Planning fundamentals

INSTAFLEX
Technical manual

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Introduction

Introduction

Foreword

Nothing is more important in piping systems installation than the reliability of the individual components and their professional installation. Our products contribute to the safety of your equipment and processes. We have the best solution for nearly every application. This manual aims to help you in the planning, selection and application of products from GF Piping Systems.

GF Piping Systems has over 50 years of experience in developing and installing plastic piping systems. We would like to share this know-how, which is state of the art, here with you. Our technical experts have carefully put together this documentation in order to provide you with the best possible support. The correct use of our products will assure the safety and reliability of your systems. But nothing is so good that it can't be improved on, so we always welcome your thoughts and suggestions.

Wishing you informative reading

Georg Fischer JRG AG

Overview

This technical manual will provide you with all the important data for the planning, product selection, processing, installation and commissioning of pressure pipelines in building technology.

The data is based on the relevant international ISO and EN standards, diverse national standards and the DVS guidelines (German Federation for Welding) as well as data provided by the manufacturers of raw materials.

Furthermore, we have also incorporated the results from extensive in-house research and testing.

This manual serves as a tool for planners and installers, enabling them to design and install complex piping systems correctly and professionally.

Product information for industrial piping systems is contained in a separate technical manual.

For information on metal piping for malleable iron fittings, PRIMOFIT and WAGA (connections for plain metal and plastic pipes), please see the GF catalogue.

Your local sales representative will be glad to supply you with additional information.

This publication makes no warranty, but serves only to impart technical information. We refer to our General Conditions of Sale.

Georg Fischer

Georg Fischer

Adding Quality to People's Lives

People all over the world expect Georg Fischer to make a significant contribution to meeting their needs now and in the future.

Comfort

The reliable supply of clean water is one of the biggest challenges of this century. **GF Piping Systems** facilitates this worldwide demand for drinking water and enables the safe transport of liquids and gases for industry.

Mobility

As people become increasingly mobile, they also demand more comfort and safety from the vehicle they use. With highly durable cast parts made of light metal and iron from **GF Automotive**, it is possible to build lightweight and safe passenger cars and commercial vehicles.

Precision

The manufacture of consumer goods and high-quality precision components requires sophisticated production technologies. **GF Agie Charmilles** offers machines and system solutions with which the necessary moulds, tools and parts are made.

GF Piping Systems

GF Piping Systems is one of the three business units of the Georg Fischer Corporation and a leading global supplier of piping systems in plastic and metal.

We are dedicated to designing, manufacturing and marketing piping systems for the safe and secure conveyance of liquids and gases.

GF Piping Systems carries over 100,000 products for diverse applications and specialised markets: from pipes and fittings to valves and measurement instruments and their respective jointing technologies. Tailor-made solutions for any application in which fluids or gases are conveyed, whether for industrial systems, in building technology or for water and gas utilities.

All-round service
Manufacturing sites in Europe, Asia and the US are near the customers and meet local requirements. All components and systems comply with the relevant standards in each market area and are tested in accredited test laboratories.

Sales companies in 12 countries and representatives in another 80 countries ensure customer support round-the-clock.

Our own distribution centres together with e-commerce and information technology ensure rapid delivery and service.

We are your partner for the safe and secure conveyance of liquids and gases.

The requirements placed on piping systems are as diverse and demanding as the applications in which they are implemented. Here you will find a selection of market segments where we offer solutions. Our wide range of systems can also be used in many other applications. Please contact us for more information.

One manufacturer - one partner: GF Piping Systems
One-stop shopping: whether pipes, fittings, jointing technology, valves or measurement and control technology – GF Piping Systems offers you all these products from one source, anywhere in the world.

Top quality
You benefit from our 50 years of know-how in product development and production, our stringent quality controls, our highly qualified staff and continuous improvement process, which all contribute to the high quality of our products.

Global presence
Our global network of sales companies and representatives make sure you get the products you need, wherever you need them. For advice or support, just contact our local experts.

Building Technology Systems of GF Piping Systems (GFPS)

INSTAFLEX

INSTAFLEX - the material

The INSTAFLEX system is made of the plastic polybutene – the ideal material for drinking water installations. It was specially developed for applications in building technology.

Polybutene has the least thermal expansion of all the plastics. The low expansion forces (30 times less than steel and 10 times less than composite piping) means that the material can absorb the expansion in itself.

This, in turn, saves on expansion legs or joints and makes it possible to use standard fasteners, so clean and aesthetically pleasing installations can be built, even where space is limited.

- space-saving installation
- no maintenance
- easy to install
- the flexibility of polybutene enables making smaller changes in direction without the use of fittings.This saves on parts and valuable on-site time.
- polybutene retains its flexibility and easy handling even at low temperatures
- pre-fabricated riser pipes can be transported in coils and installed in shafts on site easily and quickly
- very durable due to its high resistance to chemicals

Plastic pipes - the modern alternative to steel and copper

Environment

Polybutene has an excellent life cycle assessment. For example, it can be reused to build noise barriers. This ultimately conserves our natural resources.

Compared to steel and copper, the manufacture of plastic requires four times less energy. Another example of how polybutene protects our environment.

Free of deposits

- INSTAFLEX is a completely corrosion-free drinking water installation. Even after lengthy periods of non-use, the water quality remains consistent.

- With INSTAFLEX from GF Piping Systems, your drinking water is guaranteed lime-free. The smooth surface of polybutene prevents deposits from forming in the system. Free passageways ensure a high level of comfort.

Noise reduction

Of all the piping systems, polybutene has the lowest acoustic velocity, e.g. ten times lower than for steel. Thanks to this excellent sound insulation, a good night's sleep is practically guaranteed, even if the bedroom adjoins the bathroom.

INSTAFLEX - the piping system

INSTAFLEX is available in a wide range of dimensions (d16 mm to d225 mm) for universal use from single-family homes to airports or luxury cruise liners.

The d16 to d25 mm pipes can also be supplied as a pipe-in-sleeve system. The system consists of a medium-conveying pipe in a protective outer pipe. Should the inner pipe become damaged, e.g. from drilling, it can be effortlessly replaced, without breaking open the wall.

Connection technology for a minimum of fuss

Prefabrication in the workshop with the proven z-dimension method from Georg Fischer is a time and cost-saving option. Complete, pre-assembled units (e.g. a basement manifold) are rapidly installed on building sites, so you can easily meet your deadlines.

INSTAFLEX offers an optimal jointing technology for every type of application:

- compression fitting d16 - d110 (3) to connect and transition to other materials
- socket fusion fitting d16 - d110 (1) as an economical alternative in prefabrication
- electrofusion fitting d16 - d225 (2) for fast and safe jointing on site

Fusion process

Electrofusion is a controlled fusion process. Thanks to the visible fusion indicators, it is always clear to see whether a fitting has been fused or not.

Fitting is not fused

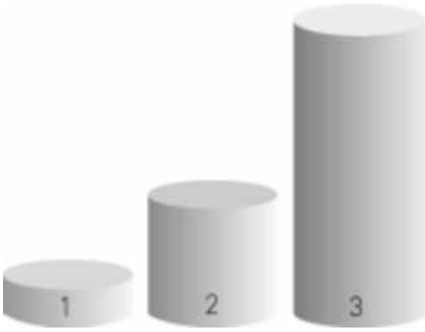
Electrofusion jointing

Fitting is fused

Less is definitely more

Weight

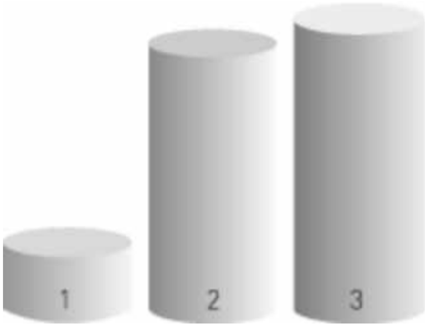
Another advantage of plastic is its low weight, which obviously makes handling and transport much easier. In contrast to metal systems, no cranes are needed.



Comparison of system weights
1 Polybutene 173 kg
2 Copper 519 kg
3 Steel 1268 kg

Energy

The energy equivalence value comprises all the process energies that are required from the raw material to the manufacture of the pipes, fittings and the thermal insulation. Also included is the amount of energy for producing the auxiliary jointing materials.



Comparison of energy equivalence
1 Polybutene 7730 MJ
2 Copper 3179 MJ
3 Steel 34173 MJ

Hygiene

Water is our most precious resource and the most strictly regulated food. In contrast to metals, which can give off copper ions, nickel or corrosion deposits to the water, polybutene does not release any taste or harmful substances at all. INSTAFLEX is, from a hygiene and health point of view, absolutely safe for use in drinking water systems.

The INSTAFLEX advantages

- economical prefabrication
- safe and fast to install
- long service life
- wide range of products
- corrosion-free
- incrustation-free
- noise reducing
- totally hygienic
- excellent life cycle analysis

Choose comfort - choose INSTAFLEX!

Quality, environmental and social policies

Quality, the environment, health and safety at work have always been considered important values at the Georg Fischer Corporation. This is manifested in the very good eco-efficiency of our products. Our products are becoming more efficient, while the environmental impact of their production and their utilisation has remained constant or is being reduced. Plastic piping systems from GF Piping Systems are lightweight for transport; they are corrosion-resistant and long-lasting. They protect our water, a most precious commodity, from the source to the end user.

Comprehensive quality management

Efficient management systems are an indispensable instrument for controlling and improving business processes. They ensure stable processes, consistently high product quality, as well as sustainable success. All the production companies and the majority of sales companies at GF Piping Systems are ISO 9001:2000 certified. In other words, an actively lived quality management system ensures that all business processes are functioning stably, are continually monitored and improved.
You can expect a quality management system from us on all levels:

- capable research and development
- modern production technology in our plants with integrated quality control
- test laboratory accredited to ISO/IEC 17025.

A certified quality management system is an essential element in achieving our highest goal: customer satisfaction.

Certified management systems

Efficient management systems are an indispensable instrument in controlling and improving business processes. They ensure stable processes, consistently high product quality, as well as sustainable success. All the production companies and the majority of sales companies at GF Piping Systems are ISO 9001:2000 and ISO 14001:2004 certified. By 2011 all our production facilities will also be certified according to OHSAS 18001 (Occupational Health and Safety Assessment Series). In other words, an actively lived management system ensures that all business processes are functioning stably, are continually monitored and improved.

Quality management

You can expect quality management from us on all levels:

- carefully selected, reliable suppliers
- capable research and development
- modern production technology in our plants with integrated quality control
- test laboratory accredited to ISO/IEC 17025.

Environmental management

The objectives of our environmental management system are:

- environmental issues are dealt with professionally
- risks are controlled
- the environmental aspects of our processes, products and services are continuously analysed and improved.

Certified management systems are an essential element in achieving our highest goal: customer satisfaction.

Customer satisfaction

Your experiences with our products and services help us to improve customer benefit and to respond rapidly to your requirements. Our employees are at your disposal with their know-how and expertise. To guarantee your satisfaction, we offer you this and more:

- comprehensive systems for a variety of applications
- high quality, reliable products
- wide range of services with customer support, customer training, fusion machine rentals, planning aids, etc.
- compliance with diverse technical specifications as well as international standards, national and application-specific approvals
- efficient logistics.

Ecology / Recycling

Clean drinking water

One of the world's most valuable resources is clean water. Providing the world with a reliable supply of drinking water is therefore a major challenge. GF Piping Systems steps up to this challenge by contributing to the global infrastructure with systems for water distribution and treatment. Water must be transported without the risk of contamination; the systems must be safe and cost-effective and the control valves must be dependable and easy to operate. GF Piping Systems satisfies all these requirements with plastic piping systems that are durable, leakproof, lightweight and corrosion resistant.

Eco-efficient products

GF Piping Systems dedicates its more than 50 years of application experience with plastic piping systems to the service of a clean environment. One example of this is the fully pre-insulated system COOL-FIT for secondary cooling and refrigeration pipework systems. It combines numerous ecological and economical benefits.

Further examples are:

- double containment pipe systems from GF Piping Systems for a safer environment for people and equipment, especially when conveying aggressive liquids
- Better energy balance of plastics compared to alternative pipe materials.

Added value for our customers

We aim to understand and meet the requirements of our customers in terms of environmentally friendly products and services, and to being a competent partner for our ecology-minded customers. We achieve this through environmentally compliant product design and production processes, in addition to intensive dialogue with our customers, which allows us to become familiar with their needs and to adapt our market performance accordingly.

Training

Invest in the training of your staff

Qualified employees are among the key success factors of a company. That is why we recommend periodic training for staff so they are always up to date with the latest technology.

GF Piping Systems offers customised training and courses at our in-house training centre. Not only is theoretical knowledge imparted, but we also make a point of providing opportunities for hands-on practice.

An interesting training programme

As a professional system and solution provider, GF Piping Systems offers a broad range of training courses focused on exchanging product know-how and application expertise, key sales arguments for the diverse requirements of our customers.

Jointing technologies and measurement and control technology are always being improved on. To keep abreast of the latest developments, lifetime training is essential. GF Piping Systems advances this cause by offering training courses for specialists from the utilities, building technology or industry. Everyone benefits from the training that focuses on the individual market segments and applications.

Courses offered

We have put together an interesting programme for sales personnel, installers, planners and plant engineers. Besides theory, we focus especially on practical experience. The Basic, Advanced and Master courses are co-ordinated and built on one another.

Up to 100 participants can receive hands-on training at the same time in our first-rate, fully equipped training facility. The trainer is selected according to the criteria of our colleagues in sales, in order to best fill your needs.

Please consult your local sales representative for more information on our current training programme.

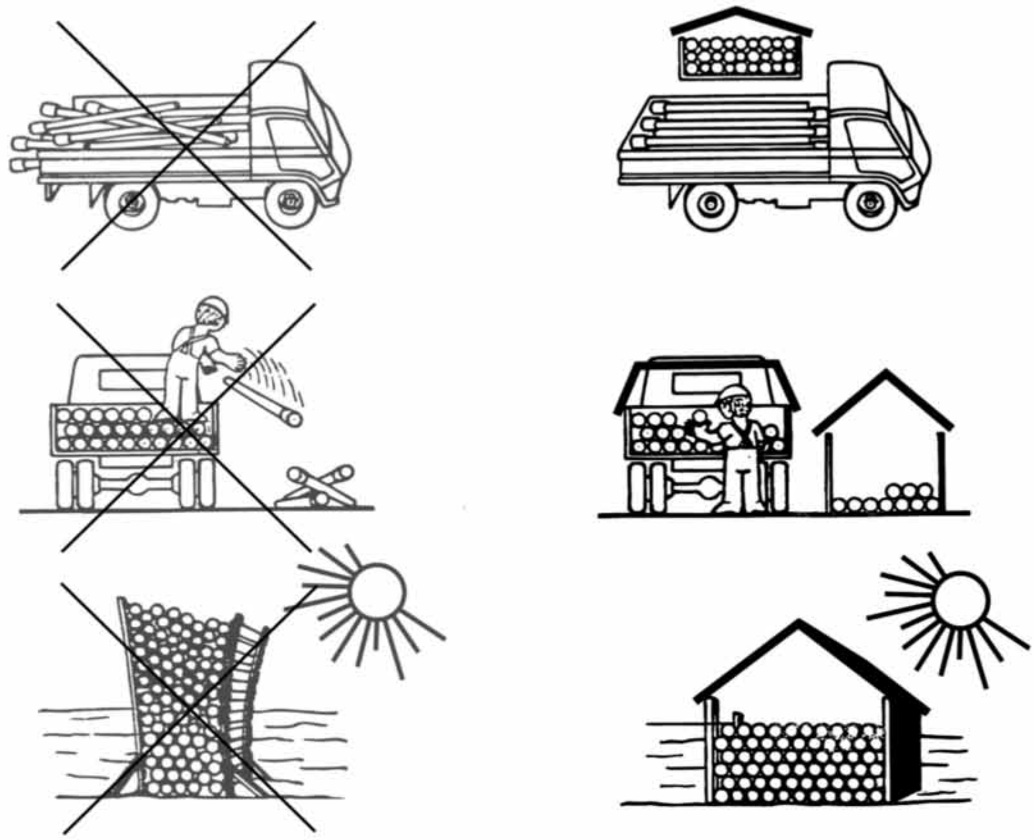
General Information

General Information

Working with plastic pipes and fittings

Transport and storage of plastic pipes

WRONG	RIGHT



Plastics are sensitive to impact and crushing at low temperatures. The temperature limit depends on the respective material.

PVC-C	0 °C
PP-R	- 10 °C
PB	- 10 °C

Plastic pipes and plastic fittings must be protected from direct sunlight and external influences. Direct sunlight, impact and pressure loads should be avoided. We recommend leaving the pipes and fittings in their original packaging until ready for use. Do not store outdoors.

Plastic fundamentals

What are polymers?

Polymers are organic compounds derived from the conversion of natural substances (e.g. natural rubber, cellulose) or from the synthesis of petroleum. Their chemical construction consists mainly of carbon and hydrogen. Depending on the particular type, additional halogens (chlorine, fluorine), oxygen, nitrogen and sulphur can be built into the polymer chain. Polymers are macromolecules. One macromolecule consists of over 1000 molecules, or monomers.

Properties of plastics

Plastics are classified into three main groups on the basis of their properties:

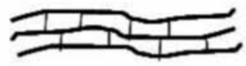
Thermoplastics
e.g. PB, PE, PVC

- linear or branched
- repeatedly meltable
- soluble, swellable
- plastic deformation

Elastomers
e.g. NBR, EPDM

- loosely crosslinked
- not meltable
- not soluble, not swellable
- no plastic deformation

Duroplastics
e.g. PUR, Epoxy



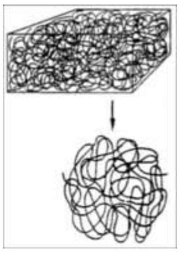
- densely crosslinked
- not meltable
- not soluble, not swellable
- no plastic deformation

Thermoplastics are generally used for manufacturing piping components; the material is injection moulded and extruded into fittings and pipes. Elastomers are the sealing material of choice in screw couplings, flanges and push-fit connectors. Duroplastics can be found e.g. in insulating foams or GFR liners (e.g. glass fibre mats wrapped around thermoplastic pipes.

Under the thermoplastics, i.e. the meltable plastics, there are two subgroups:

Amorphous thermoplastics

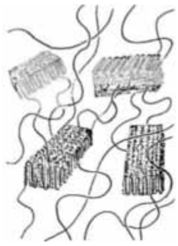
The polymer chains of amorphous (Greek «without form») thermoplastics have a random, entangled molecular arrangement.
Typical examples of amorphous thermoplastics are PVC and ABS. These plastics are dissoluble and swellable with the use of solvents and are therefore joined in piping system construction by means of solvent cementing.



Semi-crystalline thermoplastics

Semi-crystalline thermoplastics contain randomly arranged areas, as well as highly ordered areas in which the chains resemble crystal-like structures.

Among the semi-crystalline thermoplastics are polyolefins, such as polyethylene (PE), polypropylene (PP) and polybutene (PB). The partially crystalline structure is one reason these plastics are not as easily dissolved and swelled in solvents. For this reason, piping systems made of semi-crystalline materials are usually fusion jointed.



Mechanical properties of plastics

The mechanical properties of plastics, particularly those of thermoplastics, are temperature-dependent. At low temperatures, the chains become stiff and brittle, increasing the susceptibility to breakage. At higher temperatures, the chains are more pliable, which adds to the impact resistance of the material. However, strength and rigidity decreases simultaneously. Both the brittle point and the softening point are characteristic of the individual plastics and in relation to their respective molecular structures.

Plastics also tend to creep, that means to progressive deformation under load. In other words, the mechanical properties are not only temperature-, but also time-dependent. For piping system construction, the materials are therefore tested for their long-term creep strength under internal pressure according to ISO 9080. This is how the maximum operating temperatures and pressures are determined for a lifetime of 50 years.

Planning fundamentals for plastic piping systems

Criteria for materials selection

Country-specific operating conditions

see chapter "Pipe Dimensioning"

Pressure and temperature data, service life, safety factor, medium

see chapter "Materials"

Environmental aspects

see chapter "Introduction"

Select the material

Criteria for dimensioning

Specified operating pressure, safety factor

see chapter "Materials"

Specified pipe cross-section, pressure loss

see chapter "Pipe Dimensioning"

Determine the pipe diameter
Pressure rating/dimension

Criteria for product selection

Possible applications for the product

see chapter "General Information / Materials"

Jointing technology

see chapter "Jointing Technology"

Processing technology and installation technology

see chapter "System Technology and Application Technology"

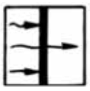
INSTAFLEX range of products
see separate programme

Basic properties of plastics

Low density = low weight
Plastics, e.g. PB = 0.94 g/cm^3
(copper 8.9 g/cm^3)

Chemical resistance = no corrosion like for metals
Installing different metals can lead to electrochemical corrosion in piping systems. This is not the case for plastics.

Hot water and pressure resistance
Certain plastics satisfy the requirements for drinking water pipes according to current building standards.



Low thermal conductivity = minimal heat loss
Plastics are poor heat conductors, but good insulators.

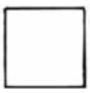
- PB 0.19 W/mK (acc. ASTM E1530)
- PE 0.37 W/mK
- Cu 400 W/mK
- St 50 W/mK

Condensation formation
Thanks to the low thermal conductivity of plastic, less condensation forms on plastic pipes than on metal.

Wear resistant
Plastic pipes have an abrasion resistance which is up to four times greater than that of steel pipes.

Leak-tight joints
Plastics can be fused, cemented and compressed. Fusion joints are made absolutely leak-tight without additional materials.

Sound transmission
Polybutene has a low elasticity coefficient (E-modulus). This warrants low noise transmission.



Smooth surface
The smooth surface means less pressure loss and less incrustation.

Expansion
Plastics react to changes in temperature more strongly than metals. The linear expansion of plastics is approx. 10 times greater than that of steel.

Fire behaviour
Plastics are flammable. They are classified according to the customary flammability tests for building materials.

Not electrically conductive
Cannot be used for potential equalisation.

Solar radiation
Plastics are sensitive to UV rays and must not be exposed to them.

Materials

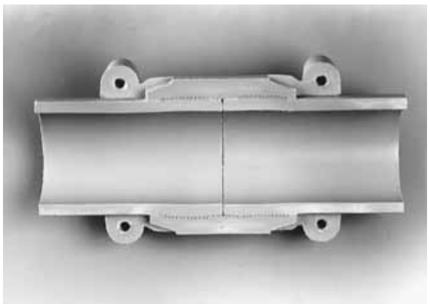
Materials

The material Polybutene (PB)

General

Polybutene (PB) is a semi-crystalline thermoplastic from the polyolefin group of polymers. Its high flexibility, temperature resistance and creep rupture strength render this material ideal for use in hot and cold water pipes. PB is created via polymerisation of 1-butylene (C_4H_8), i.e chaining together the basic molecules (monomers). PB is a non-polar material, as are polyethylene (PE) and polypropylene (PP).

The most suitable jointing method for PB is heat fusion. For pressure piping, electrofusion and socket fusion are generally preferred.



Electrofusion

Socket fusion

The creep strength is certified to MRS 14 (minimum required strength) and according to EN ISO 9080 in long-term testing.

The polybutene used by GF Piping Systems for building technology applications features the following qualities:

- High long-term creep strength
- Good resistance to corrosion
- High flexibility
- High resistance to heat ageing
- High resistance to stress cracking
- High noise insulation

Material properties

Properties	Values	Unit	Test norm
Density	0.94	g/cm³	ISO 1183
Melt flow index MFI 190/2.16	0.4	g/10 min	EN ISO 1133
Yield stress at 23 °C	20	MPa	EN ISO 527-1
Elongation at break at 23 °C	300	%	EN ISO 527-1
Flexural modulus of elasticity at 23 °C	450	MPa	ISO 178
Notched impact test at 23 °C	37	kJ/m²	EN ISO 179/1eA
Notched impact test at 0 °C	20	kJ/m²	EN ISO 179/1eA
Ball indentation hardness (132 N)	43	MPa	EN ISO 2039-1
Coefficient of thermal expansion	0.13	mm/mK	ASTM D696
Thermal conductivity at 23 °C	0.19	W/mK	ASTM E1530
Moisture absorption at 23 °C	0.01-0.04	%	EN ISO 62

Mechanical properties

The crystallinity of polybutene (PB) at approx. 50 % is low compared to other polyolefins, rendering it both flexible and robust. These properties are very advantageous for prefabricating riser pipes. The material has very good creep rupture strength at high temperatures and under permanent loads, thus permitting high pressures with relatively small wall thicknesses.

The long-term behaviour under internal pressure is illustrated in the long-term diagram based on the standard EN ISO 15494. The threshold values for pipes and fittings, which are given in the pressure-temperature diagram for PB, are deduced from this. See diagram on page 4 of this chapter.

Resistance to chemicals, weather and UV radiation

Polybutene (PB) is non-polar and therefore easily withstands chemical attack.

For more information, please see the chapter on Chemical Resistance or contact one of our sales companies. When stored or used outdoors, PB, like most natural and plastic materials, will become damaged, especially by the ultraviolet wavelengths of solar radiation in combination with atmospheric oxygen (photooxidation).

Plastic pipes and plastic fittings must be protected from direct ultraviolet radiation. The pipes and fittings are best left in their packaging until ready to use. Do not store outdoors. Please see the chapter General Information.

Thermal properties

Impact resistance and rigidity

Generally speaking, polybutene (PB) may be used at temperatures between -10 °C and 95 °C. Below 0 °C the material's impact resistance diminishes somewhat, although the rigidity will increase at low temperatures. Just as for every other piping material, the medium should be protected from freezing because this could damage the pipe system. Please refer to our pressure temperature diagram, specially for the maximum working temperature.

Linear expansion

Thermoplastics, including PB, have a much lower coefficient of linear expansion than metals, namely 0.13 mm/mK. The resulting forces are, however, very much lower for PB than for metals. Please see the «System Technology and Application Technology» chapter.

Thermal conductivity

The thermal conductivity is 0.19 W/m K (ASTM C177). As a result, the insulation of a PB piping system is much more energy efficient compared to metals, such as copper.

Fire behaviour

Polybutene (PB) belongs to the flammable plastics. The oxygen index is 19%. Below 21% a plastic is considered flammable.
When the flame is removed, PB will continue to form droplets and burn without sooting. When burned, PB produces primarily carbon dioxide, carbon monoxide and water.

Persuant to UL94 (Test for Flammability of Plastic Materials), PB is rated as a slow burning plastic in the horizontal burn test.
According to DIN 4102-1, PB is classified B2 (normal combustibility) and is classified E-d2 according to EN 13501-1.
In the French classification of building materials, polybutene falls in category M3 (small flame). According to ASTM D 1929, PB self ignites at 360 °C. In case of fire, this plastic is extinguished with spray water, foam or carbon dioxide.

Electrical properties

Due to the fact that polybutene (PB) is non-polar, PB is an excellent isolator. External impurities, oxidation or weather conditions considerably reduce the isolating action. Otherwise, the electrical conductivity is practically not dependent on temperature and frequency. The specific contact resistance is $>10 \times 10^{16}$ Ωxcm, the dielectric strength 75 kV/mm.

Physiological properties

The material used by GF Piping Systems meets the formulation specifications of the relevant food law requirements.

Glossar

Density
The densityof a body is the mass m per unit volume V.

Hardness
The hardness refers to the material's resilience against penetration of a body. It is generally measured using the depth of penetration left by a load with a specific geometry in the material.

Melt Flow Index (MFI)
The Melt Flow Index (MFI) indicates how easily the melted polymer flows. It depends on the length of the molecular chains and the number of branches. The mass pressed through a standard die with a 5 kg weight in 10 minutes at 190 °C is measured.

Strength
Strength is resistance of an elastic body to deformation.

Thermal conductivity
Thermal conductivity means the energy transported within a substance in relation to temperature and surface.

Coefficient of thermal expansion
The coefficient of thermal expansion specifies the change of length of a rod, 1 meter in length, after increasing the temperature by 1 °C; it is measured in millimetres.

Impact strength
The impact strength refers to a material's breaking resistance upon impact stress. It is defined as the amount of energy that the material can absorb at its smallest cross-section before it breaks. It is determined in the Charpy notched bar impact test.

Flexural modulus of elasticity
The flexural modulus of elasticity is an expression of a material's rigidity. It is defined as the slope of its stress-strain curve in the linear range.

Tensile strength
Tensile strength is the highest tensile stress which a material can withstand before it breaks. The elongation before it breaks is referred to as elongation at break or ultimate elongation.

Hygiene standards

Polybutene (PB) complies with the KTW recommendations of the German Health Authority for plastics in drinking water. This is confirmed in the test certificate of the Hygiene Institute of the Ruhr.

Hygiene-Institut des Ruhrgebiets

Institut für Umwelthygiene und Umweltmedizin
Direktor: Prof. Dr. rer. nat. L. Dunemann

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Reference: **K-172281-09-Ko/st**
Contact person: Dr. Andreas Koch

Gelsenkirchen, 14.01.2009

TEST CERTIFICATE
according to the KTW-Guideline

(English version dated 07.11.2005, Ref.-No.: C-133437-05-Ka/st)

Product: **Drinking water-Installation-moulded parts made of PB, Group 1 (grey)**
(SKZ-Product-No.: 1681, Cert.-No.: DVGW DW-8501AT2528)

Specimen: T-piece Ø 40 mm

Production: Sternplastic Fertigungs GmbH, 8226 Schleitheim (Schweiz)

Kind of test: [ ] Product test / Permission test [X] Supervision test 2005

The a.m. **drinking water-installation "moulded parts made of PB, Group 1 (grey)"** meet the requirements according to the test report dated **07.11.2005, Ref.-No.: C-133437-05-Ka/st** for the following applications and temperatures:

Applications:	cold water (23°C)	moderately hot water (60°C)	extremely hot water (85°C)
Pipes ID < 80 mm (domestic distribution)	---	---	---
Pipes 80 mm ≤ ID < 300 mm (supply pipelines)	---	---	---
Pipes ID ≥ 300 mm (mains)	---	---	---
Simple fittings, assembled product housings for pipes ID < 80 mm	passed	passed	---
Simple fittings, assembled product housings for pipes 80 mm ≤ ID < 300 mm	passed	passed	---
Simple fittings, assembled product housings for pipes ID ≥ 300 mm	passed	passed	---
Seals for pipes ID < 80 mm	passed	passed	---
Seals for pipes 80 mm ≤ ID < 300 mm	passed	passed	---
Seals for pipes ID ≥ 300 mm	passed	passed	---
Storage systems within the domestic distribution system including repair products	passed	passed	---
Storage systems outside the domestic distribution system including repair products	passed	passed	---

as far as technically suited.

This test certificate is valid beginning with the date of issue and is ending by **07.11.2010** as far as there are no changes in the formula. After this time it can be extended for further 5 years if demanded.

The Director of the Institute
on behalf of

(Dr.rer.nat. A. Koch)

HYGIENE-INSTITUT DES RUHRGEBIETS
Institut für Umwelthygiene und Umweltmedizin

The results and conclusions exclusively refer to the investigated samples and the relevant laws.
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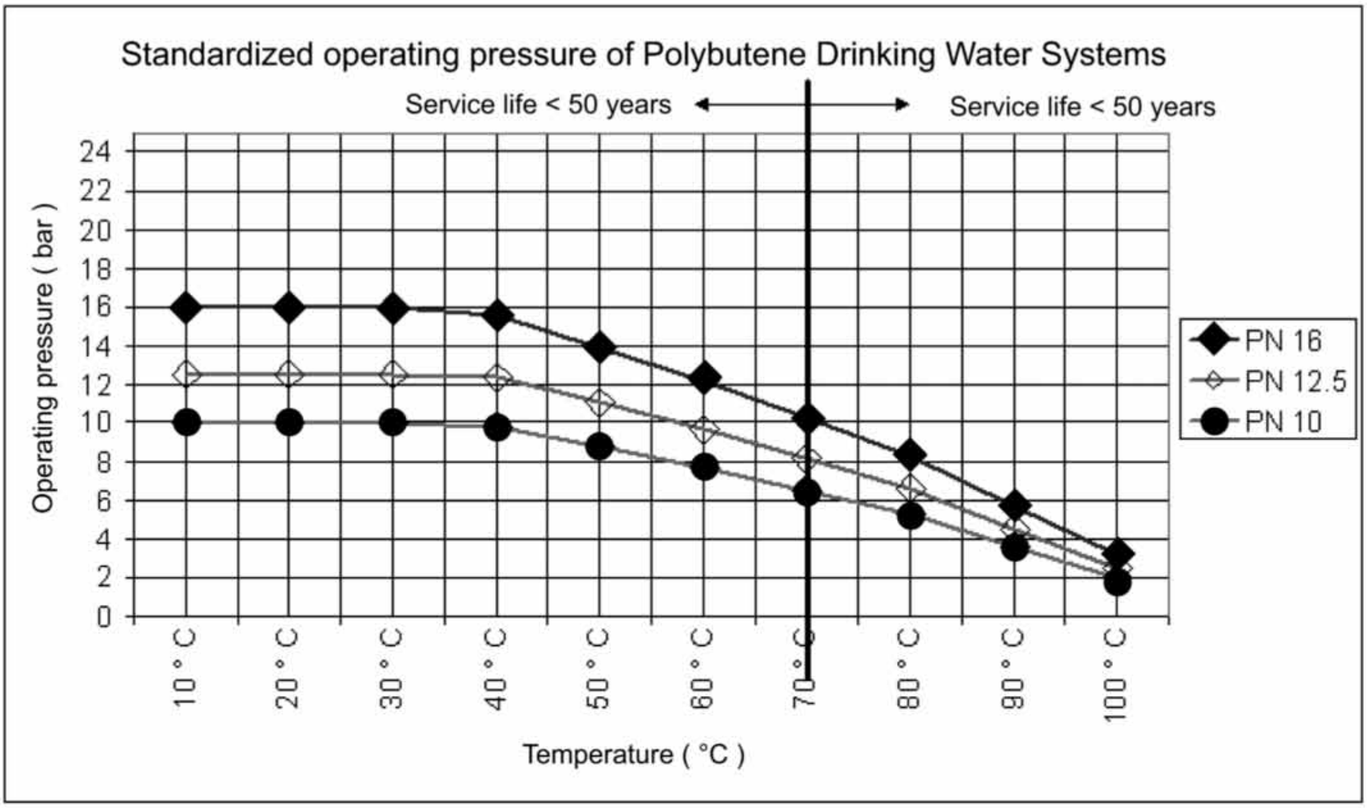
Deutscher Akkreditierungs Rat
DAP-PL-2548.00

Träger des Hygiene-Instituts: Verein zur Bekämpfung der Volkskrankheiten im Ruhrkohlengebiet e.V., Gelsenkirchen

Long-term pressure test for PB

Standardized operating pressure of polybutene drinking water systems



For operational safety and a long lifetime (service life), selecting the right material and pressure rating for the piping components is key. Other factors to be taken into consideration are operating temperature, the medium conveyed and the operating pressure range.

The INSTAFLEX d16 to d110 products have a nominal pressure of PN 16 while the pressure rating for INSTAFLEX BIG d125 to d225 falls under PN 10. The pressure-temperature diagram has been calculated for a service life of 50 years in the drinking water sector. The diagram also figures in a safety factor of SF = 1.5.

Example for INSTAFLEX d16 to d110 (PN 16)
Operating temperature: 70°C
Pressure rating: PN 16
The operating pressure taken from the diagram: 10 bar

Determining the pipe wall thickness and the pressure class

To calculate the wall thickness of polybutene (PB) pipes bearing internal pressure the Kessel formula is applied:

$$s = \frac{p \times d \times SF}{(20 \times \delta_B) + (p \times SF)}$$

s	=	pipe wall thickness [mm]
p	=	operating pressure at 20 °C [bar]
d	=	pipe outer diameter [mm]
δ_B	=	comparative stress
SF	=	safety factor of 1.5

All the pipe dimensions expressed in the standards are based on this calculation formula. According to DIN, EN and ISO standards, the **nominal pressure PN** (Pressure Nominal) indicates the permissible operating pressure in bar at 20 °C. In accordance with the European standardization of systems, the new terms will be additionally used in future.

Example

Nominal pressure PN 16 means that a pipe in this pressure class can be subjected to a pressure of 16 bar at 20 °C.

In sanitary installations, the nominal pressure is not decisive for the pipe and fitting technology, but rather the **building codes and test specifications in the respective country**. These ensure safety in the distribution of hot and cold drinking water.

The critical material requirements are not the nominal pressure, but the operating pressure and the service life.

Example

At an operating pressure of 10 bar and a lifetime of 50 years, the operating temperature may be maximum 70 °C. A safety factor of 1.5 has already been included.

Pipe data for INSTAFLEX PB pipes

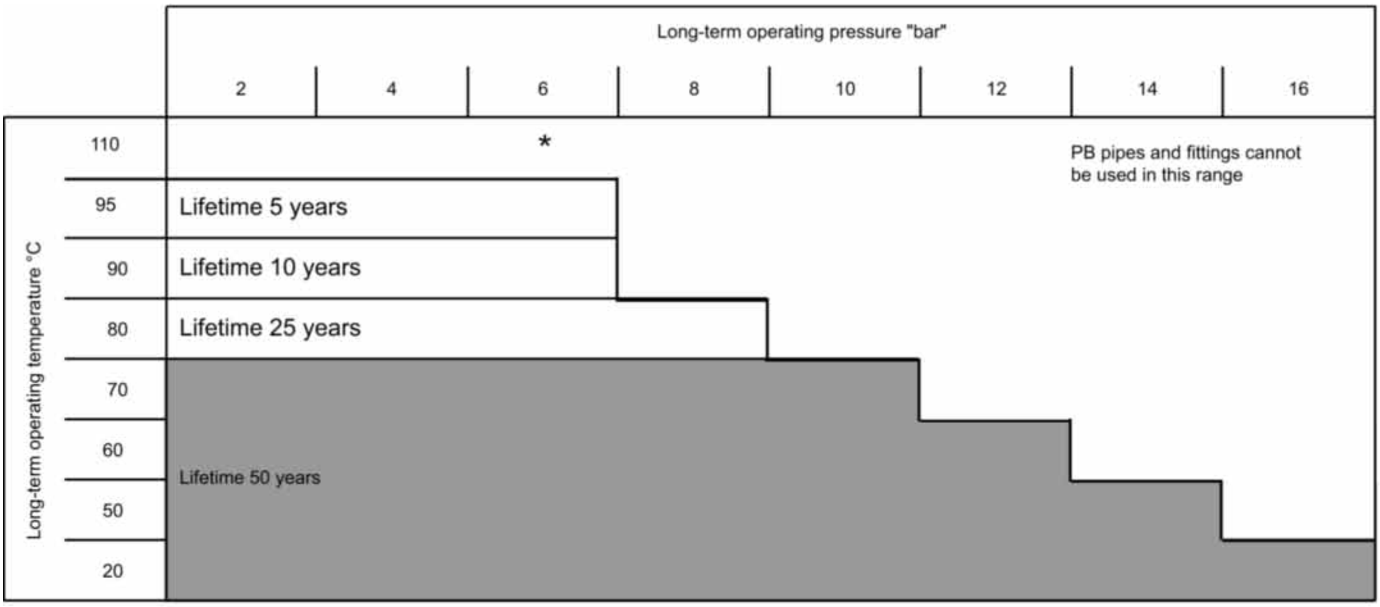
Nominal diameter DN [mm]	Pipe outer diameter d [mm]	Pipe wall thickness s [mm]	Pipe inner diameter d_i [mm]	Weight [kg/m]	Water volume [l/m]
12	16	2.2	11.6	0.088	0.10
15	20	2.8	14.4	0.141	0.16
20	25	2.3	20.4	0.152	0.33
25	32	2.9	26.2	0.254	0.53
32	40	3.7	32.6	0.392	0.83
40	50	4.6	40.8	0.610	1.31
50	63	5.8	51.4	0.969	2.07
65	75	6.8	61.4	1.354	2.96
80	90	8.2	73.6	1.960	4.25
100	110	10.0	90.0	2.920	6.36
125	125	11.4	102.2	3.950	8.20
160	160	14.6	130.8	6.460	13.40
225	225	20.5	184.0	12.700	26.60

Roughness factor k = 0.007
for polybutene per DIN 1988

Range of application for INSTAFLEX PB pipes and fittings d16 - d225

Sanitary

INSTAFLEX is used for the hot and cold water pipes in drinking water installations. National specifications are not just satisfied, they are exceeded.



