2207-1):

| $d_n$ [mm] | Gap A [mm] |
|---|---|
| ≤ d355 | 0.5 |
| 400-630 | 1.0 |
| 630-800 | 1.3 |
| 800-1000 | 1.5 |
| > 1000 | 2.0 |




Then clean the planed pipe ends (pipe, fitting) with 100% vaporizing PE cleaner and lint-free, clean paper towels.

**5 Check heating element temperature**

Heating element surface temperature (in accordance with DVS 2207):

220°±10°C

Measurement with calibrated thermocontact measuring device within the welding area at at least eight points on the circumference of the heating element.

Welding start at the earliest 30 min. after target heating element temperature has been reached (time to heat through heating element evenly everywhere).

Then set heating element in heating element take-off unit.


**6 Equalize/check bead height**

Equalize with equalizing pressure = 0.15 $N/mm^2$ until minimum bead height is achieved.

In manually controlled welding machines, see the machine operating instructions to determine the hydraulic pressure that needs to be set. In the case of CNC control, the machine automatically applies the correct parameters in accordance with the pipe wall thickness.

**7 Heating**

For heating, the contact pressure is reduced such that a transfer of heat from the heating element to the pipe ends is still ensured without uncontrolled opening as a result of the melt expansion.

Heating pressure ≤ 0.01 $N/mm^2$

In principle, it is necessary to ensure that the pipe ends are still just in contact with the heating element here.

**8 Changeover**

Wait until joint surfaces have been detached on both sides from the heating element by the take-off unit.

Swing the heating element out of the welding area without damaging or dirtying the joint surfaces.

Keep the changeover time as short as possible (keep the cooling of the joint surfaces as low as possible).

**9 Joining and cooling**

Bring the joint surfaces together quickly until shortly before they make contact.

Shortly before contact, bring the joint surfaces together with a speed close to zero.

Apply required joint pressure of 0.15$N/mm^2$ as linearly as possible (take account of joint pressure set-up time).

Maintain joint pressure during entire cooling period.

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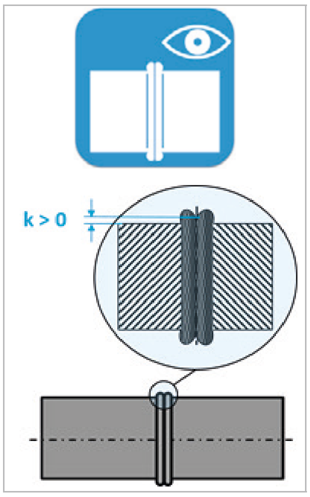
**⑩ Check and welding log**

The welded connection must be checked over the entire circumference for bead formation. The welding bead should be as even and smooth as possible over the complete circumference.

No unwelded points, bead discolorations or notches are permitted in the welded connection. Additional faults see DVS 2202 supplementary sheet 1.

Label welded connection with:

- Welding number
- Cooling time (unclamping)
- Date
- Visa/signature

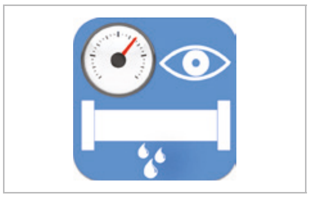



Then create manual welding log or save the electronic log with the WeldinOne software.

**⑪ Tightness check**

In all cases, the cooling time as per DVS2207-1 or specific manufacturer specifications must be adhered to.

A pressure sample can only be taken one hour after the end of cooling at the earliest.



## An overview of welding parameters

The welding parameters in accordance with DVS 2207-1 (August 2015) are summarized below:

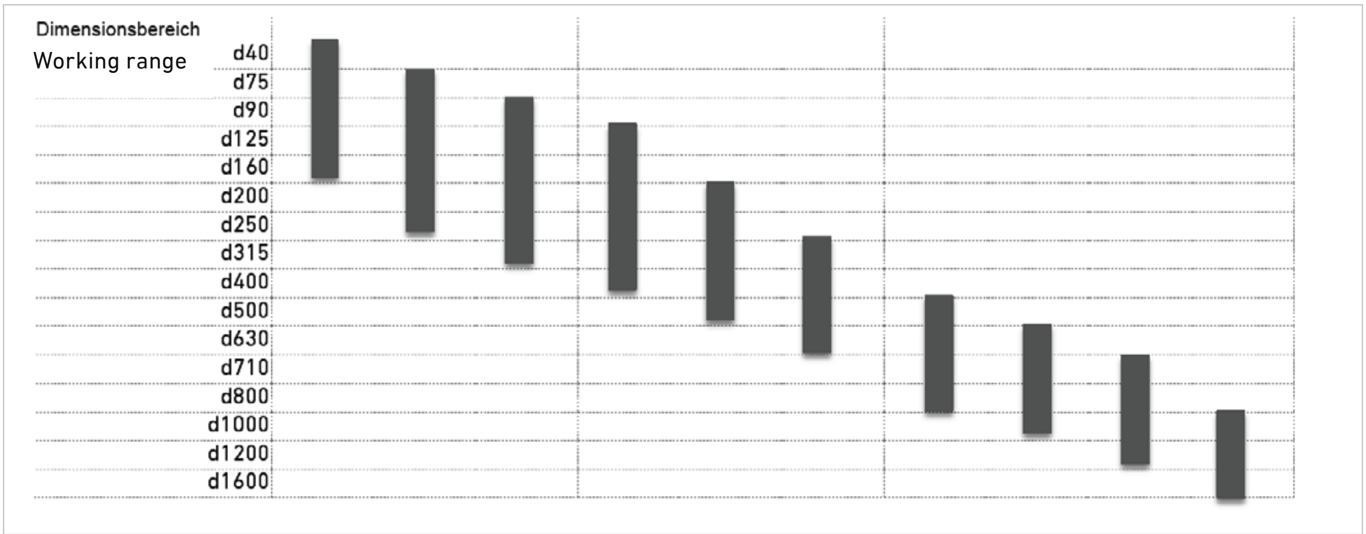
| | Equalize | Heat | Changeover | Joins | | | |
|---|---|---|---|---|---|---|---|
| Nominal wall thickness s (mm) | Minimum bead height* (mm) | Heating time (s) | Changeover time (mm) | Joint pressure set-up time (s) | Cooling time (min) | | |
| | | | | | <15°C | 15°-25°C | 25-40°C |
| ≤ 4.5 | 0.5 | ≤ 45 | 5 | 5 | 4.0 | 5.0 | 6.5 |
| 4.5 – 7 | 1.0 | 45 – 70 | 5 – 6 | 5 – 6 | 4.0 - 6.0 | 5.0 – 7.5 | 6.5 – 9.5 |
| 7 – 12 | 1.5 | 70 – 120 | 6 – 8 | 6 – 8 | 6.0 – 9.5 | 7.5 – 12 | 9.5 – 15.5 |
| 12 – 19 | 2.0 | 120 – 190 | 8 – 10 | 8 – 11 | 9.5 – 14 | 12 – 18 | 15.5 – 24 |
| 19 – 26 | 2.5 | 190 – 260 | 10 – 12 | 11 – 14 | 14 – 19 | 18 – 24 | 24 – 32 |
| 26 – 37 | 3.0 | 260 – 370 | 12 – 16 | 14 – 19 | 19 – 27 | 24 – 34 | 32 – 45 |
| 37 – 50 | 3.5 | 370 - 500 | 16 – 20 | 19 – 25 | 27 – 36 | 34 – 46 | 45 – 61 |
| 50 – 70 | 4.0 | 500 – 700 | 20 – 25 | 25 – 35 | 36 – 50 | 46 – 64 | 61 – 85 |
| 70 – 90 | 4.5 | 700 – 900 | 25 – 30 | 35 | 50 - 64 | 64 – 82 | 85 – 109 |
| 90 – 110 | 5.0 | 900 – 1100 | 30 – 35 | 35 | 64 – 78 | 82 – 100 | 109 – 133 |
| 110 – 130 | 5.5 | 1100 – 1300 | max. 35 | 35 | 78 – 92 | 100 – 118 | 133 - 157 |

(Intermediate values must be interpolated)

* Equalize minimum bead size on heating element at the end of the equalization time, join and cool with p = 0.15 N/mm², heat with p ≤ 0.01 N/mm²

## 5.2.4 Butt welding devices

| |  | | |  | | | |  | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Characteristics** | TM160 | TM250 | TM315 | GF400 | GF500 | GF630 | GF800 | GF1000 | GF1200 | GF1600 |
| **Max. jointing diameter (mm)** | 160 | 250 | 315 | 400 | 500 | 630 | 800 | 1000 | 1200 | 1600 |
| **Jointing material** | PE, PP, PB | | | PE, PP, PB | | | PE, PP | | | |
| **Working range (°C)** | -10/+45 | | | -10/+45 | | | -10/+45 | | | |
| **Input voltage (V)** | 230/115 | 230 | 230 | 400/230 | 400 | 400 | 400 | 400 | 400 | 400 |
| **Operation control** | Manual, CNC | | | Manual, CNC | | | Manual | | | |
| **Performance (W)** | 1900 | 3250 | 3850 | 5700 | 6300 | 11000 | 15000 | 19500 | 20500 | 55000 |
| **Reduction inserts / Flange adapter clamp** | Optional | | | Optional | | | Optional | | | |
| **Hoist unit** | | | | Optional | | | Optional | | | |
| **Chamfered upper clamp** | Optional | | | Optional | | | | | | |
| **Fusion protocols, transfer via USB stick** | WR, CNC version | | | WR, CNC version | | | WR version | | | |
| **Traceability via barcode scanner** | Optional (CNC version) | | | Optional (CNC version) | | | | | | |
| **Weight - base machine(kg)** | 22 | 47 | 53 | 65 | 169 | 222 | 690 | 1238 | 1346 | 3350 |

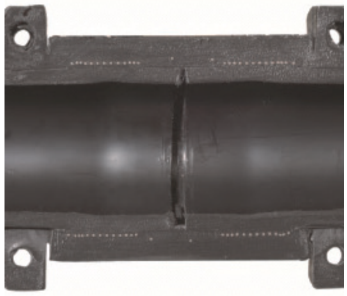
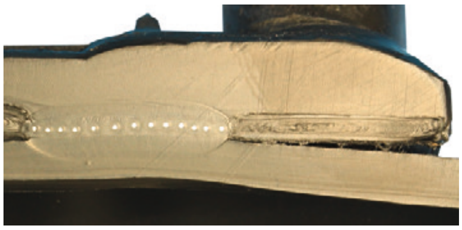


# 5.3 Electrofusion

## 5.3.1 Overview

### Material

- PE

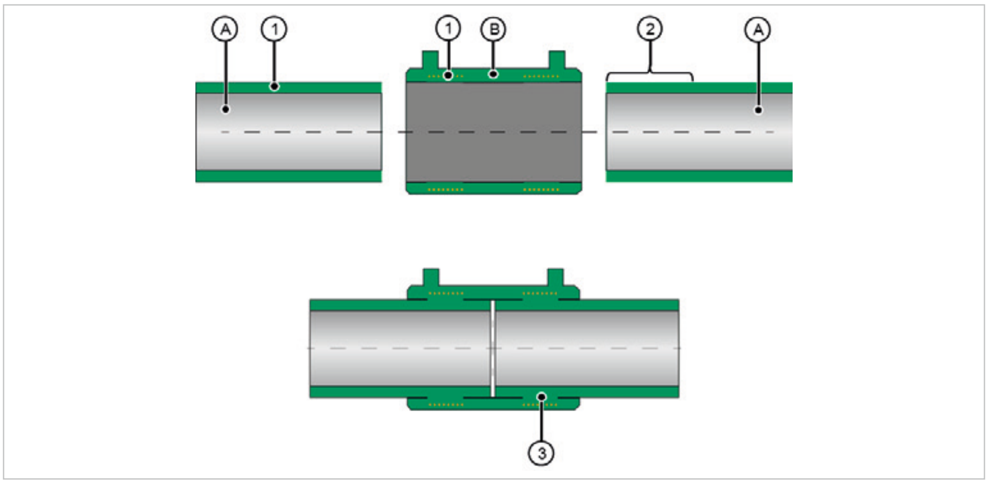
| Fusion machine | Jointing cross section | Macro view |
| --- | --- | --- |
|  |  |  |

## 5.3.2 Fusion procedure

By electrofusion, plastic pipe and electrofusion fitting are permanently connected with each other by a restraint and homogenuous joints.