A safety factor of SF = 1.5
was used in the lifetime calculation

* Short-term loads up to 110°C are possible for PBd16 and d20 pipes. Tests at 110°C with 7.5 bar internal pipe pressure resulted in lifetimes of <1 year

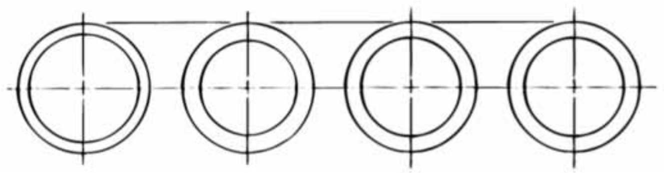
Pipe wall thickness «s»

The pipe wall thickness is determined by the comparative stress, the pipe outer diameter and the permissible positive operating pressure at 20 °C.

In reference to the 20 °C curve for a service life of 50 years with safety factor included. Comparison of the drinking water pipelines used in building technology.

Example for a pipe d 40 with DVGW/SVGW approval

Pipe material	PB (Polybutene)	PE-X (Polyethylene, cross-linked)	PP-R CT (Polypropylene, random, temperature-stabilised)	PVC-C (Polyvinyl chloride, postchlorinated)	
Pipe dimension d 40 x	3.7	5.5	4.5	4.5	[mm]
Pipe inner diameter	32.6	29.0	31.0	31.0	[mm]
Pipe inner surface	834	660	754	754	[mm²]
Nominal pressure rating	PN 16	PN 20	PN 20	PN 25	



Flow velocity at V = 2.0 l/s	2.4	3.0	2.7	2.7	[m/s]
Pressure loss at V = 2.0 l/s	18.4	32.5	23.6	23.6	[mbar/m]
DN Nominal diameter	**32**	**32**	**32**	**32**	[mm]

PN 16 means

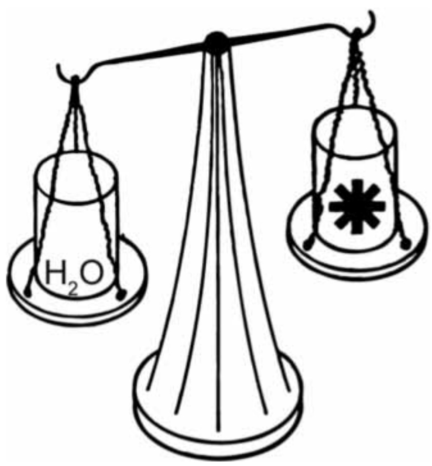
Permissible operating pressure of 16 bar at 20°C and a lifetime of 50 years assuming a safety factor of 1.5 for all materials.

Compressed air

INSTAFLEX has been designed for a temperature range of 0 to 80 °C for compressed air applications. The maximum permissible operating pressure at 20 °C is 16 bar with a calculated safety factor of 1.5.

PB in comparison to other plastics, e.g. PP-R, VPE and PVC-C as well as metals

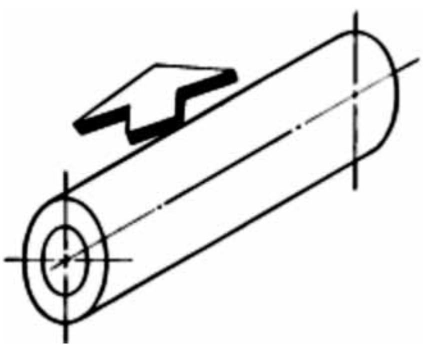
Density «ρ»	[g/cm³] [kg/dm³]
Polybutene (PB)	0.94
Polyetyhlene, cross-linked (PE-X)	0.94
Polypropylene, random (PP-R)	0.90
Polyvinyl chloride, postchlorinated (PVC-C)	1.55
Water	1.00
Steel	7.85
Copper	8.89



The density of a body is the ratio of its mass m to its volume V:

$\rho = m/V$

Thermal conductivity «λ»	[W/mK]
PB	0.19
PE-X	0.41
PP-R	0.24
PVC-C	0.14
Composite	0.43
Water	0.58
Steel	42 to 53
Copper	407.10



Thermal conductivity means the energy transported within a substance in relation to the difference of pipe inner to pipe outer temperature and the pipe wall thickness.

Thermal expansion «α»	[mm/mK]
PB	0.13
PE-X	≈ 0.20
PP-R	0.18
PVC-C	0.08
Composite	0.026
Water	-
Steel	0.012
Copper	0.018
Stainless steel	0.017

Modulus of elasticity «E»	[MPa] [N/mm²]
PB	450
PE-X	600
PP-R	800
PVC-C	2500
Composite	70000
Water	-
Steel	210000
Copper	120000

The E-modulus is the relationship of stress to strain in the elastic range of a material.

The smaller the E-modulus, the more flexible the material. As the E-modulus increases, the material becomes more flexurally rigid.

Determining the length of a flexible section

The required length of a flexible section is determined by means of the following formula:

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

Symbol definitions:

d_a = pipe outer diameter (mm)

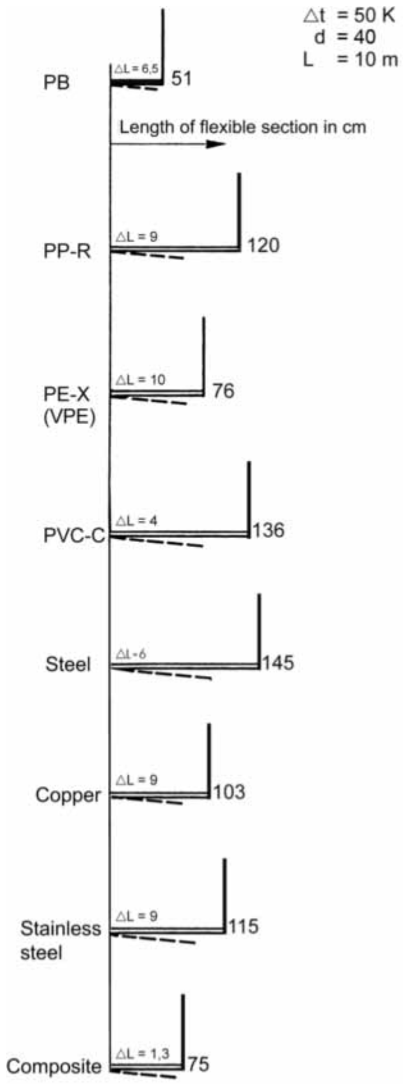
ΔL = change in length (mm)

E_{cm} = average flexural creep modulus

σ_b = permissible flexural stress ratio

Example:

Determining the length of a flexible section



Δt = temperature difference [K]

DN = nominal diameter [mm]

L = length of expansion leg [mm]

ΔL = thermally dependent change in length [mm]

Jointing systems

Just as important as the pipe and the pipe material are the jointing technology and the metal materials of the fittings.

The interplay of various factors, such as too high or too low pH values, chlorides, free carbonic acid, corrosive nitrate and sulphate ion concentrations, lead to increasingly aggressive waters. This heightens the risk of corrosion for metal materials.

Traditional installation systems made of metals, such as steel, galvanised steel, copper and with stainless steel coatings, cannot be used in every situation due to inconsistent water qualities and are no longer approved for use in certain areas.

INSTAFLEX takes account of these trends. All the fittings are made of high-quality **CR hot-pressed brass**. CR brass is resistant to corrosion according to ISO 6509, the highest international standard. CR brass is even superior to red brass in regard its mechanical properties.

In a **homogenous** jointing system, like the INSTAFLEX electrofusion and socket fusion system, of analogous polybutene (PB) for pipes and fittings, corrosion problems can also be excluded.

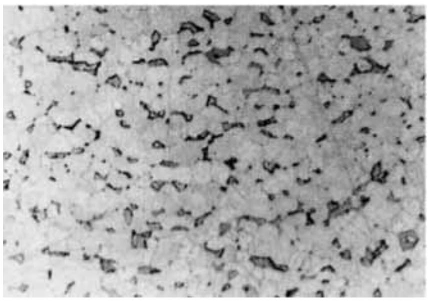
Properties of different material alloys

Material	Cast brass GK-Cu Zn 37 Pb	CR pressed brass Cu Zn 39 Pb 2	CR brass Cu Zn 36 Pb 2 As	Red brass G-Cu Sn 5 Zn Pb	Stainless steel 1.4301
Norms	DIN EN 1982	DIN EN 12420	DIN EN 12164 DIN EN 12165	DIN EN 1982	
Hardness HB 10 (N/mm²)	≥ 70	80 - 100	≥ 70	≥ 60	130 - 180
Tensile strength (N/mm²)	≥ 280	370 - 440	≈ 280	≥ 240	>500
Break elongation (%)	>20	≈ 30	≈ 30	>16	≈ 50
Yield point (N/mm²)	>90	280 - 360	≈ 200	>90	>200
Corrosion resistance	low	not quite up to ISO 6509	resistant as per ISO 6509	resistant as per ISO 6509	resistant as per ISO 6509
Abrasion behaviour	not so good	good	good	not good	good

Microstructure view of various alloys

Brass:

The dense and very homogenous microstructure of **dezincification-resistant CR hot-pressed brass** is a major contributing factor to the excellent leak tightness and strength durability of the fittings.



CR pressed brass, dense, homogenous microstructure

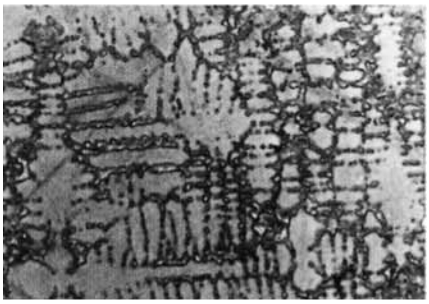
The tensile strength of the hot-pressed parts made of **CuZn39Pb2 CR brass** is min. 360 N/mm², with an elongation at break of at least 20% and a hardness HB of 75. The 0.2 % yield point is min.110 N/mm².

For hot-pressed parts of CuZn36Pb2As, **dezincification-resistant CR brass,** the tensile strength is min. 280 N/mm², with an elongation at break of at least 30 % and a hardness HB of 70. The 0.2 % yield point is min. 90 N/mm². Components, e.g. valve connections, of brass are therefore capable of handling high mechanical loads.

Red brass

The tensile strength of cast components made of **G-CuSn5ZnPb red brass** is min. 220 N/mm², with an elongation at break of at least 16 % and a hardness HB of 60. The 0.2 % yield point is min. 90 N/mm².

The acidular and coarse microstructure of red brass or cast brass fittings raises the risk of leakage, especially under mechanical loads.



Red brass, acicular, coarse microstructure

The reduced deformability of red brass compared to brass means that cracking is to be expected under building site conditions where there are high mechanical loads.

High stability, good deformability and general robustness under building site conditions are the outstanding features of **CR brass** and **dezincification-resistant CR brass** as compared to **red brass**.

INSTAFLEX metal fittings are manufactured of dezincification-resistant CR brass.

Corrosion behaviour

Dezincification

In soft water which contains chloride, brass tends to dezincify. For such water, a dezincification-resistant CR brass is preferred. The dezincification resistance of CR brass is established in ISO 6509. Further evidence of the resistance of CR brass to these waters is substantiated in 20 years of experience.

Dezincification-resistant CR brass is on a level with red brass in relation to dezincification.

Environmental stress cracking

Besides dezincifying, brass can also exhibit environmental stress cracking. Environmental stress cracking occurs when at least one of the four following conditions are present:

- a material susceptible to stress cracking
- internal/external tensile stress on the component
- a corrosive medium, e.g. ammonia
- moisture

Sources:

- EMPA report, Federal Materials Testing Institute
- Report from the Association for Brass Quality Standards

Environmental stress cracking occurs very seldom in red brass in connection with drinking water; it cannot however be completely ruled out.

Reducing environmental stress cracking

INSTAFLEX fittings are subjected to a thermal stress relieving process (stress-relief annealing). Due to its material composition which differs from brass, dezincification-resistant brass is not only much more resistant to dezincification, but also to stress cracking. Only dezincification-resistant brass is used for INSTAFLEX.

Summary

With consideration to all the properties,
correct system design and layout, and optimal selection of the material alloys, brass components, especially those made of **dezincification-resistant CR brass**, are superior to red brass in conventional sanitary installations.

INSTAFLEX components are manufactured of dezincification-resistant CR hot-pressed brass.

Other materials used in INSTAFLEX

All the system parts which come into contact with drinking water are commodities regulated by food law.

Copper alloys

Brass is a copper-zinc alloy and is deemed corrosion-resistant as well as erosion-resistant. In drinking water distribution, brass is used primarily for fittings which do not come into contact with the medium.
Material designation according to DIN 17660:
Cu Zn 39 Pb 3

Dezincification-resistant **CR brass**, in combination with low pH drinking water, is resistant to dezincification and, thanks to its composition, is also less susceptible to stress cracking.
Material designation according to DIN 12164:
CR-Cu Zn 36 Pb 2 As

Non-metal materials

Non-metal materials must comply with KTW recommendations of the German Health Authority.

Elastomers are rubber-like plastics and are mainly used for seals. In the INSTAFLEX range, elastomers can be found in the seals of removable unions and in valves.

EPDM is the acronym for ethylene-propylene-diene-rubber. The EPDM seals used in INSTAFLEX comply with KTW recommendations and can be used at a constant operating temperature of 90 °C with short-term increases up to 120 °C. EPDM seals are standard in INSTAFLEX components.

NBR (nitrile-rubber) can be used up to a constant operating temperature of 90 °C with short-term increases up to 120 °C.

Approvals

Approvals

INSTAFLEX

Approval conditions

Distribution systems for drinking water are subject to the approval of or registration with the national gas and water associations.

The approval or registration ensures that state-of-the-art technology is implemented and observed. This means of regulation obligates the system manufacturer to maintain a quality control system including a catalogue of measures and to continually and seamlessly monitor production processes.

In addition, external monitoring by a recognised test institute is mandatory. Such self-monitoring and external control guarantee the quality of the products.

Overview of national standards

Country	Basis for testing	Institute
Australia	AS/NZS 4129 MP 52-Spec 435 MP 52-Spec 012	**SAI Global**
Belgium	ATG 05/1871	**BUtgb UBAtc**
Germany	Arbeitsblatt W 544 Arbeitsblatt W 534 DIN 16968/16969 DIN 16831	**DVGW**
France	Avis Technique 14/07-1177	**CSTB**
Great Britain	British Standards BS 6920 BS7291-2 Water Regulations (WRAS)	**BSI**
Netherlands	KIWA ATA / BRL 536C	**KIWA**
Austria	ÖNORM EN ISO 15876 Richtlinie W 38	**ÖVGW**
Portugal	ISO 9001 EN ISO 15876-1 to 5 CEN ISO/TS 15876-7	**SGS**
Sweden	NKB Product Rules No. 3 BBR 3 BVL	**SITAC**
Switzerland	Bau- und Prüfvorschriften W/TPW 129, SN EN ISO 15876	**SVGW**
Spain	UNE-EN ISO 15876-1: 2004 UNE-EN ISO 15876-2: 2004	**AENOR**

Technical rules and testing regulations define the state of the art.

The **application parameters** established by the DVGW (German Technical and Scientific Association on Gas and Water) for pipe systems in drinking water installations are:

- temperature 70°C
- pressure 10 bar
- service life 50 years
- safety factor 1.5

In the framework of implementing the international ISO 15876 norm nationally, the manufacturer must indicate the application classes which correspond to his pipe system and the individual parameters. For INSTAFLEX these are:

- 16 and 20 mm: classes 1/2/4/5–10 bar
- from 25 mm: classes 1/2/4–10 bar, classes 5–8 bar

Approvals for INSTAFLEX

Country	Institute	Reg. No.	Remarks
Australia	SAI	SUK 01923	d16 - d110
Belgium	UBATc	05/1871	d16 - d110
Germany	DVGW	DW-8501AT2528 DW-8501AT2529 DW-8501AQ3144 DW-8501AW0424	d16 - d50 electro / socket fusion d63 - d110 electro / socket fusion d16 - d20 compression joints d25 - d63 compression joints
England	BSI WRAS	KM39698 0805500	d16 - d32 PB - material
France	CSTB	CSTBat-33-1177 CSTBat-78-1177 CSTBat-109-1177 CSTBat-147-1177	d16 - d110
Netherlands	KIWA	K 48336, 48341, 48377	d16 - d110
Austria	ÖVGW	W1.119	d16 - d110
Portugal	SGS	Pending	d16 - d110
Sweden	SITAC	0273/97	d16 - d110
Switzerland	SVGW VKF	8703-1961 Z16819	d16 - d110 Fire prevention approval
Spain	AENOR	001/004170 Pending	d16 - d25 d32 - d110

Shipbuilding

China	CCS	HBTO3170142	d16 - d110
Bureau Veritas	BV	12232/BO BV	d16 - d225
German Lloyds	GL	74455-96HH 21049-04HH	d16 - d225 Norma couplings
Italy	RINA	MAC187203CS Pending	d16 - d110 d125 - d225
Lloyd's Register	LR	02/20008_E2	d16 - d225
Norway	DNV	K3207 K3208 K3209 Pending	d16 - d110 d16 - d110 d16 - d110 d125 - d225
Russia	RMROS	04.00058.250	d16 - d110
USA	ABS	04-LD465502-3PDA	d16 - d110

Technical regulations and standards

Technical regulations and standards

General

Standards and regulations

Water specialists rely on the standards and regulations applicable in their respective countries.

Until a uniform **«European Technical Standard for Sanitary Installations»** is adopted, the country-specific **«Accepted Rules of Technology»** continue to be valid.

Technical regulations for water installations in:

Germany	**DIN 1988 (TRWI)**
	DIN EN 806
Switzerland	**SVGW Leitsätze W3**
	SN EN 806
Austria	**Ö-NORM B5155**
	Ö-NORM EN 806
Great Britain	**Water laws**
	BS 6920-1
	BS EN 806

The specifications also state the legal basis from which the technical and hygienic suitability of components and materials is determined. In order to verify suitability and correctly identify products, manufacturers are required to label their products and plant constructors are obligated to utilise only clearly marked products.

For the construction of drinking water systems, the following standards and guidelines apply:

Germany DIN/DVGW

- DIN 1988 (TRWI)
  DIN EN 806
- DIN 4109 Noise protection in high-rises
- DIN 4102 Fire behaviour of building materials
  DIN EN 13238
- EnEv Energy-saving ordinance

Switzerland SVGW

- W3 guidelines for building water installations
- SIA 181 Noise protection in residential buildings
- SN EN 806 Part 1: SIA 385301
- SN EN 806 Part 2: SIA 385302

Great Britain BS

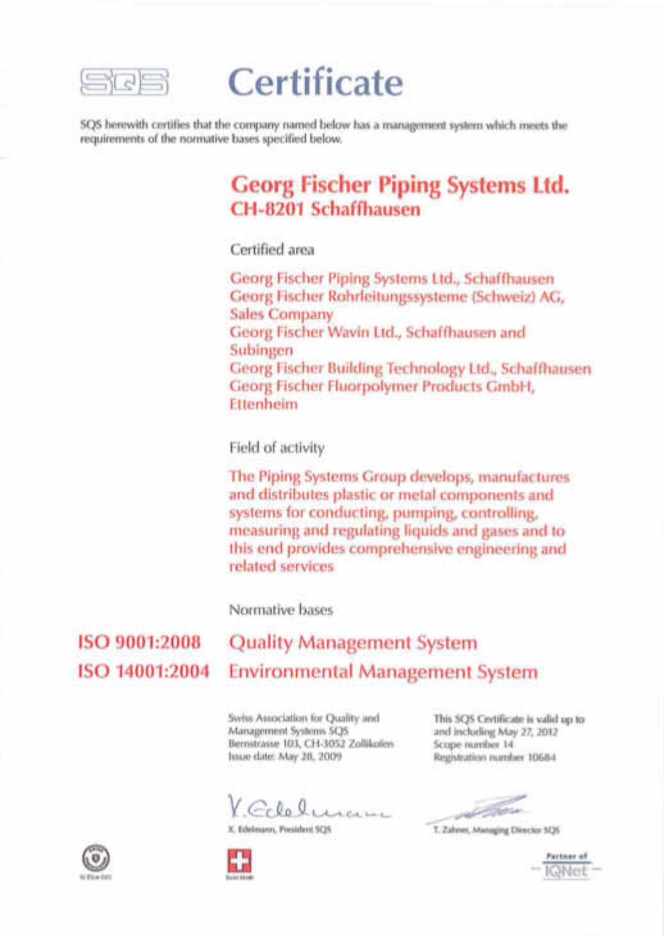
- BS 5955-8
  Specifications for the installation of thermoplastic pipes and fittings in building services: drinking water, hot water, heating installations.

Testing and certification

Quality and quality control are a top priority at GF Piping Systems!

Standards, external and internal test guidelines contain the basic specifications and hallmarks of quality required of pipes, connections and piping components. Besides checking the dimensional accuracy, the purpose of the required testing is to establish the quality and the monitoring of quality in order to ensure safety for a system lifetime of 50 years.

Proof of the hygienic suitability of pipes and components used to conduct the number one food «drinking water» is given in external testing according to the respective guidelines. Recognised, independent test centres continually monitor the quality of the PB material. Only successfully tested and quality controlled pipes and fittings may carry the seal of approval.


SQS

Certificate

SQS herewith certifies that the company named below has a management system which meets the requirements of the normative bases specified below.

Georg Fischer Piping Systems Ltd.
CH-8201 Schaffhausen

Certified area

Georg Fischer Piping Systems Ltd., Schaffhausen
Georg Fischer Rohrleitungssysteme (Schweiz) AG, Sales Company
Georg Fischer Wavin Ltd., Schaffhausen and Subingen
Georg Fischer Building Technology Ltd., Schaffhausen
Georg Fischer Fluorpolymer Products GmbH, Ettenheim

Field of activity

The Piping Systems Group develops, manufactures and distributes plastic or metal components and systems for conducting, pumping, controlling, measuring and regulating liquids and gases and to this end provides comprehensive engineering and related services

Normative bases

ISO 9001:2008 Quality Management System
ISO 14001:2004 Environmental Management System

Swiss Association for Quality and Management Systems SQS
Bernstrasse 103, CH-3052 Zollikofen
Issue date: May 28, 2009

This SQS Certificate is valid up to and including May 27, 2012
Scope number 14
Registration number 10684

X. Edelmann, President SQS

T. Zahner, Managing Director SQS

Partner of IQNet

INSTAFLEX pipes and fittings are tested and monitored for quality by the accredited «SKZ» Test Centre in Würzburg and other institutes. The frame of reference for confirmation of suitability is 50 years, based on the operating conditions in the respective country.

Under ISO and DIN norms and existing test guidelines, the manufacturer is obligated to statistically evaluate the product by means of the prescribed testing during the production process. This is set down in a catalogue of quality control measures, as well as periodic **external**

monitoring conducted by test institutes. This continuous and stringent **in-house testing** is the basis of quality control at GF Piping Systems.

Test guidelines:		
Germany	DVGW	Worksheet W534
		W544/W270
		DIN 16968 and 16969
		DIN 16831/DIN 50930
	KTW	Recommendations of the Federal Health Authority
		(BGes. BL. Jg. 1977, 1 and 2 Mitt. ff.)
Switzerland	SVGW	Building and test guidelines
		W/TPW 129
		W/TPW 143
Austria	ÖVGW	Guideline W38
		ONEN 15876
Netherlands	KIWA	BRL-K 536/01
Belgium	UBAtc	ATG 92/1871
	BUtg b	
France	SO-COTEC	C.S.T.B. Nr.: 09.24
Great Britain	WRc	Approval per British Standard BS 6920

Operating conditions

The long-term operating pressures permissible for INSTAFLEX pipes and fittings in the cold water range correspond to their nominal pressures (PN).

d16 to 110 complies with PN 16
d125 to 225 complies with PN 10

The pressure and temperature requirements for an **assumed operating duration of 50 years** with a calculated **safety factor of 1.5** are summarised in the following table.

Germany - DVGW (DIN 1988/Part 2)

Medium	**Operating overpressure [bar]**	**Temperature [°C]**	**Annual duration [h/a]**
Cold water	0 to 10 (fluctuating)	up to 25*	8760
Hot water	0 to 10 (fluctuating)	up to 60	8710
		up to 85	50

* Reference temperature for creep rupture strength: 20 °C

Switzerland - SVGW (Guideline W3)

Medium	**Load duration**	**Temperature [°C]**	**Operating pressure [bar]**
Cold water	Long-term operation	20	10
Hot water	Long-term operation	60	10
Exceptional load accumulated over the system lifetime	1000 h	95	10

Hygiene standards

Polybutene pipes have been proved to be hygienically suitable for hot and cold drinking water pipelines. The test results of the DVGW research centre at the Engler-Bunte Institute of the University of Karlsruhe have shown that polybutene pipes satisfy the KTW recommendations of the Federal Health Authority (BGA).

The suitability in terms of the material composition qualifies the INSTAFLEX system as a «commodity» under General Food Law.

The KTW guideline analyses the hygienic quality of organic materials that come into contact with drinking water. The following federal health periodicals have been published in this regard:
2005 48: 1409-1415
2007 50: 1180-1181
2008 51: In preparation, current status: 14.04.2008

Germany
Plastics in the food industry, recommendations of the Federal Health Authority; ed. R. Frank and H. Mühlschlegel, Carl Heymanns Verlag KG, Cologne, Berlin, Bonn, Munich.
LMBG (Food and Other Commodities Act) of 15.08.1974; BGesundhBL T 1, S. 1945 ff.

Austria
Per decree Zl. IV-445.850/2-6/86 of the Federal Ministry of Health and Environmental Protection as well as the investigative report kl. 1399/6-87 of the Environmental Protection Institute, body of public law.

Great Britain
According to WRC per BS 6920-1 for non-metal products used to convey water intended for human consumption with regard to their effect on the water quality.

INSTAFLEX

Fire behaviour and fire protection

Fire protection

INSTAFLEX pipes of polybutene (PB) fall under fire category **4.2** (normal inflammability) for building materials according to **VKF*** regulations and are therefore approved in Switzerland.

BZ no.: Z 16 819

In Germany polybutene (PB) pipes belong to **fire protection class B2** according to **DIN 4102**, Part 11.

If fire protection measures are required in wall and ceiling ducts for pipes from size **d32** and up, only fire-retarding sealing with the respective approval may be used.

Buried pipes generally require no special fire protection measures. The regulations in the particular country must be observed.

* Association of Cantonal Fire Insurance Companies in Switzerland

Fire behaviour

Switzerland
When exposed to an open flame, polybutene burns with a bright flame and continues to burn on its own after the source of ignition has been removed. The fumes and smoke smell of wax and paraffin. When the flame is extinguished, it smells like a candle that has gone out.

Germany
The formation of toxic or corrosive combustion products is impossible for polybutene because there are no halogens in its molecular structure.

Fire mains

When using PB pipes for fire mains, the local fire regulations must be observed.

According to SVGW guidelines W3 fire mains must be made of non-flammable material or installed in a fire-retardant manner as per **EI 30 (nbb)** :

- buried or in-wall
- in a shaft with fire bulkheads
- in an open installation, the insulation must be at least category EI 30 (nbb).

Category EI 30 (nbb)
The fire-insulated, water-filled PB pipe must be protected so that in a so-called "standard fire" the temperature on the cold side of the insulation (inner side) cannot reach 140 °C in 30 minutes. After 30 minutes, the pipeline must still be operational.

Example of insulation according to the VKF fire protection index

For an EI 30 (nbb) category, pipe half-shells of mineral wool and in the appropriate diameter are mounted staggered and adjacently, the gaps are filled with adhesive and tied with binding wire.

TA no.: 4062

F	Supporting and space enclosing structures/ false ceiling/panelling/ flameproof coatings
T	Movable closures
R	Smoke and fire-resistant closures
K	Fire dampers
S	Sealing, bulkheads
A	Elevator shaft doors

Laying pipes with bitumen

If INSTAFLEX is laid on solvent-containing bitumen tracks or if it comes into contact with solvent-containing bitumen coatings, the bitumen must first be completely dry.

Please follow the manufacturer's instructions.

In certain cases, INSTAFLEX PB pipes must be protected with solvent-resistant aluminium-clad insulation.

Laying pipes with hot-asphalt flooring

If INSTAFLEX is laid under hot-asphalt flooring, the pipes must be specially protected because this type of flooring is laid at a temperature of about 250 °C. In this case, the INSTAFLEX pipes are first laid on a rough concrete slab and covered with a granular insulation at least 10 mm deep (e.g. Perlite gravel). An insulating board of perlite and fibre must be placed on the gravel before the surface can be walked on to pour the hot asphalt.

Potential equalisation

According to DIN VDE 0100-540, potential equalisation is required between all types of protective earthing conductors and any «conductive» pipes. INSTAFLEX is not a conductive piping system and hence cannot be used for potential equalisation per DIN VDE 0100.

Protecting drinking water

If all the specifications of the national technical regulations for construction of drinking water systems are abided by, then it is safe to assume that the requirements for drinking water quality are fulfilled from the receiving point to the tapping point.

It must be warranted that neither impairment **(1)** of the drinking water, nor health risks **(2)** to the consumer may occur.

Causes of contamination or health risk in drinking water

1. Backflow of contaminated water
2. Connection to non-drinking water systems **(3)**
3. External effects **(4)**
4. Materials, supplies and auxiliary materials
5. Stagnation **(5)**
6. Unprofessional and faulty maintenance

(1) Impairment:
Changes in the drinking water which do not pose a health risk to the consumer

(2) Health risk:
Changes in the drinking water which are hazardous to health

(3) e.g. rainwater systems

(4) e.g. conducted through shafts or trenches

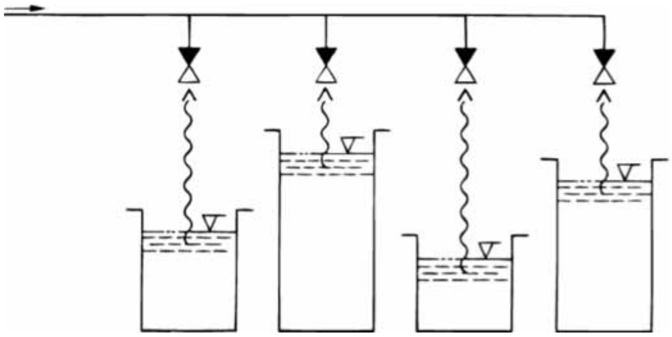
(5) For periods of stagnation of 4 weeks or more, rinsing the pipeline is recommended for hygienic reasons.

Safety measures to prevent backflow of contaminated water

Precautions must be taken to prevent backflow.

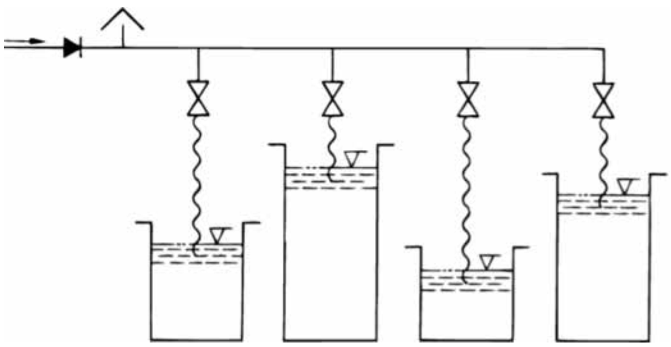
Individual protection

In individual protection, each tapping point and each device which represents a potential source of contamination or a health risk from an altered drinking water quality is safeguarded **individually**.



Collective protection

In collective protection, several or all the tapping points and devices which represent a potential source of contamination or health risk from an altered drinking water quality are protected **jointly** by one safeguard.



Sound insulation

Applicable standards

Germany	DIN 4109	Sound insulation in high-rises
Switzerland	SIA 181	Sound insulation in residential buildings

Measures

Most important in sound insulation is a suitable **floor plan**. If planning is done correctly, it is still the most effective means of sound insulation and incurs no extra costs. Rooms can be arranged advantageously from a noise prevention point of view and plumbing fixtures and pipelines placed accordingly.

Moreover, there is the requirement that **walls** of rooms needing sound insulation to which pipes (water and sewage lines), valves or plumbing fixtures are fastened must have an area-related mass (mass per unit area) of 220 kg/m² (no particular verification required). See the sound reduction index for conventional building materials.

In terms of active sound insulation in water installations, the use of **low-noise valves** is a key factor. These valves belong to valve group I, with a valve noise level according to DIN 52218 of $\mathbf{L_{AG} \leq 20}$ **dB(A).**

In structure-borne sound transmission, the sound velocity in the **material** is a major criterion. This value is determined in relation to the density and modulus of elasticity of a material. Plastics have low sound velocities which is why INSTAFLEX is ideal for sound insulation of water installations.

Sound reduction index of conventional building materials

Stone type	Wall thickness [cm]	Stone gross density [kg/m³]	Mass per unit area with mortar without plaster [kg/m²]	Weighted sound reduction index [dB]	Mass per unit area with plaster 1x1.5 cm [kg/m²] [1)]	Weighted sound reduction index [dB]	Mass per unit area with plaster 2x1.5 cm [kg/m²] [2)]	Weighted sound reduction index [dB]
Pumice-solid brick and expanded clay, e.g. Liapor	9.5 11.5 17.5 24.0 30.0	1100	104.5 126.5 192.5 264.0 330.0	37 39 44 47 50	119.5 141.5 207.5 279.0 345.0	38 40 44 48 50	134.5 156.5 222.5 294.0 360.0	40 41 45 49 51
Pumice-hollow brick and expanded clay, e.g. Liapor	17.5 24.0 30.0 36.5	1100	192.5 264.0 330.0 401.5	44 47 50 52	207.5 279.0 345.0 416.5	44 48 50 53	222.5 294.0 360.0 431.5	45 49 51 53
Honeycomb brick (small format)	11.5 17.5 24.0 30.0	1400	161.0 245.0 336.0 420.0	42 46 50 53	176.0 260.0 351.0 435.0	43 47 51 53	191.0 275.0 366.0 450.0	44 48 51 54
Light brick (large format)	11.5 17.5 24.0 30.0	1200	138.5 210.0 288.0 360.0	40 45 48 51	153.0 225.0 303.0 375.0	41 45 49 51	168.0 240.0 318.0 390.0	42 46 50 52
Porous brick, e.g. Poroton, Unipor, Pori-Klimaton	11.5 17.5 24.0 30.0	1000	115.0 175.0 240.0 300.0	38 43 46 49	130.0 190.0 255.0 315.0	39 44 47 49	145.0 205.0 270.0 330.0	40 44 48 60
Porous concrete, e.g. Ytong, Hebel	10.0 12.5 15.0 20.0 25.0 30.0 360	800	80.0 10.0 120.0 160.0 200.0 240.0 292.0	33 36 38 42 44 46 48	95.0 115.0 135.0 175.0 215.0 225.0 307.0	36 38 40 43 45 47 49	110.0 130.0 150.0 190.0 230.0 270.0 322.0	37 39 41 44 46 48 50
Sand-lime brick, solid brick	11.5 17.5 24.0 30.0	1750	201.0 306.0 420.0 525.0	44 49 53 55	216.0 321.0 435.0 540.0	45 50 53 56	231.0 336.0 450.0 555.0	46 50 54 56
Perforated brick	11.5 17.5 24.0 30.0 36.0	1500	172.5 262.5 360.0 450.0 547.5	42 47 51 54 56	187.5 277.5 375.0 465.0 562.5	43 48 51 54 56	202.5 292.5 390.0 480.0 577.5	44 48 52 54 56
Clay full brick	11.5	1800	207.0	44	222.0	45	237.0	46
Concrete	10.0	2350	235.0	46				

[1)] e.g. gypsum plaster 1.0 kg/dm³ gross density (DIN 4109 Part 3) Plaster thickness 1.5 cm = 15 kg/m², both sides = 30 kg/m²

[2)] e.g. lime plaster/lime cement plaster 1.8 kg/dm³ gross density plaster thickness 1.5 cm = 25 kg/m², both sides = 50 kg/m²

Source: DIN 1055 and manufacturer's data

Noise behaviour of INSTAFLEX polybutene (PB) valves

Noise emission from INSTAFLEX polybutene valves is less than 20 dB (A). This complies with the DIN 52218 requirements for low-noise valves in **valve group I**.

Dimension DN/d [bar/mm]	Valve noise emission L_{AG} [dB (A)] at 3 bar flow pressure
15/20	over 10
20/25	over 10
25/32	12
32/40	over 10
40/50	12
50/63	13

Sound velocity in materials

	Density [kg/dm³]	**E-modulus [N/mm²]**	**Sound velocity [m/s]**
Steel	7.95	210000	6000
Copper	8.9	120000	3900
PB (Polybutene)	0.94	450	620
PVC-C(Polyvinyl chloride, post-chlorinated)	1.56	3500	2350
PE-X(Polyethylene, crosslinked)	0.95	600	800
Soft rubber	0.90	90	320

Heat insulation of drinking water pipes

Heat insulation of the system complies with DIN 1988 requirements (drinking water - cold) and the energy conservation ordinance EnEV (drinking water - hot).

Germany

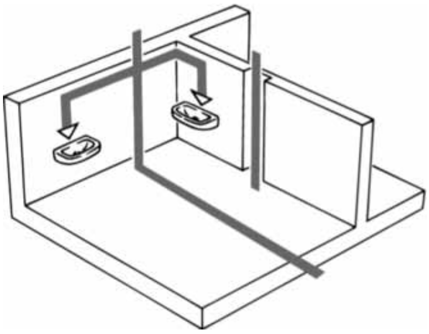
Insulation of cold water pipes (DIN 1988-2)

Cold water pipes should be placed at an adequate distance from heat sources. If this is not feasible, the pipelines should be insulated so that the water quality is not negatively affected by the heat. At the same time, cold water pipes must be protected against condensation.

The given minimum thickness of the insulation layer is based on a thermal conductivity of **λ = 0.040 W/mK**. For other thermal conductivities, the thickness of the insulation layer needs to be recalculated. According to DIN 1988-2 the following thicknesses of the insulation layer for drinking water pipes (cold) must be taken into account:

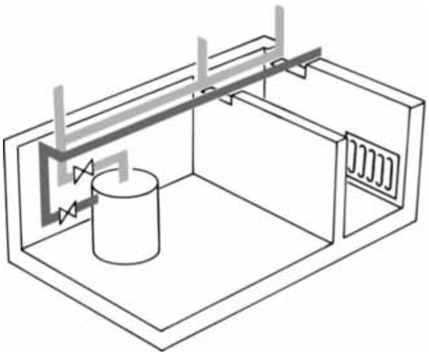
Installation situation I
4 mm minimum thickness of insulation layer

- pipeline installed openly in unheated rooms (basement)
- pipeline on concrete ceiling
- pipeline in duct, without hot water pipe
- pipeline in wall slit, riser pipes



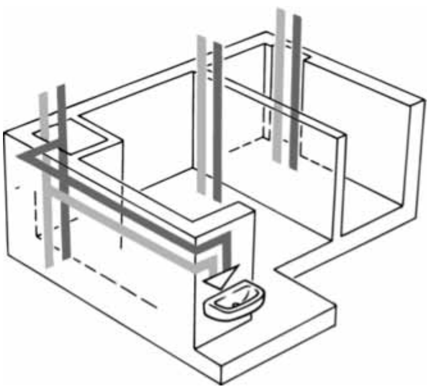
Installation situation II
9 mm minimum thickness of insulation layer

- pipeline installed openly in heated room



Installation situation III
13 mm minimum thickness of insulation layer

- pipeline in duct, next to hot water pipe
- pipeline in wall recess, next to hot water pipe



Insulation of hot water pipes according to EnEV (Energy Conservation Ordinance)

To limit heat dissipation, heat distribution pipes and hot water pipes as well as valves must be insulated.

Central heating pipes which are located in heated rooms or in structural elements between heated rooms of **a user** and whose heat output can be affected by shutoff devices need not be insulated. This also pertains to hot water pipes up to an inner diameter of 22 mm which are not connected to the circulation and are not equipped with electric pipe heaters.

Although the EnEV ordinance does not call for mandatory insulation of drinking water installations, they should nevertheless be insulated for the following reasons:

- reduction of heat dissipation
- sound insulation
- protection of piping

The given minimum thickness of the insulation layer is based on a thermal conductivity of **λ = 0.035 W/mK**. For other thermal conductivities, the thickness of the insulation layer needs to be recalculated. Insulation layer thicknesses for hot water pipes according to EnEV can be found in Table 1:

Table 1:

Line	Type of pipeline/valve	Minimum thickness of insulation layer, based on thermal conductivity 0.035 W/mK
1	Inner diameter up to 22 mm	20 mm
2	Inner diameter between 22 mm and 35 mm	30 mm
3	Inner diameter between 35 mm and 100 mm	same as inner diameter
4	Inner diameter more than 100 mm	100 mm
5	Pipes and valves according to lines 1 to 4 in wall and ceiling recesses, in pipe intersection area, at connection points, for central pipe network distributors.	½ of requirements of lines 1 to 4
6	Central heating pipes according to lines 1 to 4, which are installed after this ordinance has come into effect in structural elements between heated rooms of various users.	½ of requirements of lines 1 to 4
7	Pipes according to line 6 in floor construction	6 mm

For pipe insulation arrangements other than a circular insulation (e.g. eccentric), an equivalent restriction of heat dissipation, as in Table 1, must be warranted.

Switzerland

Hot water pipes are to be insulated in compliance with cantonal energy and building law.

Great Britain

Installation systems must be insulated according to Part 2 of the Building Regulations, making certain that the appropriate measures are taken. Evidence must be provided that the maximum heat loss is below the value given in the Non-Domestic Heating Compliance Guide.

Circulation lines

Switzerland

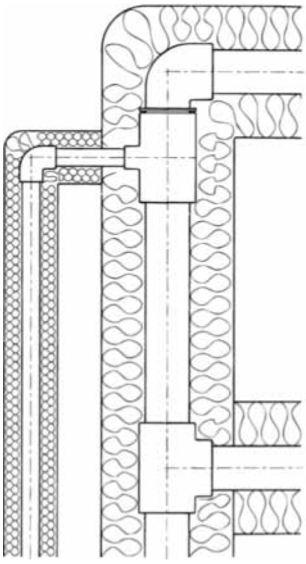
Hot water and circulation pipes are to be insulated in compliance with cantonal energy law.

Germany

Hot water and circulation pipes are to be insulated according to the energy conservation ordinance EnEV. A circulation line is calculated and regulated under DIN 1988 and W 551/W 552/W 553.

Conventional dual lines

Both pipelines must be insulated and fastened separately.

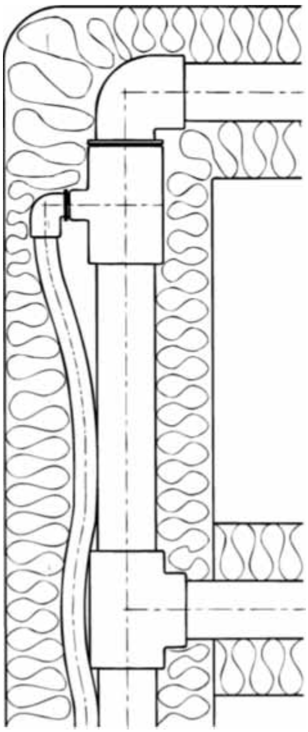


Hot water pipe and circulation pipe as dual line

Pipe-to-pipe configuration

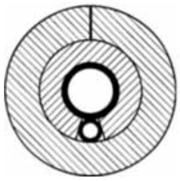
Both pipelines required only one set of insulation and fastening. This entails less cost and effort. Calculations have shown that this configuration results in ca. 30 % less heat loss compared to the conventional solution.

Source: SIA-Ing. Karl Bösch, Switzerland

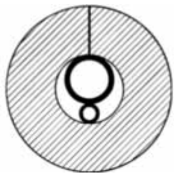


Hot water pipe and circulation pipe in a pipe-to-pipe configuration

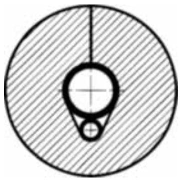
Examples for pipe-to-pipe configuration



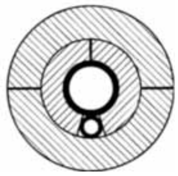
Double, soft polyethlylene (PE) insulation



Soft polyethylene (PE) insulation



Mineral insulation (fibreglass) tied with wire

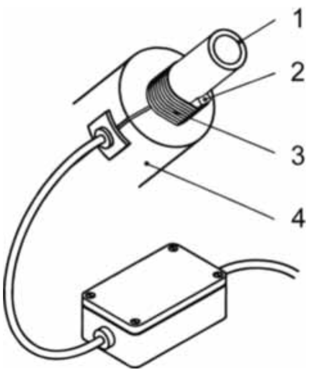


Hard-foam polyethylene (HDPE)insulation tied with wire or sheathed

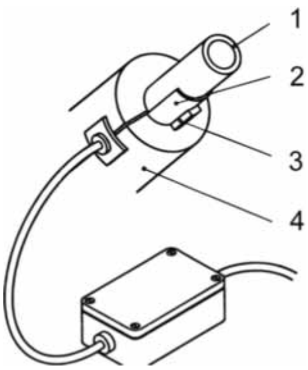
+GF+

Trace heating

Self-regulating trace heaters whose surface temperature does not exceed 65 °C may be used on the pipes. The trace heater has to be adapted to the water temperature. For better heat transfer, the entire length of the trace heater should be attached with a wide aluminium tape so that it covers as much of the medium-conveying pipe as possible. For pipes with carriers, the trace heater should be attached to the carrier.



1 INSTAFLEX pipe
2 Trace heater
3 Aluminium tape
4 Insulation



1 INSTAFLEX pipe
2 Carrier
3 Trace heater
4 Insulation

When installing trace heaters on INSTAFLEX pipes, please follow the installation instructions of the heater manufacturer. Do not double wrap the trace heater on INSTAFLEX pipes. This also applies to carriers.

Drinking water heater

Continuous flow heater

The maximum temperatures permitted for long-time operation are specified in the operating conditions.

The use of continuous flow heaters in connection with INSTAFLEX pipes has been tested and approved. Thermally or electronically controlled devices are preferable to hydraulically controlled ones because these can in some instances continue to heat uncontrolled causing INSTAFLEX to overheat.

The advantages of a modern plastic piping system like **INSTAFLEX** can be fully utilised with an electronically-controlled continuous flow heater from the companies **STIEBEL ELTRON, VAILLANT** and **AEG**. Tests with AEG continuous flow heaters in our test lab showed no negative effects on INSTAFLEX, even in case of malfunctions (brief overheating, air pockets in the heat exchanger, etc.).

Safety equipment of drinking water heating systems has been taken up in DIN 1988, Part 2, Paragraph 6.2.2 per decree of the **DVGW-FA W 5.01 of 11.11.1991**.

The requirements for safety equipment of drinking water heating systems are set down in DIN EN 60335-1, Part 1. For electric heaters of drinking water, the following standards also apply:

- VDE 0700-1, Part 1
- DIN EN 603352-2-15/VDE 0700-15, Part 15
- DIN EN 60335-2-24/VDE 0700-24, Part 24
- DIN EN 60335-2-35/VDE 0700-35, Part 35
- DIN EN 60335-2-80/VDE 0700-80, Part 243

To protect pipe materials and joints, temperature control units or safety temperature limiters should be used with drinking water heaters which guarantee that the water temperature cannot exceed 95 °C at any time and in any location, even with post-heating (coasting). On hydraulically controlled devices, an automatic shutoff must ensure that pressures above 10 bar cannot occur due to post-heating.

Condensation

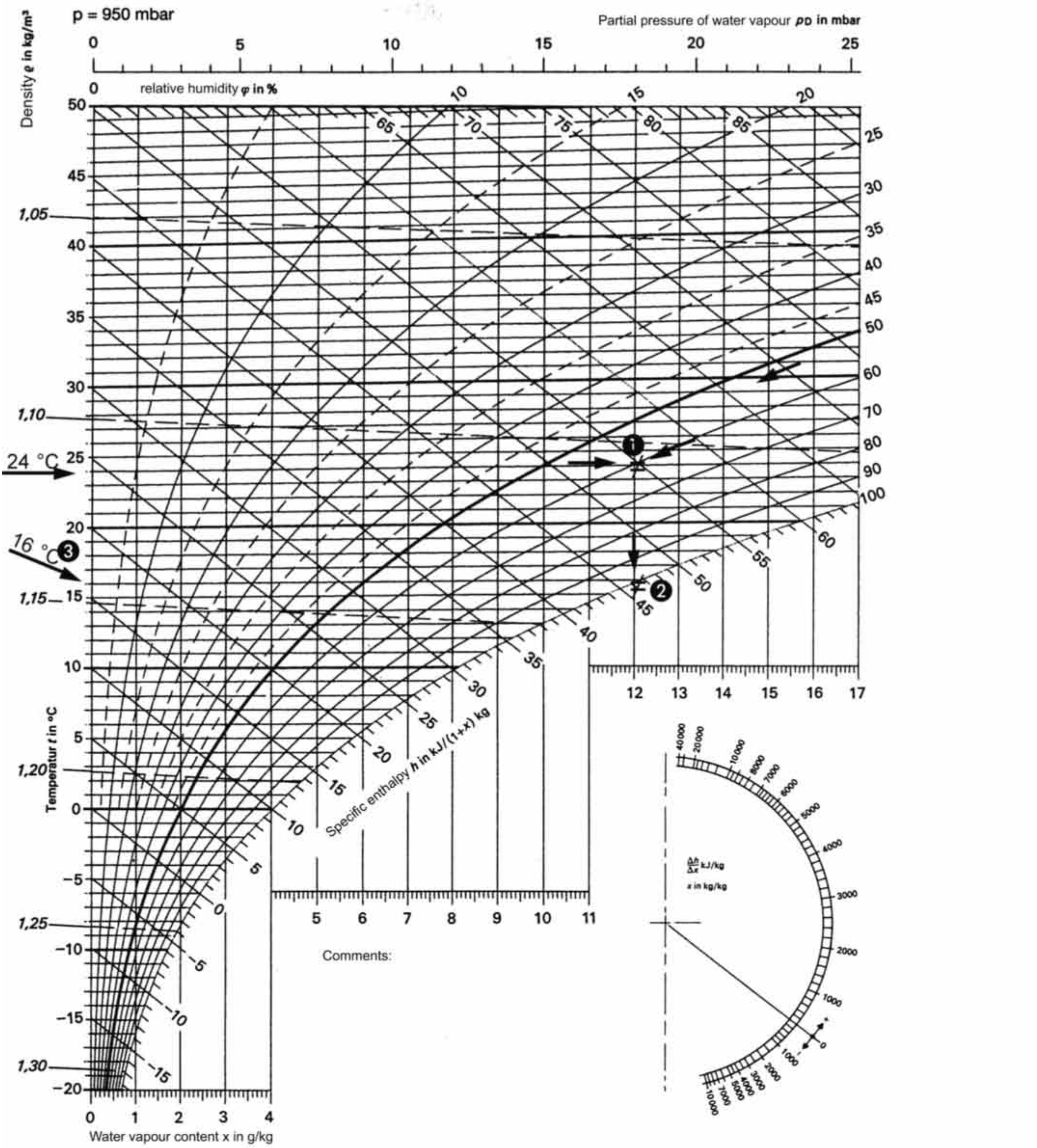
According to DIN 1988, Part 2, it is not necessary to protect pipes against the formation of condensation if they are adequately encased, e.g. pipe-in-sleeve. INSTAFLEX polybutene pipes are offered as a pipe-in-sleeve system from dimension d16 to dimension d25.

Determining condensation formation on pipes

The h-x diagram (Mollier diagram) indicates how high the moisture content of air is in relation to temperature and pressure.

h	=	enthalpy
x	=	moisture content in air
H	=	540 m above sea level

H - x diagram



Example:
Water temp. 16 °C
Air temp. 24°C
Air humidity 60%

❶ Find intersection of 24 °C air temperature and 60% air humidity

❷ Form intersection at 100% relative humidity.Vertically under intersection point❶

❸ Minimum pipe surface temperature to avoid formation of condensed water

Pipe surface temperature

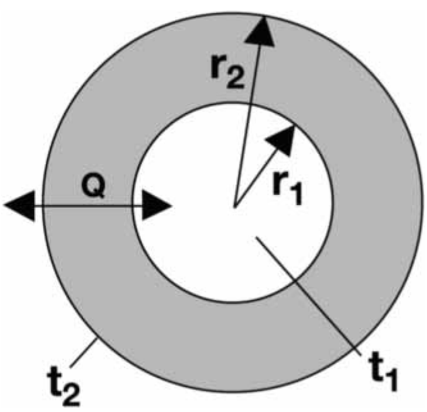
	d40	Pipe outer temperature [°C]														
W	22	18.8	19.1	19.5	19.8	20.1	20.4	20.7	21.1	21.4	21.7	22.0	22.6	23.3	23.9	24.5
a	21	18.2	18.5	18.8	19.1	19.4	19.7	20.1	20.4	20.7	21.0	21.3	22.0	22.6	23.2	23.7
t	20	17.5	17.8	18.1	18.4	18.7	19.1	19.4	19.7	20.0	20.3	20.6	21.3	21.9	22.5	23.2
e	19	16.8	17.1	17.4	17.7	18.1	18.4	18.7	19.0	19.3	19.6	20.0	20.6	21.2	21.9	22.5
r	18	16.1	16.4	16.7	17.1	17.4	17.7	18.0	18.3	18.6	19.0	19.3	19.9	20.5	21.2	21.8
	17	15.4	15.7	16.1	16.4	16.7	17.0	17.3	17.6	18.0	18.3	18.6	19.2	19.9	20.5	21.1
t	16	14.7	15.1	15.4	15.7	16.0	16.3	16.6	17.0	17.3	17.6	17.9	18.5	19.2	19.8	20.4
e	15	14.1	14.4	14.9	15.0	15.3	15.6	16.0	16.3	16.6	16.9	17.2	17.9	18.5	19.1	19.8
m	14	13.4	13.7	14.0	14.3	14.6	15.0	15.3	15.6	15.9	16.2	16.5	17.2	17.8	18.4	19.1
p	13	12.7	13.0	13.3	13.6	14.0	14.3	14.6	14.9	15.2	15.5	15.9	16.5	17.1	17.8	18.4
e	12	12.0	12.3	12.6	13.0	13.3	13.6	13.9	14.2	14.5	14.9	15.2	15.8	16.4	17.1	17.7
r	11	11.3	11.6	12.0	12.3	12.6	12.9	13.2	13.5	13.9	14.2	14.5	15.1	15.8	16.4	17.0
a	10	10.6	11.0	11.3	11.6	11.9	12.2	12.5	12.9	13.2	13.5	13.8	14.4	15.1	15.7	16.4
t	9	10.0	10.3	10.6	10.9	11.2	11.5	11.9	12.2	12.5	12.8	13.1	13.8	14.4	15.0	15.7
u	8	9.3	9.6	9.9	10.2	10.5	10.9	11.2	11.5	11.8	12.1	12.4	13.1	13.7	14.4	15.0
r	7	8.6	8.9	9.2	9.5	9.9	10.2	10.5	10.8	11.1	11.4	11.8	12.4	13.0	13.7	14.3
e	6	7.9	8.2	8.5	8.9	9.2	9.5	9.8	10.1	10.4	10.8	11.1	11.7	12.4	13.0	13.6
[°C]	5	7.2	7.5	7.5	8.2	8.5	8.8	9.1	9.4	9.8	10.1	10.4	11.0	11.7	12.3	12.9
	4	6.5	6.9	7.2	7.5	7.8	8.1	8.4	8.8	9.1	9.4	9.7	10.4	11.0	11.6	12.3
		12	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**24**	**26**	**28**	**30**
		Air temperature [°C]														

Example:
Polybutene pipe: 40 x 3.7
Water temperature: 16 °C
Air temperature: 24 °C
Air humidity: 60 %
Minimum pipe surface temperature from h-x diagram 15.5 °C

The temperature of 18.5 °C. taken from the pipe surface temperature table, means that condensation will not form.

GF Piping Systems will gladly provide you with data for other pipe dimensions from the INSTAFLEX system.

Calculation of pipe surface temperature



$$Q = \frac{2 \cdot \pi \cdot l \cdot (t_1 - t_L)}{\dfrac{\ln \frac{r_2}{r_1}}{\lambda} + \dfrac{l}{\alpha_K \cdot r_2}}$$

$$t_2 = t_1 - \frac{Q \cdot \ln \frac{r_2}{r_1}}{2 \cdot \pi \cdot l \cdot \lambda}$$

Q	=	heat flow [W]
l	=	pipe length [m]
t_1	=	water temperature [°C]
t_2	=	outer pipe surface temperature [°C]
t_L	=	air temperature [°C]
α_K	=	heat transfer coefficient [W/m² * K], calculated from measurements
λ	=	heat conductivity of the material [W/m * K]
r_1	=	pipe inner radius [m]
r_2	=	pipe outer radius [m]

Surface temperature of different pipes

	Pb		Steel		Copper	
Heat conductivity λ [W/m * K]	0.19		67		372	
Heat transfer coefficient [W/m² * K]	25		25		25	
Air temperature t_L [°C]	20		20		20	
Water temperature t_1 [°C]	10	60	10	60	10	60
Pipe dimension	d40 x 3.7		d42 x 3.25		d35 x 1.5	
Pipe surface temperature t_2 [°C]	13	47	10	60	10	60

Calculating heat emission from uninsulated polybutene pipes

$$k_R = \frac{\pi}{\frac{1}{\alpha_i \cdot d_i} + \frac{1}{\alpha_i \cdot d_a} + \frac{1}{2 \cdot \lambda} \cdot \ln \frac{d_a}{d_i}}$$

Example:
Uninsulated PB pipe d40 x 3.7

α_i= 6000 W/m²K
α_a= 10 W/m²K
λ = 0,19 W/mK

k_R	=	overall heat transfer coefficient [W/mK]
α_i	=	heat transfer coefficient on inside (water-pipe) [W/m²K]
α_a	=	heat transfer coefficient on outside (pipe-air) [W/m²K]
d_a	=	pipe outer diameter [m]
d_i	=	pipe inner diameter [m]
λ	=	heat conductivity of polybutene [W/mK]

$$k_R = \frac{\pi}{\frac{1}{6000 \cdot 0.0326} + \frac{1}{10 \cdot 0.04} + \frac{1}{2 \cdot \lambda} \cdot \ln \frac{0.04}{0.0326}} = 1.18 \frac{W}{mK}$$

$$\dot{Q} = k_R \cdot (T_a - T_i)$$

$$\dot{Q} = \text{heat loss (heat output)}$$
$$T_a = \text{ambient temperature}$$
$$T_i = \text{media temperture}$$

T_a = 20°C
T_i = 60°C

Temperature difference ΔT = 40K

$$\dot{Q} = 1.03 \cdot (60 - 20) = 41.2 \frac{W}{m}$$

+GF+

Heat emission for INSTAFLEX PB pipes, uninsulated

	ΔT	(t_1-t_2)	20	30	40	50	60	70	k R
Pipe-	16	11.6	8.98	13.47	17.97	22.46	26.95	31.44	0.449
	20	14.4	10.91	16.37	21.83	27.28	32.74	38.20	0.546
	25	20.4	14.06	21.09	28.11	35.14	42.17	49.20	0.703
dia-	32	26.2	17.52	26.29	35.05	43.81	52.57	61.34	0.876
	40	32.6	21.16	31.74	42.32	52.90	63.48	74.06	1.058
	50	40.8	25.48	38.22	50.96	63.71	76.45	89.19	1.274
meter	60	51.4	30.61	45.92	61.22	76.53	91.84	107.14	1.531
	75	61.4	35.10	52.64	70.19	87.74	105.29	122.84	1.755
	90	73.6	40.02	60.03	80.04	100.05	120.06	140.07	2.001
	110	90	45.98	68.97	91.96	144.95	137.94	160.93	2.299
	d_a [mm]	d_i [mm]	Q [W/m]						[W/mK]

Heat loss Q [W/mk]

Values for polybutene

α_i = 6000 W/m²k
α_a = 10 W/m²k
λ_R = 0.19
λ_D = 0.0025 W/mk

Fluid temperature of 5-12 °C
Room temperature with maximum humidity 75 % r. h.

ΔT = temperature difference [K]
d_a = pipe outer diameter [mm]
d_i = pipe inner diameter [mm]
Q = heat loss (heat emission) [W/m]
k_R = overall heat transfer coefficient [W/mK]
α_i = heat transfer coefficient inside [W/m²k]
α_a = heat transfer coefficient outside [W/m²k]
λ_R = heat conductivity of polybutene [W/mk]
λ_D = heat conductivity of insulation [W/mk]

Insulation thickness of cold water polybutene pipes

	Room temperature [°C]					
Dimension	**15**	**20**	**25**	**30**	**35**	**40**
d16 x 2.2	10	10	20	20	20	30
d20 x 2.8	10	10	20	20	20	30
d25 x 2.3	10	10	20	20	20	30
d32 x 2.9	10	10	20	20	20	30
d40 x 3.7	10	10	20	20	30	30
d50 x 4.6	10	10	20	20	30	30
d63 x 5.8	10	20	20	30	30	30
d75 x 6.8	10	20	20	30	30	30
d90 x 8.2	10	20	20	30	30	30
d110 x 10.0	10	20	20	30	30	30

Flushing drinking water pipelines

According to EN 806, DIN 1988, as well as the W3 Guidelines of the Swiss Association of Gas and Water (SVGW), drinking water pipelines must be flushed thoroughly in order to remove residue, such as rust, shavings, traces of cutting oil and welding flux.

For this reason the pipelines must be flushed intermittently with an air/water mixture and drinking water while under pressure. This type of flushing is mandatory for **metal pipelines** because of corrosion.

In the corrosion-proof drinking water distribution system INSTAFLEX, where no auxiliary materials, e.g. cutting oil, welding flux or adhesives, are used for fusion, compression or push-fit joining, this costly method of flushing is not necessary.

However, flushing the lines is still advised for hygienic reasons. This is done by filling the system with drinking water and then opening all the outlet valves. See also the chapter on disinfection of drinking water systems.

Germany
For more information on flushing drinking water systems please see the ZVSHK data sheet based on TR-WI DIN 1988.

Disinfection of drinking water systems

In order to supply drinking water which is clean and pure, it is crucial that the water does not become contaminated on its way to the consumer. Worksheet W291 of the DVGW regulatory body (German Technical and Scientific Association on Gas and Water) describes how to disinfect components which come into contact with drinking water, e.g. pipelines. A contamination of the drinking water with pathogenic germs can have such devastating consequences that every possible measure to avoid such risk must be taken.

Correct disinfection of drinking water systems is an important prerequisite to ensure compliance with the strict microbiological threshold values and recommended values of drinking water ordinances.
Disinfectants are hazardous substances for health and the environment, which is why their use must be carefully planned and executed according to the guidelines of occupational safety and environmentally compatible disposal.

Optional disinfectants

Sodium hypochlorite	$NaOCl$
Hydrogen peroxide	H_2O_2
Potassium permanganate	$KMnO_4$
Calcium hypochlorite	$Ca(ClO)_2$

Disinfection can take place either during the pressure test or when the disinfectant solution is allowed to stand for at least 12 hours in the pipeline. Due to the higher pressure during the pressure test, the water containing disinfectant can penetrate into the pores and gaps.

Following disinfection, the pipeline must be flushed thoroughly, and prior to starting up the system again, it must be ascertained that the threshold values for disinfectants in drinking water are not exceeded.

Recommended values for disinfection of drinking water according to the EU Guideline of 15th July 1980

No.	Description	Permissible added amount [mg/l]	Threshold value after treatment [mg/l]	Calculated as	Reaction product	
					Threshold value after treatment [mg/l]	calculated as
1	Chlorine Sodium hypochlorite, Calcium hypochlorite, Magnesium hypochlorite Chloride of lime	1.2	0.3	free chlorine	0.01	Trihaloge methane
2	Chlorine dioxide	0.4	0.2	ClO_2	0.2	Chlorite
3	Ozone	10	0.05	O_3	0.01	Trihalogen methane

Jointing technology

Jointing technology

Non demountable joints

Compression joints

INSTAFLEX compression joints from d16 to d110

Application areas

- To join PB pipes in the diameters d16 to d110 mm;
- To make transitions from plastic to metal pipes or valve connections;
- To put the joint and pipe under temperature and pressure loads immediately after assembly.

Requirement profile

A compression fitting must be

- plastics-oriented,
- functionally reliable,
- cost-efficient.

To us, the term "plastics-oriented" means that the characteristics specific to the plastic material, such as

- notch and creep behaviour,
- flexural strength and heat resistance,
- thermal expansion,
- production tolerances

have been taken into consideration.

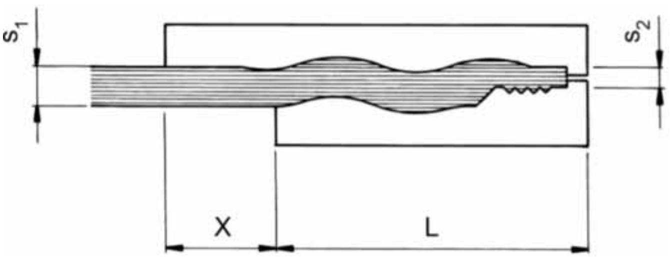
A major factor contributing to a plastics-oriented approach for compression joints is partitioning the joint into a

- holding area and a
- sealing area.

This partitioning has a positive effect on the notching behaviour of the plastic.

In the **holding area**, in other words the area in which the plastic pipe is subjected to the greatest assembly and installation load, there is a rounded, wave-like profile in which the plastic pipe is anchored to prevent notching and slipping.

In the **sealing area** we have a chiselled, serrated profile that digs into the pipe, thus ensuring a permanent seal.



Due to the long insertion depths of our compression fittings, we are able to prevent the plastic pipe from creeping. This is due to the fact that long insertion lengths create large pressing areas and large pressing areas entail small surface pressures.

Thermal expansion is accounted for by reducing the wall thickness, especially for the larger dimensions from d40. By decreasing the wall thickness, the thermal expansion is also reduced, which has a positive effect on the good creep behaviour of the plastic as well.

Functional reliability

By functionally reliable we mean a permanent seal between the plastic pipe and the compression fitting body, without O-rings or other elastomer seals, based on a hypothetical lifetime of the system of 50 years.

We also understand the term "functional reliability" to mean a compression joint which is easy to assemble without special tools (e.g. torque wrench).

Tighten the union nuts firmly. It is not possible to damage the plastic pipe by excessive tightening of the clamping element.

Functionally reliable also refers to a compression fitting that is delivered to the building site ready to install, thus ruling out assembly errors.

Spanner sizes:
d16 = 24 AF
d20 = 27 AF

In addition, we consider the transition area from the plastic pipe to a metal area (valve connection, metal thread, etc.) to be an expression of "functional reliability".

Cost-efficiency

In our view, a compression fitting is cost-efficient when it is delivered pre-assembled so that it can be installed anywhere, without tools and when a durable, leakproof joint is guaranteed.

The cost efficiency of a compression fitting takes the purchase price as well as the ease of installation into consideration because today the portion of costs for wages is much higher than for material costs. This underscores the significance of receiving a ready-to-install compression fitting on site, enabling a fast, easy and reliable joint to be made in little time.

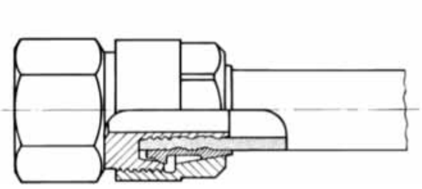
Time-tested and safe

INSTAFLEX compression fittings have been developed according to the following criteria:

- plastics-orientation
- functional reliability
- cost-effectiveness

This means:

- creep behaviour has been accounted for by strictly separating the holding and sealing functions
- notching behaviour has been taken into consideration in the waved holding profile
- a durable, leakproof joint without O-rings
- transitions from plastic to metal with compression fittings
- easy, fast and safe assembly without special tools


KV: d16/d20

Assembly of INSTAFLEX compression joints d16 to d20

With

INSTAFLEX system tools,

assembly is plastics-oriented and safe. Optimal handling contributes to a rational assembly.

INSTAFLEX system tools:

- ratchet wrench (d16 = 24 AF, d20 = 27 AF)
- circlip pliers
- protective pipe cutter

Cut the pipe and protective pipe with the pipe cutter.

Use only the protective pipe cutter to shorten the protective pipe to keep from damaging the conduit pipe.

Working with the protective pipe cutter

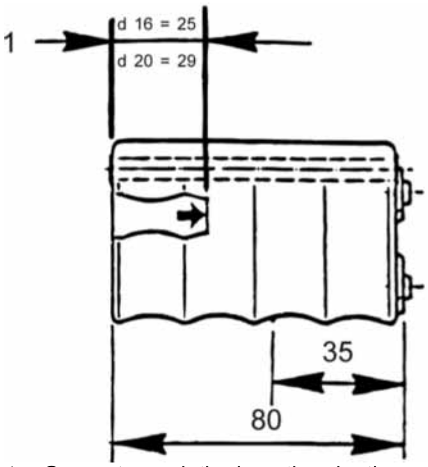
To safely cut the protective pipe surrounding a conduit pipe, it is essential to use the pipe cutter specially designed for protective pipes. Use only this protective pipe cutter to cut the protective pipe so as not to damage the inner conduit pipe. The following pipe dimensions can be cut with the protective pipe cutter:

- d16/d20 mm
- d25 mm

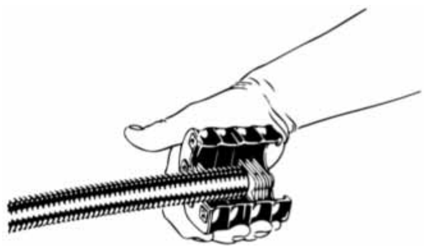
Shorten the protective pipe with the appropriate protective pipe cutter corresponding to the valve connection:

- 35 mm for single valve connections
- 80 mm for double valve connections

The cutoff lengths are marked on the protective pipe cutter:

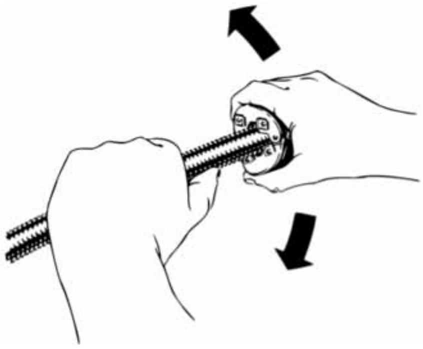


1 Gauge to mark the insertion depth for d16/d20
35 Gauge for single valve connection
80 Entire length for double valve connection

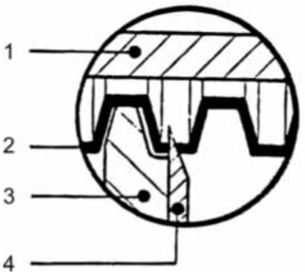


Align the cutter with the groove of the protective pipe.

Press the cutter jaws lightly together and move the protective pipe cutter back and forth. Twist off the cut pipe section with the cutter or by hand.



Cutting process



1 Conduit pipe
2 Protective pipe
3 Guide
4 Blade

Mark the insertion depth corresponding to the conduit pipe:

- d16 = 25 mm
- d20 = 29 mm

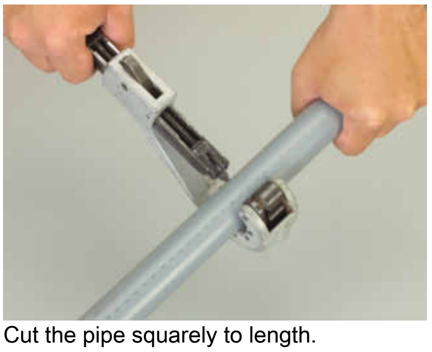
The insertion depths are indicated on the protective pipe cutter.

Insert the conduit pipe in the compression fitting up to the insertion depth marking, holding it with the pliers or by hand.

Hold the compression fitting with a barrel nipple while tightening the union nut with the corresponding ratchet wrench (d16 = 24 AF, d20 = 27 AF). Up to 2 mm of the compression ferrule is then visible for dimension 16.

Result: You have connected the compression fitting.

Assembly of INSTAFLEX compression joints d25 to d50



Cut the pipe squarely to length.

Mark the insertion depth:
- d25 = 14 mm
- d32 = 17 mm
- d40 = 19 mm
- d50 = 21 mm

Slide the pipe into the fitting up to the socket base.

Tighten the union with two suitable pliers.

Result: You have connected the compression fitting.

Assembly of INSTAFLEX compression joints d63 to d75

Cut the pipe squarely to length.

Chamfer the pipe end with the peeling tool.

Slide the flange and the compression ferrule over the pipe. Drive the support ring completely into the pipe.

Slide the pipe with the support ring completely into the union body.

Push the compression ferrule and the flange up to the union body.

Make sure the screws are tightened evenly, so the parts cannot wedge. Finish tightening the three screws to create a positive fit between the flange and the union body.

Result: You have connected the compression fitting.

Assembly of INSTAFLEX compression joints d90 to d110

Cut the pipe squarely to length.

Chamfer the pipe end with the peeling tool.

Slide the flange, the compression ferrule, the support ring and the O-ring onto the pipe in this order.

Drive the support ring completely into the pipe.

Slide the pipe with the individual parts into the union body all the way to the base.

Make sure the screws are tightened evenly, so the parts cannot wedge. Finish tightening the three screws to create a positive fit between the flange and the union body.

Result: You have connected the compression fitting.

Socket fusion joints

INSTAFLEX socket fusion of d16 to d110

The basics
Building on several decades of experience in the fusion of plastics, GF Piping Systems has developed an ideal fusion method for polybutene (PB) to create reliable, homogenous pipe joints in sanitary installations.

INSTAFLEX fittings and pipes comply with the national standards and requirements specific to the respective country. INSTAFLEX pipes and fittings are made of the same PB material, so a homogenous fusion joint is formed.

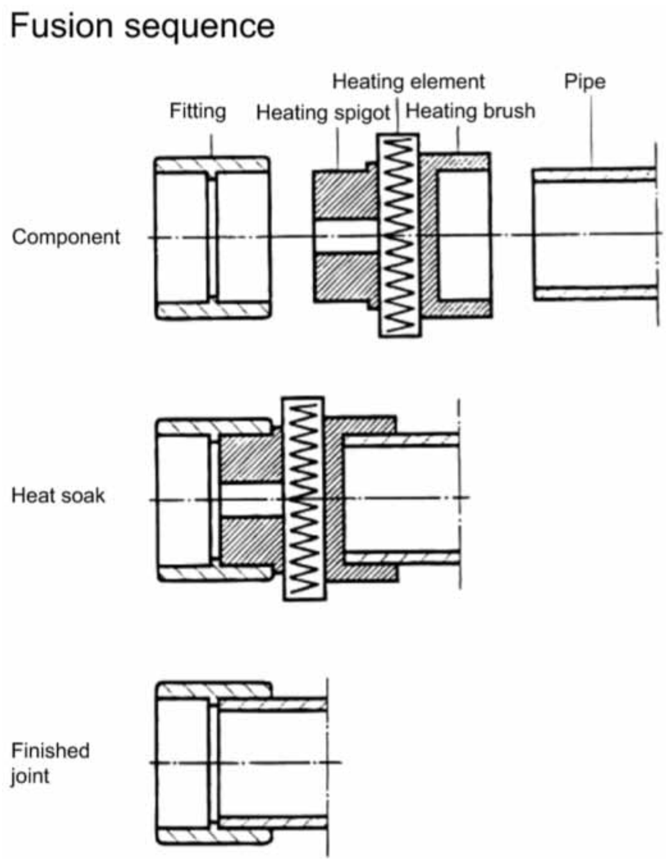
Heating-element socket fusion

In socket fusion the pipe and the fitting overlap and are fused without the use of auxiliary materials. Pipe ends and fitting sockets are heated with the help of a socket or spigot-shaped heating element to a specific fusion temperature and then joined. The pipe, socket and heating element are dimensioned so that a fusion pressure is built up during the fusion process.

The fusion temperature is 260 ±10°C (250°C - 270°C). Socket fusion may be done manually up to and including d63 pipe outer diameter with chamfered pipe ends.

Tools required
The tools and equipment required to create socket fusion joints, as well as for electrofusion, must comply with DVS Guideline 2208, Part 1.

In addition to the plastic pipe cutter, a pipe chamfering tool is required for fusion prepping. For socket fusion an electrically heated and electronically controlled hand-held fusion device and/or a fusion machine are necessary. Provided that the equipment, machines, heating bushes and spigots conform to DVS Guideline 2208, fusion may be performed with any commercially available tools.



INSTAFLEX fusion tools for socket fusion

INSTAFLEX fusion tools have been specifically designed for the **INSTAFLEX** piping system.
This specification of tools has decisive benefits in terms of

- pipe pick-up,
- heating element and
- stop position

which are essential for a

- plastics-oriented,
- functionally reliable and
- cost-efficient

fusion joint.

Hand-held fusion device

The hand-held fusion device is heated electrically (230 V/50 Hz), with a wattage of 800 W. The welding blade is also available in a 110 V/60 Hz version for United Kingdom. The electronic temperature control ensures a consistent temperature on the heating tools.

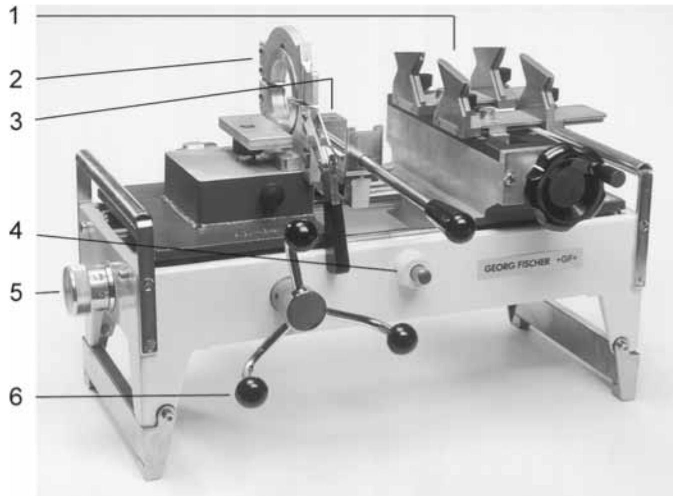
1 red
2 green

The temperature can be readjusted with a control screw. The status can be read from the red and green control lamps.

- red and green lights on
  device is heating up
- red light on, green blinking
  device is at fusion temperature
- red light on, green light off
  temperature too high, device lowers temperature automatically

Fusion machine

The use of a bench-mounted fusion machine has proved highly advantageous when prefabricating with INSTAFLEX.