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 Inseration depth
- ③ Jointing level

### 5.3.3 Advantages and properties

The use of electrofusion to connect pipes and fittings allows safe, rational, economic and efficient installation of underground and aboveground PE piping systems.

#### Advantages

- Integral connections PE-PE, meaning no sealing element is required
- Restraint present, so no counter-support is required for underground lines
- Connection of pipes made of PE80, PE100 as well as a combination of PE80 and PE100
- Different SDR classes can be welded together
- No fusion bead on inside of the pipe
- Small space requirement for execution because of lightweight and compact fusion devices
- Fast pipe-laying speed (compared to conventional butt fusion) because fusion device is barely fixed
- Fully automatic fusion process (high process reliability)
- Gap-free traceability through welding logs and identification of the welded components
- Low investment need because all dimensions are fused with one fusion device

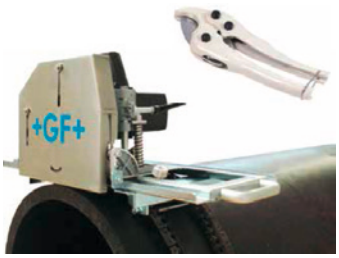
**For additional information about using the fusion procedure for corresponding materials, see www.gfps.com**

## 5.4 Basic information about welding preparation

**Insufficient preparatory measures can lead to a faulty welded connection. The functionality and life of the product can be adversely affected.**

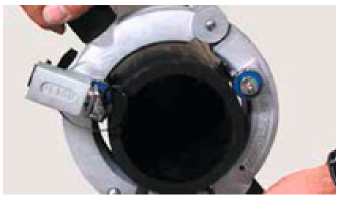
### 5.4.1 Cutting pipe ends

Coarse dirt must be cleaned from the working area on the pipe. If water is used, the pipes must be completely dry prior to separation. Then separate the pipe ends at a right angle with the pipe separating device and deflash the cut surfaces. The tools must neither permanently deform nor damage the pipe. The use of lubricants during separation is not permitted. Suitable tools for this are pipe cutters or a guided electronic pipe saw.




### 5.4.2 Peeling

PE pipes are often stored without protection against direct sunlight or dirt. They must be peeled with a suitable peeling tool directly before the start of welding. In the injection-molded products, peeling is not required if they were stored correctly.



It is in principle possible to peel spigot ends on fittings (spigot fittings, ball valves or transition adapters) if this is required by the process. This does not have a negative impact on the welding result, provided that peeling is carried out correctly and the resulting diameter of the spigot end is within the tolerance of the permitted diameter after peeling (see table below).

In the area of the welding zone, the pipe surface must be machined without gaps. For the reliable removal of the oxide layer, a rotating peeler should be used with a constant wall thickness removal ≥ 0.2 mm. The peeling result is to be checked for even chip formation and min. cut depth. The peeled area must not be subsequently touched.

Ensure a small annular gap formation between fitting and pipe. Therefore regularly check the quality and wear of the peeling blade on the peeler. In cases of doubt regarding too much wall removal, see the minimum permitted pipe diameters below.

Flat spots, bulges , scratches and grooves are not permitted on the welded area after peeling. For verification of peeling after welding, at least 1 cm must be added to the insertion depth of couplers and fittings and 4 cm to the length of a saddle.

| Nominal pipe outside diameter $d_n$ (mm) | Min. permitted pipe outside diameter after peeling (mm) at 20°C* |
|---|---|
| 20-25 | $d_n$ -0.4 |
| 32-63 | $d_n$ -0.5 |
| 75-225 | $d_n$ -0.6 |
| 250 -315 | $d_n$ -0.7 |
| >315 | $d_n$ -0.8 |

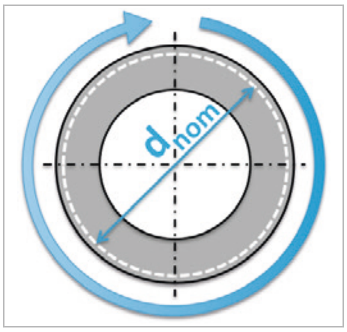
* If ambient temperature varies greatly, the nominal diameter dn is to be converted with formula $\Delta d = d * (1+\alpha/3*\Delta T)$.

**Example for d225:**

$d_n$ = 225.0

Min. perm. pipe Ø after peeling = 225.0 mm - 0.6 mm = 224.4 mm

(measure with circometer)

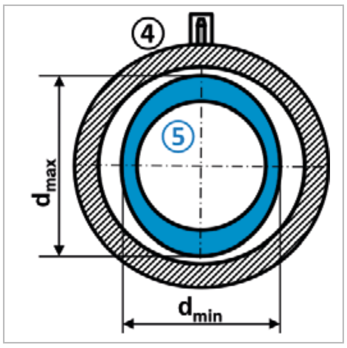



### 5.4.3 Ovality

During welding, the ovality must be within the tolerances defined in the standards. As a general rule, the values from DVS2207-1 can be used.

If the values are outside the tolerance range, measures must be taken, e.g. the use of re-rounding tools.

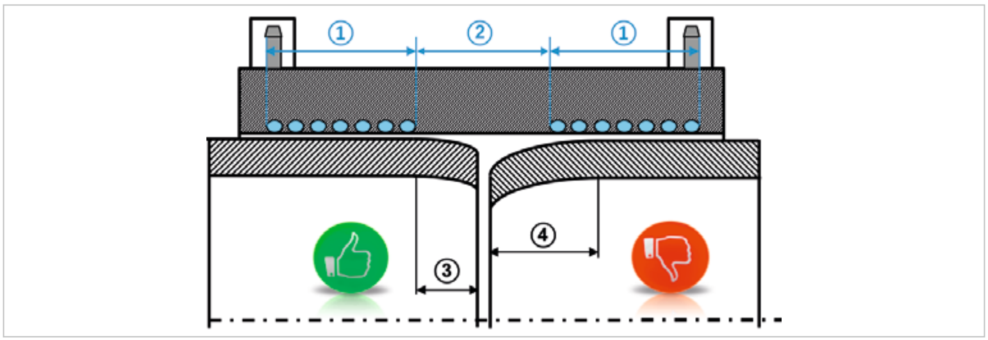
DVS 2207-1 permits a maximum pipe ovality of 1.5% or a maximum of 3 mm. For larger ovalities, use re-rounding clamps.




④ Fitting
⑤ Pipe

## 5.4.4 Pipe end reverse

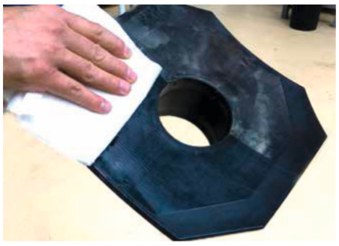
If there is excessive reverse on the pipe ends, the heating coil zones must be sufficiently covered. In cases of doubt, visually check the pipe ends with a spirit level and compare reversed ends with half inner cold zone. If necessary, cut pipe ends to size at right angles directly before welding.




① Heating coil zone
② Cold zone
③ Permitted pipe end reverse
④ Impermissible pipe end reversel

## 5.4.5 Cleaning

As a result of the manufacturing process, the heating coil is completely embedded in the fitting. As a result of the closed and smooth surface, residue-free cleaning of building site dirt (dust, sand, mud) if easily possible on ELGEF Plus electrofusion fittings.



The PE cleaner (e.g.Tangit PE cleaner), or PE cleaning cloths dampened with cleaner by the manufacturer in a closable plastic box must be a 100% rapidly vaporizing liquid. Agents tested in accordance with DVGW VP 603 or NTA8828 meet this requirement. The use of alcohol/water mixtures available commercially can, as a result of the water they contain, lead to a reduction in quality and therefore must not be used. The paper for cleaning must be clean, unused, absorbent, lint-free and not colored. Cleaning cloths soaked with Tangit PE cleaner are permitted.

Cleaning can only be carried out on the peeled welded area. Otherwise, there is the risk of dirt being transferred to the cleaned surface. If marking pens are used, it is essential to ensure that no ink gets into the welding zone area. If subsequent cleaning is required, the ink must not be wiped into the welding zone. Ink that gets into the welding zone cannot be completely removed even by repeated cleaning. The pipe must be re-machined or replaced.

During welding, the contact surfaces must be clean and dry. It is necessary to ensure that cleaning agents are completely vaporized without residue prior to welding. This applies in particular for cold temperatures, as the cleaning agent vaporizes more slowly than in warm temperatures.

IV

### 5.4.6 Mark fitting position

It must be possible to check both the insertion depth for sockets and fittings and the position for saddle moldings by means of a marking.

- Always perform marking after cleaning
- From d110, make at least 3 marks on the circumference.

### 5.4.7 Stress-free installation

During installation of the fitting, stress-free assembly of all components must be ensured. Electrofusion fittings may be neither tilted nor pushed with force onto the pipe end.

If necessary, use suitable re-rounding, clamping or holding devices (for example on coiled pipes in house connections). Stress-free assembly by means of the clamping device must then be maintained up to the end of the cooling period.

### 5.4.8 Avoid air flow & visual check

Before the start of the welding process, the pipe ends must undergo a visual check, in particular also of the interior. At this point in time, foreign bodies such as loose stones or other foreign matter can still be removed easily.

The pipe ends must then be closed by suitable means, e.g. end caps. This can prevent disruptive air flows ("chimney effect"). This applies to electro and butt weldings. This effect is particularly strong in vertically installed pipelines.

### 5.4.9 Welding & check

Use fusion machines that are compatible with ELGEF Plus fittings

- Connect the welding cable to the fitting in load-relieving way
- Read in the welding barcode using a scanner or barcode reader
- Start the welding procedure
- Pay attention to special occurrences
- Check the welding display
- Check the welding device for error messages, create a welding protocol if necessary


For general safety, welding should be supervised up until the end of the cooling period and a distance of at least 1m to the welding should be maintained.

### 5.4.10 Temperature-compensated welding times

All ELGEF Plus electrofusion fittings have a barcode that automatically adapts the welding time to the ambient temperature of the welding device.

Electrofusion fitting, pipe and welding device must be at the same temperature prior to welding. Take account of the time for equalizing the temperature. We recommend storing the components for welding in the same area for approximately 20 min. before welding.

## 5.5 Installation process

The following installation process is representative for all ELGEF Plus couplers and fittings. The detailed, individual installation process can be accessed on a smart phone by scanning the QR code on the bag packaging.

For detailed information, please see our homepage www.gfps.com or contact your regional GF sales office.

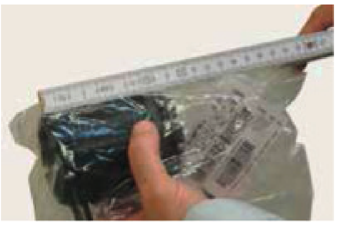
**1 Cut pipes**

Clean pipe ends roughly, cut at right angle with pipe cutter and if necessary deburr edges.

The pipe ends must be cut at an exact right angle. The insertion depth of the electrofusion coupler must be completely filled out.

**2 Determine peeling length**

Measure area which must be peeled on the still packed product with a yardstick and then mark on the pipe with an addition of approx. 1 cm.



**3 Peel pipes**

Peel pipe with a rotary peeler. Check the peeling resilt. Note min. peeling of 0.2 mm as well as max. allowable wall thickness reduction.

**4 Clean pipe**

Clean pipe only in the peeled area with Tangit PE cleaner and lint-free, colourless and clean cloth in circumferential direction, let the cleaner exhaust. Do not touch the fusion zone and avoid contamination.

**5 Mark the fitting position**

Mark insertion depth with yardstick and permanent marker on the pipe. To avoid contamination do not subsequently touch the welding zone.

IV

**6 Fitting installation**

Directly before assembly – and without touching the welded area – take the ELGEF Plus fitting out of its packaging and push it onto the pipe. The insertion depth markings on the pipe are used to control and adjust the position. To allow installation without tension use clamping tools.

**6 a.)**

In vertical installations or an environment in which an airflow can occur, the pipe ends must be closed.

**6 b.)**

In vertical installations or in positions in which a clamping tool cannot be used, suitable measures must be taken to eliminate installation stress.

**6 c.)**

In vertical installations or in positions in which a clamping tool cannot be used, suitable measures must be taken to hold the pipes and fittings in position and prevent any movement of the components.

**7 Fusion**

Fuse in accordance to the user manual of the fusion unit. Control and supervise fusion process.

**8 Check**

During and after fusion, check fusion indicators* on the product. After fusion check message on the fusion unit.

* The popping up of fusion indicators is the visual confirmation that welding pressure occurred. They do not enable conclusions to be drawn regarding the quality of the connection. The height of the fusion indicators can vary.

**9 Cooling time**

Also ensure there is no stress during the cooling period, therefore do not move the connection until the minimum cooling time (CT) as per barcode label has passed.

## 5.6 Cooling times ELGEF Plus coupler & fittings

After the fusion process, our MSA electrofusion units directly display the cooling time after which the clamping tool can be removed. If other electrofusion units are used, the cooling time up to removal of the clamping tool is indicated on the barcode label with “CT”. After this cooling time, the welded connection can be moved.

The longer cooling times in the table below apply for the load-bearing capacity for the tightness test.

**T4.12 Cooling times for ELGEF Plus coupler and fittings**

| $d_n$ (mm) | Remove clamping tool (min.) | Tightness test* | |
|---|---|---|---|
| | | STP ≤ 6 bar (min.) | STP ≤ 18 bar (min.) |
| 20-63 | 6 | 10 | 30 |
| 75-110 | 10 | 20 | 60 |
| 125-160 | 20 | 30 | 75 |
| 180-225 | 20 | 45 | 90 |
| 250-315 | 30 | 60 | 150 |
| 355-400 | 60 | 120 | 180 |
| 450-630 | 60 | 150 | 210 |
| 710-800 | 90 | 150 | 240 |
| 900-1200 | 60 | 150 | 240 |

* Including the cooling time to removal of clamping tool; STP = system test pressure.

The cooling time specifies how long it takes for the welded connection to cool to a corresponding reference temperature. The reference temperature is a measure for the stability of the connection and thus what loads/stresses the connection can be subjected to. For removal of the clamping tool, Georg Fischer uses a ref. temp. of 110 °C, a ref. temp. of 80 °C for an internal pressure of 6 bar and a ref. temp. of 20 °C (ambient temperature) for an internal pressure of 18 bar.

## 5.7 Cooling times for ELGEF Plus saddles & PVTs

After the fusion process, our MSA electrofusion units directly display the cooling time after which the welded connection can be mechanically loaded. If other electrofusion devices are used, the cooling time up to removal of the clamping tool is indicated on the barcode label with “CT”. After this cooling units, the welded connection can be moved. The longer cooling times in the table below apply for the load-bearing capacity for the tightness test.

**T4.13 Minimum cooling time for ELGEF Plus saddles and pressure tapping valves (PTVs)**

| $d_n$ (mm) | Mechanical load, Pressureless tapping (min.) | Tightness test / tapping under operating pressure | |
|---|---|---|---|
| | | STP ≤ 6 bar (min.) | STP ≤ 18 bar (min.) |
| 40, 50 Monobloc | 10 | 20 | 30 |
| 63-160 Monobloc | 20 | 30 | 90 |
| 63-400 Duobloc | 20, 30* | 30 | 90 |
| 110-630 branch saddle | 30 | 45 | 90 |
| Branch saddle topload 315 - 1000 x outlet 160/225 | 45 | 90 | 180 |
| Branch saddle topload 500 - 2000 x outlet 315/500 | 60 | 120 | 240 |

* With injection molded bottom part for $d_n$110 and $d_n$160
STP System test pressure

The cooling time specifies how long it takes for the welded connection to cool to a corresponding reference temperature. The reference temperature is a measure for the stability of the connection and thus what loads/stresses the connection can be subjected to. For removal of the clamping tool, Georg Fischer uses a ref. temp. of 110 °C, a ref. temp. of 80 °C for an internal pressure of 6 bar and a ref. temp. of 20 °C (ambient temperature) for an internal pressure of 18 bar.

## 5.8 Mechanical joints

### Overview

Of the many diverse solutions offered by GF Piping Systems for mechanical joints, the following table offers information on the conventional methods used in industrial piping system construction:

**T4.14 Overview of mechanical connections**

| Figure | Connections typre | Gasket | Connection of plastic with |
|---|---|---|---|
|  | Transition adapter with thread | PTFE Tape | Plastic / metal |
|  | Flange connection | O-ring<br>Profile seal | Plastic or metal |
|  | MULTI/JOINT®<br>Wide range fitting | Special seal | Suitable for all pipe materials |
|  | iJOINT<br>Compression fitting | Lip seal | plastic |
|  | PRIMOFIT<br>Compression fitting | Profile seal | Plastic or metal |
|  | Universal coupling | Special seal | Plastic or metal |

## 5.9 Transition adapter with thread

The transition adapters are system-compliant and only compatible with ELGEF Plus coupler and fittings.

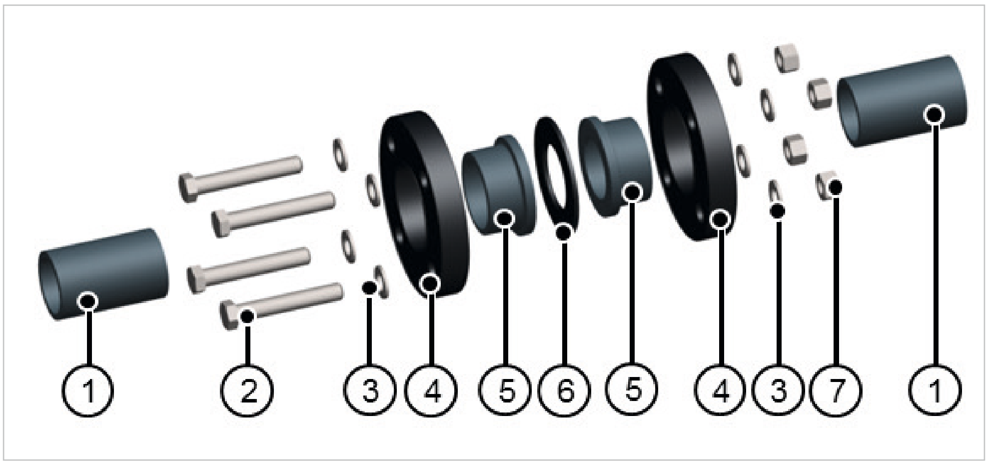
### Thread types

The following thread types are used:

| Designation of the thread | Standard | Description | Application |
|---|---|---|---|
| Rp | ISO 7-1, EN 10226-1 | Parallel internal (female) thread, where pressure-tight joints are made on the threads | Transitiol and threaded fittings, Malleable cast iron fittings |
| R | ISO 7-1, EN 10226-1 | Conical external (male) thread, where pressure-tight joints are made on the threads | Transition and threaded fittings, Steel pipes |

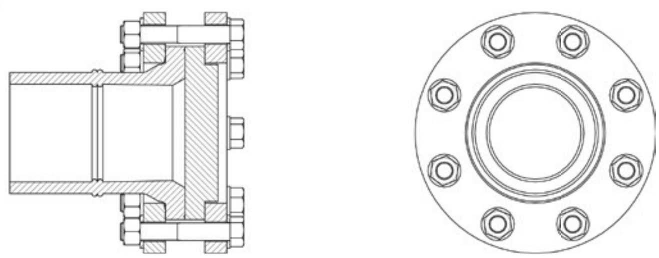
## 5.10 Flange connections

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




1. Pipe
2. Bolt
3. Washer
4. Flange
5. Valve end / flange adapter
6. Flange seal
7. Nut

## 5.10.1 Comparison of flange connections

| Flange connection | Properties |
|---|---|
| PP-V flange | • Corrosion-free all-plastic flange made of polypropylene PP-GF30 (fiber-glass reinforced)<br>• High chemical resistance (hydrolysis-resistant)<br>• Maximum possible break resistance due to elasticity (deforms if it is tightened too much)<br>• Use for ambient temperatures up to 80 °C<br>• The temperature of the medium is restricted by the material of the plastic piping system<br>• UV-stabilized<br>• With integrated bolt-fixing<br>• Self-centering aid for the flanges on the flange adapter<br>• Symmetric design allows assembly on either side: A „reverse" installation is never possible. All important information is readable<br>• V-groove (patented)<br>• Even distribution of forces across the flange (preserves life expectancy of components)<br>• Supports a longer-lasting torque for a safe joint |
| PP steel flange | • Very robust and stiff due to the steel inlay<br>• Corrosion-free plastic flange made of polypropylene PP-GF30 (fiber-glass reinforced) with steel inlay<br>• High chemical resistance (hydrolysis-resistant)<br>• Maximum ambient temperature 80 °C<br>• UV-stabilized |
| Steel, galvanized | • Extremely robust and rigid |
| Blind flange | • Combination of a backing flange and a PE100 end blank.<br>• Combines end blanks in the dimensions d63 to d315 with the PP-V backing flange.<br>• Dimensions d355 to d630 are combined using a loose-type flange made from PP with a steel insert.<br>• With the blanking flange set, the piping system can be closed off using the same material.<br>• If the piping system is extended, the backing flange can be used again, cutting down on additional costs.<br>• Suitable for pressure piping<br>• Easy assembly of the blank flange set: The end blank is centered on the inner diameter of the backing flange.<br> |

## 5.10.2 Creating flange connections

When making a flange connection, the following points have to be taken into account:

### Usage information

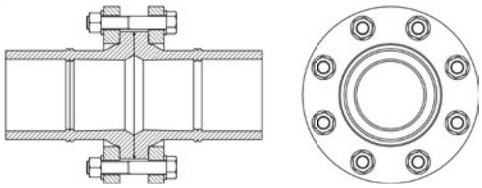
Backing flanges are identified with the following pictograms of the usable flanges:

Butt fusion

### Orientation of bolts beyond the two main axes

- For horizontal pipelines, 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”, page 102. However, deviations may occur in practice, e.g. through the use of stiff bolts or pipe axes that are not aligned. The Shore hardness of the gasket can also influence the necessary tightening torque.
- We recommend checking the tightening torques 24 hours after assembly according to the specified values and, if necessary, retighten them. Always tighten diagonally here, as well.
- After the pressure test, the tightening torques must be checked in any case and, if necessary, retightened.