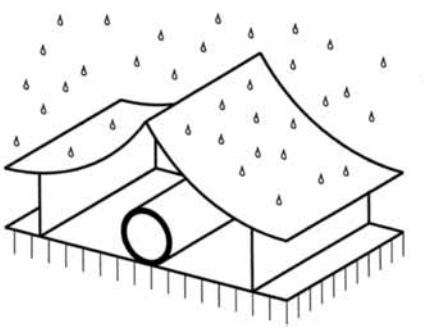
1 Prisma clamps for pipes and fittings d16 - d63
2 Round clamping device for fittings up to d63
3 Pick-up for hand-held heating element
4 Limit stop button for basic setting
5 Adjusting knob for stop positioning
6 Handwheel to move the slide

The electric functions are identical with those of the hand-held fusion device, the wattage is also 800 W. Easy handling and a special pick-up for fittings enable stress-free fusion, making this machine a valuable aid in the fusion process.

Fusion preparation d16 to d110

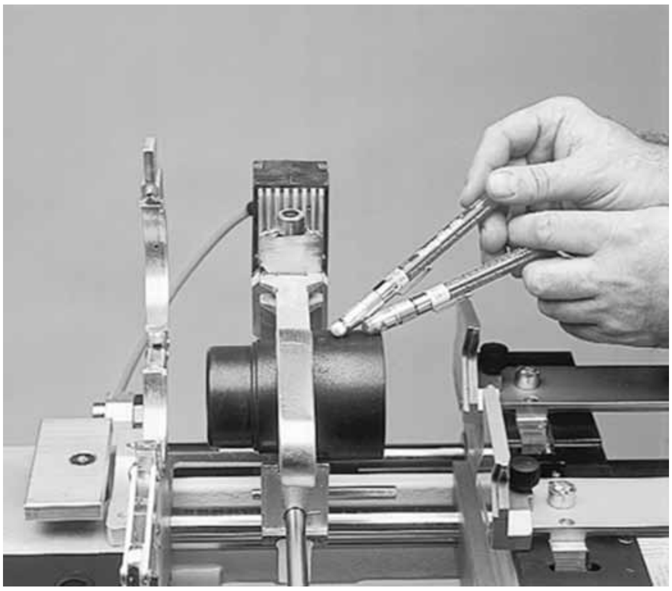
Fusion preparation

Protect the fusion equipment and the work area from dampness and dirt.



Periodic temperature check

Set the fusion temperature of the heating element at 260 °C. The temperature required for socket fusion with **INSTAFLEX** is between 250 °C and 270 °C. You can check the fusion temperature on the outside of the heating bush with tempil sticks. This temperature check should be repeated periodically, especially if the weather conditions are adverse.



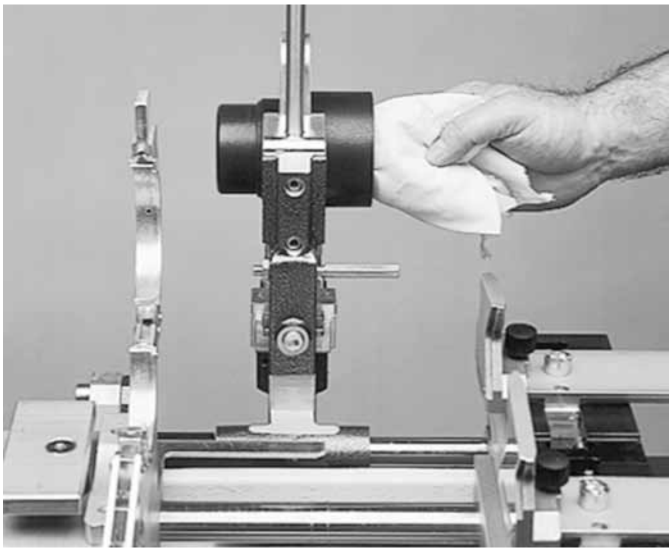
Temperature check

The correct temperature of the heating element has been reached when the 253 °C stick melts on the outside of the heating bush and the 274 °C stick does not melt. Socket fusion can be performed at ambient temperatures down to -10 °C if the fusion parameters are maintained.

Cleaning the heating socket and spigot

Clean the heating bush and heating spigot after each fusion with a clean, dry, lint-free paper **without** a cleanser.

Caution:
Hot. Can cause burns. The heating tools are heated to 270 °C.



Cleaning

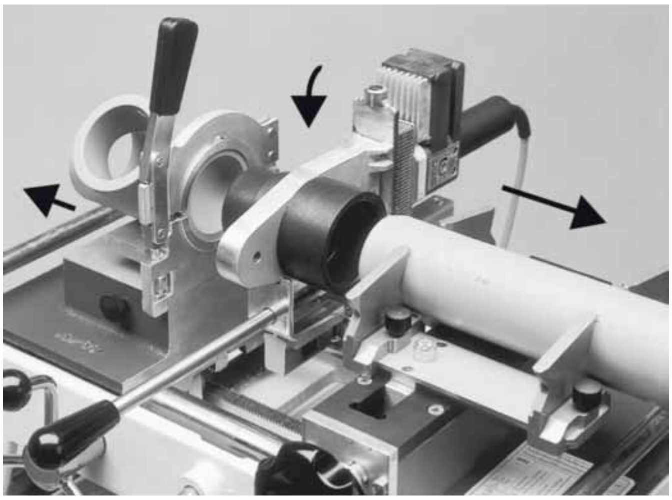
Attention:

Damaged or worn heating bushes can lead to faulty fusion. Replace damaged heating bushes or send them back to GF Piping Systems for recoating.

Fusion machine check

Before beginning with the fusion, the machine adjustments should be checked, with particular attention given to:

- axial alignment of the fitting and pipe clamps with the heating bushes and spigots and
- the correct setting of the end stops.



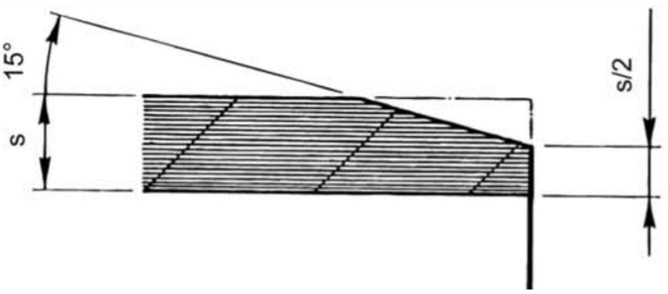
Cut the pipe

Cut the pipe squarely to length.

Chamfer the pipe ends

Chamfer the pipe ends of dimensions d25 and above. This ensures correct insertion of the pipe in the socket-shaped heating bush. The chamfering also reduces the force required to insert the cold pipe in the heating bush. Chamfer the pipe ends at a 15° angle to half of the wall thickness.

Attention:
Do not chamfer d16 and d20 pipes.



Chamfer

Cleaning the fitting and pipe

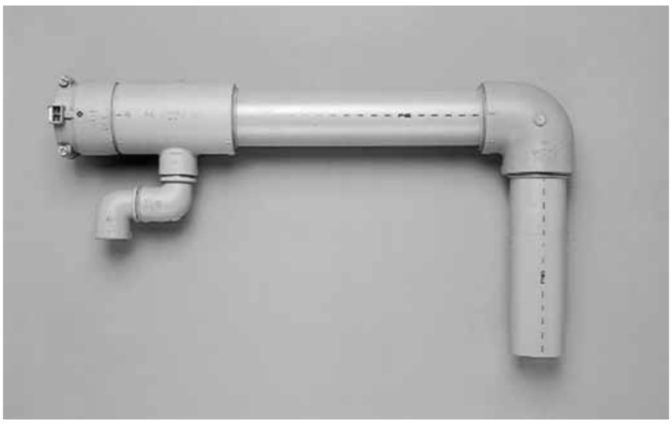
Clean the jointing surfaces of the parts to be joined - fitting and pipe end - immediately before beginning with the fusion. Use an absorbent, lint-free paper and the cleaning fluid **Tangit KS cleaner, Art. no. 799 298 023**. Wipe off the cleaning fluid completely with cleaning paper.

Cleaning the pipe end

Cleaning the fitting

It is not necessary to mark INSTAFLEX for fitting and pipe alignment since the following markings have already been made in the factory:

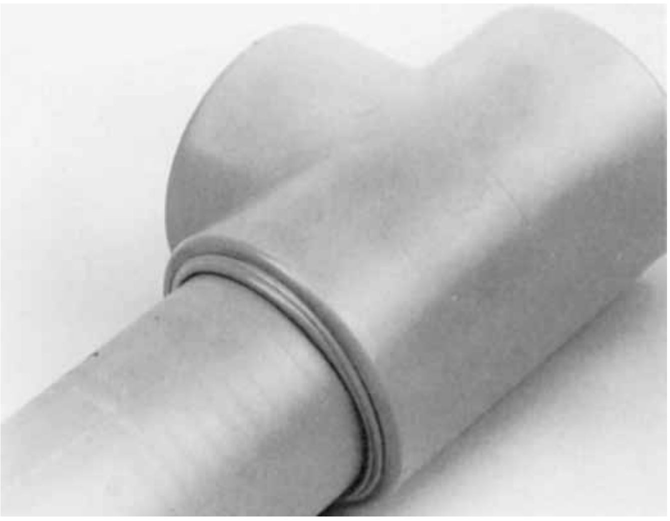
Pipe	Line marking
Fitting	Marking every 45°

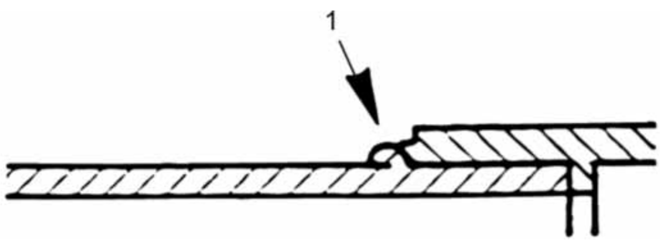


Fusion parameters

Pipe outer diameter d [mm]	Minimum wall thickness s [mm]	Insertion depth and joining depth (fusion length) [mm]	Heat soak time t [s]	Holding time t1 [s]	Cooling time t2 [min]
16	2.0	15	5	15	2
20	2.0	15	6	15	2
25	2.3	18	6	15	2
32	2.9	20	10	20	4
40	3.7	22	14	20	4
50	4.6	25	18	30	4
63	5.8	28	22	30	6
75	6.8	31	26	60	6
90	8.2	36	30	75	6
110	10	42	35	90	6

Fusion check
Check the outer bead of the fusion weld. The fusion bead must go around the entire circumference.





1 fusion bead

Pressure test
All the fusion joints must be completely cooled before beginning with the pressure test. Wait at least **one hour** after the last fusion has been made.

Welder requirements
All welders must be trained to perform fusion. In order to qualify, certification for plastic fusion may be obtained from a specialised institute, e.g. SKZ Würzburg, as described in DVS 2212. Please contact your local GF sales office.

A special training programme is also offered by GF Piping Systems for fusion of INSTAFLEX pipes and INSTAFLEX fittings.

For obligatory handling and safety instructions, please see the «Instructions for PB Socket Fusion».

Manual fusion of d16 to d63

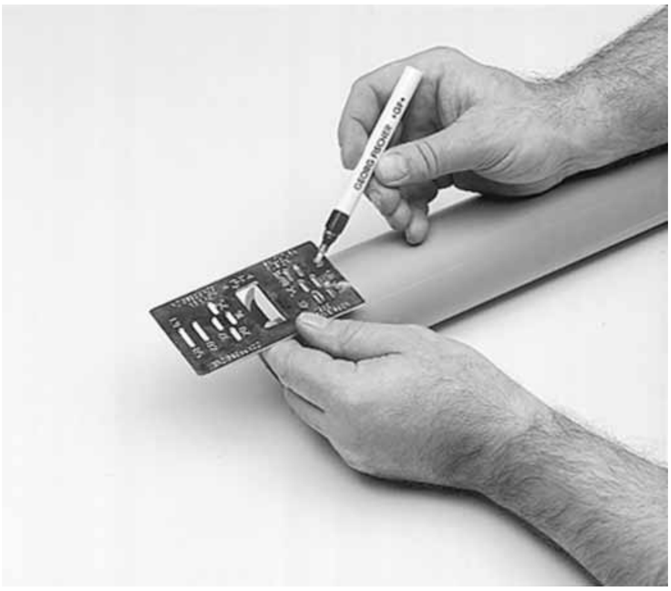
Clean the fitting and pipe
Clean the jointing surfaces of the parts to be joined - fitting and pipe end - immediately before beginning the fusion. Use an absorbent, lint-free paper and the cleaning fluid **Tangit KS cleaner, Art. no. 799 298 023**. Wipe off the cleaning fluid completely with cleaning paper.

Cleaning the pipe end

Cleaning the fitting

Mark the insertion depth
Mark the insertion and joining depth according to the pipe. Make sure the mark stays visible when heating and joining.

Pipe dimension d [mm]	Insertion and joining depth (fusion length) [mm]
16	15
20	15
25	18
32	20
40	22
50	25
63	28



Mark the insertion and joining depth

The insertion depth is also marked on the fitting for all INSTAFLEX fittings.

Heat soak the pipe end and socket fitting
Slide the pipe end and fitting onto the heating socket or spigot without twisting and not too quickly. (Material melts slowly).

The heat soak time begins when the pipe and fitting are completely inserted in the heating socket or on the heating spigot. After the heat soak period, pull the fitting and pipe **slowly** off the heating tools and without twisting or turning.

Pipe dimension d [mm]	Heat soak time t [s]
16	5
20	6
25	6
32	10
40	14
50	18
63	22

Joining the pipe and fitting

Join the fitting and the pipe immediately after heat soaking and without axial rotation.
The holding and cooling times must be observed.
Do not twist the parts during and after joining.

The marking must always be visible!

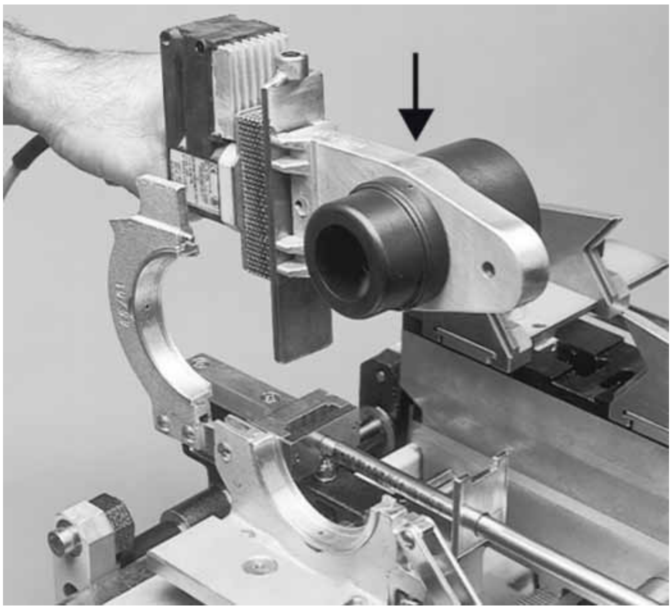
Joining the fitting and pipe

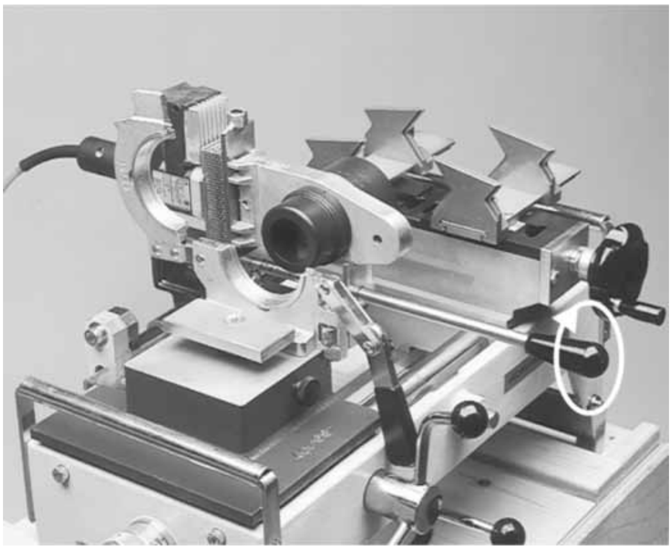
Pipe dimension d [mm]	Holding time [s]	Cooling time Minimum [min]
16	15	2
20	15	2
25	15	2
32	20	4
40	20	4
50	30	4
63	30	6

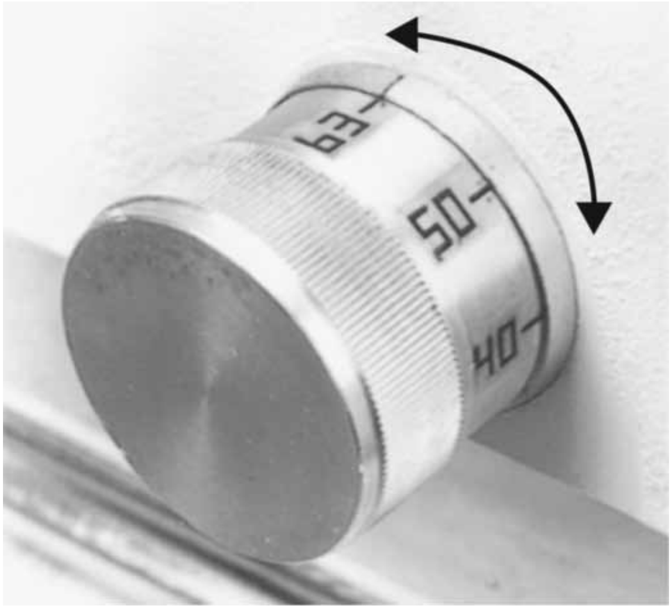
Holding time:
During this time the joined parts (fitting and pipe) must be held securely without twisting or turning.

Cooling time:
The fused parts (fitting and pipe) may only be subjected to further installation loads when the cooling time has elapsed.

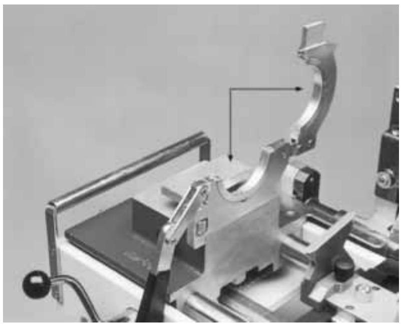
Bench-mounted fusion of d16 to d63

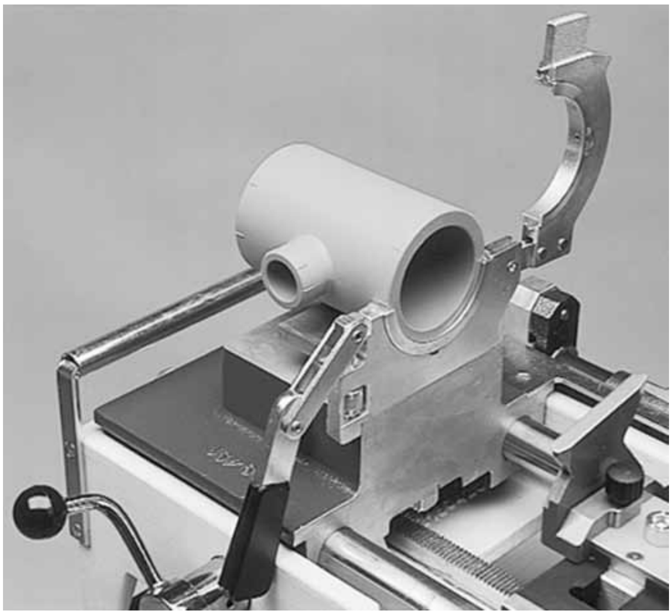

Mount the welding blade in the fixture provided.

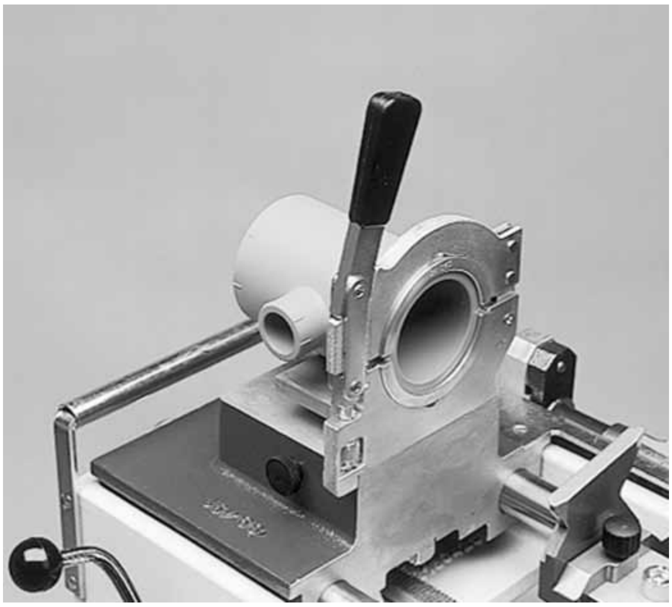

Fasten the welding blade with the handle bar.

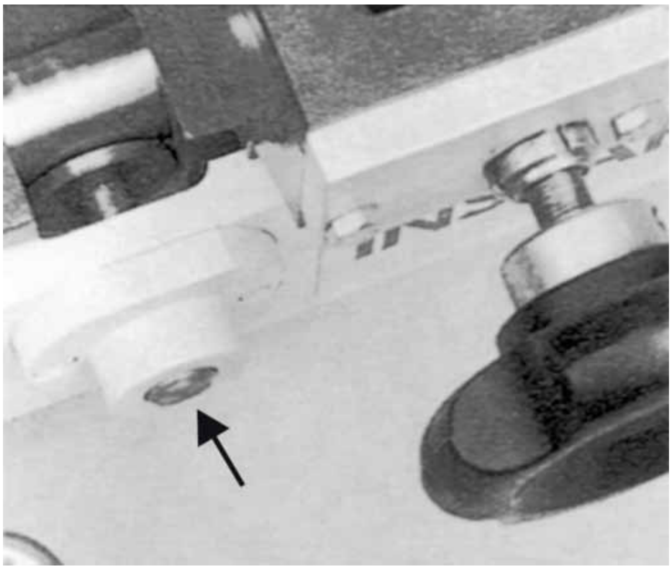


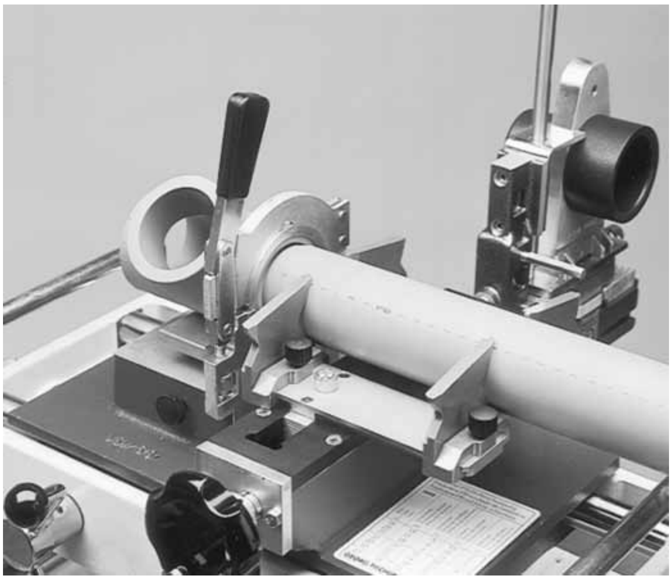
Set the stop system to the dimension to be fused.

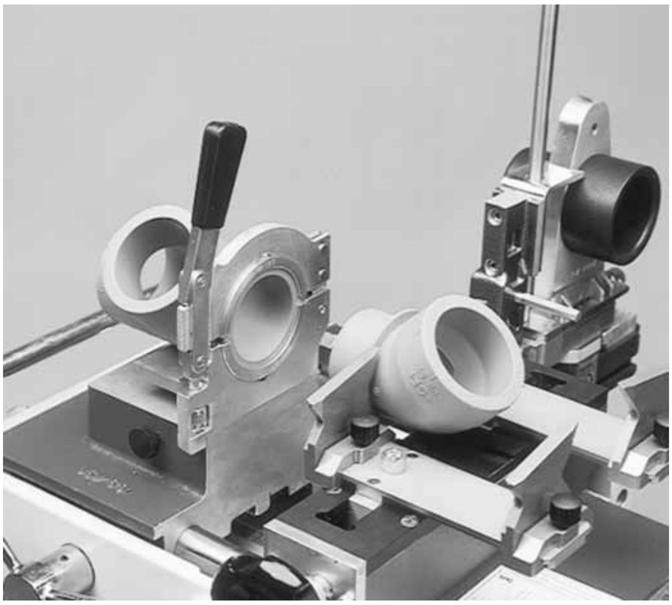

Mount the clamping inserts in the corresponding dimension in the support fixture.

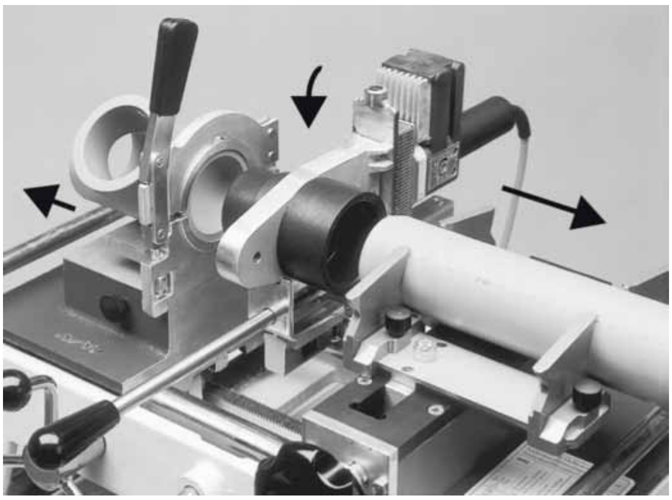

Place the fitting in the pick-up.

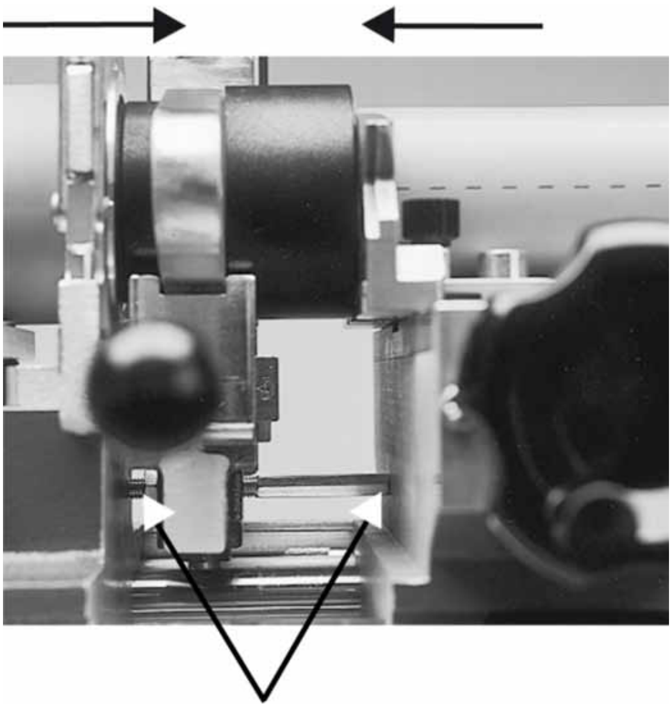

Secure the fitting in the pick-up.


Press the limit stop button and move the slides together up to the stop with the handwheel.

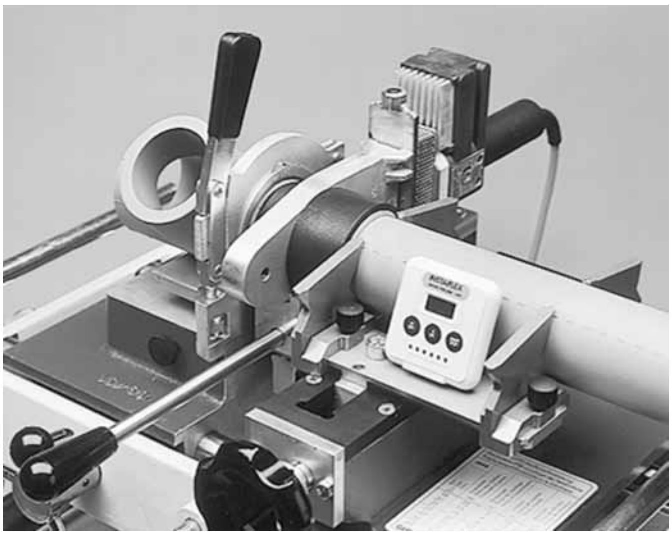

Slide the pipe flush up to the fitting end and secure it in the prisma clamp.


You can also clamp fittings in the prisma clamp to fuse very tight fitting combinations.


Move the slides with pipe and fitting apart and swivel in the heating element.

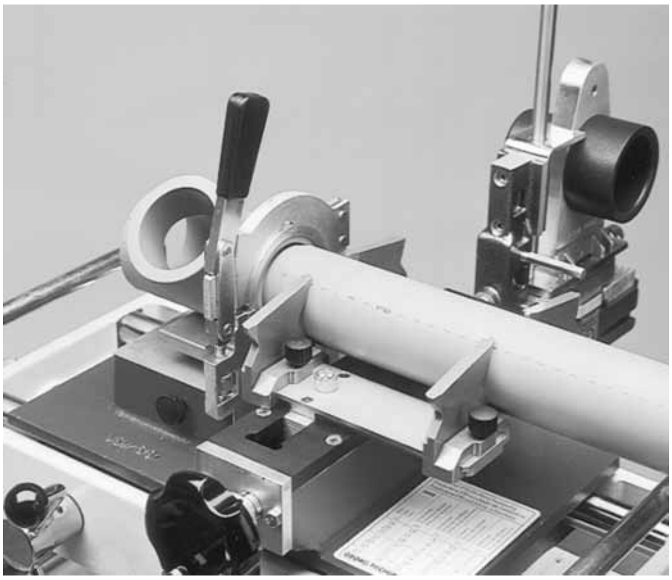


Heat soak the pipe end and the socket fitting. This is done by sliding the pipe end and socket fitting slowly onto the heating socket or heating spigot. (Material melts slowly).
Move the two slides together up to the stop.



The heat soak time begins when the pipe and the fitting are completely in the heating socket or on the heating spigot.

Pipe dimension d **[mm]**	Heat soak time **[s]**
16	5
20	6
25	6
32	10
40	14
50	18
63	22

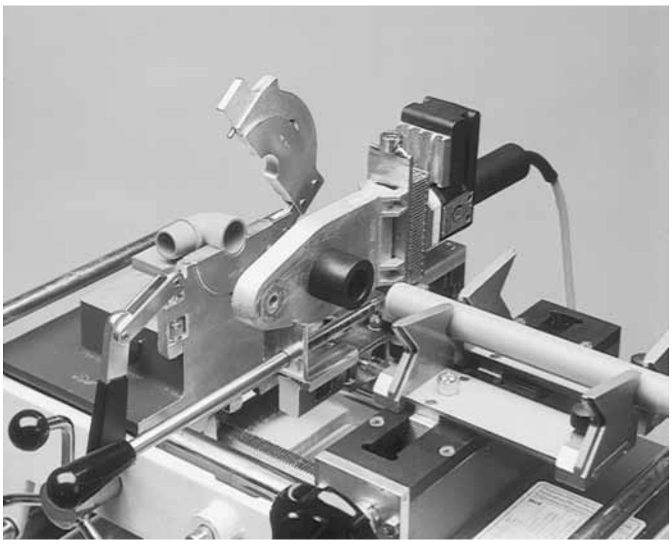


After the heat soak, remove the pipe and fitting slowly from the heating tools, swivel out the heating element and immediately join the pipe and fitting together. The holding and cooling times must be observed.

Holding time:
During this time, the joined parts (fitting and pipe) must remain clamped in the machine.

Pipe dimension d **[mm]**	Holding time **[s]**	Cooling time Minimum **[min]**
16	15	2
20	15	2
25	15	2
32	20	4
40	20	4
50	30	4
63	30	6

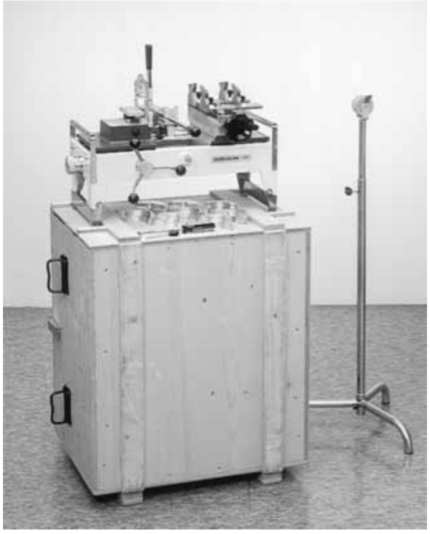
Changing dimensions

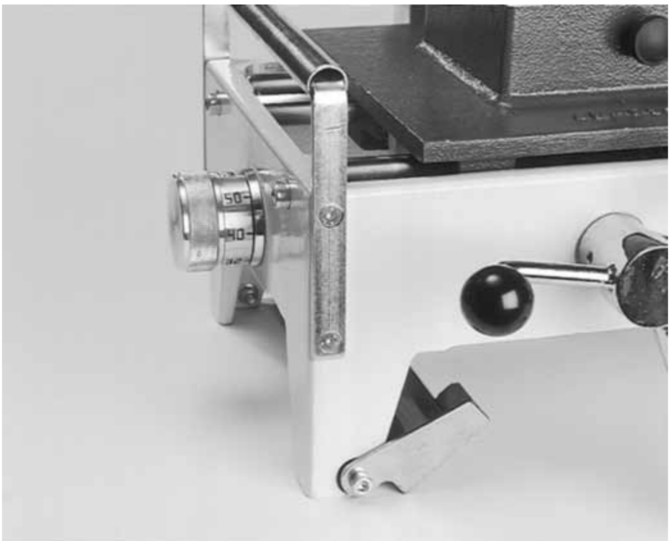


Caution: Hot. Danger of burning!
Remove the heating socket and heating spigot from the hand-held welding blade and replace with the heating socket and spigot in the desired dimension. The clamping inserts are exchanged for the fitting pick-up. The prisma clamp is not dependent on the dimension.

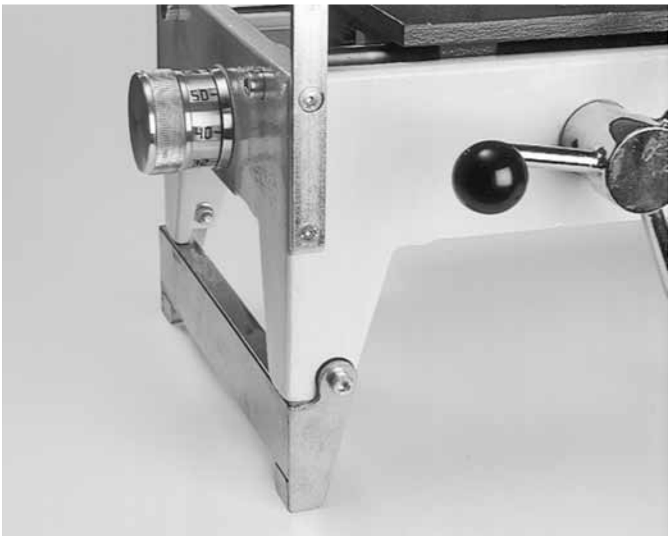
Transport

To transport the machine in its wooden crate, the machine pedestal needs to be folded up. The wooden crate can also be used as a workbench.





Transport position of the pedestal



Work position of the pedestal

Fusion protocol
Fusion protocols are to be issued upon request. Please see example on the following page.

Fusion protocol

Fusion protocol

❑ Socket fusion

❑ Electrofusion

Job No:__________ Welder name:__________ Fusion device, Company:__________

Item: __________ Company:__________ Type / No:__________

Manufacturer, System:__________ Material:__________

1	2		3					4				5
Serial No. Date	Work piece		Weather					Fusion data				Comments
	Pipe dim. mm	Wall thickness mm	Sun	Wind	Dry	Humid	Temp. °C	Heat soak time sec	Holding time sec	Cooling time min	Fusion temp. °C	
Example:												
1/21.4.88	**d 32**	**2,9**	**x**		**x**		**26°**	**8**	**20**	**4**	**265°**	

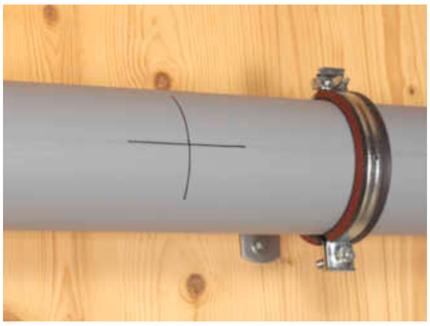
Weld-in saddles d50 to d110

Assembly instructions for weld-in saddles in dimensions d50 to d110

Select the drill dimension:

- One drill for outlets: 20, 25, 32
- One drill for outlets: 40, 50

The heating bushes for the corresponding dimension



Mark the drilling point

Mount a pipe bracket about 15 to 20 cm next to the drilling point to prevent the pipe from bending out during assembly.

Drill through pipe wall with the drill (code no. 761 068 033). Use a speed-controlled drill with 300-350 rpm.
Important:
The hole must be drilled at a right angle.

Chamfering the drill hole makes it easier to insert the heating bush in the next step.

Clean the pipe and the drill hole with Tangit KS cleaner (code: 799 298 023). Wipe off all the cleaning fluid with the cleaning paper.

Clean the weld-in saddle with Tangit KS cleaner (code: 799 298 023). Check that the saddle dimension corresponds to the pipe dimension.

Mount heating bush on the welding blade.

Slide both the weld-in saddle and the pipe onto the heating bushes at the same time.
Heat soak time, see Table 1

1 Melt bead

After heat soaking the pipe and saddle, an even bead must have formed around the drill hole.

Immediately after pulling off the heating bush, push the weld-in saddle into the pipe. Do not twist or turn the saddle.
Holding and cooling time, see Table 1

The heating bushes must be cleaned after each fusion joint. There must be no polybutene material left on the heating bushes.

Result: the saddle is welded in the pipe.

Various connections can be mounted on the saddle.

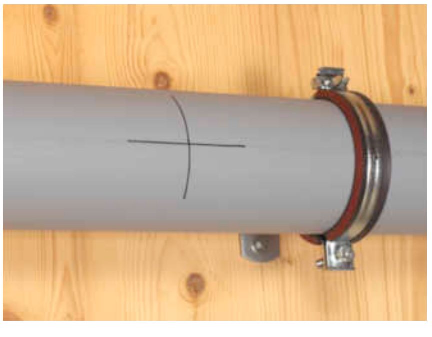
Weld-in saddles d125 to d225

Assembly instructions for weld-in saddles in dimensions d125 to d225

Select the drill dimension:

- One drill for outlets: 20, 25, 32
- One drill for outlets: 40, 50

The corresponding heating bushes for the dimension.



Mark the drilling hole

Drill a hole through the pipe wall. Use a speed-controlled drill with 300-350 rpm.
Important:
The hole must be drilled at a right angle.

Chamfer 3 to 4 mm of the drill hole, which makes it easier to insert the heating bush in the next step.

Clean the pipe and the drill hole with Tangit KS cleaner (code: 799 298 023). Wipe off all the cleaning fluid with the cleaning paper.

Clean the weld-in saddle with Tangit KS cleaner (code: 799 298 023). Check that the saddle dimension corresponds to the pipe dimension.

Mount the heating bushes on the welding blade.

+GF+

Slide both the weld-in saddle and the pipe onto the heating bushes at the same time.
Heat soak time, see Table 2

1 Melt bead

After heat soaking the pipe and saddle, an even bead must have formed around the drill hole.

Immediately after pulling off the heating bush, push the weld-in saddle into the pipe. Do not twist or turn the saddle.
Holding and cooling time, see Table 2.

The heating bushes must be cleaned after each fusion joint. There must be no polybutene material left on the heating bushes.