**For more information on 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.

**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.**

## 5.10.3 Bolt tightening torque guidelines for metric (ISO) flange connections with PP-V, PP- steel and PVC flanges

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

| Pipe outer diameter $d_n$ (mm) | Nominal diameter DN (mm) | Bolt tightening torque MD (Nm) | | |
|---|---|---|---|---|
| | | Flat ring maximum pressure 10 bar / 40 °C | Profile gasket maximum pressure 16 bar | O ring maximum pressure 16 bar |
| d16 | DN10 | 10 | 10 | 10 |
| d20 | DN15 | 10 | 10 | 10 |
| d25 | DN20 | 10 | 10 | 10 |
| d32 | DN 25 | 15 | 10 | 10 |
| d40 | DN 32 | 20 | 15 | 15 |
| d50 | DN 40 | 25 | 15 | 15 |
| d63 | DN 50 | 35 | 20 | 20 |
| d75 | DN 65 | 50 | 25 | 25 |
| d90 | DN 80 | 30 | 15 | 15 |
| d110, 125 | DN 100 | 35 | 20 | 20 |
| d140 | DN 125 | 45 | 25 | 25 |
| d160, 180 | DN 150 | 60 | 35 | 30 |
| d200, 225 | DN 200 | 70[1)] | 45 | 35 |
| d250, 280 | DN 250 | 65[1)] | 35 | 30 |
| d315 | DN 300 | 90[1)] | 50 | 40 |
| d355 | DN 350 | 90[1)] | 50 | - |
| d400 | DN 400 | 100[1)] | 60 | - |
| d450, 500 | DN 450, DN500 | 190[1)] | 70 | - |
| d560, 630 | DN 600 | 220[1)] | 90 | - |

[1)] Maximum operating pressure 6 bar
Bolt tightening torque guidelines for ISO flange connections

**Please observe the special bolt tightening torques listed for butterfly valves DN25 and DN300. See also the section “Planning fundamentals for butterfly valves, hand-operated”.**

## 5.10.4 Bolt tightening torque guidelines for ASME flange connections with PP-V, PP- steel and PVC flanges

| Flange size (inch) | Nominal diameter DN (mm) | Bolt tightening torques (lb-ft) | |
|---|---|---|---|
| | | Flange ring maximum pressure 10 bar / 40 °C | Profile gasket maximum pressure 16 bar |
| ½" | DN15 | 15 | 10 |
| ¾" | DN20 | 15 | 10 |
| 1" | DN25 | 15 | 10 |
| 1¼" | DN32 | 15 | 10 |
| 1½" | DN40 | 15 | 10 |
| 2" | DN50 | 30 | 20 |
| 2½" | DN65 | 30 | 20 |
| 3" | DN80 | 40 | 30 |
| 4" | DN100 | 30 | 20 |
| 6" | DN150 | 50 | 33 |
| 8" | DN200 | 50 | 33 |
| 10" | DN250 | 60[1)] | 40 |
| 12" | DN300 | 75[1)] | 53 |

[1)] Maximum operating pressure 6 bar

## 5.10.5 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 | SW19 (18) | 1.7 | 10.4 |
| DN32–DN125 | M16 | SW24 | 2.0 | 14.1 |
| DN150–DN350 | M20 | SW30 | 2.5 | 20.2 |
| DN400–DN500 | M24 | SW36 | 3.0 | 20.2 |
| DN600 | M27 | SW 41 | 3.0 | 23.8 |

| Flat gasket (mm) | Thickness (mm) |
|---|---|
| DN10–DN80 | ca. 2 |
| DN100–DN600 | ca. 3 |

| Profile seal (mm) | Thickness (mm) |
|---|---|
| DN10–DN40 | ca. 3 |
| DN50–DN80 | ca. 4 |
| DN100–DN125 | ca. 5 |
| DN150–DN300 | ca. 6 |
| DN350–DN600 | ca. 7 |

| Flange | PP-V | PP steel | Stahl (hole circle PN16) | Stahl (hole circle PN10) |
|---|---|---|---|---|
| DN10 | – | – | – | – |
| DN15 | 16 | 12 | – | – |
| DN20 | 17 | 12 | – | – |
| DN25 | 18 | 16 | – | 12 |
| DN32 | 20 | 20 | – | 14 |
| DN40 | 22 | 20 | – | 14 |
| DN50 | 24 | 20 | – | 16 |
| DN65 | 26 | 20 | – | 16 |
| DN80 | 27 | 20 | – | 18 |
| DN100 | 28 | 20 | – | 18 |
| DN125 | 30 | 24 | – | 25 |
| DN150 | 32 | 24 | – | 20 |
| DN200 | 34 | 27 | 24 | 20 |
| DN250 | 38 | 30 | 30 | 22 |
| DN300 | 42 | 34 | 34 | 26 |
| DN350 | 46 | 40 | 35 | 28 |
| DN400 | 50 | 40 | 38 | 32 |
| DN450 | – | – | – | 36 |
| DN500 | – | 54 | 46 | 38 |
| DN600 | – | 64 | | 42 |

| Metric flange adapters for butt fusion joints | Thickness (mm) | |
| --- | --- | --- |
| | PE SDR11 | PE SDR17/17.6 |
| d16/DN10 | – | – |
| d20/DN15 | 7 | – |
| d25/DN20 | 9 | – |
| d32/DN25 | 10 | – |
| d40/DN32 | 11 | – |
| d50/DN40 | 12 | 12 |
| d63/DN50 | 14 | 14 |
| d75/DN65 | 16 | 16 |
| d90/DN80 | 17 | 17 |
| d110/DN100 | 18 | 18 |
| d125/DN100 | 25 | 25 |
| d140/DN125 | 25 | 25 |
| d160/DN150 | 25 | 25 |
| d180/DN150 | 30 | 30 |
| d200/DN200 | 32 | 32 |
| d225/DN200 | 32 | 32 |
| d250/DN250 | 35 | 25 |
| d280/DN250 | 35 | 25 |
| d315/DN300 | 35 | 35 |
| d355/DN350 | 40 | 30 |
| d400/DN400 | 46 | 33 |
| d450/DN500 | 60 | 60 |
| d500/DN500 | 60 | 60 |
| d560/DN600 | 60 | 60 |
| d630/DN600 | 60 | 60 |

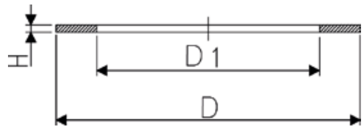
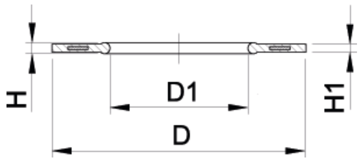
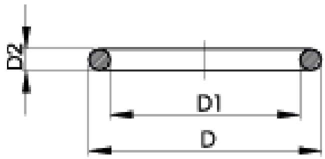
| Valves installed in flange connection (mm) | Installation length (mm) | |
| --- | --- | --- |
| | Butterfly valve Type 567/578 | Butterfly valve Type 038/039 |
| DN32 | – | – |
| DN40 | – | – |
| DN50 | 45 | 43 |
| DN65 | 46 | 46 |
| DN80 | 49 | 46 |
| DN100 | 56 | 52 |
| DN125 | 64 | 56 |
| DN150 | 72 | 56 |
| DN200 | 73 | 60 |
| DN250 | 113 | 68 |
| DN300 | 113 | 78 |
| DN350 | 129 | 78 |
| DN400 | 169 | 102 |
| DN450 | 179 | 113 |
| DN500 | 190 | 126 |
| DN600 | 209 | 146 |

## 5.10.6 Selection of gaskets for flange connections

When selecting suitable flange seals for thermoplastic piping systems, the following factors must be taken into account:

- Operating conditions
- Sealing forces
- Gasket form
- Dimension
- Material

### Type of gasket

| Flat gasket | Profile gasket | O-Ring |
|---|---|---|
|  |  |  |







In applications with low operating pressures, the customary flat gasket, which is made of 2 to 5 mm thick sheet material (depending on the nominal width), is sufficient. Flange connections with flat gaskets require flanges with sufficient stiffness. All flanges by GF Piping Systems meet these requirements.

For higher operating and testing pressures, profile flange gaskets and O-rings have proven useful. Compared to flat gaskets, profile flange gaskets consist of two parts. One is the crowned flat gasket part, which is reinforced with steel, and the other is the profile gasket part (O-ring, lip seal) on the inner side of the gasket.

Stabilized profile flange gaskets, as well as O-ring gaskets, have the following advantages:

- Reliable seal with low bolt tightening torque
- Usable at higher internal pressures and internal vacuum
- Minor influence of flange or collar surface
- Safe operation when connecting pipes 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 gasket | Vacuum (p = 0 bar to 16 bar T = entire application range | With or without sealing grooves |
| O-ring | Vacuum (p = 0 bar to 16 bar T = entire application range | One side with groove |

### Gasket material

The choice of a gasket material is based on the flow media. Details about the suitability of the gasket material, or specifically its chemical resistance, can be found in the GF Piping Systems resistance tables.

The use of gasket materials with a high degree of hardness, as in steel pipes, 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 (for water applications) or FPM (for gas applications), with a Shore-A hardness of up to 75° are preferable.

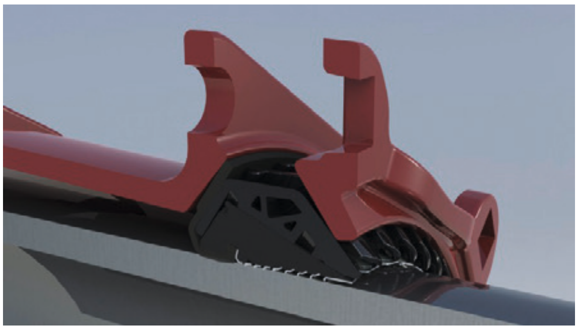
### Gasket dimension

The dimensions of the gaskets are set in the general standards for pipe jointing components. Excessive dimensional deviations in the inside or outside diameter of the gasket compared to the flange adapter or valve end cause increased mechanical stress of the flange connection, accelerated wear of the inner side of the gasket, as well as deposits inside the pipe.

## 5.11 MULTI/JOINT 3000 Plus

### 5.11.1 Overview

Material
- All pipe materials

| Wide range fitting | Sealing system cross section | Suitable for all pipe materials |
|---|---|---|
|  |  |  |

### 5.11.2 Connection technology

Wide range fittings connect pipes by means of compression. When the bolts are tightened, a seal is pressed onto the pipe surface. In the restraint version, a Uni/Fiks ring secures the connection. The Uni/Fiks ring is provided with gripping elements ("Fiksers"), which transfer the axial forces (through the internal pressure) or tensile forces that occur, to the pipe surface and as a result create a restraint connection. As a result of this unique design, use is possible on all pipe materials.

The MULTI/JOINT 3000 Plus fittings have a wide range of up to 43 mm and connect pipes with a pipe outside diameter of 46 mm to 637 mm (DN50-600). This wide range allows different pipe materials to be connected with ease.

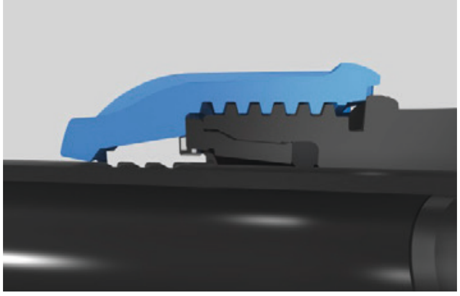
THE ORIGINAL · DAS ORIGINAL · EL ORIGINAL · HET ORIGINEEL · MULTI/JOINT ® MULTI/JOINT ® MULTI/JOINT ®

### Advantages and properties

- Easily accessible bolts with anti galling coating – this prevents cold welding
- Maximum angular deflection of ± 8° per socket side. For a coupling, this means a total maximum angular deflection of 16°
- Restraint for aboveground and underground installation
- Flanges with separate flange bores for PN10 or PN16. (DN425-600 combi-flanges)
- The technical design life of all MULTI/JOINT 3000 Plus products is 50 years
- All fittings are supplied with hygienic protection. This means the fittings are optimally protected against external influence and damage until they reach the construction site

**For more information see www.waga.nl**

## 5.12 iJOINT

| Compression fitting | Connection cross-section | Easy assembly |
|---|---|---|
|  |  |  |

### 5.12.1 Connection technology

The iJOINT compression fitting connects PE pipes by compressing the seal. When the nuts are tightened, a lip seal is pressed onto the pipe surface. A grip ring secures the connection. The grip ring transfers the axial forces (through the internal pressure) or tensile forces that occur to the pipe surface and as a result creates restraint.

| Body and thrust ring | Properties |
|---|---|
| Body and thrust ring | UV-stabilized polypropylene impact-resistant copolymer with high long-term age resistance in accordance with ISO 9080. |
| Coupling nut | UV-stabilized blue polypropylene impact-resistant copolymer |
| Clamp ring | Polyoxymethylene (POM) |
| Seal | NBR lip seal to d63<br>NBR profile seal from d75 to d110 |
| Reinforcing ring (for internal thread) | Stainless steel AISI 430 |
| Thread | External thread conical / internal thread cylindrical in accordance with ISO 7 |

### Advantages and properties

- For water installations up to 16 bar
- Temperature range: -10°C to +45° C
- Fast and easy installation
- No pipe preparation required (e.g. chamfering)
- No special tools required
- The special lip gasket allows a smoot pipe insertion and provides at the same time the best possible tightness also in case of out of roundness or slightly scratched pipes.
- Reusable

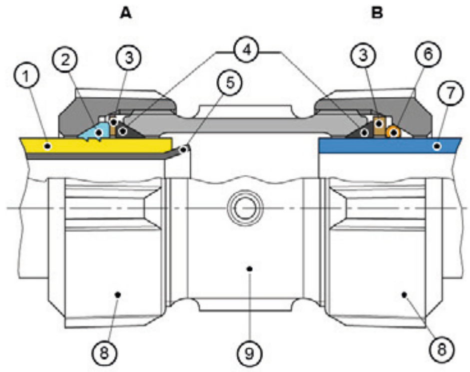
**For more information on using iJOINT, see www.gfps.com**

# 5.13 PRIMOFIT

## 5.13.1 Overview

### Material

- Steel pipes, butt weld tubes and lead pipes
- PE-, PE-Xa pipes

| Compression fitting | Connection cross section |
| --- | --- |
|  |  |



A PE connection
B Steel connection
1 PE pipe
2 Locking ring for PE pipe
3 Washer
4 Rubber seal
5 Insert stiffener
6 Locking ring for steel pipe
7 Steel pipe
8 Nut
9 Coupling body

## 5.13.2 Connection technology

PRIMOFIT is a compression fitting which offers full end load capability. Additionally it allows a misalignment of the connected pipes up to 3° per compression joint. In pre-assembled condition of PRIMOFIT compression fittings, the inner diameter of the internal components seal, washer and locking ring are bigger than the maximum outer diameter of the pipe. Therefore pipe insertion without dismantling is granted. By tightening the nut the seal is pressed into the space between conical surface of the fitting body and the outer surface of the pipe. At the same time a clamping effect is applied on the locking ring, which enables full end load resistance. For connecting PE and PE-Xa pipes an insert stiffener that is designed to fit into the inner diameter of the pipe is required, which increases the resistance of the PE / PE-Xa pipe to the radial forces.

### Advantages and properties

- Main applications: water, gas, oil, compressed air, fuel
- Pressure/temperature: up to maximum 16 bar, -20 to 150 °C (depending on sealing material)

**Material:**

- Nut and body: white malleable cast iron EN-GJMW-400-5 in accordance with EN1562 with black or hot-dip galvanized surface
- Seal: NBR, EPDM or FKM
- Pre-assembled ready for installation – no need for dismantling
- Individually packaged with color code system, barcode (EAN) and assembly instructions
- Spare-pack system (sealing kits) for flexible solutions and reuse
- No special tools or skills necessary
- No special pipe preparation needed (e.g. cutting threads)
- Fast assembly, no cooling times – time-saving installation
- Non-destructive dismantling possible
- Small and compact fitting can be used in awkward places

i **For more information on using PRIMOFIT, see www.gfps.com and www.fittings.at**

IV

# 5.14 UNI-Coupling

## Material

- PE, PVC, PP, ABS, GFK
- Steel, rubber coated steel, galvanized steel, ductile cast iron, copper[1], copper-nickel, aluminum[2]

| UNI-Coupling | Connection cross section |
| --- | --- |
|  |  |

1 Soft annealed copper pipes only in conjunction with reinforcement rings

2 Dependent on pipe wall thickness

## 5.14.1 Connection technology

Stainless steel couplings connect pipes by means of compression. When the screws are tightened, a seal with a conical structure is pressed onto the pipe surface. In the tension-resistant design, an anchoring ring secures the connection. The anchoring ring transfers the axial forces (through the internal pressure) or tensile forces that occur to the pipe surface. This creates restraint. As a result of this unique design, use is possible on various pipe materials.

### Advantages and properties

This coupling made of stainless steel offers numerous advantages over similar connection elements. This is because this coupling contains two special components that make it so unique. A patented seal prevents leaks and a specially shaped anchoring ring ensures a reliable and permanent connection. As a result of the uncomplicated structure, the coupling is quick to install. Thanks to the type diversity, it can be used as a connector between pipes of different materials and with different outside diameters. Better, faster and more reliable than you have known before. UNI-Coupling offers you an easy-to-install solution that saves time and money.

- Material throughout: W5  1.4571
- Patented seal with compensation principle
- No strip insert required (exception only with vacuum > 0.5 bar negative pressure)
- Anchoring ring for maximum tensile strength
- Bridging of greater pipe dimensions with larger clamping range
- Up to 5% angular deflection possible
- Continuous weld seam on housing (no corrosion)
- Up to 35 mm gap between pipe ends possible
- Angular deflection up to 5°
- 3 mm tolerance for connection with different pipe outside diameters

**For more information on using UNI-Coupling, see www.gfps.com**

# ELGEF Plus System

## Content

# 1 The ELGEF Plus electrofusion system

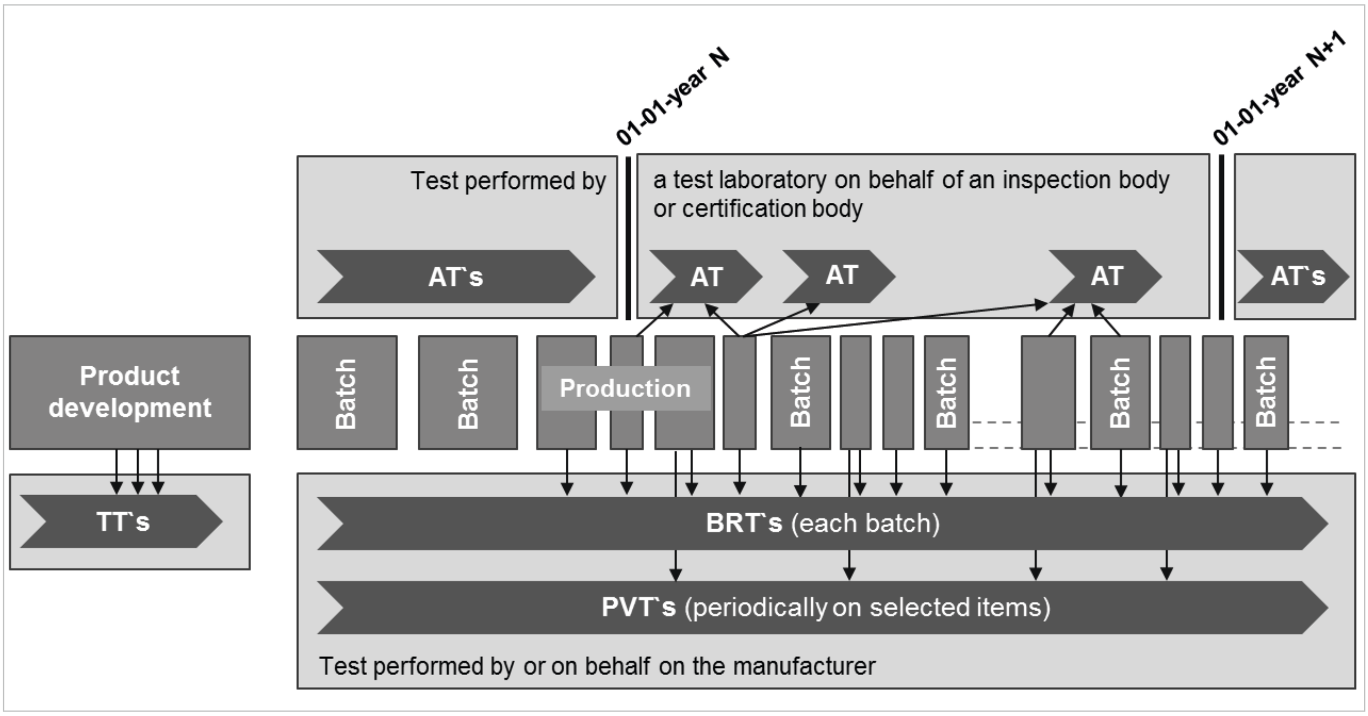
ELGEF stands for **EL**ektroschweissen **GE**org **F**ischer and has been the brand name of the electrofusion system from GF for over 30 years now. The system consists of electrofusion fittings and saddles as well as PE ball valves and spigot fittings.

## 1.1 Quality

ELGEF Plus products undergo strict quality control as defined in the internal quality plan. This quality is checked and confirmed by means of internal and external audits.

The quality plan defines the procedure, the means and the chronological sequences necessary to verify and document the specified quality targets for the ELGEF Plus products. ISO10005 and the approvals and standards listed in Chapter 4 serve as the specification.

**Interrelationship and chronological sequence of the TT/AT/BRT/PVT tests**




**TT** Type Test; a test performed in order to prove that the material or the parts meet the requirements listed in the relevant standards.
**AT** Audit Test; a test performed by or on behalf of a certification body.
**BRT** Batch Release Test
**PVT** Process Verification Test; the planned random sampling of parts and materials in order to verify the process continuity.

## 1.2 Field of application

ELGEF Plus electrofusion and spigot fittings are developed, approved, manufactured and monitored according to the applicable standards EN 12201, ISO 4427 (water), EN 1555, ISO 4437 (gas), EN ISO 15495 (industrial application) as well as other local standards.

### Suitable pipes

ELGEF Plus electrofusion and spigot fittings are suitable for welding PE standard pipes made of PE63, PE80, PE100 and PE100 RC whose melt flow rate (MFR) is between 0.2 and 1.4 g/10 min. and corresponds with the common pipe standards EN12201-2, EN 1555-2, DIN 8074/75, ISO 4427-2 and ISO 4437-2. The restricted diameter tolerance class B and the upper limit dimension of ovality are recommended for straight lengths. Separate product-specific or manufacturer-specific approvals apply for PE-X pipes.

For pipes with a minimum wall thickness $s_{min}$ ≥ 3,0 mm, ELGEF Plus electrofusion fittings can generally be welded in the following SDR and dimensional range:

- d20 – d800 mm SDR 11
- d90 – d1200 mm SDR 17/17.6

ELGEF Plus fittings can also be welded compatibly with other SDR classes. The permissible SDR range is shown on the barcode attached to the fitting and must be confirmed by the responsible GF branch in doubtful cases.

When different SDR classes are used in one system, the highest SDR level determines the maximum operating pressure.

### Ambient temperature

ELGEF Plus electrofusion fittings can be installed using GF electrofusion machines at ambient temperatures of between -10°C and +45°C. The measures described in DVS 2207-1 must be taken in the case of adverse weather conditions (rain, frost, insolation etc.).

**Examples:** Protection from adverse weather conditions

Protecting the welding zone using a tent

Water residues must be pumped off

V

### Maximum operating pressure

After installation in a piping system, ELGEF Plus electrofusion and spigot fittings are exclusively intended for allowing media such as gas or water to flow through the pipe within the permissible pressure and temperature limits or for controlling this flow.

| | Water (20 °C) | Gas (20 °C) |
|---|---|---|
| PE100 | Max. operating pressure at C=1.25 PFA [bar] | Max. operating pressure at C=2.0 MOP [bar] |
| SDR11 | 16 | 10* |
| SDR17 | 10 | 5* |

* Please note deviations according to national regulations (e.g. CH) or product-specific restrictions!
PFA Maximum permissible operating pressure for water (pression de fonctionnement admissible)
MOP Maximum permissible operating pressure for gas (maximum operating pressure)

## 1.3 Identification

### 1.3.1 Batch no. (production batch)

Important information on logistics (article no./EAN code/batch/weight), applicability (standards/approvals/application) and simplified installation (online operating manual/manual welding data) can be found on the bag or box packaging. The batch no. (production batch) is also permanently moulded into the product in the form of a series marking providing information on production year and production batch.


18 Year of production
1 Production batch

In this case: batch no. 1801
Meaning: 1st production batch produced in 2018

## 1.3.2 Welding data and traceability

### Welding data

There are various different ways of transmitting the welding data to the welding unit. The most widespread (and recommended) method is by reading in a welding barcode. The contents of this welding barcode are described in the standard ISO 13950. Input errors are avoided by reading in the welding barcode. The welding parameters are automatically transmitted to the welding unit.

If it is not possible to read in the welding data automatically by means of the welding barcode, the welding data can be entered manually.

### Temperature-compensated welding times

All ELGEF Plus electrofusion fittings have a barcode which automatically adapts the welding time to the ambient temperature of the welding unit. Electrofusion fitting, pipe and welding unit have to be on the same temperature level before welding begins. Please note the time necessary for adapting the temperature!

### Traceability

Continuous traceability safeguards the operation of the piping system. For each component, the entire processing chain can be traced back to the production of the raw materials.