Result: the saddle is welded in the pipe.

Various connections can be mounted on the saddle.

Weld-in saddles fusion times

Fusion times

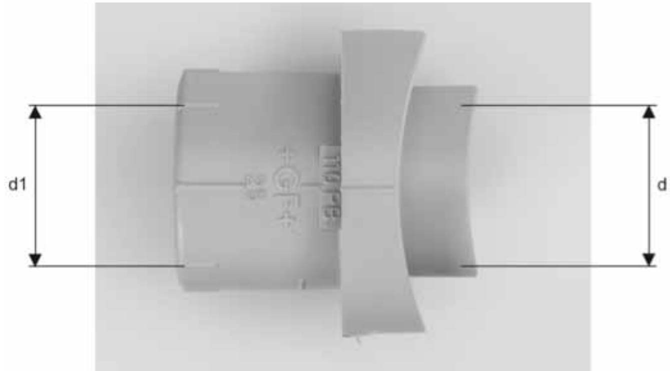


Table 1

Dim. d - d1	Temp. °C	Weld-in saddle on pipe			Pipe in weld-in saddle		
		Fusion time			Fusion time		
		Heat soak time sec.	Holding time sec.	Cooling time min.	Heat soak time sec.	Holding time sec.	Cooling time min.
50 - 20	260	22 - 24	30	4	6	15	2
50 - 25	260	22 - 24	30	4	6	15	2
50 - 32	260	22 - 24	30	4	10	20	4
63 - 20	260	22 - 24	30	4	6	15	2
63 - 25	260	22 - 24	30	4	6	15	2
63 - 32	260	22 - 24	30	4	10	20	4
75 - 20	260	24 - 26	30	4	6	15	2
75 - 25	260	24 - 26	30	4	6	15	2
75 - 32	260	24 - 26	30	4	10	20	4
90 - 20	260	26 - 28	30	4	6	15	2
90 - 25	260	26 - 28	30	4	6	15	2
90 - 32	260	26 - 28	30	4	10	20	4
110 - 20	260	28 - 32	30	4	6	15	2
110 - 25	260	28 - 32	30	4	6	15	2
110 - 32	260	28 - 32	30	4	10	20	4

Table 2

125 - 32	260	29 - 33	30	4	10	20	4
125 - 40	260	31 - 35	30	4	14	20	4
125 - 50	260	31 - 35	30	4	18	30	4
160 - 32	260	28 - 30	120	4	10	20	4
160 - 40	260	42 - 45	120	4	14	20	4
160 - 50	260	42 - 45	120	4	18	30	4
225 - 32	260	25 - 30	120	4	10	20	4
225 - 40	260	45 - 50	120	4	14	20	4
225 - 50	260	45 - 50	120	4	18	30	4

Pipes d125 to d225: drill hole with 3 to 4 mm chamfer

Weld-in saddles spacing

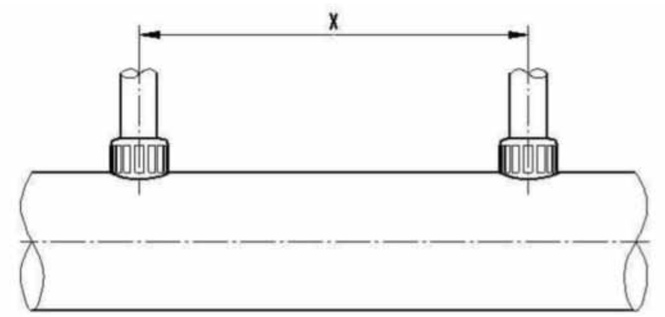
Spacing weld-in saddles
When positioning the weld-in saddles on the INSTAFLEX pipe, the following distances are important:

- distance between two weld-in saddles
- distance of the weld-in saddle across the circumference
- distance between weld-in saddle and fitting

It is also imperative to check that the saddle dimension on the pipe side corresponds to the pipe dimension.

Distance between two weld-in saddles

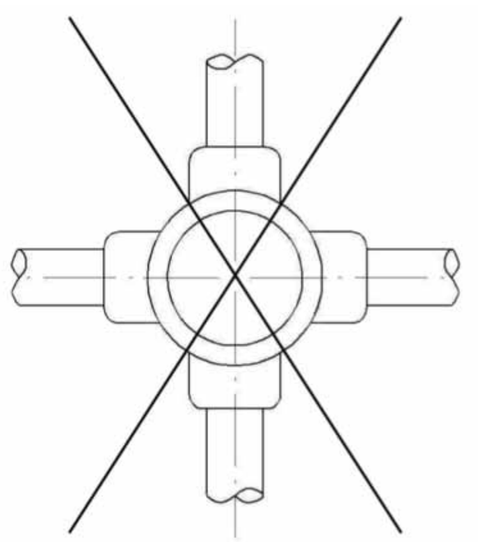
The minimum distance X between two weld-in saddles must be at least **30 mm** . This distance applies to pipe dimensions 50 to 225 mm with all outlets. Burst and pulsation tests were conducted on welded-in saddles to determine this distance.



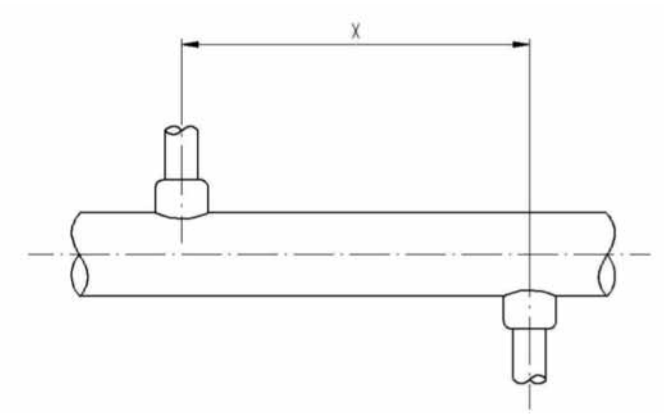
Allowed

Distance of weld-in saddle across circumference

Pipe dimensions d50 to d90
If a weld-in saddle has been welded into the pipe, another or more weld-in saddles may not be welded in across the circumference at this point. Alternatively, another saddle may be welded in with a minimum distance X of 30 mm across the circumference. This applies to pipe dimensions 50 to 90 mm with outlets d20, d25 and d32 mm.

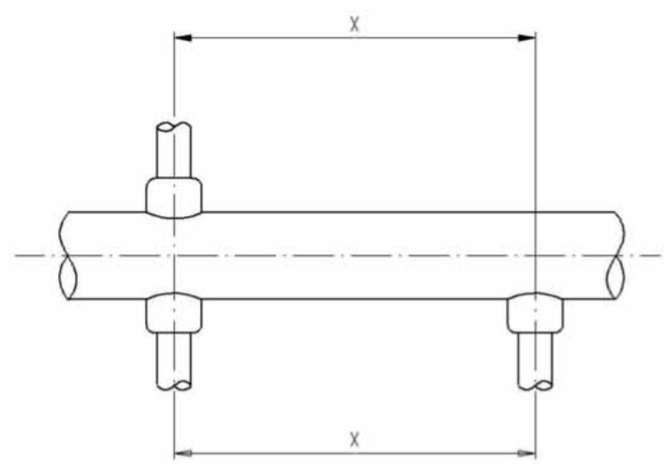


Not allowed!



Allowed

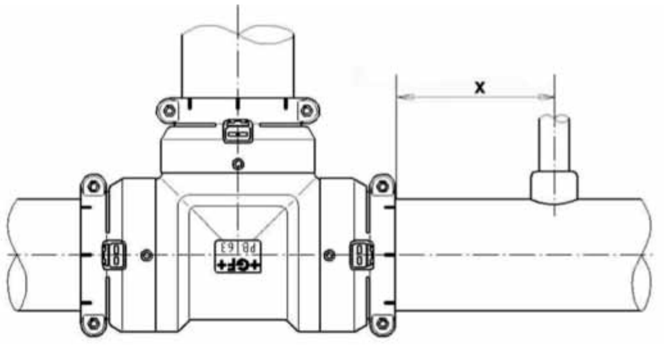
Pipe dimension d110 to d225
If a weld-in saddle has been welded into a d110 to d225 pipe, **it is allowed** to weld in another weld-in saddle across the circumference. The minimum distance of X = 30 mm from saddle to saddle must be observed in this case as well.
It is not allowed to weld in more than 2 saddles across the circumference.



Allowed

Distance between weld-in saddle and fitting

The minimum distance X between weld-in saddle and fitting must be at least 30 mm. This applies to dimensions 50 to 225 mm irrespective of the outlet dimension.



Allowed

Electrofusion joints

INSTAFLEX electrofusion joints for d16 to d110

The same polybutene (PB) material is used for INSTAFLEX pipes and fittings, which guarantees a homogenous fusion joint.

General requirements

INSTAFLEX electrofusion fittings made of PB are suitable for operating pressures up to 16 bar at 20 °C and 10 bar at 70 °C. The guidelines of the respective countries and the specifications for a homogenous joint were integrated in the development.

The electrofusion process

In electrofusion the pipe and the fitting overlap and are fused without auxiliary materials. The heat required to fuse the pipe and fitting is supplied with the help of the resistance wires embedded in the socket.

The electrical energy supply is controlled by the **INSTAFLEX HWSG-3 fusion device**. The required fusion pressure is achieved via the dimensionally adapted INSTAFLEX pipes and INSTAFLEX electrofusion fittings. The pipes and fittings cannot be combined with other systems.

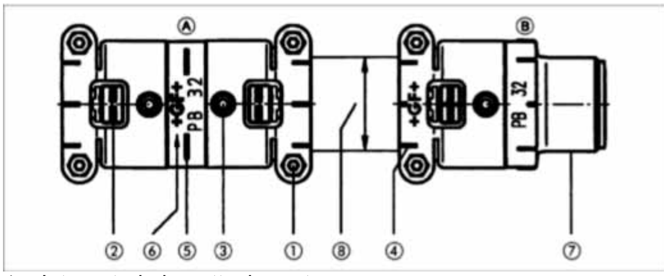
INSTAFLEX electrofusion fittings

In developing the INSTAFLEX electrofusion sockets, the special requirements of building technology piping systems were taken into consideration:

- no support fixtures
- minimal pipe end prepping as possible
- no axial displacement of pipes during assembly
- simple cable connections for functional and safe operation
- clearly visible product identification and fusion indicator
- easy transition from electrofusion to socket fusion

All these requirements, as well as the benefits of the INSTAFLEX socket fusion fittings, were the basis for development of the INSTAFLEX electrofusion fittings.

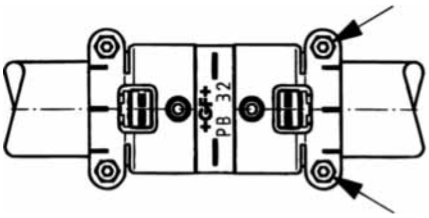
Features of INSTAFLEX electrofusion fittings



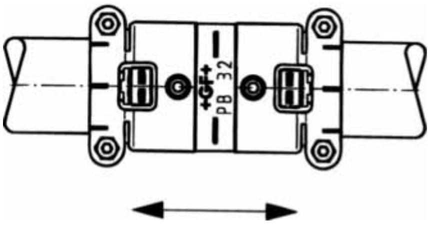
1 Integrated pipe attachment
2 Coded single-plug connector for fusion cable
3 Optical fusion indicator
4 Degree marking (every 45°) for component combinations
5 Insertion depth marking
6 Type designation incl. manufacturer, material and dimension
7 Spigot for socket fusion
8 Fitting inner diameter designed as sleeve

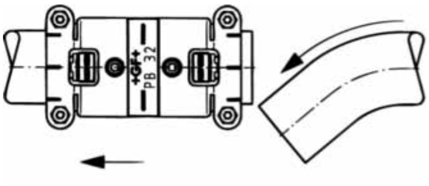
Advantages of INSTAFLEX electrofusion fittings

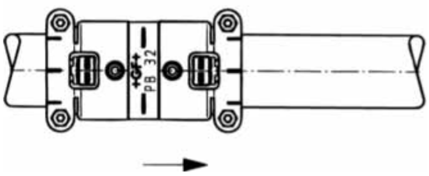
Integrated pipe attachment
Thanks to the pipe attachment integrated in the fitting, additional pipe support is not necessary for fusion. This is a big advantage in installation, especially in difficult to reach places as is often the case in plumbing installations (heating pipes, ventilation shafts in the way).

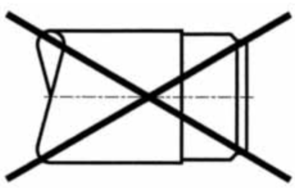


Sleeve
The dimensions of INSTAFLEX pipes and electrofusion fittings are adapted to one another. The electrofusion socket is designed as a sleeve and the centre stop must be broken out, but no machining of pipe ends is required.



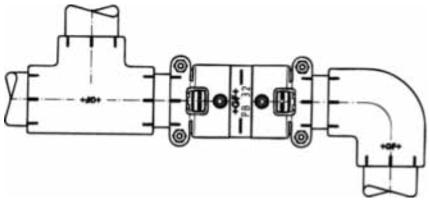






**Attention!
Electrofusion sockets may not be used to compensate length. Both pipe ends must be pushed up to the stop in the socket.**

Fitting markings
The degrees marked on the fitting (every 45°) make it possible to position components exactly, for example for prefabrication of piping combinations.



INSTAFLEX HWSG-3 Fusion Device

The INSTAFLEX HWSG-3 fusion device has been specially designed for fusion of INSTAFLEX electrofusion fittings with pipes.

Features of the INSTAFLEX HWSG-3 fusion device are:

- the dimension connected is identified by measuring the electrical resistance
- no errors due to incorrectly set parameters
- fully automated fusion process
- start and finish of fusion process is signalled acoustically and visually
- interruptions in the fusion process are indicated
- simultaneous fusion of three different dimensions is possible



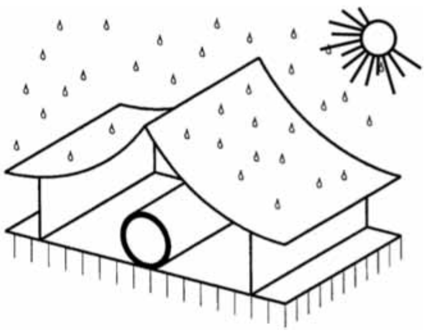

Electrofusion fittings

Fusion parameters

Pipe outer diameter d	Insertion depth l		Fusion time
	Socket	Fitting	t
[mm]	[mm]	[mm]	[s]
16	38	38	37
20	40	40	47
25	42	42	55
32	42	42	70
40	47	47	120
50	49	49	145
63	51	51	180
75	67	67	185
90	74	74	200
110	80	80	210

Fusion preparation

Protect the fusion device and the fusion area from dampness and dirt.



Cut the pipe squarely and deburr the inside of the pipe. Do **not** chamfer the pipe end! Use a plastic pipe cutter.

Clean the jointing surfaces of the parts to be joined - fitting and pipe end - immediately before starting. Use an absorbent, lint-free paper and the cleaning fluid **Tangit KS cleaner, Art. no. 799 298 023**. Wipe off all the cleaning fluid with the cleaning paper.

Cleaning the fitting


Cleaning the pipe end

Marking the insertion depth

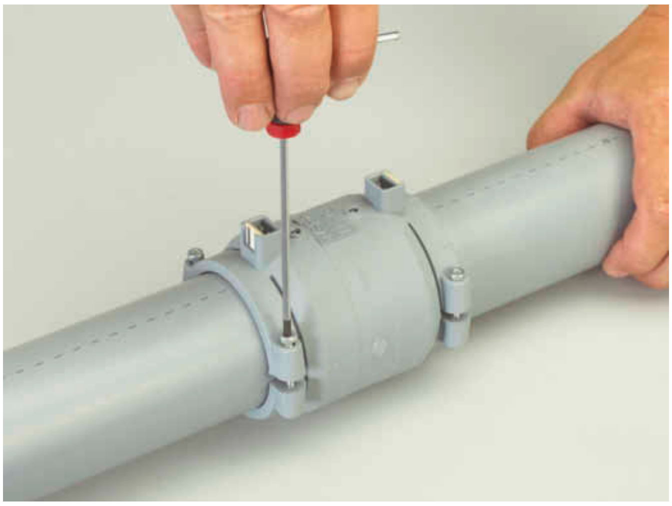
Mark the insertion and joining length accordingly on both pipes. Make sure the marking stays visible during fusion.

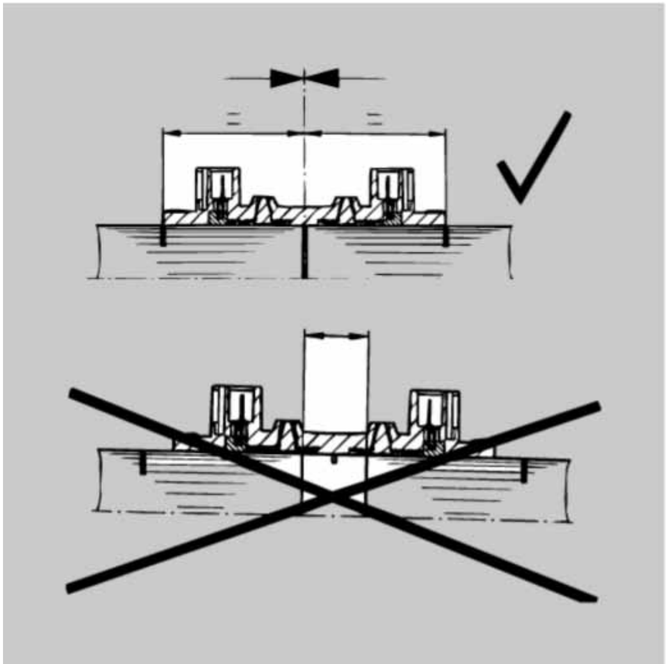
Do not use a wax pencil.

+GF+

Push the pipes into the fitting up to the marking. Make sure the pipe faces butt against each other in the middle of the socket. Tighten the screws alternately on the integrated pipe attachment.

Note:
With a pipe surface temperature above 40 °C and the related expansion, it is difficult to push the fitting onto the pipe because of the required tight tolerances.





Pipes must butt in the middle of the socket

«Start» fusion

Connect the fusion device to the mains.

Plug the fusion cable into the fitting. You can perform up to three fusion welds at the same time.

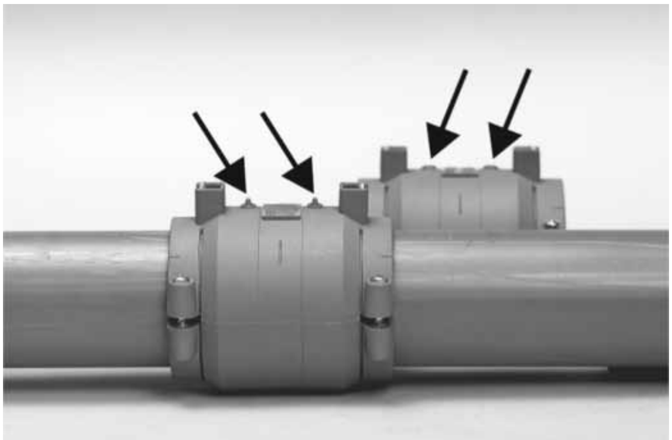
Start fusion with the button:

Pipe dimension d [mm]	Fusion time t [s]	Cooling time t_1 [min]
16	37	2
20	47	2
25	55	2
32	70	4
40	120	4
50	145	4
63	180	6
75	150	6
90	200	6
110	210	6

During the fusion process the parts to be joined - fitting and pipe - may only be subjected to the forces which normally occur in installation (pipe fastening) according to the guidelines.

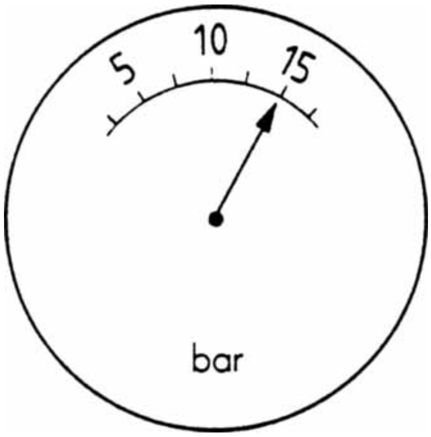
Cooling time:
The joined parts - fitting and pipe - may only be exposed to further installation forces when the cooling time has elapsed.

Fusion check
Check the fusion with the optical fusion indicator. A fused socket can be identified by means of the emerging material pin.



Pressure test

Before starting the pressure test, all the fusion welds must be fully cooled. Observe the minimum waiting time of **one hour** after finishing the last fusion.



Please see the chapter on Pressure Testing.

Functions of the INSTAFLEX HWSG-3 fusion device

The following conditions must be met for the fusion device to function accurately:

Mains voltage	min. 185 V	max. 264 V
Mains frequency	min. 47 Hz	max. 65 Hz
Temperature	min. -15°C	max. 40°C

These values are continuously checked by the fusion device during the process. The fusion process is interrupted if there are deviations and the control lamp indicates an **error**.

Operation

1. Connect the device to the mains. All the control lamps will light up for two seconds. The mains indicator goes on:

2. Connect the fusion cable to the respective fitting. The "Ready" light goes on.

Each fusion channel is able to identify the fitting connected and its dimension independently. Up to three fusion welds can be performed in different dimensions simultaneously. Fusion channels which are not connected are blocked during the fusion process (no current).

3. Start the fusion process with the button:

The fusion indicator blinks and a beep signals the beginning of the fusion process:

The "Ready" light of the connected fusion channel goes on:

To stop the fusion push:

Attention:
The process cannot be resumed afterwards and the fusion is not complete.

4. The fusion is completed after the longest fusion time has elapsed. You will hear a beep and the control lamp "End" will light up.

The "Ready" indicator for channels with shorter fusion times (different dimensions) will go out when the fusion has been completed:

5. Remove the fusion cable from the fitting. The Mains indicator lights up:

All three fusion channels are free for the next fusion.

Technical data

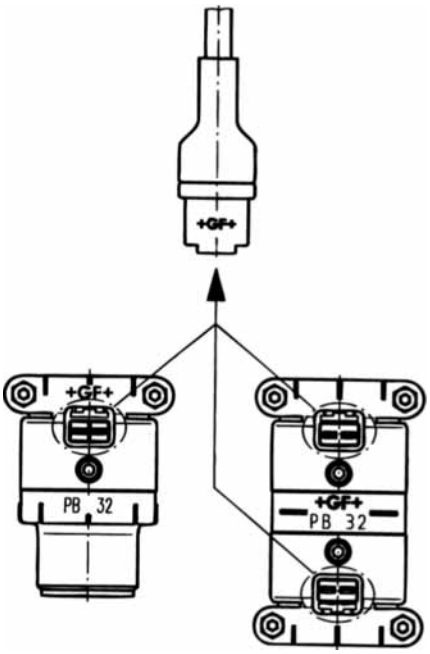
Voltage:	V_{Prim}	230 V
	V_{Sec}	185 V
Frequency:	50/60 Hz	
Current:	I_{Prim}	7.5 A
	I_{Sec}	3 x 2.5 A
Power:	P_{Prim}	25 - 1400 W
Device no.		

England:

Voltage:	V_{Prim}	110 V
	V_{Sec}	185 V
Frequency:	60 Hz	
Current:	I_{Prim}	13 A
	I_{Sec}	3 x 2.5 A
Power:	P_{Prim}	1500 W
Device no.		

Fitting connection

The coding in the plug part of each electrofusion fitting transmits to the fusion device the data on the fitting connected and its dimension.



Electrofusion fitting connections

Cleaning

If soiled, clean the device with a damp cloth. Only use alcohol or spirit on the front panel and the typeplates, **no** thinner or solvent.

Error messages

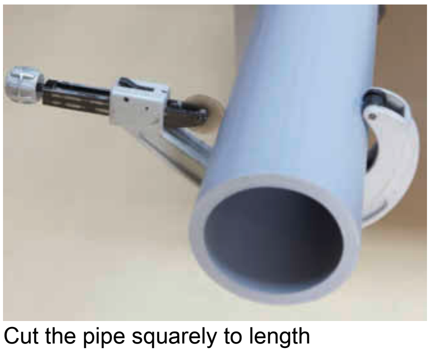
Problem	Troubleshooting
1. Connecting the device to the mains	
All the control lamps are blinking:	
• Mains voltage is not in the required range (185–264 V)	Select another power source.
• Ambient temperature too high or too low (-15– +40 °C)	Protect device from heat or cold.
No indication:	
• No mains voltage	Check mains fuse.
• Device defect	Replace the device. Have the device checked by GF Piping Systems or a service centre.
2. Plugging fusion cable into fitting	
«Ready» lamp does not light up:	
• Defective fusion cable	Replace cable.
• Defective fitting	Replace fitting.
3. «Error» lamp blinks	
• The cause is not under points 1 and 2	Replace the device. Have the device checked by GF Piping Systems or a service centre.
4. Fusion aborts	
«Error» lamp blinks: • Fusion cable disconnected from fitting • Change in the allowed mains voltage • Change in the allowed ambient temperature	Disconnect the fusion cable from the fitting. Disconnect from the mains. **Wait at least one hour before performing the fusion again.** If the problem continues: Replace the defective device. Have the device checked by GF Piping Systems or a service centre.

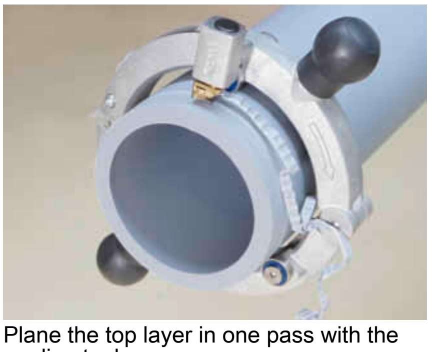
For the obligatory handling and safety instructions, please see the manual for PB electrofusion of d16–d110 with the HWSG-3.

INSTAFLEX BIG

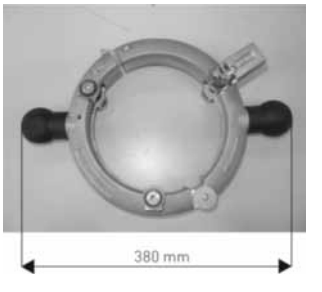
Assembly instructions for INSTAFLEX electrofusion joints d125 to d225

Assembly of INSTAFLEX BIG electrofusion sockets


Cut the pipe squarely to length


Plane the top layer in one pass with the peeling tool.

Peeling lengths for electro-socket fusion

Dimension [mm]	**Peeling length**  [mm]	**Total required length** (with peeling tool)  [mm]	**Width of peeling tool**  [mm]
d125	90	190	360
d160	95	190	380
d225	110	210	450

Cleaning the socket
Clean the jointing surfaces of the socket and the pipe end. Use an absorbent, lint-free paper and cleaning fluid **Tangit KS cleaner, Art. no. 799 298 023**. Wipe off all the cleaning fluid with the cleaning paper.

Cleaning the pipe end
Clean the jointing surfaces of the socket and the pipe end. Use an absorbent, lint-free paper and cleaning fluid Tangit KS cleaner, Art. no. 799 298 023. Wipe off all the cleaning fluid with the cleaning paper.

Mark the insertion and joining depth accordingly. Make sure the marking stays visible during fusion.

Slide the socket on the pipe.

Fasten the socket to the pipe with the strap retainer.

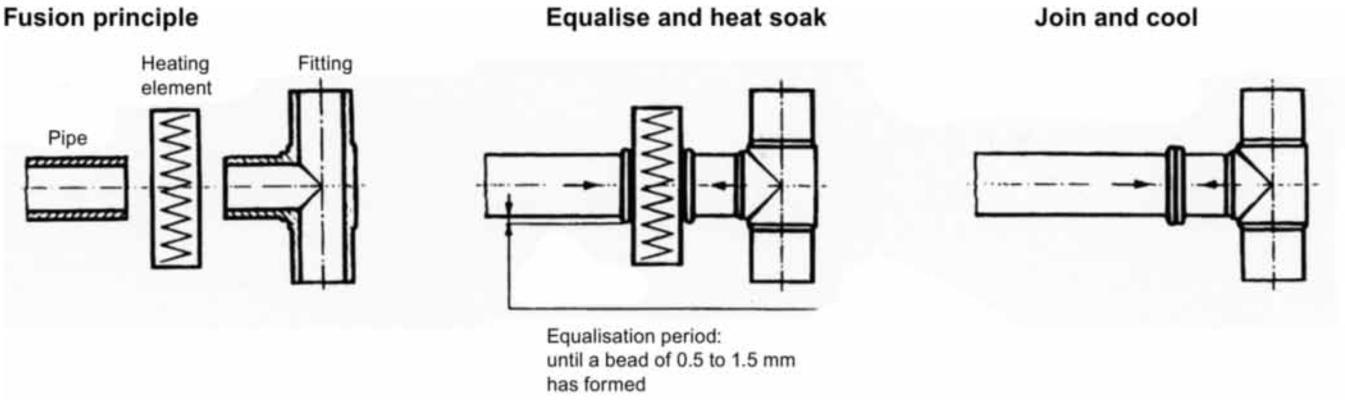
Connect the fusion cable of the MSA 250 Ex Multi Plus to the electrofusion socket.

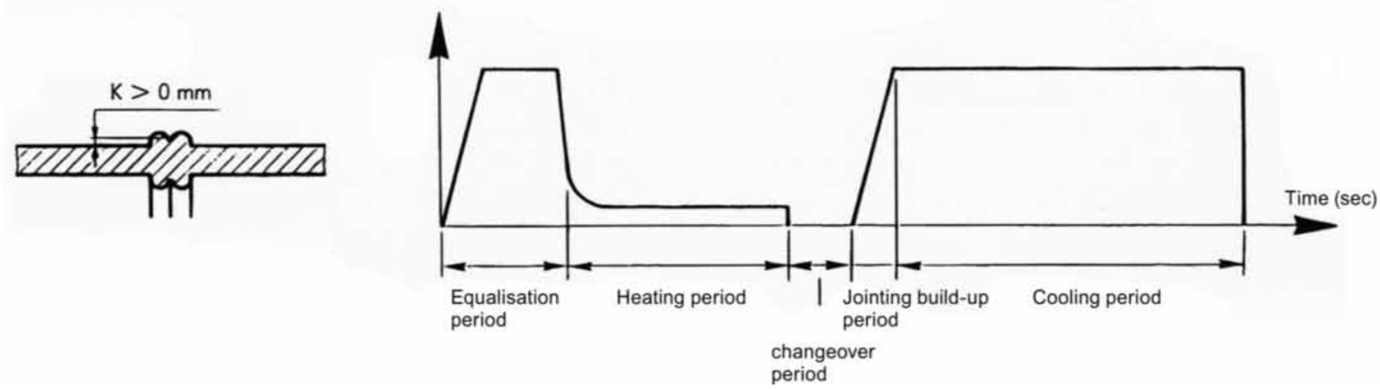
Scan the coding with the barcode reader. This transmits the fusion data to the fusion device.

Start the fusion process.

Butt fusion

Heating element for butt fusion



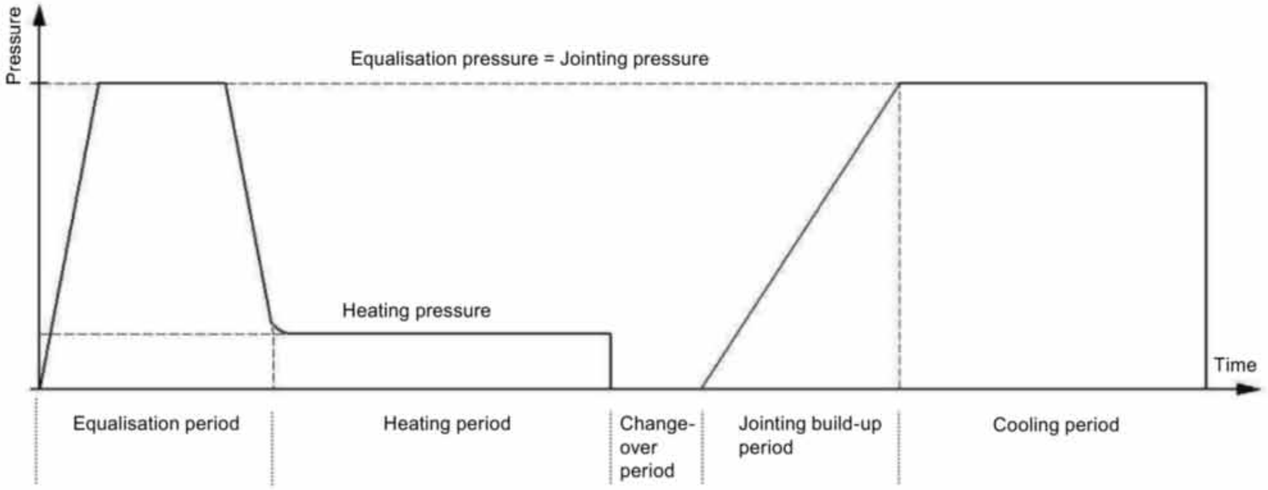


The fusion surface is the circular ring area of the pipe. The stability of the pipe is equivalent to the stability of the fusion weld. However, the pipe loses stability if there is the slightest deviation in the fusion parameters.

Fusion may only be performed by **persons trained** by GF Piping Systems or persons with the respective certification. Each fusion must be documented in a fusion protocol.

+GF+

Fusion parameters for GF SG 315



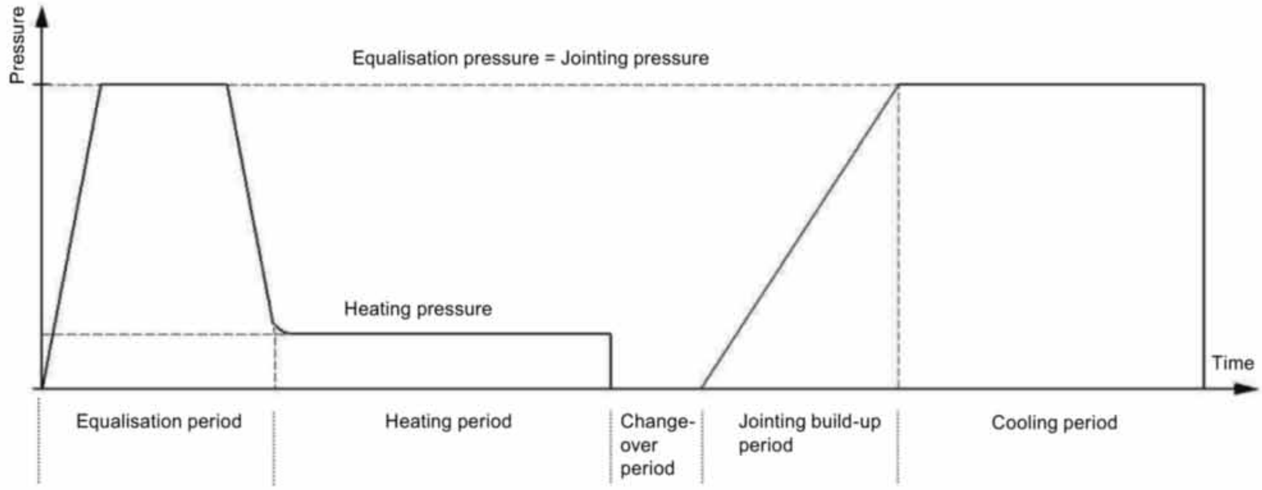
Pipe dimension dxs [mm]	Equalisation pressure p = 0,1 N/mm² — Equalisation pressure [daN]	Equalisation pressure p = 0,1 N/mm² — Height of bead [mm]	Heating pressure p = 0,01 N/mm² — Heating pressure [daN]	Heating pressure p = 0,01 N/mm² — Heating period [sec]=[min]	max. Changeover period [sec]	Jointing build-up period [sec]	Jointing pressure p = 0,1 N/mm² — Equalisation pressure [daN]	Jointing pressure p = 0,1 N/mm² — Cooling time [min]
110x10.0	31	1	3	95=1.35	6	8-12	31	10-16
125x11.4	41	1	4	95=1.35	6	8-12	41	10-16
160x14.6	67	1	7	145=2.25	7	10-15	67	17-24
225x20.5	132	1.5	13	220=3.40	8	10-15	132	20-30

Heating element temperature: 260 °C ± 10 °C

Add the joining force to the drag resistance of the slide.

If a different butt fusion machine is used than the GF SG 315, the definitive values must be adapted to the respective fusion machine. See also the butt fusion parameters on the following pages. GF fusion machines are also available for rental. Please contact your local sales representative or Georg Fischer Building Technology Ltd, Dept. CSO. Tel. +41 (0)52 631 36 59, Fax +41 (0)52 631 28 57.

Butt fusion parameters for GF 160, TM 160, KL 160

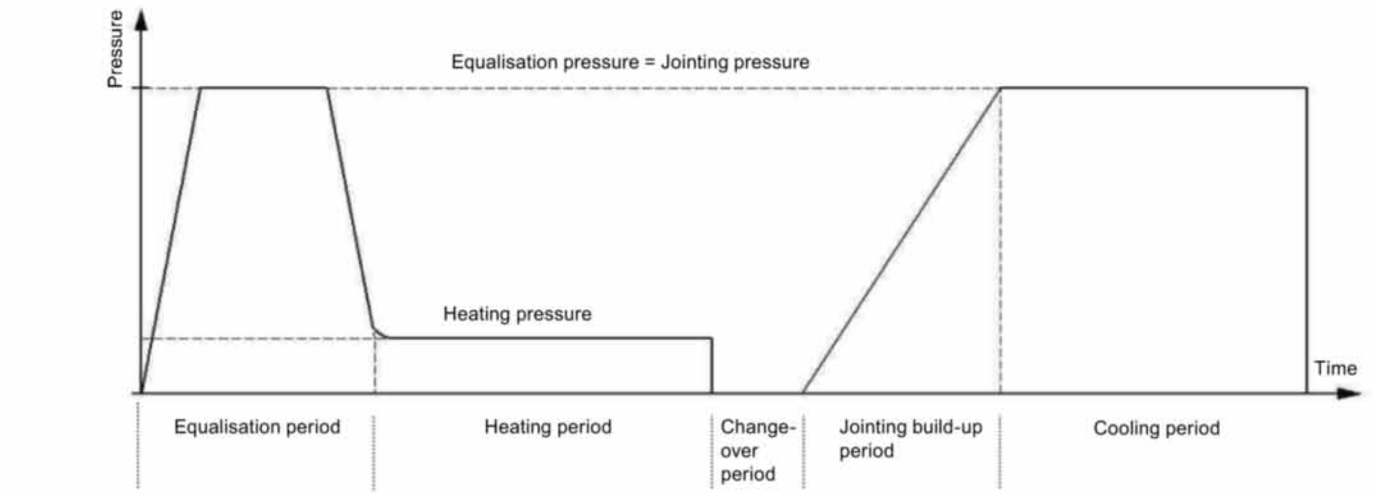


Pipe dimension dxs	Equalisation pressure p = 0,1 N/mm²		Heating pressure p = 0,01 N/mm²		max. Changeover period	Jointing build-up period	Jointing pressure p = 0,1 N/mm²	
[mm]	Equalisation pressure [daN]	Height of bead [mm]	Heating pressure [daN]	Heating period [sec]=[min]	[sec]	[sec]	Equalisation pressure [daN]	Cooling time [min]
110x10.0	9	1	1	95=1.35	6	8-12	9	10-16
125x11.4	12	1	1	95=1.35	6	8-12	12	10-16
160x14-6	19	1	2	145=2.25	7	10-15	19	17-24

Heating element temperature: 255 °C ± 10 °C
Add the joining force to the drag resistance of the slide.

+GF+

PB butt fusion parameters for GF 250, GF 314, KL 250, KL 315, TM 250, TM 315



Pipe dimension dxs [mm]	Equalisation pressure p = 0,1 N/mm² — Equalisation pressure [daN]	Equalisation pressure p = 0,1 N/mm² — Height of bead [mm]	Heating pressure p = 0,01 N/mm² — Heating pressure [daN]	Heating pressure p = 0,01 N/mm² — Heating period [sec]=[min]	max. Changeover period [sec]	Jointing build-up period [sec]	Jointing pressure p = 0,1 N/mm² — Equalisation pressure [daN]	Jointing pressure p = 0,1 N/mm² — Cooling time [min]
110x10.0	6	1	1	95=1.35	6	8-12	6	10-16
125x11.4	8	1	1	95=1.35	6	8-12	8	10-16
160x14-6	13	1	1	145=2.25	7	10-15	13	17-24
225x20.5	26	1.5	3	220=3.40	8	10-15	26	20-30

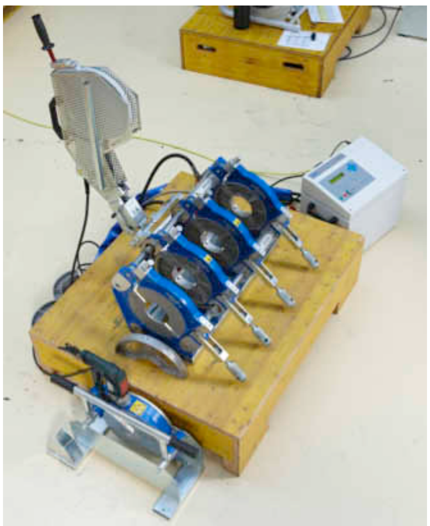
Heating element temperature: 225 °C ± 10 °C

Add the joining force to the drag resistance of the slide.

Butt fusion jointing

Fusion machine: GF 250

Control unit: Suvi 400



Complete fusion unit, consisting of GF 250 fusion machine, Suvi 400 control unit, planer and heating element

Switch the Suvi 400 control unit on with the main switch on the right side of the machine.

The display shows: Fusion start Press. Press the green button I.

The display shows: GF250CNC 1531.

	Explanation
GF250	Type name of fusion machine
CNC	Control unit Suvi 400
1531	Machine number

If the machine was switched off, e.g. in the morning, press the grey button I. This switches the heating element on.

Check the settings. If the settings are correct, confirm with the green Enter button.

Select the material used with the blue arrows. For INSTAFLEX BIG select PB.

	Material
PB	Polybutene
PP	Polypropylene
HDPE	PE high density
PE 80	Polyethylene 80
PE 100	Polyethylene 100

Confirm with the green Enter button.

Select the pipe dimension with the blue arrows.

Confirm with the green Enter button.

The display flashes: Pressure rating: SDR 11, S 5. The pressure rating indicates for which pressure the pipe has been designed. INSTAFLEX Big = PN10

The display shows: Wall thickness. If the wall thickness is correct, confirm with the green Enter button.

The display shows the following data: material, dimension and pressure rating. Check the data.

The display shows: Data o.k.? Confirm with the green Enter button.

Screw the correct dimension of the holding device for pipe / fitting into the clamping unit.

Clamp the pipes and / or fittings in the holding device.

The display shows: Clamp pipe(s). Confirm with the green Enter button.

The display shows: Dragging force measuring. Press the green >button until the red control lamp in this field lights up.

The display flashes between: Planer unit please insert and Pipe ends planing.

Place the planer in the fusion machine and switch the power on.
Attention:
The planer only starts when this work step has been confirmed on the control unit.

The display shows: Pipe ends stop planing. Press the green >button until the red control lamp in this field lights up.
When a shaving has been taken from both pipe ends without stopping, confirm with the green >button until the red control lamp in this field lights up.

The display shows: Planer unit Please remove. The planing process is finished and the planer shuts off automatically. When the planer unit is switched off, take it out of the fusion device and put it back in its proper fixture.

The display shows: Clamping check. Press the green >button. The fusion device conducts an automatic check of the clamping.

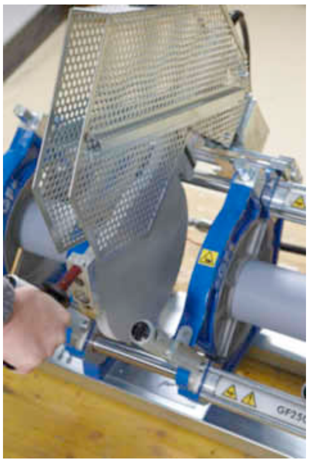
The display shows: Alignment ok <YES>+open machine.
The offset between the pipes or the pipe and fitting is less than >1 mm. Press the green Enter button.
If the offset <1 mm between the pipe ends or the pipe and fitting, you can move the pipe ends apart, turn the pipes so that the offset is 1 mm.

The display shows: Cleaned? <Yes>.

Clean the jointing surfaces of the parts to be joined - fitting and pipe end. Use an absorbent, lint-free paper and cleaning fluid **Tangit KS cleaner, Art. no. 799 298 023**. Wipe off all the cleaning fluid with the cleaning paper.

The display shows: Cleaned? Confirm with the green Enter button.

The display shows: Insert heater.

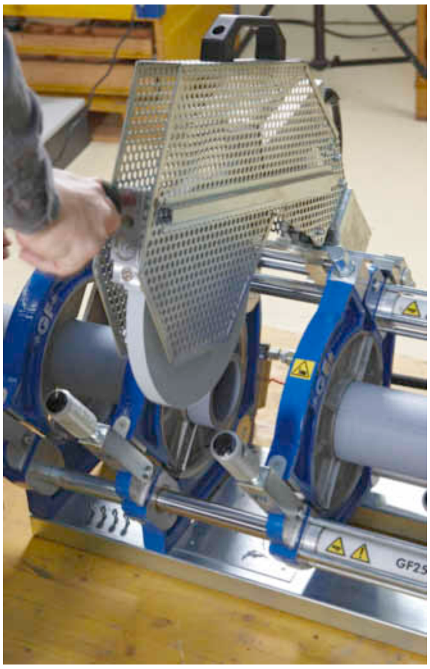


Swivel in the heater.
Warning:
Hot. Danger of burning. The heating element has a temperature of 260 °C.

The display shows: Start fusion. Press the green >button until the red lamp in this field lights up. The two pipes or the pipe and the fitting move together.

Wait until a 1 mm bead has formed on both sides of the heating element.

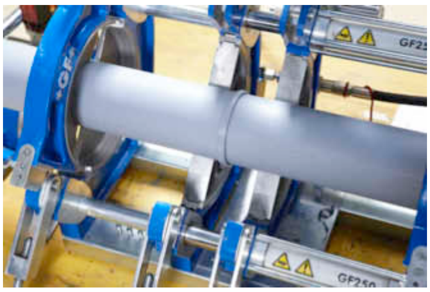
The display shows: Bead size: 1.0mm reached. This information should be checked visually by the welder. Confirm with the green Enter button.
The fusion device reduces the contact pressure on the heating element.



The fusion device begins to beep. After 10 seconds remove the heating element from the fusion device and return it to its proper place.
Warning:
Hot. Danger of burning. The heating element has a temperature of 260 °C.

The fusion device moves the pipes or the pipe and the fitting together. The cooling time begins.

The display shows when the cooling time has ended. Press the green Enter button.
The fusion device releases the fusion.



Remove the fused pipes or the pipe and fitting.
Result: you have completed a butt fusion joint.

Fusion protocol

Fusion protocols are to be issued upon request.

Please see example on the following page.

Fusion protocol

Fusion protocol

❑ Socket fusion

❑ Electrofusion

Job No:________________ Welder name:________________ Fusion device, Company:________________

Item: ________________ Company:________________ Type / No:________________

Manufacturer, System:________________ Material:________________

1	2		3					4				5
Serial No. Date	Work piece		Weather					Fusion data				Comments
	Pipe dim. mm	Wall thickness mm	Sun	Wind	Dry	Humid	Temp. °C	Heat soak time sec	Holding time sec	Cooling time min	Fusion temp. °C	
Example:												
1/21.4.88	**d 32**	**2,9**	**x**		**x**		**26°**	**8**	**20**	**4**	**265°**	

Function check of HSWG-3

Servicing HWSG – 3

Checklist for functional check of HWSG by the user

Company: ______________________________

Address: ______________________________

ZIP/town: ______________________________

Tester: ______________________________

Serial-No.: ______________

Test	Yes	No[1]
• Do all LEDs light up for about 2 seconds when switched on?	☐	☐
• Is there a long and a shord beep when switching on?	☐	☐
• Does de LED „Ready“ light up and is there a short beep when fitting is attached? **(Carry out test with all connections individually)**	☐	☐
• Can the fusion be started with the „Start“ button?	☐	☐
• Does the „Fusion“ LED flash during the fusion process?	☐	☐
• Can the fusion that has been started be completed: does the LED „End“ light up at the end, can a short beep be heard at the end and after successful fusion do all „Ready“ LEDs go out?	☐	☐
• Does the equipment go into „Defect mode“		
- when it is switched on?	☐	☐
- on starting the fusion process?	☐	☐
- during the fusion process?	☐	☐
• Defective contact in the mains cable (check plug and cable entry by moving the cable?)	☐	☐
• Defective contact in the fusion cable (check contact pins in plug and contact pin in the connection plug for fittings by moving the cable)?	☐	☐
• Is device in order mechanically (front film and housing not broken)?	☐	☐
• Has periodic servicing been carried out by the official service centre (within last 2 years?)	☐	☐
• Are there any loose parts inside the equipment (shake it to find out)?	☐	☐

Tester's comments: ______________________________

____

____

____

Date/Tester's signature: ______________________________

Maintenance: Clean device if it gets dirty with a damp cloth. Clean casing, front plate and type plate only with alcohol or spirit. Do not use any thinner or solvent.

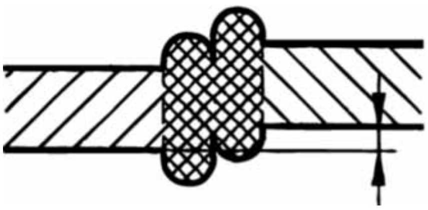
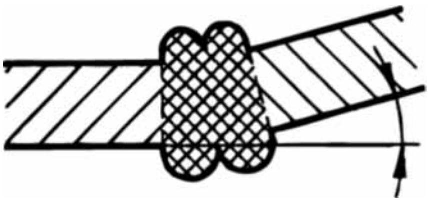
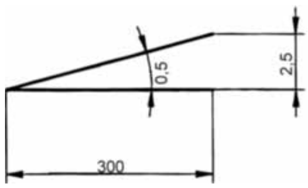
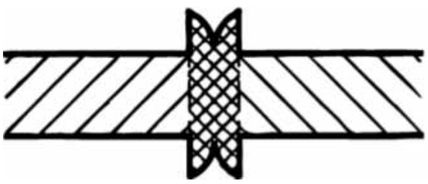
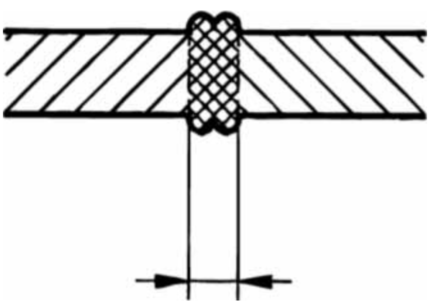
[1] If you are unable to resolve the error message / problem yourself, the HWSG equipment should be

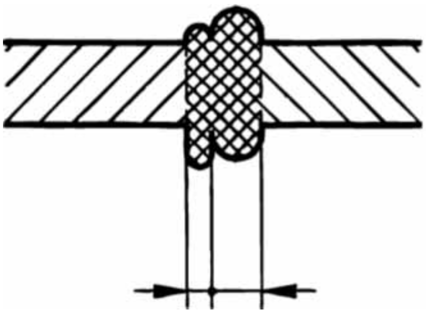
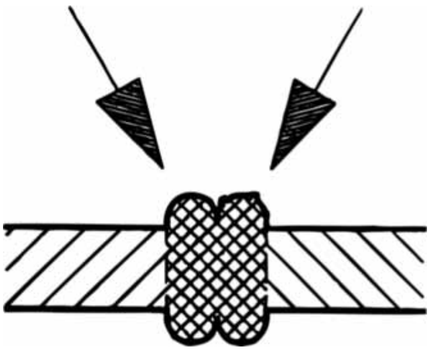
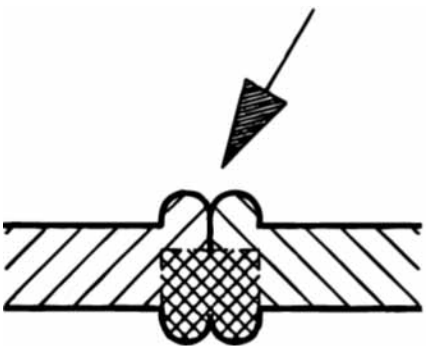
Fusion errors

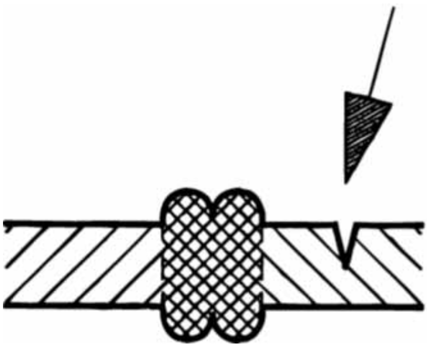
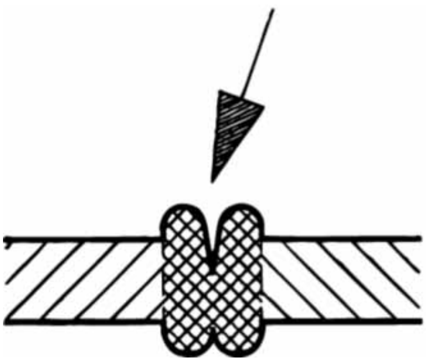
Evaluating fusion joints

The quality of fusion joints is evaluated on the building site in the framework of pressure testing and visual inspection of the joints.

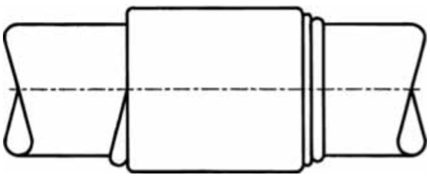
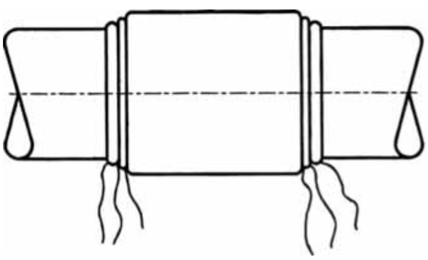
Errors in butt fusion

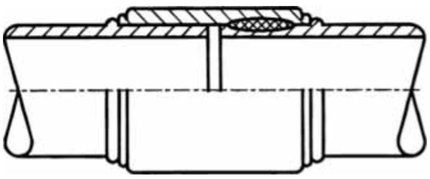
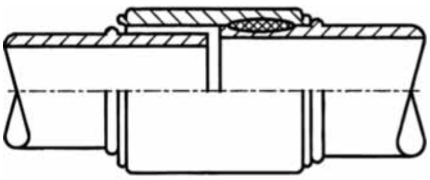
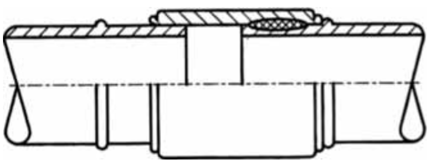
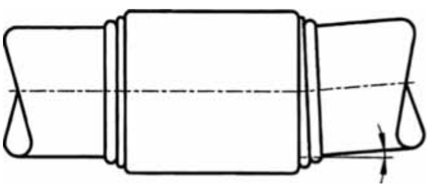
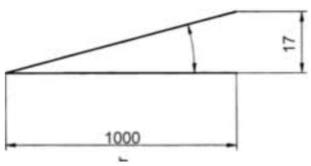
Characteristics/Description	Cause	Troubleshooting
1. Misalignment of jointing surfaces  Jointing surfaces are offset	Set-up error Clamping devices Non-round pipe cross-section	Adjust machine set-up. Check clamping devices. Clamp the pipes around the circumference.
2. Angular deviation 	Set-up error  	Adjust machine set-up.
3. Narrow, raised bead 	Fusion pressure too high	Check machine settings. Check calculations and fusion pressure.
4. Improperly formed fusion point  Bead formation is too wide or too narrow	Wrong heat soak time Wrong heating element temperature Wrong fusion pressure	Check heat soak time. Check temperature on heating element. Check machine settings.

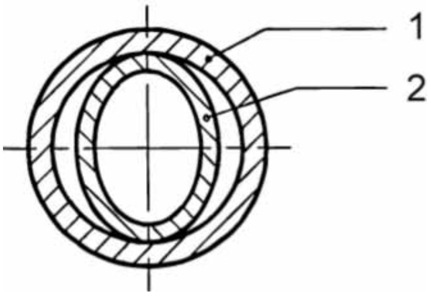
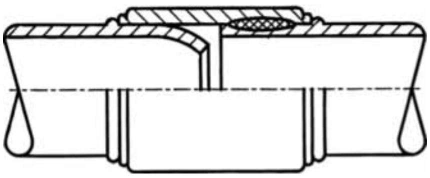
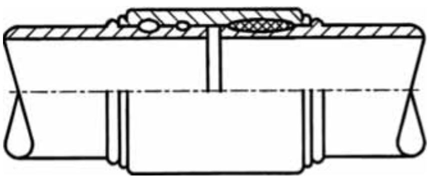
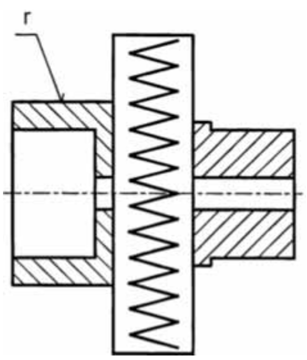
5. Uneven fusion bead 	Faulty fusion device Error in fusion preparation	Check machine settings. Cut pipe at right angle. Plane jointing surfaces.
6. Thermal damage  High gloss surface with bubbles or nodules	Heating element temperature too high Heat soak time too long	Check temperature on heating element. Check heat soak time.
7. Faulty bonding in fusion area  Insufficient bonding locally or over whole surface	Heat soak time too short Fusion pressure too low Heating element temperature too low	Check heat soak time. Check machine settings. Check temperature on heating element.

8. Notches and furrows on pipe, running longitudinally or traversely to fusion weld 	Clamping tools on machine Incorrect transport Faulty preparation of fusion weld	Check clamping tools. Ensure correct transport. Check pipe edges before fusion. Only use suitable tools.
9. Faulty bonding due to bead notches  Local notching in fusion bead	Fusion pressure too low Heat soak time too short Cooling time too short Faulty preparation of fusion weld	Check machine settings. Check heat soak time. Adhere to holding and cooling times. Only use suitable tools.

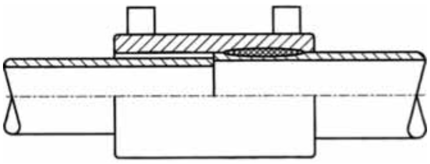
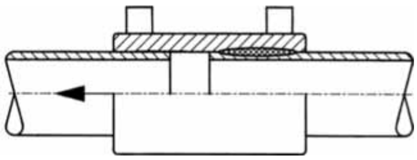
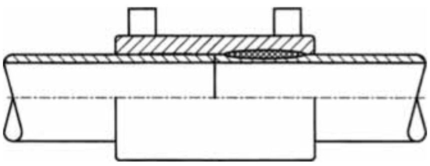
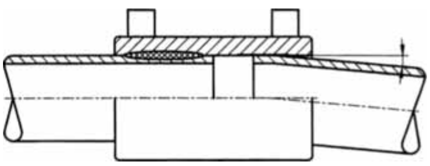
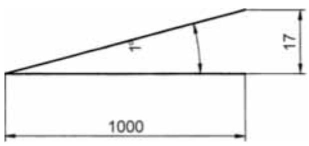
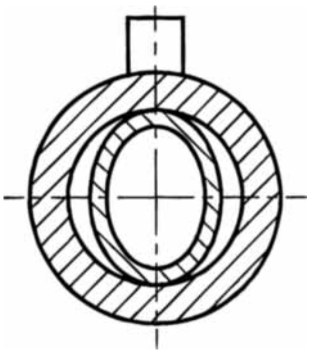
Errors in socket fusion

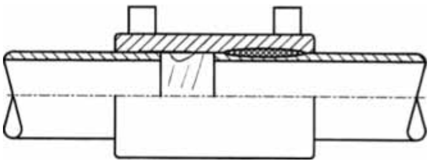
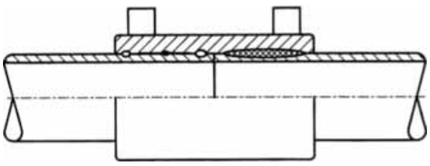
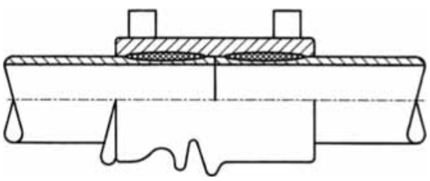
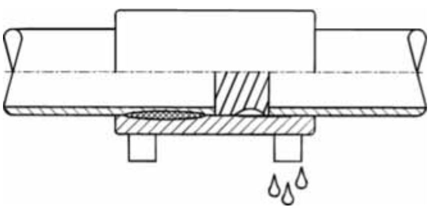
Characteristics/Description	Cause	Troubleshooting
1. Faulty formation of fusion bead  Different bead formations or non-existent beads	Unallowed tolerances or joined at an angle Heat soak time too long Fusion temperature too high or too low	Check dimensions of pipe, fitting, heating mandrel and heating sleeve. Check heat soak time. Check temperature on heating sleeve.
2. Strand formation on fusion bead 	Temperature too low during fusion Heat soak too short Heating tools pulled off too fast	Check temperature on heating sleeve. Check heat soak time. Pull parts off heating tools more slowly.

3. Dirty fusion bead  Discoloration of fusion bead	Heat soak too long Soiled heating sleeve and mandrel (burnt material) Dirty fusion surfaces	Check heat soak time. Clean heating sleeve and heating mandrel before every fusion. Clean pipe and fitting before fusion.
4. Bonding fault due to insufficient melting  Incomplete fusion locally or over whole surface with separation in the jointing area	Wrong pairing of materials Soiled heating sleeve and mandrel (burnt material) Dirty jointing surfaces Temperature too low	Only join identical materials with one another. Clean heating sleeve and heating mandrel before every fusion. Clean pipe and fitting before fusion. Tighten heating sleeves.
5. Bonding fault due to insufficient form-fit  Axial or circumferential channels form locally or over whole surface	Notches in pipe surface Unallowed tolerances Incorrect mechanical machining Pipe not flush when inserted	Check pipe prior to fusion. Check dimensions of pipe, fitting, heating sleeve and heating man-drel. Check machining tools. Check clamping fixtures on ma-chine.
6. Bonding fault due to incomplete pipe insertion  Insufficient length of weld with insuf-ficient bonding	Pipe not pushed in far enough Axial movement during holding time Changeover time too long Heat soak too short Heating element temperature too low	Mark insertion depth on pipe and adhere to it. Observe holding time. Secure pipe and fitting to prevent axial movement. Join pipe and fitting immediately af-ter pulling from heating tools. Check heat soak time. Check temperature on heating sleeves.
7. Angular deflection (permissible up to 1°)  Incomplete bonding locally or over whole surface	Fusion machine incorrectly set up Pipe ends out of square  	Check machine set-up. Cut off pipe ends square with pipe cutter.

8. Bonding fault due to deformation  Non-round pipes are not leak tight	Oval pipes due to incorrect storage Radius of curvature of ring too little or unsuitable clamping device Pipes are crushed during cutting	Check ovality of pipe ends prior to fusion and calibrate or press round. Avoid pressure loads. Store pipes properly. Use appropriate system tools (machines, devices). Check cutting tools.
9. Constricted pipe cross-section 	Temperature too high during fusion Heat soak too long Fusion pressure too high Pipe pushed in too far during heating or joining	Check temperature on heating sleeves. Check heat soak time. Check dimensions of pipe, fitting, heating mandrel and heating sleeve. Mark insertion depth on pipe and adhere to it.
10. Pores due to foreign body inclusions  Incomplete bonding locally or over whole surface	Steam formation during fusion (wet pipes) Dirty fusion tools External effects	Clean pipes prior to fusion. Clean heating sleeves and mandrels prior to fusion. Protect fusion area from external effects during the fusion process.
11. Temperature too high or too low 	Temperature too high or too low Heating tools not flat up against surface Heating tools are loose Voltage fluctuations in mains supply Dirty heating tools	Correct temperature. Check surfaces of heating tools and heating blade. Tighten heating tools. Connect fusion machine to separate power supply. Clean heating sleeves and mandrel prior to fusion.

Errors in electrofusion

Characteristics/Description	Cause	Troubleshooting
1. Bonding fault due to insufficient form-fit  Axial or circumferential channel formation locally or over whole surface	Notches in pipe surface or pipe very oval Unallowed tolerances Incorrect mechanical machining	Check pipe prior to fusion. Check dimensions of pipe. Check machining tools.
2. Bonding fault due to insufficient form-fit  Pipe slides out	Pipe not fixed correctly in socket or lack of fusion pressure	Apply or check pipe fixation.
3. Bonding fault due to insufficient melting 	Wrong pairing of materials Soiled fusion surfaces Defective or non-compatible fusion device	Only join identical materials with one another. Clean pipe and fitting prior to fusion. Check equipment. Use system-based equipment.
4. Angular deflection (1° permissible) 	Error in set-up Load during fusion process 	Check clamping device. Cut pipe ends square with pipe cutter. Prevent loads during fusion.
5. Bonding fault due to deformation  Non-round pipes are not leak tight	Oval pipes due to incorrect storage Radius of curvature of ring too little or unsuitable clamping device Pipe ends crushed during cutting	Check ovality of pipe ends prior to fusion, calibrate or press round. Avoid pressure loads. Store pipes properly. Use system tools (machines, devices). Check cutting tools.

6.	Bonding fault due to insufficient pipe insertion  Pipe ends not flush or on the stop	Pipes not pushed in far enough Unsquare pipe ends	Mark insertion depth on pipe and adhere to it. Cut off pipe ends square with pipe cutter.
7.	Bonding fault due to foreign body inclusions  Accumulation of pores, separation in jointing surface	Contaminated surfaces Steam or gas formation during fusion	Clean pipe and fitting prior to fusion. Only fuse dry pipes and fittings. For repairs: empty pipelines prior to fusion and protect fusion zone from dampness and dirt.
8.	Fusion indicator not visible	Tolerance error of pipe or fitting, no fusion pressure, non-round pipes, insertion depth too little or insufficient form-fit Defective fusion device	Check dimensions of pipe and fitting. See other troubleshooting measures. Check fusion device.
9.	Thermal damage  Heavy material escape on fitting, deformation on fitting and/or pipe	Fusion time too long Wrong selection of dimension on device Immediately repeating the fusion process	Check equipment. Check settings, see above. Only repeat the fusion process per manufacturer's recommendations.
10.	Fault indication or error message on fusion device	Defective fusion machine, follow manufacturer's instructions	Follow manufacturer's instructions on device or in documentation. Have device repaired by GF Piping Systems or a service centre.
11.	Leakage at plug contact  Medium escapes through plug	Insertion depth of pipe in socket not adhered to or resistance wire melts itself free and comes into contact with the medium, creating a capillary effect.	Mark insertion depth on pipe and adhere to it. Cut pipe ends square with pipe cutter.

Demountable joints

Threaded connection joints

Plastic/plastic joints

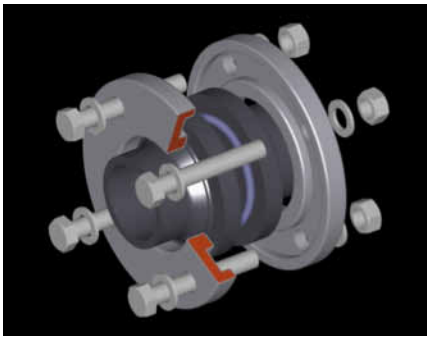
Demountable joints or flange connections with a gasket (O-ring) are used to join plastic pipes as well as plastic pipes with valves (valves, pumps) up to dimensions

- d63 mm for unions and
- d225 mm for flange connections.

It does not take much force to join a flange with and O-ring. That is why we recommend using a torque wrench so as not to overtighten the screws. The following table contains the reference values for fastening the screws in flange connections with O-rings or flange seals:

Pipe outer diameter	[mm]	20	25	32	40	50	63
Torque	[Nm]	10	15	15	20	25	35

Pipe outer diameter	[mm]	75	90	110	125	160	225
Torque	[Nm]	40	40	50	50	60	75



Plastic/metal joints

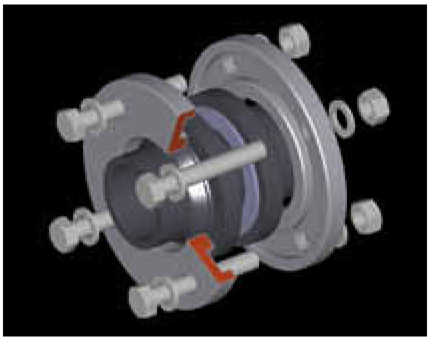
For transitions from plastic to metal, flange connections with gaskets (O-rings) are generally used because the sealing surfaces of the metal flanges are usually serrated.

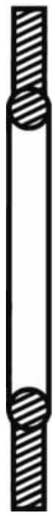
Use a torque wrench to screw together the flange or flange adaptor. The following tables contain the reference values for fastening the screws of flange gaskets.

Pipe outer diameter	[mm]	20	25	32	40	50	63
Torque	[Nm]	10	15	15	20	25	35

Pipe outer diameter	[mm]	75	90	110	125	160	225
Torque	[Nm]	40	40	50	50	60	75

Flange gasket





Chemical resistance

Chemical resistance

Introduction

Plastics are materials used in modern piping system construction. Plastic pipes have proved highly suitable not only for conducting water, but also for very corrosive media.

Chemical compounds react differently to plastics depending on the interaction of their components. This can result in deviations from the data given for the individual components. Please feel free to contact us for an individual consultation.

Chemical-physical resistance of polybutene (PB)

The chemical-physical resistance of polybutene (PB) corresponds largely to that of the polyolefins (semi-crystalline thermoplastics).

We suggest you check with your sales representative regarding the use of INSTAFLEX in non-drinking water applications on a case-by-case basis.

Pipe joints

INSTAFLEX socket fusion joints

INSTAFLEX socket fusion joints exhibit the same chemical resistance as INSTAFLEX pipes.

INSTAFLEX electrofusion joints

INSTAFLEX electrofusion joints can basically be used with all polybutene-compatible media. See also the List of Chemical Resistance. Polybutene may not be used with the media listed below:

- Hydrogen bromide — HBr
- Hydrogen fluoride (hydrofluoric acid) — HF
- Fluorosilic acid (hydrofluorosilicic acid) — H2SiF6
- Hydrogen chloride (Hydrochloric acid) — HCl
- Hypochloric acid (Hypochlorous acid) — HOCl aqueous

This list makes no claim to be complete. If you do not find the substance on this list, please contact your local sales representative.

Material for metal pipe joints

The following metal material in INSTAFLEX has contact with the media:

Alloy	Brass, dezincification-resistant
DIN	EN 12134, EN 12165, EN 12168, EN 12420
Nomenclature	CuZn 36 Pb 2 As (CR brass)

The material listed in the table above can be used for water distsribution in building technology. This material complies with the specific guidelines for drinking water installations.

For other non-domestic drinking water systems, the given material must be checked for its suitability.

Flanged joints and unions

For flanged joints and unions, the material of the sealing elements must be taken into consideration.

See the List of Chemical Resistance.

Sealing materials (elastomers)

The lifetime of sealing materials can vary greatly from that of the pipe material depending on the operating and load conditions.

For compressed air applications with air containing mineral oils, the EPDM seals must be replaced with seals made of NBR.

Seal material	General chemical-physical resistance	Max. operating temperature
EPDM Ethylene-propylene-diene-rubber	Resistant to aggressive, oxidating media Not resistant to hydrocarbons, oils and greases	90 °C (short-term 120 °C)
NBR Nitrile rubber	Resistant to hydrocarbons, oils and greases Not resistant to oxidating media	90 °C (short-term 120 °C)

INSTAFLEX valves

INSTAFLEX polybutene valves can be used in water pipelines for building services.

Corrosion behaviour of copper and copper alloys against various substances

Besides their favourable physical and mechanical properties, one of the main reasons for the widespread use of copper alloys is their resistance to corrosion.

The corrosion behaviour of metals depends on a variety of factors. This makes it nearly impossible to give general information which would be valid under any operating conditions. In addition to the type and purity level of the corrosive substance, its concentration and temperature play a major role in the corrosion process. Flow velocity and flow conditions of the fluids must also be taken into account when assessing the suitability of a material.

Oxygen or oxidizing agents (chemicals) have a special significance in the corrosion of copper and copper alloys. They intensify the attack on metal, especially in acids. The following data, which has been mainly taken from technical literature on the relative corrosion resistance of copper and its most important alloys against 170 different substances, is based on the results of laboratory tests, practical experience under operating conditions and general knowledge of corrosion processes.

The list provides a general overview on the use of copper and copper alloys and makes no claim to being complete. Again, damage caused by selecting the wrong material should be prevented. The data applies only to standard operating conditions and are not an unconditional recommendation. Under certain circumstances it may be necessary to conduct extensive practical tests under near-operation conditions in addition to the usual laboratory tests. This is the only way to make an absolutely reliable prognosis of the medium's corrosion behaviour.

The symbols in the corrosion table signify the following:

+ resistant

o conditionally resistant (use must be clarified)

- not resistant

Chemical resistance

Aggressive media					Chemical resistance											
Medium	Formula	Boiling point °C	Concentration	Temperature °C	PB	EPDM	NBR	Brass	Ceramic	Hastelloy	PEEK	Ryton	Stainless Steel (1.4401)	Titanium		
Compressed air, containing oil				20	-	++	O									
				40												
				60												
				80												
				100												
				120												
				140												
Ethylene glycol, technically pure	$HO-CH_2-CH_2-OH$	198	technically pure	20	++	++	++									
				40		++	++									
				60		++	++									
				80		++	-									
				100		-										
				120												
				140												
Nitrogen	N_2	Gas		20	++	++	++									
				40		++	++									
				60		++	++									
				80		++	O									
				100		O										
				120												
				140												
Oxygen, gaseous	O_2		technically pure	20	++	O										
				40		++										
				60		O										
				80												
				100												
				120												
				140												
Propylene glycol, technically pure	$C_3H_8O_2$	188	technically pure	20	++	++	++									
				40		++	++									
				60		++	++									
				80		++	-									
				100		-										
				120												
				140												

System technology and application technology

System technology and application technology

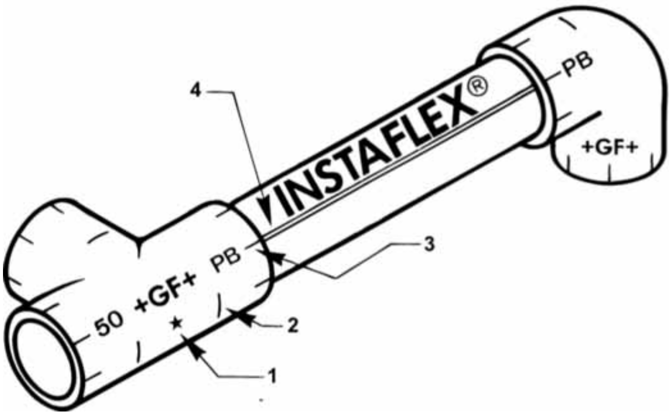
General

Polybutene (PB) fittings for socket fusion

The fitting design which includes

- alignment markings
- insertion depth marking,
- product identification and
- longitudinal marking on pipe

makes your work with the INSTAFLEX installation system faster and more cost-efficient.



1 Name of manufacturer, dimension, material, production code

2 Insertion depth marking (fusion length)

3 Alignment marking (every 45°), for component combinations

4 Pipe longitudinal marking

The alignment marking and pipe longitudinal marking make it easier to produce component combinations. Since the fitting and pipe do not need to be marked, a lot of time is saved and the markings enable more accurate work.

Insertion depth marking (fusion length)
Marking the insertion depth on the pipe prevents formation of an inner bead in the fusion zone provided that the fusion is performed correctly. By marking the insertion depth you can use the z-dimension MBT 140 DE for installation.

INSTAFLEX

break

Polybutene (PB) electrofusion fittings, HWSG-3

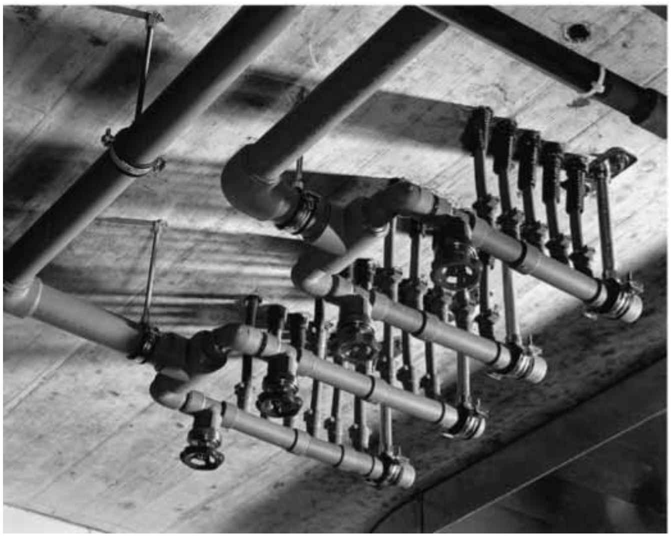
Electrofusion fittings

The INSTAFLEX electrofusion fitting line of products consists of a complete range of fittings in the dimensions d16 to d110. The individual fitting types can be found in the product catalogue. The fittings have been designed so that each pipe connection is fused separately. An integrated fastening device, a coded plug connection, a markings every 45 degrees for alignment and a visual fusion indicator as well as the insertion depth marking enable **individualized work according to the stage of construction or prefabrication** . An electric screwdriver and the HWSG-3 fusion device are the tools required for working with the INSTAFLEX electrofusion fittings.

HWSG-3 electrofusion device

The INSTAFLEX HWSG-3 with three independent fusion channels enables individual fusing of fittings and sockets.You can **perform three separate fusions in different dimensions at the same time irrespective of the fitting type**.
Thanks to the coded fittings, the fusion device recognises the type of fitting and its dimension. Fusion data does not have to be entered anymore and the fusion process runs fully automatically at the push of a button.
The fusion progress is indicated via control lamps and an acoustic signal.

FAST - SAFE - ECONOMICAL - the modern INSTAFLEX installation technology



Multistory installation

Distributing drinking water comfortably throughout the house is a challenging task. INSTAFLEX is made to accommodate the high demands placed on drinking water installations in new buildings and in renovation projects.

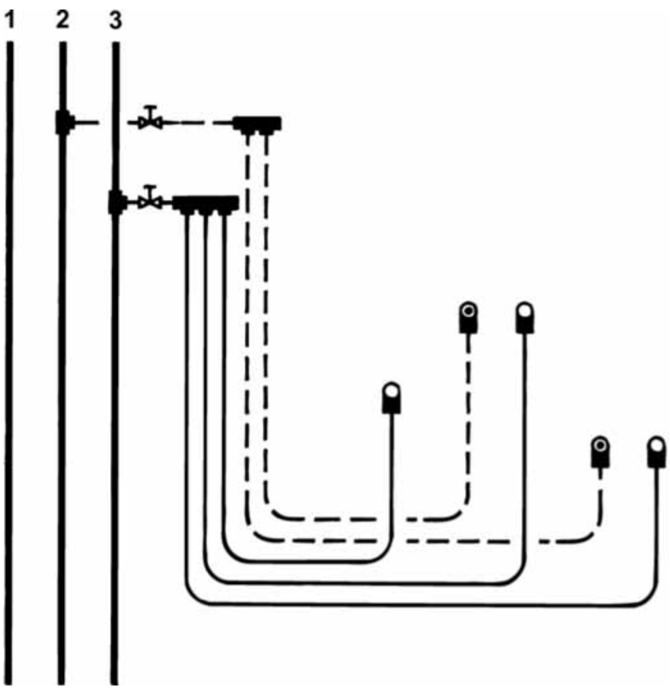
Piping layout
Layout is possible with the flexible polybutene (PB) pipes in coils and with INSTAFLEX rods. It doesn't matter whether you use the pipe-in-sleeve system or the traditional installation technology.