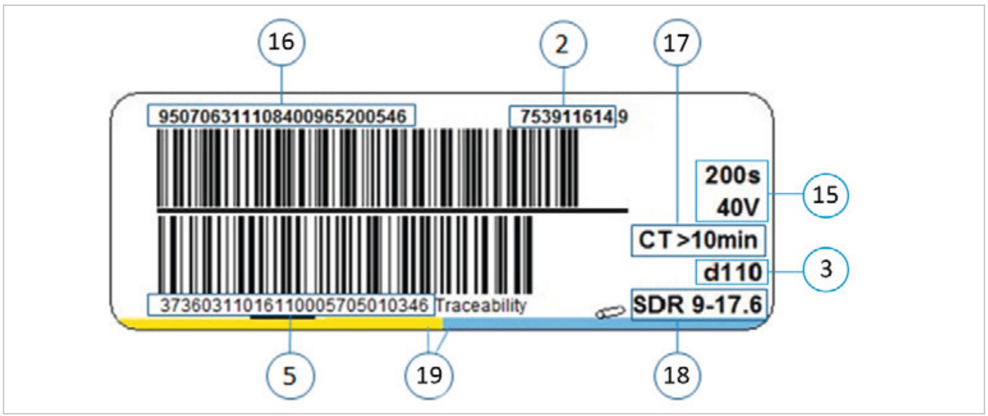
The system of traceability is described in the standard ISO 12176, Part 4.

Besides the welding barcode, the sticker attached to the ELGEF Plus electrofusion fitting also includes the traceability barcode. The information on the cooling time and the applicability of the permissible SDR classes of the pipe complete the welding data. In addition, the manual welding data in various temperature ranges is displayed on the bag label.

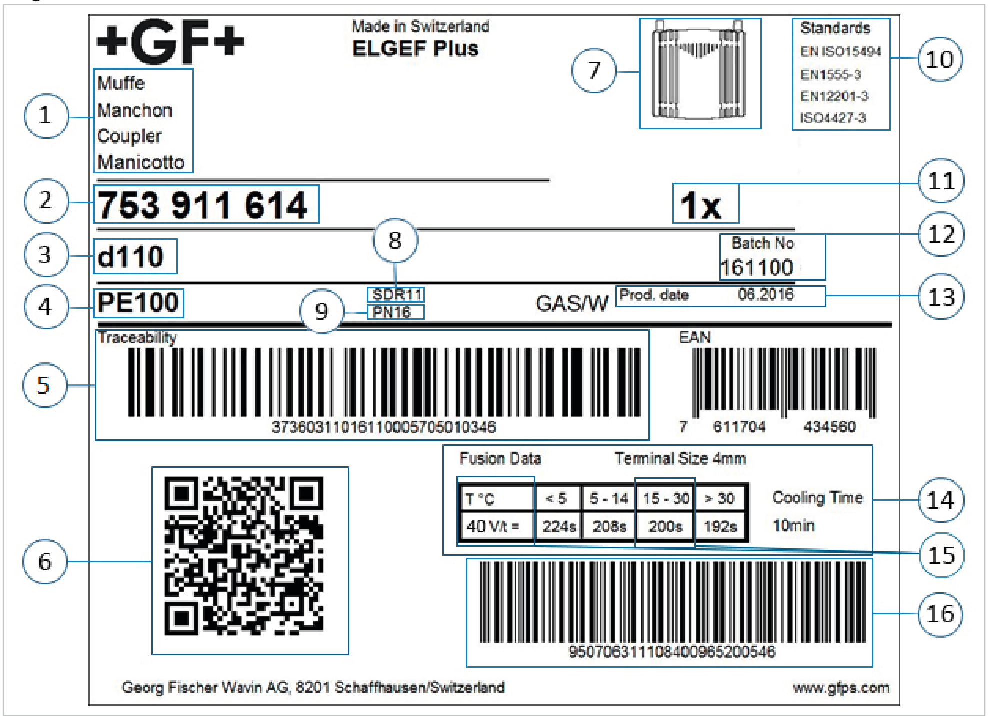
### Documentation

The documentation of the work sequence for pipe installations is becoming more and more important. In this connection, the WeldinOne software assists you in welding or system maintenance. The Welding Book software extends the data about the joint beyond the welding records gathered by the electrofusion and butt welding units. The software automatically combines images made using any smartphone camera with the welding records in each case in order to document all preparatory activities such as peeling and using clamp holders as well as using the correct fittings and pipes. The Barcode Creator helps you to create the Operator IDs for your fitters in accordance with your competences and the ISO 12176-3 standard. It creates the order number in a transparent way in order to trace the installation or the construction site and allows the automatic assignment of your joint to a certain code. The Barcode Creator creates certain codes for the tools used at the construction site and even for pipes (manufacturer, type, diameter and date of purchase).

**Barcode label**




**Bag label**




1. Product name
2. Code number
3. Dimension
4. Material
5. Traceability code ISO 12176
6. Unitary QR-Code
7. Product picture
8. SDR-Class of the fitting
9. Max. operating pressure
10. Norms / Approval
11. Number of items
12. Batch-No.
13. Production month and year, YY.XXXX
14. Manual Welding data
15. Nominal welding time and welding voltage
16. Welding-Barcode ISO 13950
17. Min. Cooling time
18. SDR-Class of the Pipes
19. Color bar: yellow = Gas, blue = Water

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

# 1.4 CAD library

## Product library of GF Piping Systems

With this CAD library, GF Piping Systems aims to provide designers and engineers with even better and more efficient support for the design of piping systems.

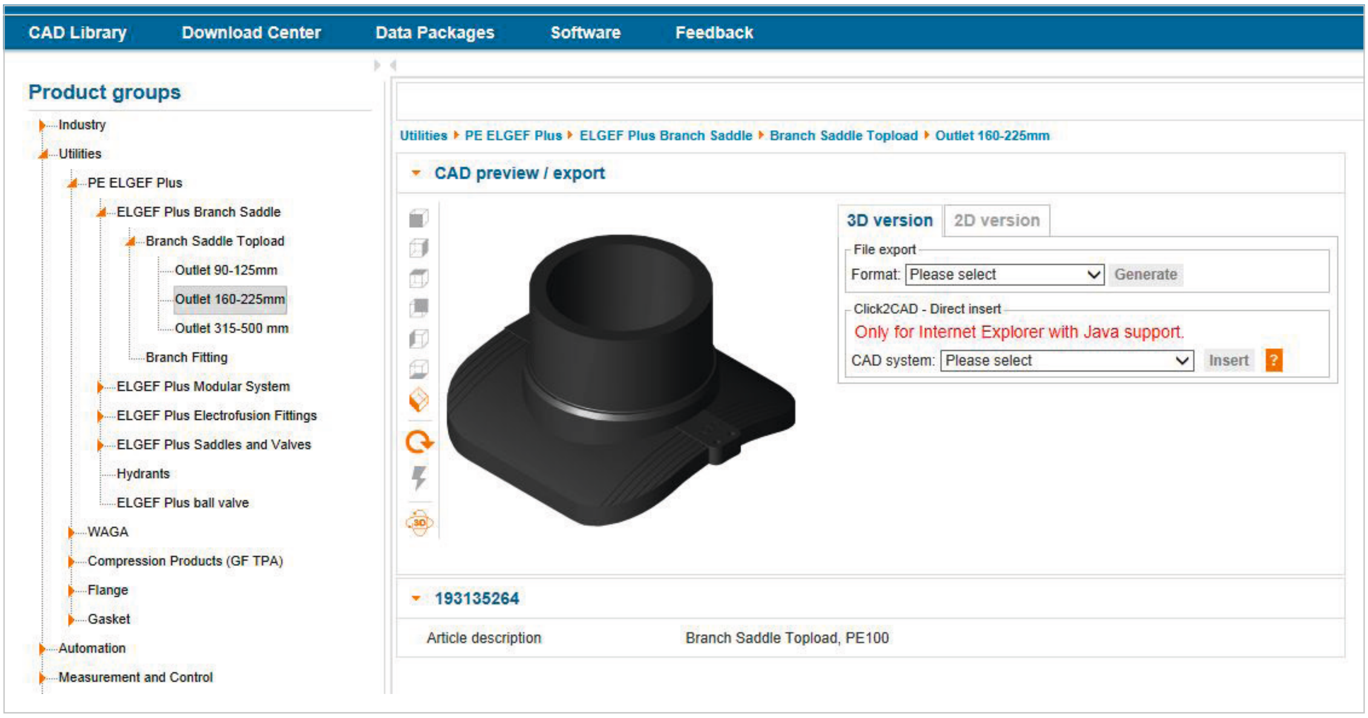
Three-dimensional models (3-D models) of all piping components by GF Piping Systems in the area of industrial applications can be called up via the database. The user creates two dimensional drawings (2-D drawings) on his own in the desired views.

The library does work independently from the user's CAD system. Many systems and interfaces are supported.

The database comprises over 30,000 drawings and technical data regarding pipes, 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
- Pipes, 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




G5.9 Sample presentation of a CAD library

**Direct access to the online CAD library at http://cad.georgfischer.com**



V

# 2 Couplers and fittings

## 2.1 System advantages of ELGEF Plus couplers

**ELGEF Plus couplers d20-63 – integrated pipe fixation**

ELGEF Plus electrofusion couplers d20-63 are equipped with an "integrated pipe fixation".

This facilitates pipe installation for:
- Vertical pipe sections
- The preinstallation of fittings, metal adapters or valve modules
- The prefixation of coiled pipe ends (does not replace the use of clamping devices)

**ELGEF Plus couplers d20-160 – easy-to-remove center stop**

All ELGEF Plus electrofusion couplers d20-160 are equipped with a removable center stop. This facilitates pipe installation:
- An end stop can be felt when the pipe is inserted
- When the coupler is pushed over the pipe, the center stop can be „ejected" easily by the pipe

**ELGEF Plus couplers - number of welding zones**

ELGEF Plus electrofusion couplers d20-500 have two interconnected (monofilar) welding zones, i.e. both welding zones are welded in one welding process.

As a result of the necessary power input, two separate (bifilar) welding zones are required for ELGEF Plus couplers ≥ d560. This means that each pipe end can be welded separately using these electrofusion couplers.

**ELGEF Plus couplers – easy to install and easy to push over pipes**

Thanks to the covered wires and the specially developed electrical design, all ELGEF Plus electrofusion couplers are able to bridge a relatively large gap. For this reason, the couplers have a larger internal diameter. This facilitates pipe installation:
- When the coupler is pushed onto the pipe end
- When the coupler is slided over the pipe, thus reducing the installation time

**ELGEF Plus couplers d355-800 – active reinforcement**

ELGEF Plus electrofusion couplers d355-800 are equipped with an „active reinforcement". The outer PE ring expanded in the manufacturing process exerts its tension when heated during the welding process and actively presses onto the internal ring during welding. This causes the gap between pipe and fitting to be closed actively and expansion of the coupler to be inhibited.

In other words:
- The couplers are easier to push over the pipe, thus facilitating installation
- Reduced installation times are possible without preheating or additional equipment

## 2.2 System advantages of ELGEF Plus fittings

**ELGEF Plus fittings d20-63 – integrated pipe fixation**

ELGEF Plus electrofusion fittings d20-63 are equipped with an „integrated pipe fixation".

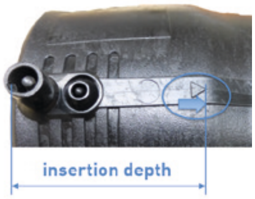
These facilitate pipe installation for:

- Vertical pipe sections
- The preinstallation of fittings, metal adapters or valve modules
- The prefixation of coiled pipe ends (does not replace the use of clamping devices)

**ELGEF Plus fittings – easy to install and easy to push onto pipes**

Thanks to the covered wires and the specially developed electrical design, all ELGEF Plus electrofusion fittings are able to bridge a relatively large gap. For this reason, the fittings have a larger internal diameter. This facilitates pipe installation when the fittings are pushed onto the pipe end and reduces the installation time.