INSTAFLEX with its system components is the ideal solution for the most diverse requirements: from single-family or duplex homes to subsidised housing to exclusive residential buildings.

Optimal drinking water distribution on every floor is easy thanks to single pipelines, continuous pipelines, ring mains, T branches as well as continuous lines with circulation and the corresponding fittings.

Single pipeline

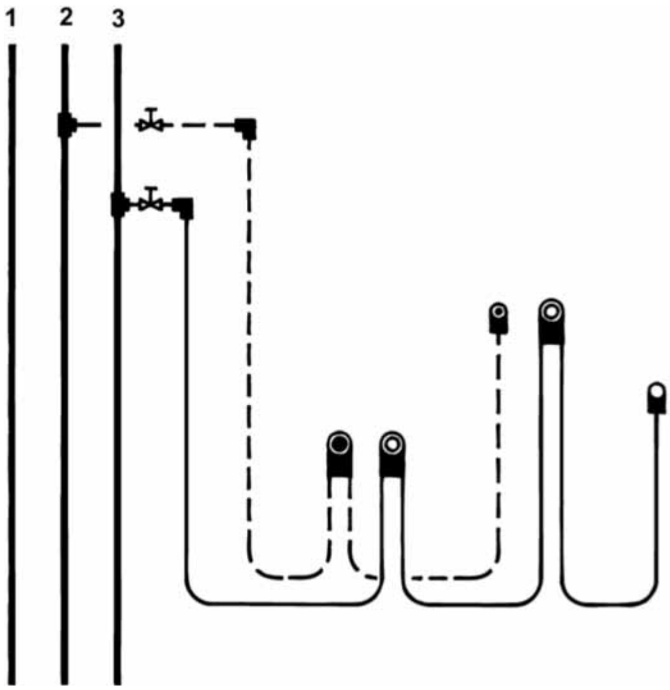
- Uncomplicated planning
- Simple pressure loss calculation and dimensioning
- Each tap supplied by a separate line
- Low pressure losses
- Short flushing time and high level of comfort
- Individual tap connections
- Easy replacement of the medium pipe in pipe-in-sleeve systems
- No connections in the floor



1 Circulation line
2 Hot water line
3 Cold water line

Continuous pipeline

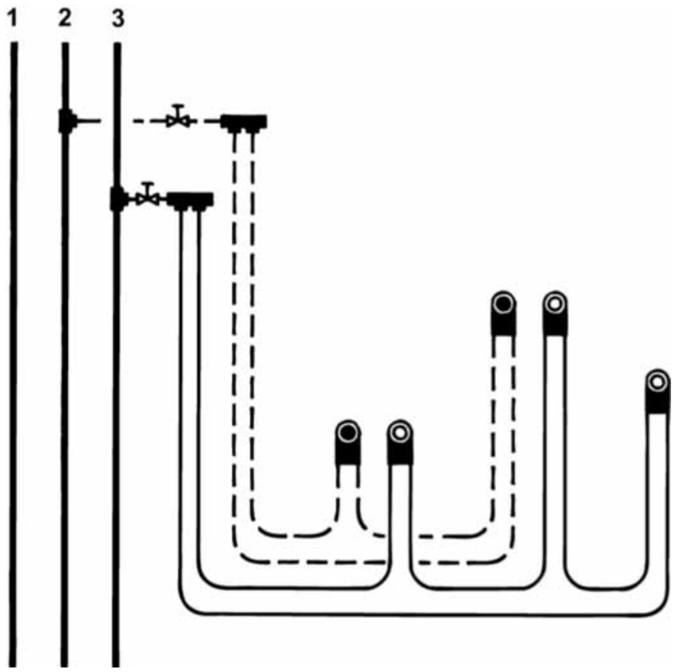
- Several taps supplied with one line
- Fewer pipes required
- Single and double tap connections



1 Circulation line
2 Hot water line
3 Cold water line

Ring mains

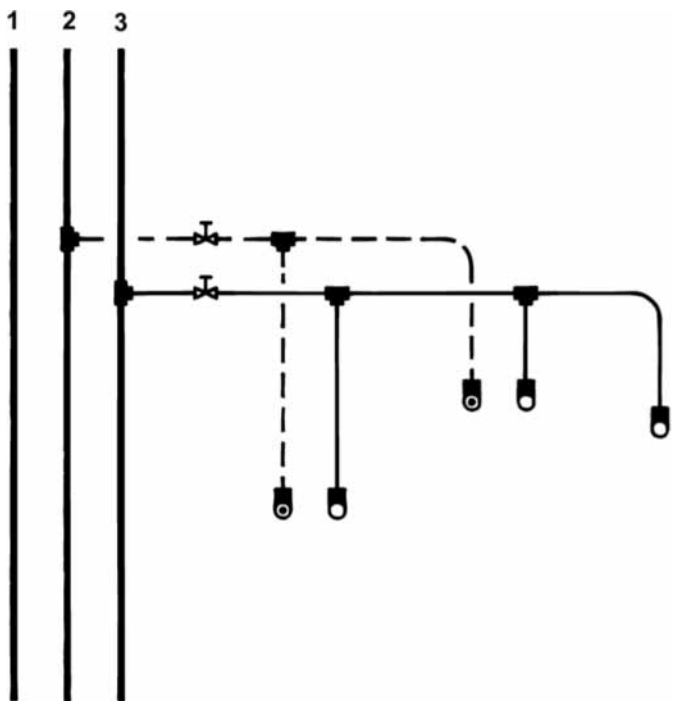
- Each tap is supplied from two sides
- No stagnated water
- Pressure loss 1/3 less than in continuous lines
- Double tap connections



1 Circulation line
2 Hot water line
3 Cold water line

T-branches

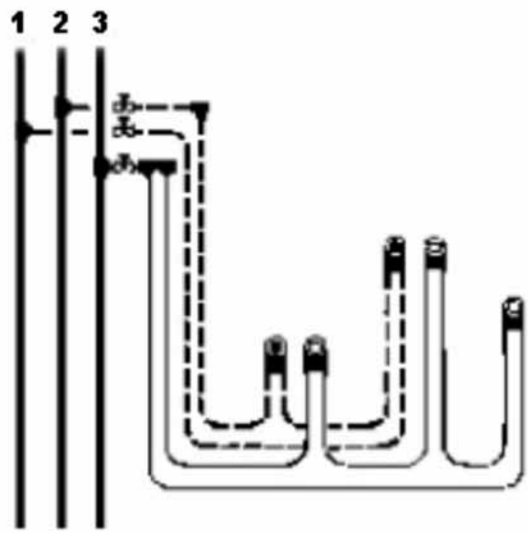
- Several taps supplied by one line
- Less space required for pipe rack
- For renovation work, pipes can be laid in available recesses
- Fusion and/or compression fittings
- Individual tap connections
- Fewer pipes required



1 Circulation line
2 Hot water line
3 Cold water line

Continuous pipeline with circulation

- Possibility of legionella-free operation
- Hîgh level of comfort
- Hot water right up to tap



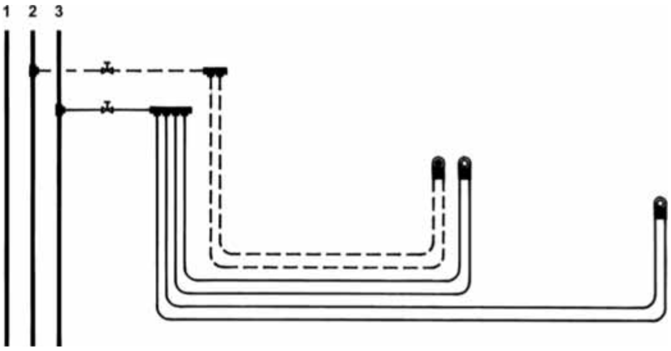
1 Circulation line
2 Hot water line
3 Cold water line

Pipe layout for large tapping valves
Tapping valves with an outlet flow rate of $V_R > 0.4$ l/s can be connected with parallel supply lines in dimension d16. With parallel supply lines (2 x d16) the pressure loss is about 20 % less than with a single pipeline of the next higher dimension (d20). An ideal solution wherever there are only low supply pressures

Example:

Tapping valve
$V_R = 0.6$ l/s
Single pipeline d20
ΔP_R= 110 mbar/m
Dual pipeline 2 x d16
(V_R = je 0.3 l/s)
ΔP_R= 90 mbar/m
Difference ≈ 20 %

Pipe layout in rough concrete floors



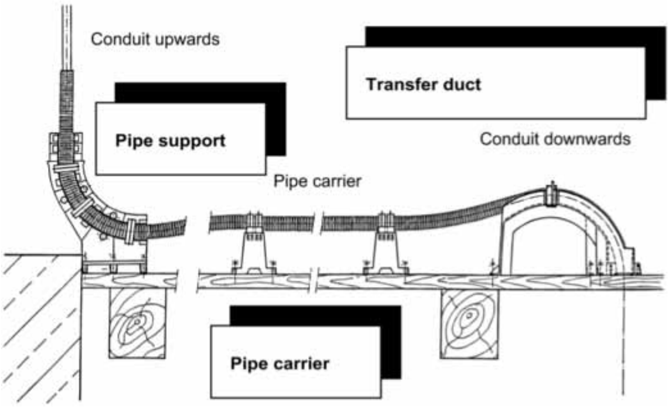
1 Circulation line

2 Hot water line

3 Cold water line

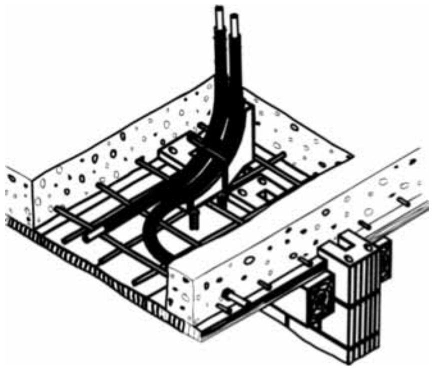
New developments open up new perspectives to planners and installers. They not only contribute to economisation but also improve performance. An example of this is the pipe-in-sleeve system for rough concrete floors, which facilitates installation considerably. Laying the pipework in the rough concrete has proven to be one of the most efficient installation methods in practice today.

The main advantage of the pipe-in-sleeve system is that the medium-conveying pipe is separated from the surrounding structure by the protective sleeve. When installed professionally, when the bending radius is adhered to and the provided installation aids are used, mechanical damage to the pipeline is excluded. The pipe can be replaced at any time, if necessary.



Pipe support

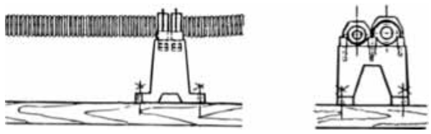
The pipes are supported by placing the pipes (d16, d20) in the supports and fastening them with clips. To additionally stabilise the pipes from above you can insert a reinforcement rod (diameter 10 mm) in the pipe support. Several pipe supports may be placed, 45 mm apart, next to one another.



Article no. 760 853 399

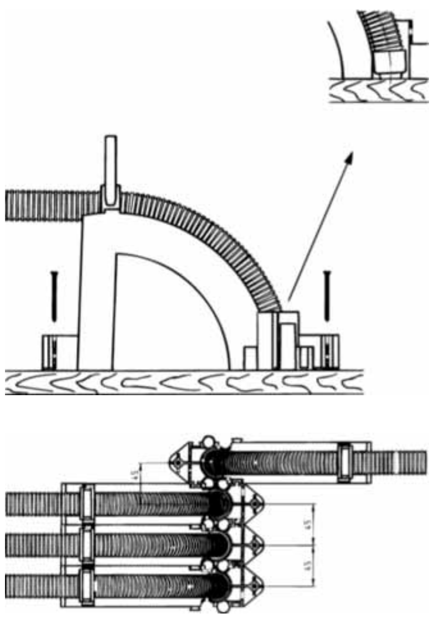
Pipe carrier

Pipe carriers serve as spacers for the protective sleeve and the pipeline and keep them at a safe distance from the formwork. They also mark the run of the pipeline in the ceiling. Drilling into the pipes from below can be prevented with this pipe carrier.



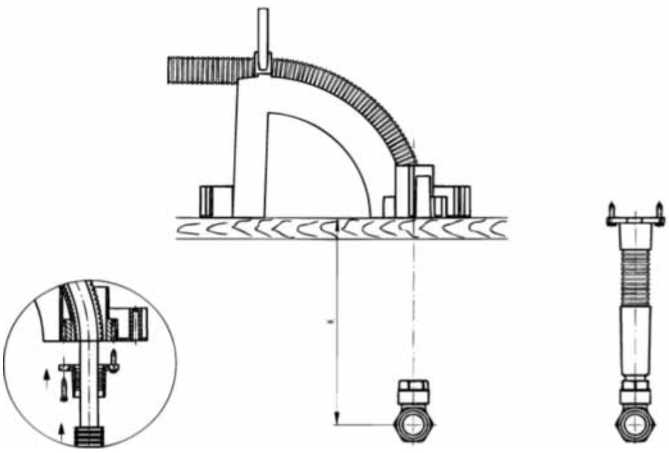
Article no. 760 853 759

Formwork duct



Article no. 760 853 300

Close off the end of the protective pipe with the sleeve (red/green) enclosed in the pipe box. Place the pipe (d16 or d20) in the guide and fasten with the clip. Several guides can be used side by side, 45 mm apart, in the same or opposite direction

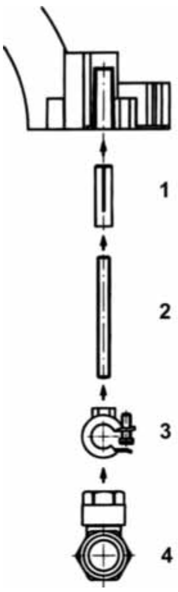


Coupling

d16 Article no. 760 853 316

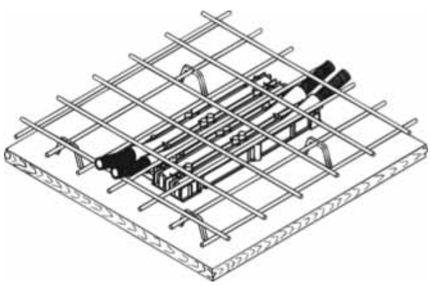
d20 Article no. 760 853 753

After removing the formwork, pull the medium- conveying pipe the required length (x) through to the distributor. The protective sleeve is then attached with the corresponding coupling.



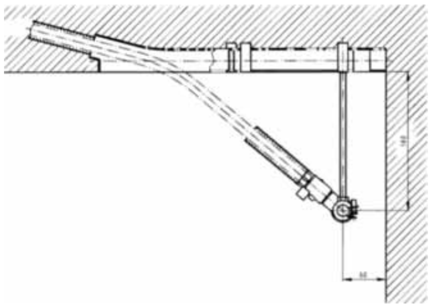
1 Metal dowel M8
2 Threaded rod M8
3 Pipe clip
4 Distributor

Formwork box



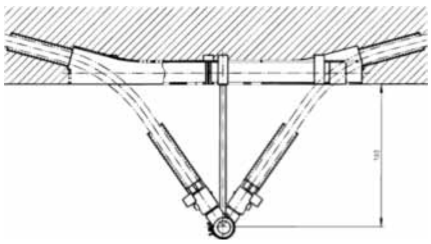
Pipes in d16 and d20 can be pushed with the protective sleeve directly in the formwork box. Contrastly, d25 pipe can only be inserted without protective sleeve. Several formwork boxes can be placed side by side, 45 mm apart, in the same or opposite direction. Nail the formwork box directly to the formwork under the lower reinforcement with the enclosed nails.

Distributor arrangement with one-sided pipe support



After removing the formwork, you can connect the pipeline downward to the distributor. The distributor fastening is similar to that of the formwork duct.

Distributor arrangement with two-sided pipe support



Article no. 760 853 299

Fasten the distributor with metal dowels M8 in the provided openings and then secure it with INSTAFLEX pipe clips and threaded bolts M8.

Pipe installation on rough concrete floor

When laying pipes on a supporting structure (concrete floor), which serves as the basis for a free floating floor, **DIN 18202** regulations must be observed.

Acoustical bridges and/or variations in the floor depth should be avoided.

If pipelines are laid on the supporting structure or in the insulation, they must be embedded in a deformation-resistant material or secured with fastening elements. The surface should be levelled out again (compensation) before laying the insulation layer.

If two pipes are laid parallel in the insulation with a deformation-resistant covering, impact sound insulation should be provided for.

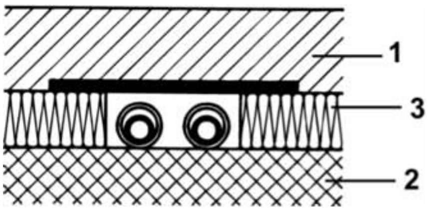
If, during the planning phase, cut-outs are prepared for the pipe run in the rough concrete, the pipelines can easily pass through the floor in this conduit.

For pipes laid in a duct on the rough concrete floor or in the insulation, a protective sleeve must be used. This is not the case for pipes embedded above the insulation directly in the floor similar to floor heating. These can be laid without a protective sleeve.

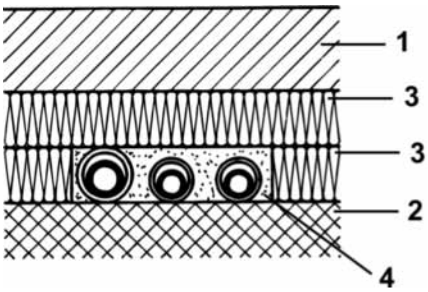
If a different material is used for the flooring, e.g hot asphalt, then measures must be taken so as not to damage the plastic piping laid in or under the insulation.

The insulation requirements in **DIN 1988-2** for cold water and in the **energy conservation ordinance (EnEV)** for hot water must be complied with.

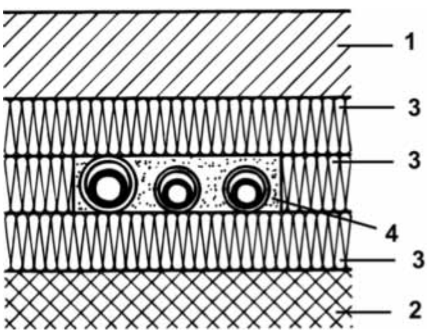
Examples:



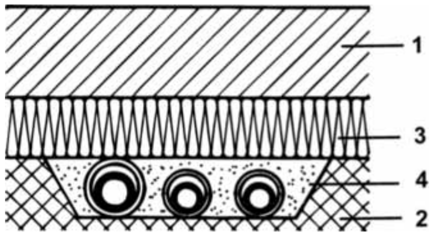
Pipes laid on the rough concrete floor in the insulation layer with deformation-resistant covering



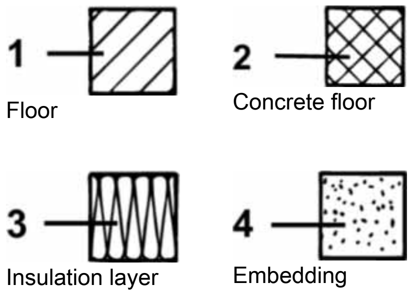
Pipes laid on the rough concrete floor in the insulation or compensation layer with deformation-resistant embedding



Pipes laid in the middle of the insulation layer with deformation-resistant embedding

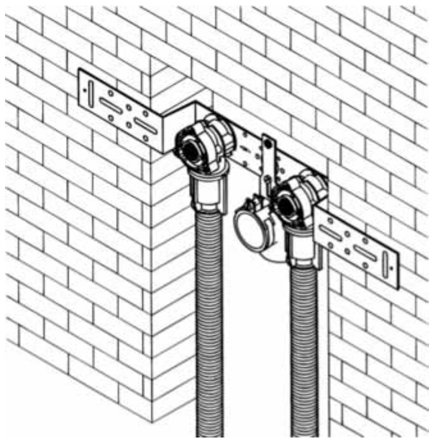


Pipes laid in the floor duct with deformation-resistant embedding



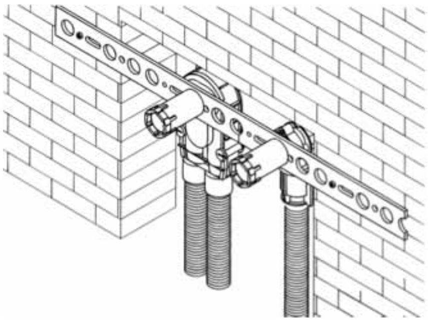
Pipe installation in masonry (recessed mounting)

Although the guidelines are opposed to recessed mounting, this type of installation is often found in renovation and modernisation work. For new constructions, particularly when pipes are laid on or in the rough concrete floor, it is recommended that they are fitted in wall recesses.
Horizontal wall recesses should be avoided, wherever possible.



A range of installation tools enables rational fastening of fitting connections in wall recesses.

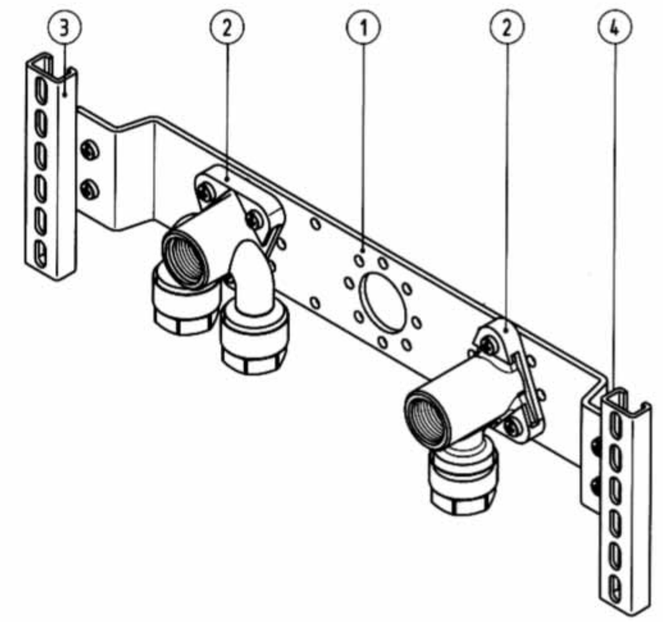
If you are using the pipe-in-sleeve system, it is not necessary to subsequently protect the pipe in the masonry. The respective insulation requirements should be complied with here as well.



Pipe installation in lightweight walls

Special care must be given when installing multistory pipes in lightweight walls or wood walls. The forces produced by valve use need to be safely transferred to the stud frame via the valve connection.

Pipe-in-sleeve systems must be adequately secured in the hollow spaces with appropriate fastening materials. .



INSTAFLEX
1 Spacer bar
2 Valve connections

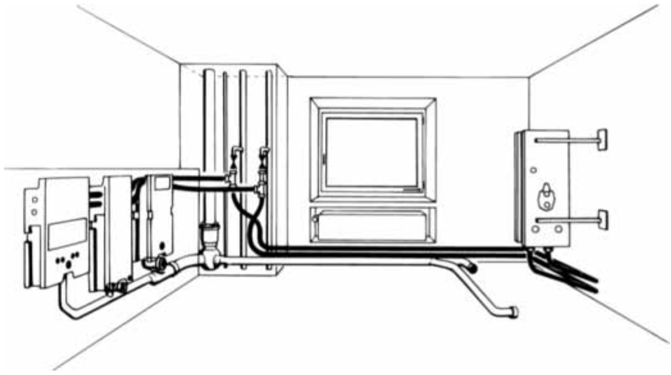
Wall manufacturer
3 Mounting rail
4 Mounting plate

Attention:
When installing valve connections in lightweight constructions or wooden walls, only mount valve connections **without** housings on the spacer.

To fasten valve connections, you require a combination of INSTAFLEX installation accessories and accessories from the wall manufacturer.

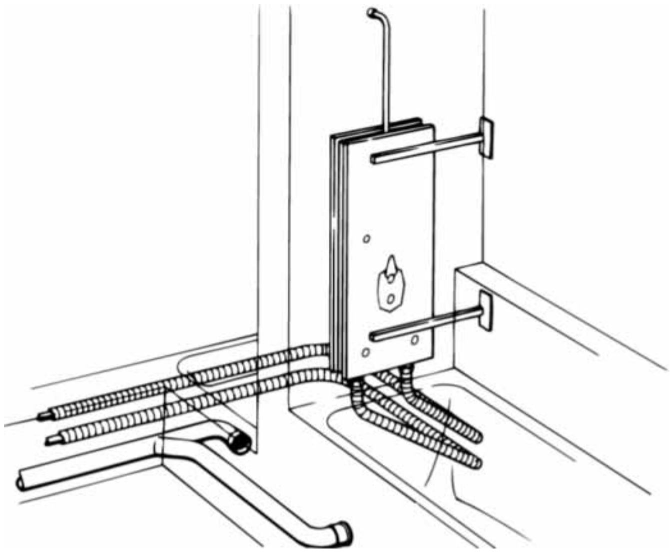
Front-wall installation with installation modules

Modules mounted on the installation wall can be connected like valve connections to single, continuous or ring mains. You can connect all commercially available installation modules with the corresponding INSTAFLEX system components.

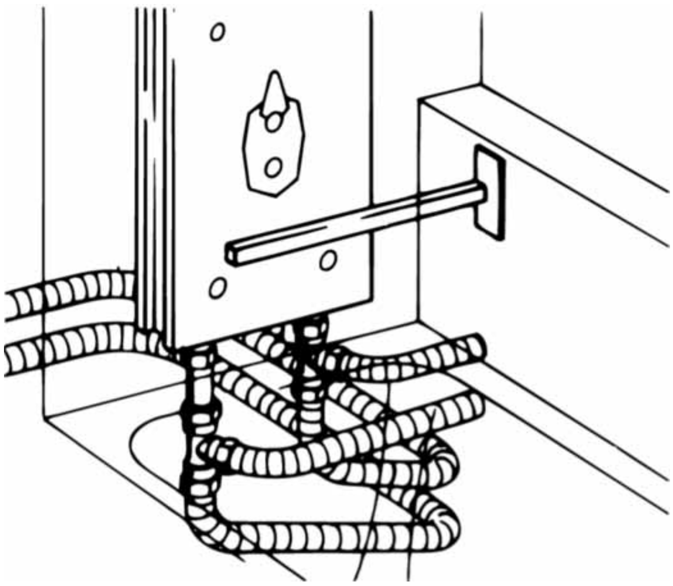


Dual line arrangement with central riser zone

Pipework as single and continuous line



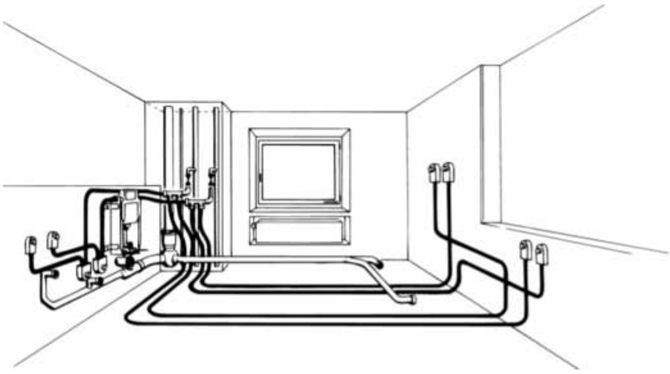
Module connection with single line



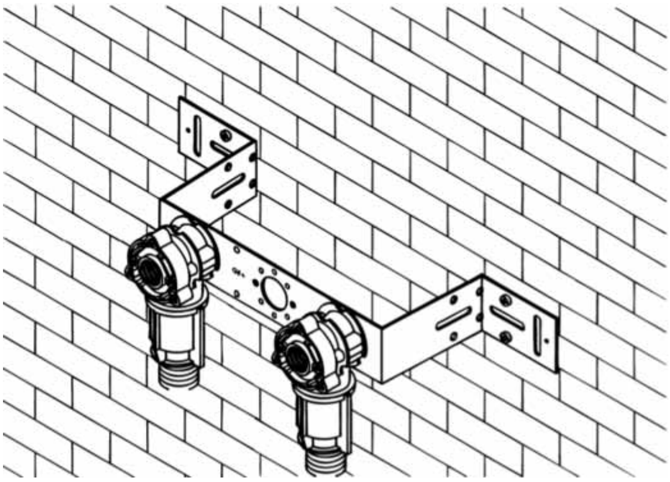
Module connection with continuous line (T-branch)

Conventional front-wall installation

In conventional front-wall installation, the INSTAFLEX pipes are laid in protective sleeves on the installation wall and fastened with the respective materials (bracket or similar).
The valve connections are fastened in the interior wall space on the installation wall with the designated fastening material for the system.

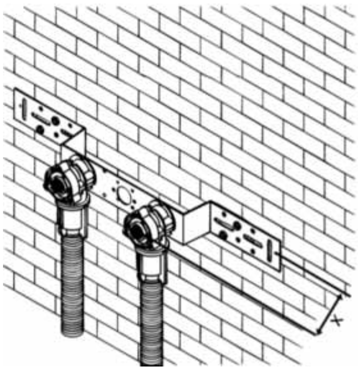


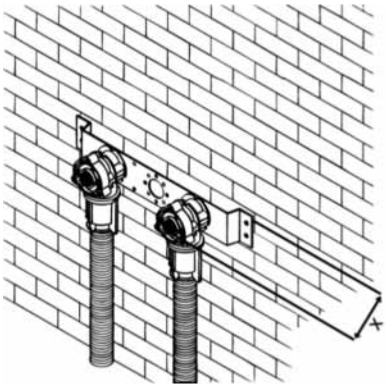
INSTAFLEX front-wall installation in dual line arrangement with central pipe shaft



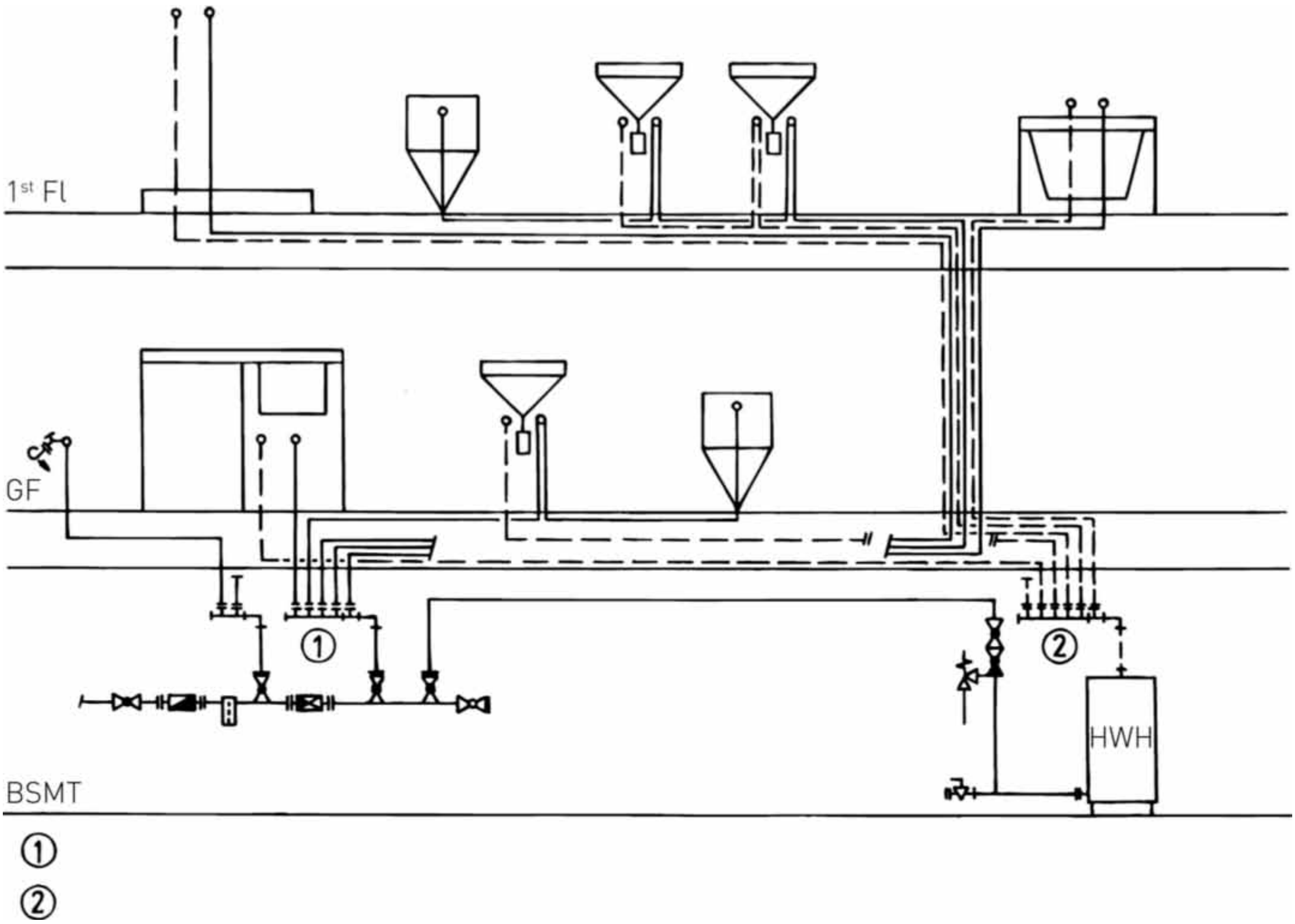
INSTAFLEX single and double valve connections with designated fastening materials for front-wall installation.

Maximum front-wall measurement x = 17.5 cm





Manifold arrangement



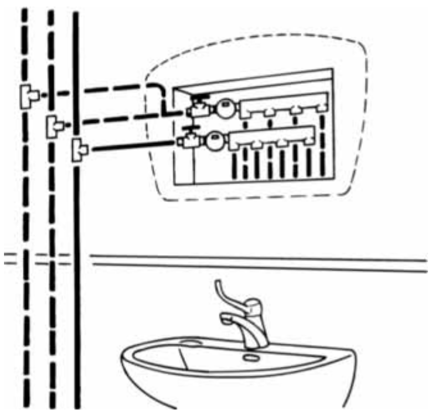
1 Cold water manifold

2 Hot water manifold

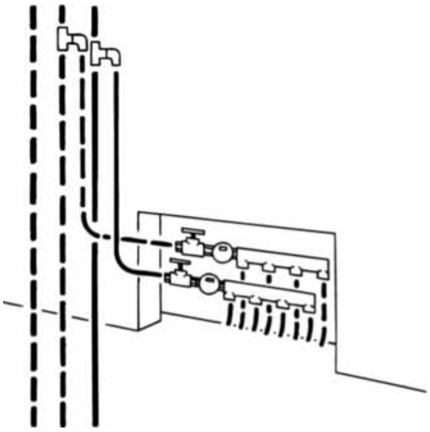
Examples:

The manifold of a pipe-in-sleeve system is usually installed in the basement of single-family homes and duplexes. It is advisable to place the hot water manifold as closely as possible to the hot water heater. The shorter the distance between the manifold and the water heater, the shorter the flushing time of the cooled stagnant water will be. This reduces water and heat loss.

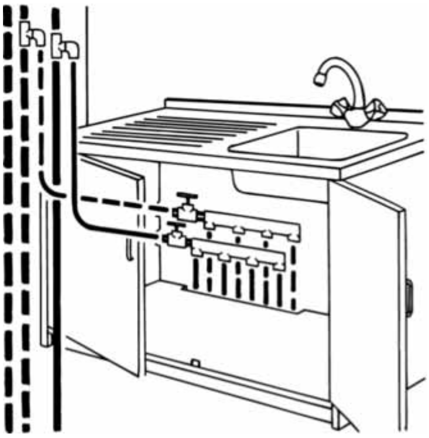
In multi-family residences or similar buildings with a central hot water supply and manifolds within the flats or individual units, we recommend placing the manifold as closely as possible to the user. The hot water circulation can also be conducted close to the user. Keeping the tie lines from the manifold to the user as short as possible will reduce flushing times as well as water and heat loss.



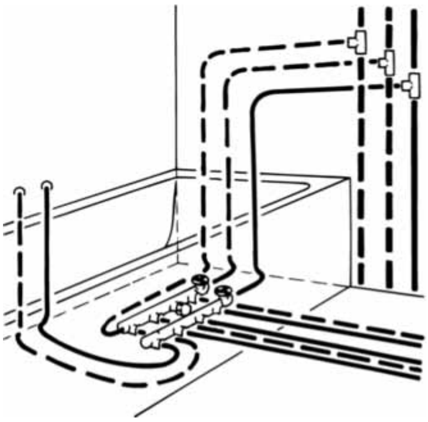
Manifold in pre-planned recess behind the mirror



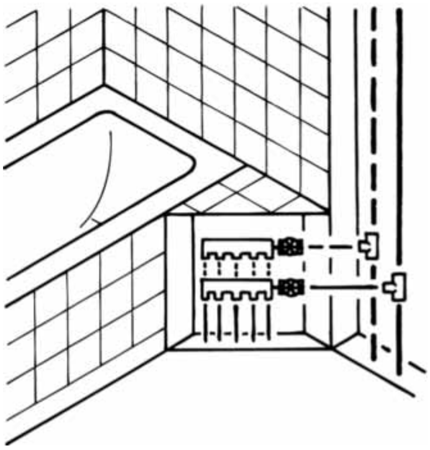
Manifold in the wall with or without service cabinet, with access panel for maintenance



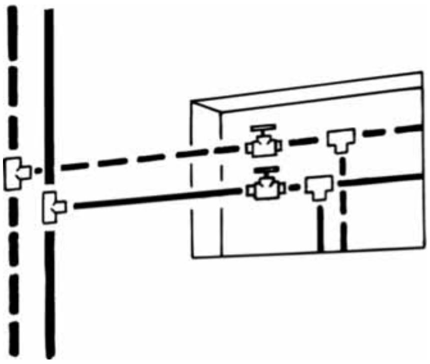
Manifold under the kitchen sink or in the cupboard, easy access



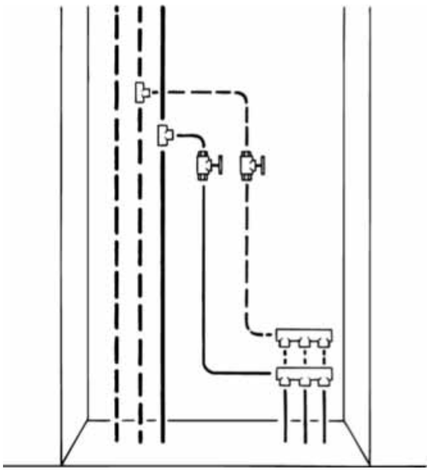
Manifold in the bathtub side wall or under the bath, access panel for maintenance



Manifold in the corner next to the bathtub provides additional shelf space.