**ELGEF Plus fittings d75-250 – insertion depth marking**




There is an insertion depth marking on ELGEF Plus electrofusion fittings d75-250. This facilitates the measurement of the welding zone length without the packaging of the fitting having to be opened at an early stage, allowing the fitting to become contaminated.

**ELGEF Plus fittings d75-180 – angle marking**

There is an angle marking on ELGEF Plus electrofusion fittings d75-180 at the coupler opening of the fitting. This facilitates the alignment of the fitting with regard to angle and position during installation without additional measuring equipment being required.

**ELGEF Plus fittings – number of welding zones**

ELGEF Plus electrofusion fittings d20-180 have two interconnected (monofilar) welding zones, i.e. both welding zones are welded in one welding process. To facilitate installation, ELGEF Plus electrofusion fittings ≥ d200 have two separate (bifilar) welding zones.

This means that, with these electrofusion fittings, each pipe end can be welded separately.

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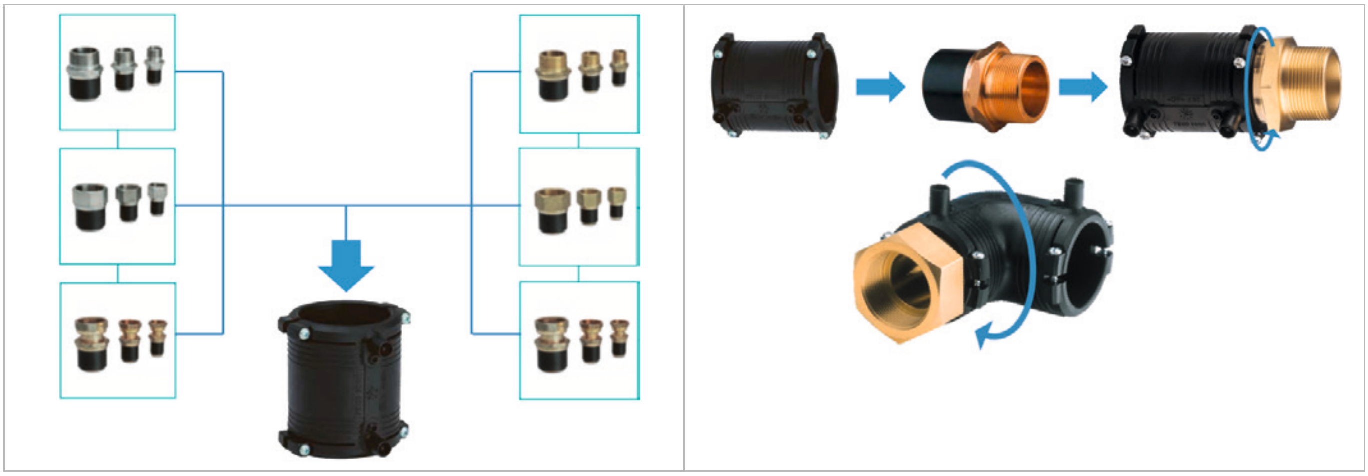
## 2.3 System advantages of ELGEF Plus transition adaptors



**ELGEF Plus transition fittings d20-63 – modular system**

ELGEF Plus electrofusion transition couplers and fittings d20-63 are structured as a modular system. A wide range of transition variants can be created from one coupler or fitting. This flexibility makes installation easier and faster – and reduces your installation costs. These transition adaptors can only be used in conformity with the system in connection with ELGEF Plus electrofusion fittings.

This increases your installation flexibility and reduces the necessary warehouse space:

- Complete system with few individual parts
- Reduction of warehouse storage by up to 50% in value terms
- Flexible mounting to valves as a result of being able to rotate and screw the adaptor until just before welding begins
- Materials approved for use with drinking water – optionally in brass or stainless steel

During installation, it should be noted that the piping must withstand mechanical stresses and the expected corrosive stresses coming from the outside. If necessary, the transition adaptors must be coated or covered. The existing soil conditions and the installation and operating conditions are crucial for the selection of the pipe covering.

The outer coating or covering has to meet the various requirements in a suitable way as follows:

Excellent stability against external influences after installation, such as aggressive soils, stray currents, microorganisms, plant growth etc.

# 3 Saddles and pressure tapping valves (PTVs)

## 3.1 System advantages of ELGEF Plus saddles

**ELGEF Plus saddles d63-400 – modular system**

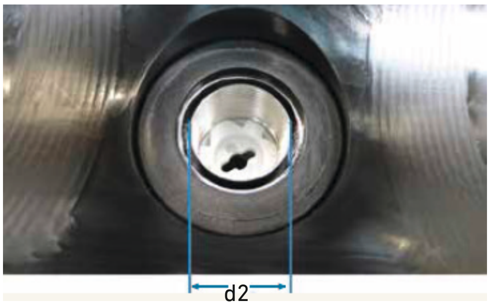
ELGEF Plus electrofusion Duobloc saddles d63-400 are structured as a modular system. It is possible to create a wide range of variants from one Duobloc saddle - such as tapping saddles, tapping saddles with a gas stop, PTVs, stop-off saddles and spigot saddles with cutter - for different outlet dimensions.

This increases your installation flexibility and reduces the necessary warehouse space:

- Complete system with few individual parts
- Reduction of warehouse storage by up to 50% in value terms
- Variable assembly possible as the outlet can be rotated by 360°
- Vertical or horizontal installation possible

This flexibility makes installation easier and faster – and this in turn reduces your installation costs. In the modular system, only additional components conforming to the system are permitted!

**ELGEF Plus saddles d63-400 – large tapping diameter**




ELGEF Plus electrofusion saddles have extra large tapping diameters (d2). They also have considerably larger cross-sections than the usual commercially available products.

This causes a lower pressure loss and gives the operator the following advantages:

- More pressure arrives at the consumer at the same input pressure or
- The pressure in the supply pipe can be reduced

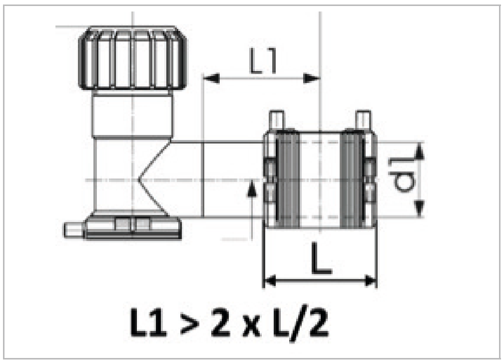
**ELGEF Plus saddles – outlet spigot no longer needs to be peeled**

We lay particular emphasis on cleanliness during the production of the electrofusion fittings, and each fitting is „cleanly" packed in a bag. As a result, the connecting spigots to the electrofusion saddle or to the outlet pipe do not need to be peeled - on condition that they are used immediately upon removal from the protective bag:

- This saves valuable installation time
- There are no expenses for special peeling tools

In this way, you can reduce the costs of your house connecting project, making you more competitive. If the outlet spigots are peeled correctly, this still does not reduce the quality. The usability is ensured. We recommend cleaning the outlet spigot using Tangit PE cleaner.

**ELGEF Plus saddles - length of the outlet spigot**




In the unfavorable event of an installation error, the length of the outlet spigot allows a second welding process to be carried out. The outlet spigot of the ELGEF Plus electrofusion saddles can be shortened in the case of an installation or welding error, and the remaining length allows the outlet to be rewelded*:

- When necessary, this saves considerable installation time and reconditioning costs
- This saves you from trouble with the residents and the network operator

* This does not apply when an integrated excess flow valve is used

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**ELGEF Plus branch saddles – efficient installation of reduced outlets**

ELGEF Plus branch fittings are an extremely reliable and hugely economical way of installing reduced outlets and offer you the following advantages when they are newly installed:

- Variable positioning on the main pipe
- 1 weld less in comparison with a T-piece
- For main pipes d63 - d2000 with outlet solutions d63 - d500
- Full pressure class possible
- Considerably lower material costs
- Overall installation costs are reduced considerably as a result of the shorter installation time and the smaller size of the trench

When integrated later:

- Can be integrated under operating pressure
- The usual common not tapping methods can be used
- Smaller trench size in inner city areas
- Optimum alternative to the T-piece for new installation, later integration and renovation/repairs

## 3.2 System advantages of tools - tapping saddles

| Article no. | Installation tools |
|---|---|
| 799 198 047 | Installation and tapping keys for saddles (external hex SW8, internal hex 10 and 17) |
| 799 150 378 | Hex key for saddles and branch saddles (external hex SW8) |

**T5.15 Monobloc tapping saddles d40, d50**

| | $d_n$ | Tapping key | Test cap | Tapping adaptor* |
|---|---|---|---|---|
|  | 40<br>50 |  |  | Not necessary! |

* Tapping with no gas losses.

**T5.16 Monobloc tapping saddles with sprayed lower section**

| | $d_n$ | Tapping key | Test cap | Tapping adaptor* |
|---|---|---|---|---|
|  | 63<br>90<br>110<br>125<br>160 |  |  | Not necessary! |

* Tapping with no gas losses.

**T5.17 Duobloc tapping saddles with rotatable outlet**

| | $d_n$ | Tapping key | Test cap | Tapping adaptor* |
|---|---|---|---|---|
|  | 63<br>-<br>400 |  | S54 for outlet d20-40<br>S67 for outlet d50-63<br> | S54 for outlet d20-40<br>S67 for outlet d50-63<br> |

* Tapping with no gas losses

**T5.18 Pressure tapping valves (PTVs):**

| | dn | Tapping key | Test cap | Tapping adaptor* |
|---|---|---|---|---|
|  | 63<br>-<br>400 | Ratchet<br>External hex<br>SW14 | Not<br>necessary! | Not<br>necessary! |
| | | 13 revolutions<br>Outlet d32 | | |
| | | 28 revolutions<br>Outlet d63 | | |

* Tapping with no gas losses

## 3.3 Stop-off adaptors

**ELGEF Plus stop-off adaptors – the repair solution for shut-off under gas pressure**

For the short-term shut-off of gas pipes while repairs are being made, stop-off adaptors are often used in the low-pressure range. Using an ELGEF Plus stop-off adaptor and an ELGEF Plus saddle, the shut-off adaptor can be connected to the piping quickly and easily.

This increases your installation flexibility and reduces the necessary warehouse space:
- Complete system with few spare parts
- Reduction of warehouse storage by up to 50% in value terms

## 3.4 Spigots saddle with cutter

**ELGEF Plus spigot saddles with cutter – a cost-efficient solution for new buildings**

A PE spigot with cutter can also be integrated into the modular system of ELGEF Plus electrofusion saddles:
- In doubtful cases, this reduces the height of the pipe covering
- It also saves you money on the components

## 3.5 Excess flow valves

Excess flow valves are for emergency shut-off after damage to or the destruction of branch pipes and prevent gas from escaping uncontrollably. This makes them an active protective element designed to reduce the risk of accident.

**Excess flow valves in the ELGEF Plus saddles**

The modular ELGEF Plus range of tapping saddles also includes variants with an excess flow valve:
- Reduced warehouse and component costs thanks to flexibility and modular system
- Variants for all pressure levels up to 10 bar available

Standard variants:
- Type AD UE 25 mbar – 1 bar with overflow orifice
- Type B UE 200 mbar – 5 bar with overflow orifice
- Type 1-5 bar without overflow orifice

# 4 Spigot fittings

The PE100 range of spigot fittings from Georg Fischer is the ideal addition to the ELGEF Plus electrofusion range, offering proven technology in an enormous range of variants.

Angles, curves, T-pieces, reductions, end caps and flange adaptor are available in the dimensional range between d20 and d1000 mm. They are easy to integrate into the ELGEF Plus system using ELGEF Plus couplers or fittings. Depending on the installation situation, these can also be butt-welded.

## 4.1 System advantages of ELGEF Plus spigot fittings

**Georg Fischer spigot fittings d20-1000 – comprehensive range**

First and foremost, the range of spigot fittings from Georg Fischer includes a wide range of variants. The width and depth of the range are crucial for their main applications. Numerous reductions and T-pieces with reduced outlets can help you out in special situations.

This increases your installation flexibility and lowers your effort on site, thus saving costs.

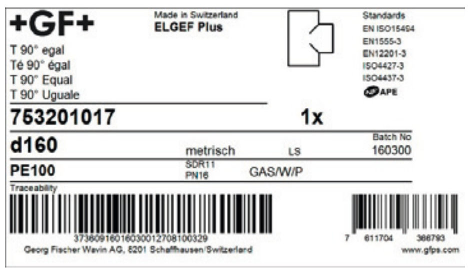
**Georg Fischer spigot fittings d20-315 – individually packed in PE protective bags**

Immediately after production, the spigot fittings from Georg Fischer are packed in PE protective bags and boxes. As with the ELGEF Plus electrofusion fittings, this prevents oxidation of the surface due to UV light. In other words, when the spigot fittings are transported and stored correctly, you can dispense with peeling the fittings on site:
- This reduces your installation time
- It also saves installation costs

**Georg Fischer spigot fittings d20-315 – complete traceability**

All spigot fittings from Georg Fischer are consistently equipped with the traceability barcode.

This increases your installation flexibility and lowers your input on site, thus saving costs:
- You feel secure in the knowledge that all quality-relevant factors of the welding joint have been sustainably documented
- Reduced search costs when damage occurs




**Georg Fischer Spigot fittings d355-800 - Designed for BIG ideas**

Large dimensions are a challenge for users and installers. Injection-moulded socket fittings up to d500mm support installation with features such as:
- Angle / insertion depth markings on the spigot
- Supporting surfaces for a spirit level
- Centring aid for flanges

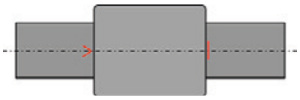
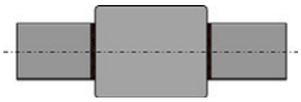
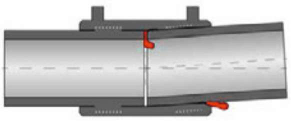
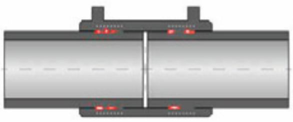
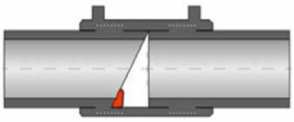
Up to dimension d800mm, Georg Fischer offers spigot fittings which are fully pressure rated and have no pressure reduction factor.

# 5 Installation guidelines - error prevention

### Frequent causes of error and remedial measures

Here is a list of causes which can lead to errors during electrofusion as a result of careless preparation, but are easy for the expert personnel to prevent by observing a small number of principles:

The errors in welding joints for heating coils are described in detail In DVS 2202, Supplement 2. In the following, we provide a short description of the most frequent causes of error as well as remedial measures without going into the details of the description, the test methods or the evaluation criteria.

| Figure | Cause of error | Remedial measures |
|---|---|---|
|  **G5.10 External welding error – insertion depth** | Insertion depth not seribed or incorrectly | Mark correctly and follow instructions |
|  **G5.11 External welding error – inadequate peeling** | There is no visible machining extending beyond the fitting body<br><br>The visible machining is:<br>• irregular<br>• inadequate (chip thickness)<br>• not continuous<br>• non present<br>• excessive (pipe undersized)<br>• impermissible (manual scraping for PE-X) | Mark correctly and follow instructions.<br>Suitable peeling device and regular maintenance |
|  **G5.12 Internal welding error - twisting** | Angular deviation with displacement of heating spiral and melt with or without separations in the joining plane, increased material flow, for example through<br>• non-flush pipe ends<br>• inadequate curvature radii in the case of ring coils<br>• bending moment on the sleeve<br>• movement during the welding<br>In extreme cases, this incorrect installation can lead to local overheating with smoke and flame development. | Use of clamping devices |
|  **G5.13 Internal welding error – shape inaccuracy** | Channel formation locally, over large axial areasor radially around the circumference, e.g. due to:<br>• notches and/or grooves in the pipe surface<br>• deviating diameter tolerance (pipe undersized)<br>• incorrect machining<br>• mechanical damage<br>• flaking | Suitable peeling device and regular maintenance<br>Replacement of the peeling blade |
|  **G5.14 Internal welding error – incomplete pipe insertion** | Pipe ends offset or not touching each other or the stop on one or both sides in the sleeve and melt emergence on the inside or outside, e.g. due to:<br>• insufficient pipe insertion on both sides / one side (no adequate coverage in the joining plane)<br>• unequal pipe insertion<br>• pipe end not cut off at a right angle<br>In extreme cases, this incorrect installation can lead to local overheating with smoke and flame development. | Cutting of the pipe ends at right angles.<br>Use a suitable pipe cutter |

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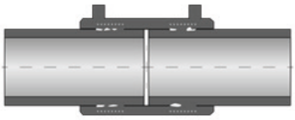
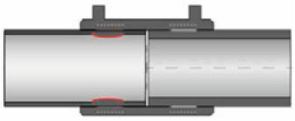
| Figure | Cause of error | Remedial measures |
|---|---|---|
|  **G5.15 Internal welding error – inadequate material bond** | Incomplete joint locally or over large areas with or without separation in the joining plane, e.g. due to:<br>• insufficient welding energy (e.g. premature welding termination)<br>• moisture<br>• contaminated surface<br>• impermissible material combinations | • Precleaning of the pipe, cleaning in the peeled area only; clean, lint-free paper; solvent evaporates completely, avoid touching the cleaned pipe surface.<br>• Use data of fitting to be welded only<br>• Comply with cooling time and avoid time pressure |
|  **G5.16 Internal welding error - SDR class not permissible** | Wall thickness of the pipe is outside of the SDR range specified by the fitting manufacturer. In extreme cases, this incorrect installation can lead to local overheating with smoke and flame development. | • Check compatibility on the barcode label before welding<br>• Use data of fitting to be welded only |

## Rewelding

If welding is aborted, e.g. as a result of external influences (such as generator breakdown), rewelding can be carried out after the materials have completely cooled down to the ambient temperature. The following points must be complied with here:

- Checking and correction of the cause of error. The relevant error message from the electrofusion unit gives indications as to the possible cause of error.
- It is not permitted to remove the clamping devices holding the joint.
- The fitting must be protected from contamination and moisture. It is not permitted to use additional coolants (cold water etc.) to accelerate the cooling process.

Checking of the fitting resistance at the electrofusion unit: fitting resistance must have the initial value again after cooling. It is not permitted to reweld joints if the tightness test was unsuccessful.

# 6 Electrofusion units


## 6.1 Overview of electrofusion units

| | MSA 125 | MSA 230 | MSA 330 | MSA 2.0 | MSA 340 | MSA 2.1 | MSA 2 MULTI | MSA 4.0 | MSA 4.1 |
|---|---|---|---|---|---|---|---|---|---|
| Material | PE/PP | PE | PE/PP | PE/PP | PE/PP | PE/PP | PE/PP/PB/ PVDF | PE/PP | PE/PP |
| **Electrical data** | | | | | | | | | |
| Protection class | IP54 | IP54 | IP54 | IP65 | IP54 | IP65 | IP65 | IP65 | IP65 |
| Switch | ✓ | ✓ | ✓ | | ✓ | ✓ | ✓ | ✓ | ✓ |
| Output voltage | 8-42V | 39-40V | 8-48V | 8-48V | 8-48V | 8-48V | 3.6-40V | 8-48V | 8-48V |
| Output current max (A) | 50 | 90 | 110 | 90 | 110 | 90 | 90 | 110 | 110 |
| Display | Graphical | Alphanum | Alphanum | Graphical | Alphanum | Graphical | Graphical | Graphical | Graphical |
| **Data and operating control system** | | | | | | | | | |
| Protocols | 350 | 350 | 500 | 350 | 1000 | 1000 | 500 | 5000 | 5000 |
| Export protocols | ✓ | ✓ | ✓ | | ✓ | ✓ | ✓ | ✓ | ✓ |
| Welding data format | CSV/PDF | CSV | CSV/PDF | | CSV/PDF | PDF/BIN | PDF/BIN | PDF/BIN | PDF/BIN |
| Language variants | 4 | 9 | 11 | Symbols | 11 | Symbols | Symbols | 27 | 27 |
| **Mechanical data** | | | | | | | | | |
| Weight (kg) | 13 | 19 | 23 | 11.9 | 23 | 11.9 | 11.9 | 12.5 | 12.5 |
| Power cable length (m) | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| Welding cable length (m) | 3 | 3 | 4 | 3 | 4 | 4 | 4 | 4 | 4 |
| **Functions** | | | | | | | | | |
| Order number | | ✓ | ✓ | | ✓ | ✓ | ✓ | ✓ | ✓ |
| Manual welding data input | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Traceability | | | | | ✓ | | | ✓ | ✓ |
| GPS | | | | | ✓ | | | ✓ | ✓ |
| Workflow configuration | | | ✓ | | ✓ | ✓ | ✓ | ✓ | ✓ |
| WeldinOne-compatible | ✓ | ✓ | ✓ | | ✓ | ✓ | ✓ | ✓ | ✓ |
| QR code | | | | | | | | Optional | ✓ |
| WLAN scanner | | | | | | | | | ✓ |
| Online service apps | | | | | | | | | ✓ |
| Mobile network comm. | | | | | | | | | ✓ |

## 6.2 Demands on generators

### Generators

Generators are used to ensure a reliable supply of electricity to the electrofusion unit at construction sites. The following requirements must be taken into account here:

- Generator maintained regularly (once yearly according to DVS) with sufficient output power for the electrofusion unit and the electrofusion fittings to be welded
- Sufficient fuel for the generator for the time it takes to make the necessary welds
- The generator supplies the electrofusion unit only (no other consumers)

The generator provides the electrofusion unit with a safe and stable electrical network - even under load - with the following basic conditions:

- Power output >3.5 kVA (or from d355 >6 kVA)
- Voltage 230 V ±10 %
- Frequency 50 Hertz ±10 %
- Current (back-up fuse) 13 to 20 A

### 6.2.1 Accessories

#### Adaptors

As the connectors on the cable of the electrofusion unit are subject to wear due to frequent insertion and removal, adaptors should be used. This reduces the costs and prevents unnecessary failure of the electrofusion unit. Worn-out adaptors must be replaced.

#### Angle adaptors

Some installations which are located in inner-city areas or use multifunctional pipes offer very little space. In order to have sufficient room for the power supply of the electrofusion fitting while minimizing installation height, it can be helpful to use angle adaptors.

#### Extension cables

Maximum 20 m with a cross-section of 2.5 $mm^2$.

### 6.2.2 Practical tips

#### Strain relief of welding cable

In the restricted space available in the trench, you could trip over the welding cable. If the welding cable is attached between electrofusion unit and ELGEF Plus fitting with strain relief (by wrapping the cable once around the pipe), the welding process is not interrupted in spite of this occurrence.

#### Unwinding the cable roll

As a result of the electromagnetic effect of a coil, cable drums between generator and electrofusion unit must be unwound completely at all times.

# 7 Tools and accessories for electrofusion

## Overview

The tools used for electrofusion must be coordinated with the electrofusion system. The following table is an overview of the tool groups and accessories including a representative example:

**T5.19**
**Overview of tools and accessories for electrofusion**

| Figure | Tool group and accessories | Dimensional ranges | Purpose |
|---|---|---|---|
|  | Rotary peelers | d20-1200 | Remove the oxide layer through peeling of the pipe or spigot end when preparing for welding |
|  | Cleaning agents | - | Residue-free cleaning of the welding surfaces when preparing the pipe |
|  | Cutting tools | d10-1600 | Allow plastic pipes to be separated at right angles |
|  | Tapping tools | - | For the tapping of tapping saddles |
|  | Clamping and alignment tools | d20-630 | Allow stress-free installation during the welding and cooling process |
|  | Installation tools (topload) | d280-630 | For welding tapping saddles and branch saddles |
|  | Installation tools (topload) | d315-2000 | Welding branch saddles |
|  | Re-rounding tools | d25-2000 | Mechanical compensation of pipe ovalities during the welding and cooling process |
|  | Squeeze-off tools | d20-250 | Mechanical squeeze-off tools are suitable for shutting off (squeezing off) PE pipes during repair and extension work. |
|  | Marking and measuring | - | Determining the diameter of the components to be welded. Marking the peeling area and the insertion depth |

# Index



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