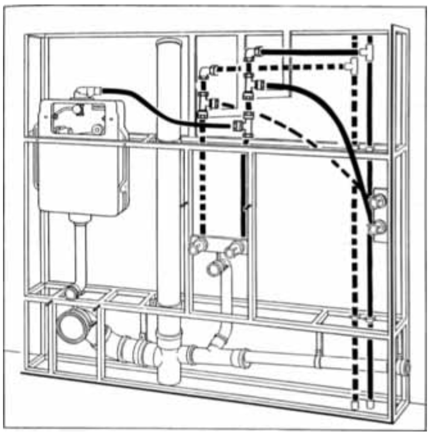


Manifold in hotel rooms or similar units



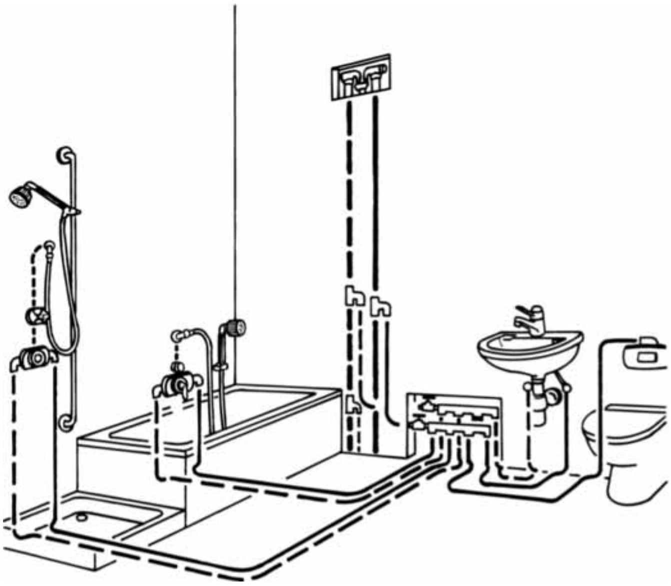
Manifold in installation shaft with concealed valve

+GF+

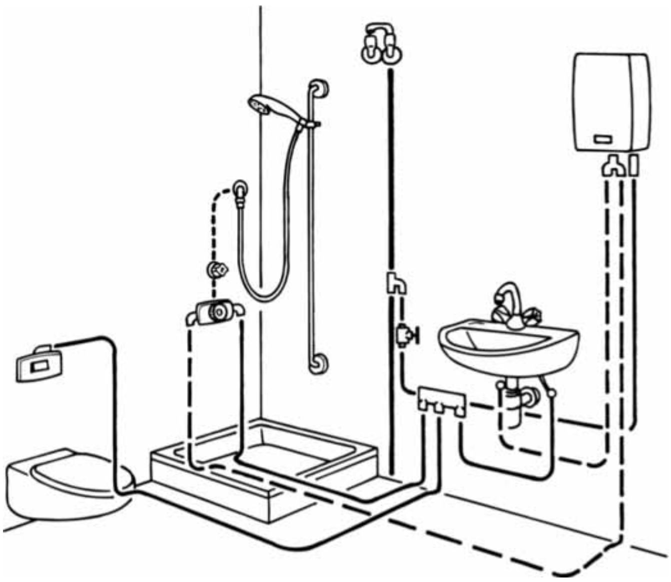


Tee pieces in frame elements

Hot water supply



Distribution in a flat with a central hot water supply



Distribution in a flat with a decentralised hot water supply, e.g. with continuous flow heater

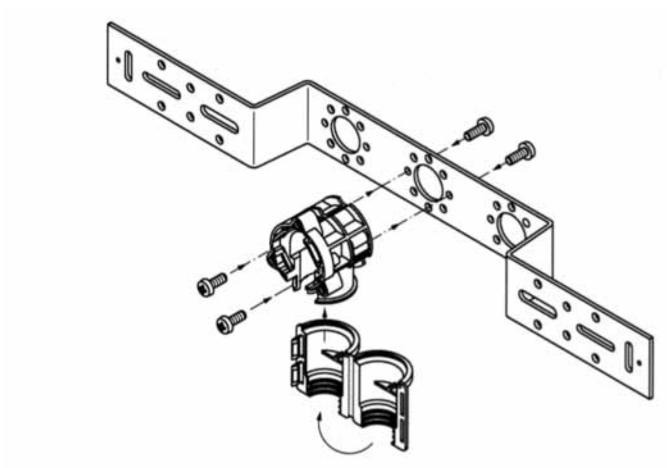
Connecting valves and appliances

A key connecting element between the plastic piping and the user is the valve or appliance connection.

These connections ensure a safe transition to the consumer connection. The many different designs on offer allow us to satisfy diverse connecting requirements. INSTAFLEX valve connections also meet the needs of the market, whether in-wall or on-wall, front-wall or recess mounted, brickwork, wood or plaster walls, elements or framework.

Do not use valve connections with housings in drywall constructions.

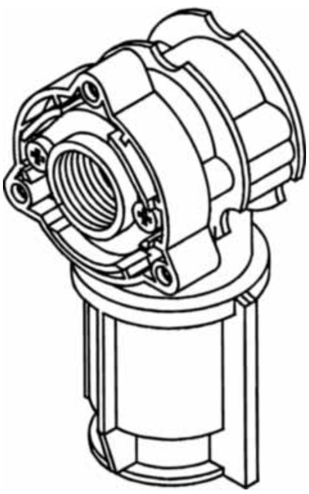
Basic design



INSTAFLEX valve connection with single spacer bracket for recessed mounting

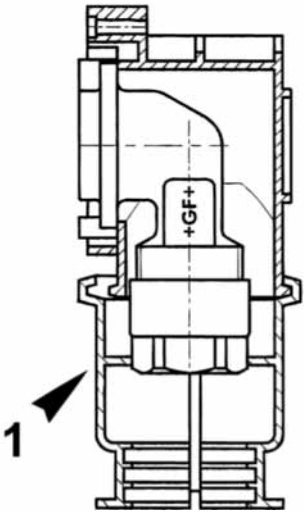
Single and double valve connections with housing

Valve connection with housing for in-wall mounting



Requirements:

- in-wall mounting
- connector elbow exchangeable in combination with pipe-in-sleeve system
- pre-assembled on a spacer
- easy and fast mounting
- reliable connection from plastic pipe to valve



1 The housing can only be closed when the pipe has been installed.

Housing upper part = blue

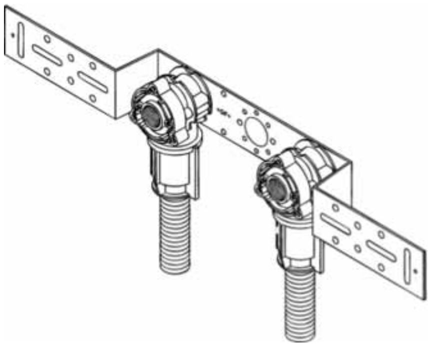
Housing bottom part = light grey

The INSTAFLEX valve connection with housing is composed of three main parts

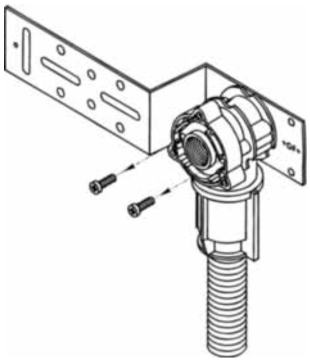
1. The connector elbow with the proven, patented INSTAFLEX compression fitting. It comes pre-assembled in the upper part of the housing.
2. The upper part of the housing is fastened directly on the spacer to guard the connector elbow against the masonry. It furthermore warrants easy replacement of the pipeline in case of mechanical damage.
3. The bottom part of the housing serves to anchor the protective sleeve, to guard the compression fitting against mortar and other building materials, as well as protection against unmounted compression fittings.

The INSTAFLEX valve connection with housing therefore satisfies all the demands placed on it. Replacing valve connections in hollow spaces is made easier by running the protective sleeve straight from the valve connection and adding a fastening point before the first change in direction.

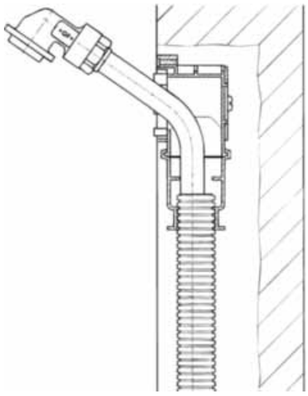
Example:



Concealed in the masonry of a recessed installation



Exchangeablity of the connector elbow is warranted after assembly.

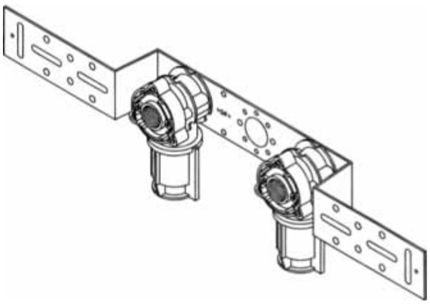


After removing the two fastening screws, the connector elbow can be taken out of the housing from the front.

Attention:

A double connection can only be replaced by opening the masonry. In drywall constructions, pre-assembled valve connections with housing may not be mounted on brackets because this could cause the connector to break off.

Assembly



Assembly instructions are included in the product packaging.

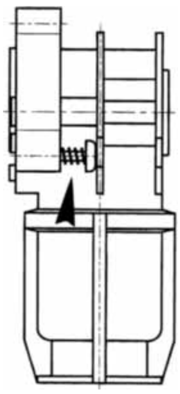
Only use the enclosed screws to fasten the valve connections on the spacer.

Attention:
Do not use any valve connections with housing for lightweight constructions or wood walls.

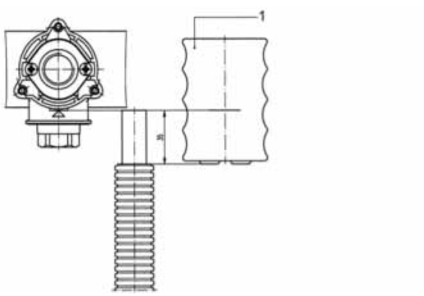
Tighten the screws which are pre-mounted in the upper part of the housing.

Fix the sub-assembly in the wall recess.

Detach the bottom part of the housing from the top part so that the compression fitting is visible.

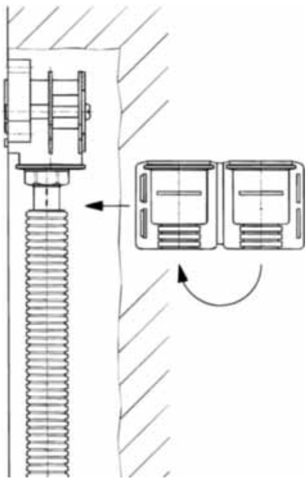


Cut the pipe at the height of the marking (arrow) on the upper part of the housing. Shorten the protective sleeve by 35 mm with the INSTAFLEX protective sleeve cutter.



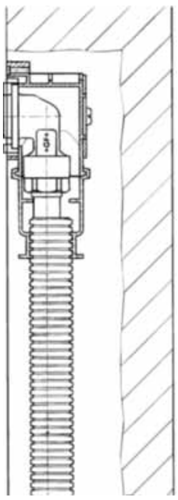
1 INSTAFLEX protective sleeve cutter

Insert the pipe into the pre-assembled compression fitting and tighten the coupling nut.

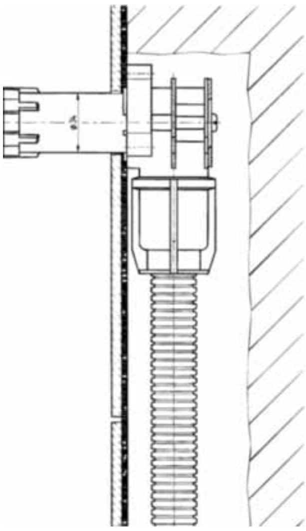


Attach the bottom of the housing and close it. You can only close the bottom part when the coupling nut has been mounted correctly.

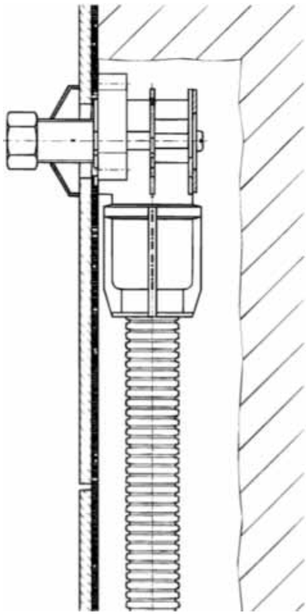
Thanks to this safety mechanism no visual inspection is necessary subsequently.



Close off the ½" connecting thread with the INSTAFLEX backing stem.
The backing stem seals directly on the fitting, dispensing with the need for additional sealing for leak tightness. At the same time, the backing stem serves as protection when plastering and tiling the wall.



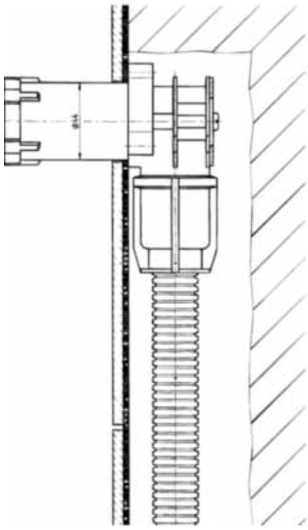
The wall opening of the backing stem (34 mm) is easily covered with the rosette of the valve (50 mm).



If you want to replace the connector elbow, the wall opening has to be enlarged to at least 44 mm.

Enlarge the wall opening by using a 44 mm or larger backing stem.

Attention:
The size of the covering rosette should be proportionately larger than backing stem, e.g. use a 60 mm covering rosette for a 44 mm backing stem.



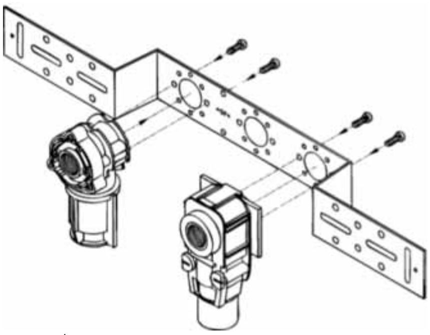
For the exact assembly sequence, please follow the assembly instructions enclosed in the packaging.

Single valve connection with housing	**Double valve connection with housing**
	
Screw connector housing on the spacer and fix in the wall recess.	Screw connector housing on the spacer and fix in the wall recess.
	
Open the protective sleeve bracket, insert the pipe, mount the compression fitting, snap protective sleeve bracket shut.	Open the protective sleeve bracket, insert the pipe, mount the compression fitting, snap protective sleeve bracket shut.

Assembling valve connections with blue housing

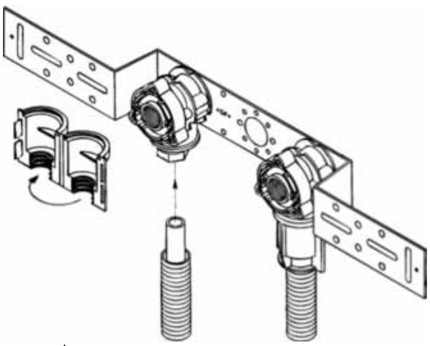
In masonry

Valve connection, single



d16 - $^1/_2$" thread
d20 - $^1/_2$" thread

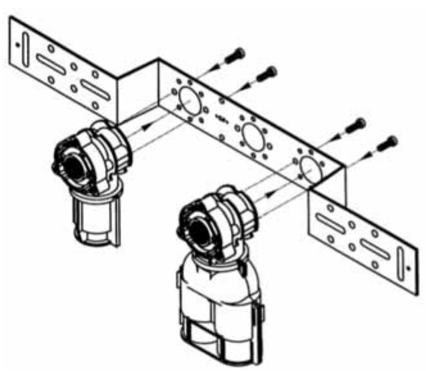
Screw the valve connection onto the spacer.



d16 - $^1/_2$" thread
d20 - $^1/_2$" thread

Open the protective sleeve bracket and mount the pipe in the compression fitting.
Then snap the protective sleeve bracket in place.

Valve connection, double

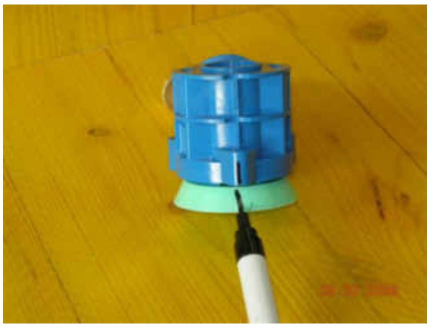


with $^1/_2$" thread

Mounting is same as for single valve connection.

Assembly procedure for valve connections on planking

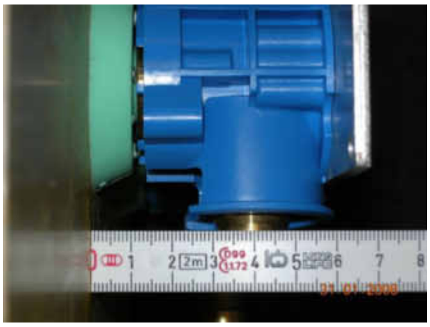
Fastening disk with 55 mm x ½ " diameter



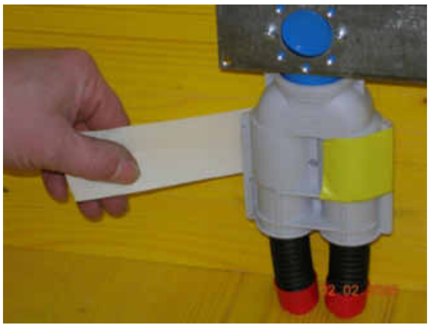
Mark the screw positions on the valve connection and the fastening disk.

Draw reference lines and mount the fastening disk with four nails.

Screw the valve connection on the fastening disk.



Make sure the dimensions correspond to the illustration.



Connect the pipes and mount the spacer. Then thinly wrap the housing of the valve connection with adhesive tape.

After pouring the cement

After removing the formwork

Turn out with suitable flat bar 5 x 25 mm

Result with too much wrapping

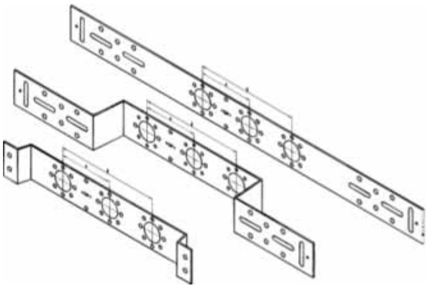
Result when not wrapped

Fastening valve connections in facing concrete

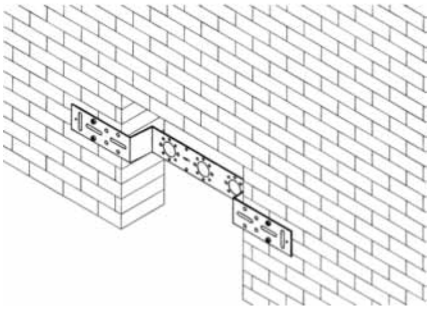
Fastening with nailed-on plastic fastening disk and metal spacer bar.
If you use facing concrete, nail on the plastic fastening disk and use a metal spacer bar.

Fastening accessories

Fasten drain valves to bathtubs, showers and wash basins so that their function is not impaired. Use spacer bars to anchor the valve connection asemblies as a fixed point in the masonry.

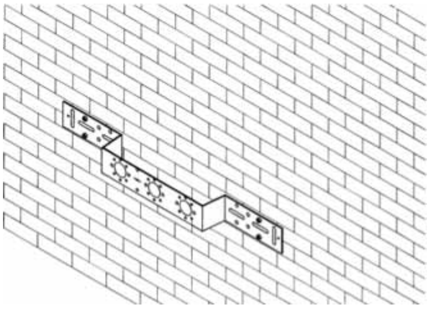


Spacer bars act as fasteners for the valve connections and anchor them in the masonry, while also providing a gauge for bore holes in valve connections. The gauge for bore holes refers to the distance between hot and cold water connections.



Bent spacer bar for recessed mounting

The many different types of spacers enable anchoring valve connections in diverse wall constructions.



Bent spacer bar for interior wall spaces

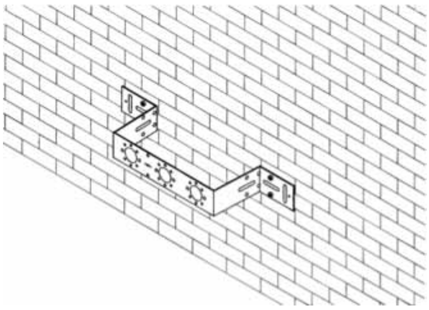
Spacer use

Spacing 153 (150)
for bathtub, shower valves and other

Spacing 100
for continuous flow heater, tanks and other

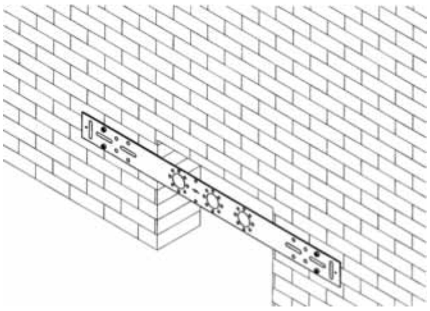
Spacing 80
for pillar wash-stands

Single mounting
for surface-mounted toilet cisterns, washing machines and other



Spacer bar for interior wall spaces

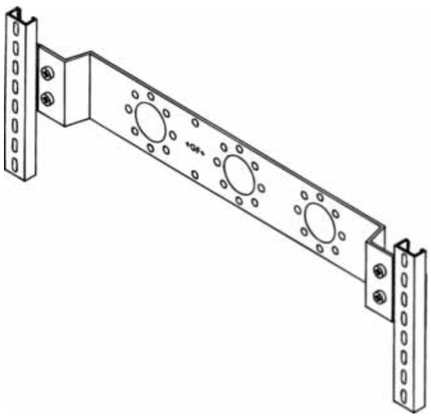
Note:
For interior wall spaces use a flat spacer and bend to the front wall dimension (X).
Maximum dimension 17.5 cm



Flat spacer bar for recessed mounting

For Knauf, Rigips and Glock single-plank walls, a separate spacer bar was designed which fits on the fastening elements supplied by the manufacturers of the wall partitions.

Attention:
Only use valve connections **without** housing on the spacer bars for Knauf, Rigips, Glock single-plank walls. See also the wall manufacturer's documentation.



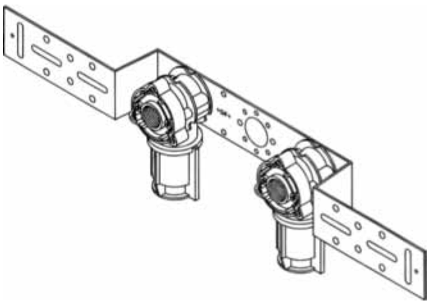
INSTAFLEX spacer bars are manufactured from one piece; they reduce assembly efforts thanks to simplified procedures.

There is no limit to the number of times a rail may be used for valve connection installations.

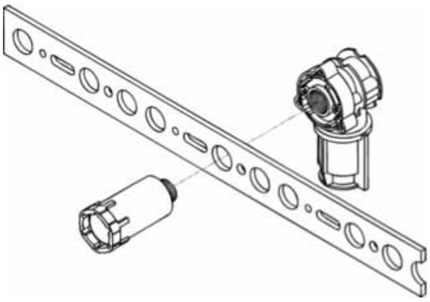
Make sure the rail is removed after bricking up the wall recess but before the plaster work.

This increases the assembly effort as more procedures are required.

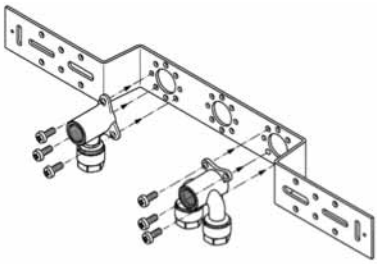
Valve connections and fastening



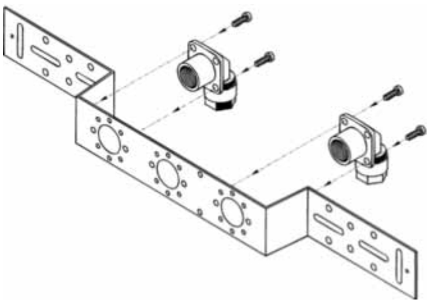
Single-valve connection with housing for recessed mounting



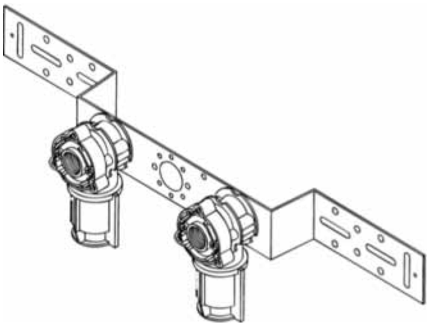
Single-valve connection with housing for recessed mounting with mounting rail



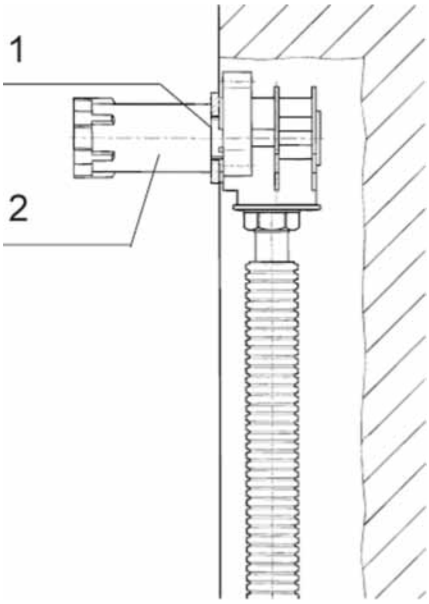
Single and/or double-valve connections without housing for recessed mounting, fastened to spacer with threaded bolts M6 x 20



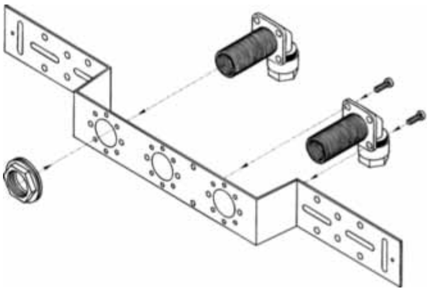
Valve connections with flange for interior wall spaces, fastened to spacer with threaded bolt M6



Single and/or double-valve connections with housing for interior wall spaces



1 Mounting rail
2 Backing stem
Fasten the valve connection with the backing stem to the mounting rail.



Valve connections with flange without housing for recessed mounting or interior wall spaces, fastened to spacer with threaded bolts M6 or with coupling nut 3/4"

Attention:
Protect valve connections without housing from the masonry by wrapping them with felt tape or foam insulation.

+GF+

Run-off support

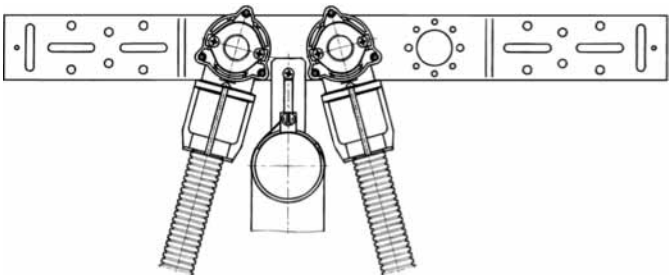
When connecting mixing taps for horizontal surfaces via corner valves, make sure to take the run-off into consideration when installing the valve connections, e.g. for wash basins and kitchen sinks.

Depending on the type of wash basin (with or without pillar), the gauge for bore holes is between 80 and 153 mm.

Fasten the run-off support to the spacer bar with a threaded bolt M6.

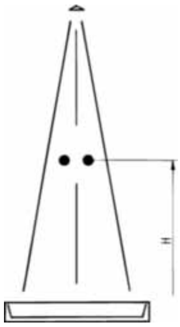
Attention:
The same arrangement is used for double-valve connections.

Mount the run-off support with a bore hole gauge of 80 mm. Valve connections with housing can be placed at an angle of 17.5 or 35°, respectively. The run-off support is fitted between 60 and 80 mm under the connections.

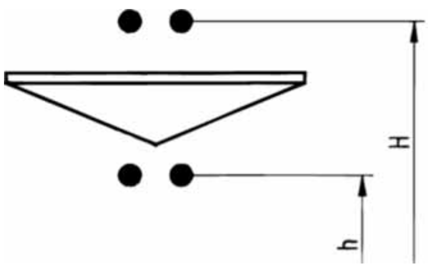


Installation dimensions

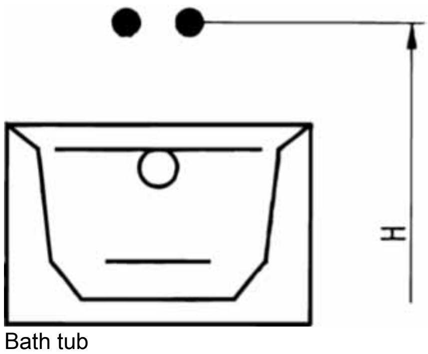
Attention:
Always measure the installation dimensions from the finished floor level.



Shower
H = 116–120 cm
Gauge for bore holes 150 (153)
Observe the manufacturer's instructions of showers



Wash basin and kitchen sink
H = 101 cm
h = 55 cm
Gauge for bore holes 80–150 (153)
Observe the manufacturer's instructions of wash basins



Bath tub
H = 71 cm
Gauge for bore holes 150 (153)
Observe the manufacturer's instructions of bath tubs

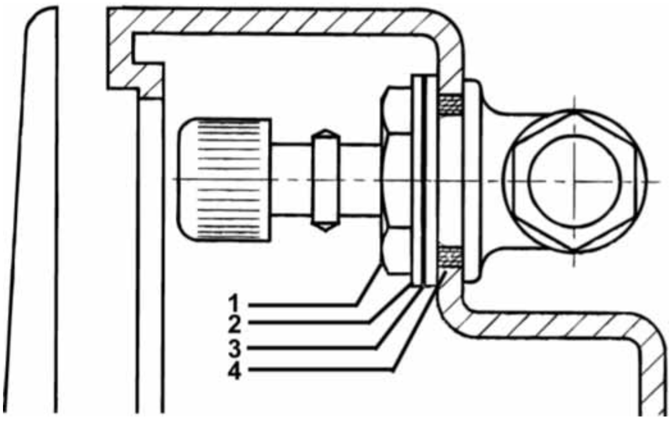
Surface-mounted toilet cystern and bidet
H = 75 cm
h = 10–15 cm
h = 10–15 cm-
Gauge for bore holes 150 (153)
Observe the manufacturer's instructions of toilet cysterns

Connecting concealed toilet cysterns, single and double

Connections for concealed toilet cysterns are not exchangeable.

Connection with INSTAFLEX
For a concealed toilet cystern, assemble the shut-off valve connection outside the toilet cystern.
Push the single or double-valve connection into the opening on the toilet cystern (35 mm) and fasten it from the inside with the corresponding fastening accessories.

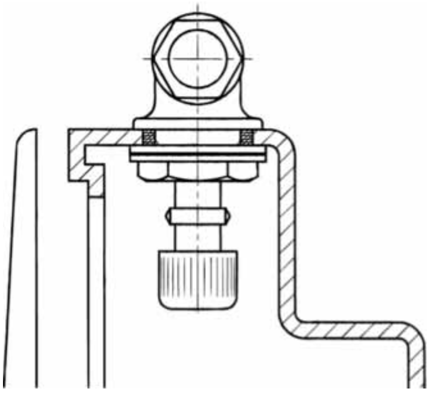
Assembly from the back

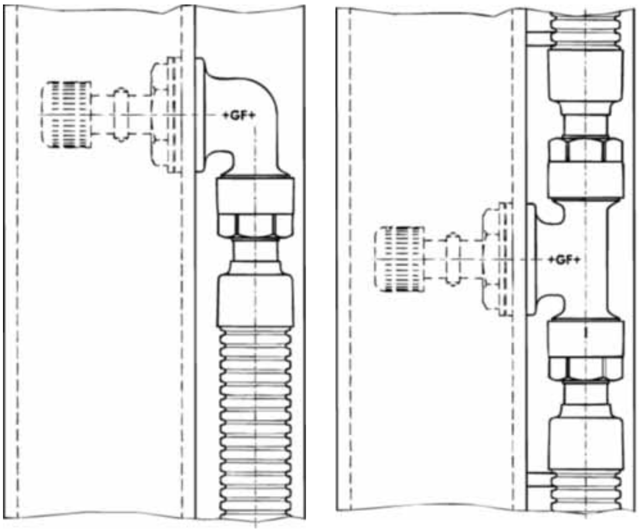


1 Nut
2 Spacer ring
3 Gasket
4 Housing

Assemble the angle check valve outside the toilet cys-tern in the valve connection (single or double). Slide a fastening nut (1") over the angle check valve to fasten the connection.

Assembly from above





Protect the valve connection from the masonry by covering it with a foam rubber insulation.

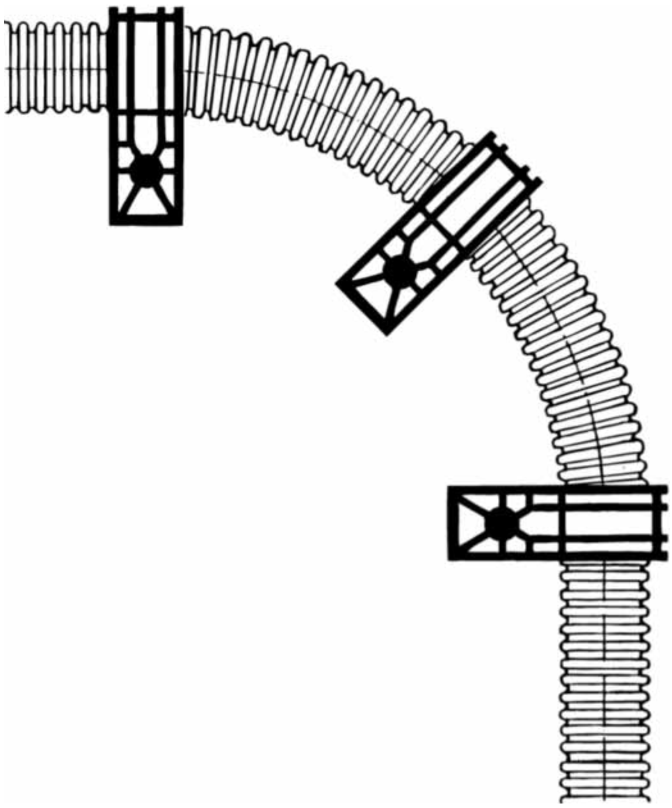
Replacement of multistory piping

INSTAFLEX piping is a perfect alternative to rigid installations. The flexible pipe-in-sleeve system can be laid so that the medium-conveying pipe is easily replaced in case of mechanical damage (e.g. drilling).

To ensure easy replacement, the following points should be noted:
Dirt, stone chips, cement slurry, etc. may not get into the gap between the medium-conveying pipe and the protective sleeve. This can be prevented with correct assembly and by using the INSTAFLEX installation tools and aids listed below:

- INSTAFLEX formwork box
  article no. 760 853 299
- INSTAFLEX formwork duct
  article no. 760 853 300
- INSTAFLEX pipe support
  article no. 760 853 399
- INSTAFLEX sleeve for protection
  article no. 760 854 986 d16 red
  article no. 760 854 987 d16 green
  article no. 760 854 988 d20 red
  article no. 760 854 989 d20 green

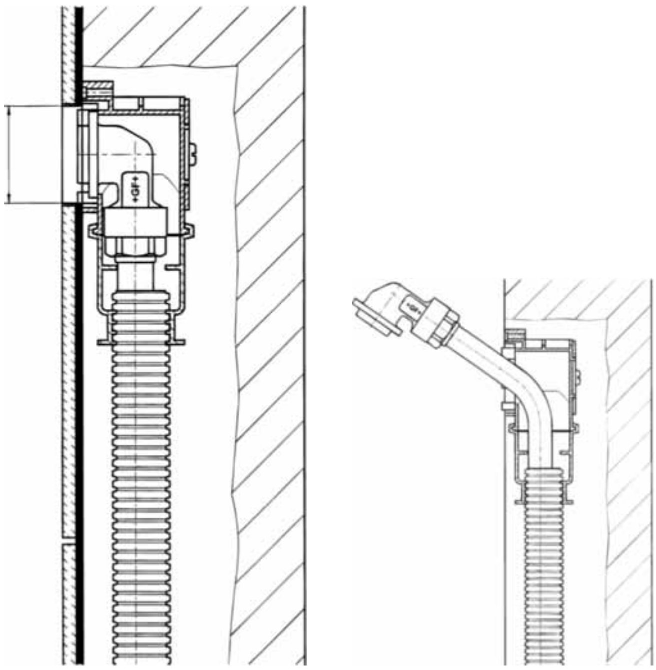
Do not exceed the **minimum bending radius of R = 10 x d** (d16, d20, d25, d32) between two connections when installing a pipe section. If there are more than 4 changes in direction, the bending radii should be larger in order to warrant easy replacement.
If you are using the pipe-in-sleeve system, you must secure the pipes inside the protective sleeve adequately, especially in the bend area and the hollow spaces.



Pipe fastening in hollow spaces to ensure replaceability:
Secure the pipe bends with at least two to three clips. Straight pipes are fastened every 1 to 1.5 m.

Manifolds should be accessible. If you build it in-wall, we recommend providing a service opening.

Valve connections are limited to a maximum installation depth of 60 mm. The installation depth is measured from the front edge of the wall covering to the back edge of the connection. To replace a single and double connection, a wall opening of 55 or 70 mm, respectively, is required.



After removing the two fastening screws, the connector elbow can be taken out of the housing from the front.

Attention:
Double connections can only be replaced by opening up the masonry.

SVGW guidelines (Swiss Association for Gas and Water) on replacing INSTAFLEX pipes according to the **W 3 guideline**

Plastic piping systems must be installed according to the W3 guidelines for building drinking water installations as well as the manufacturer's instructions.[1]

Installation Guidelines (SVGW-W 3)

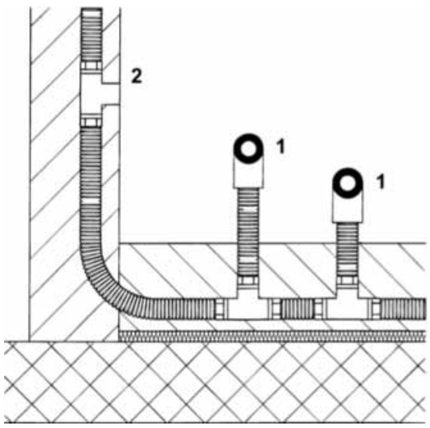
I. When installing flexible pipe-in-sleeve systems in solid floor and wall constructions (concrete), the pipes must be exchangeable and the position of the connectors visible from the outside.[2]

II. Bend-resistant pipes may not be cemented in.

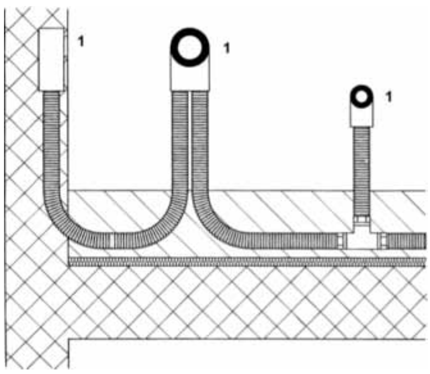
III. Plastic pipes and the respective connectors (compression or welded) laid in-wall must be provided with a jacketing to protect the system parts from mechanical and chemical damage.

IV. **Compression joints may be used in-wall.** They may be laid in flooring and in non-concrete walls without having to be discernible from the outside.[3]

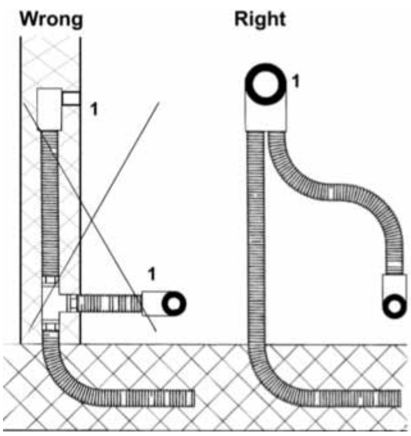
[1] SVGW-W 3 Art. 4.120
[2] SVGW-W 3 Art. 4.620
[3] SVGW-W 3 Art. 5.100



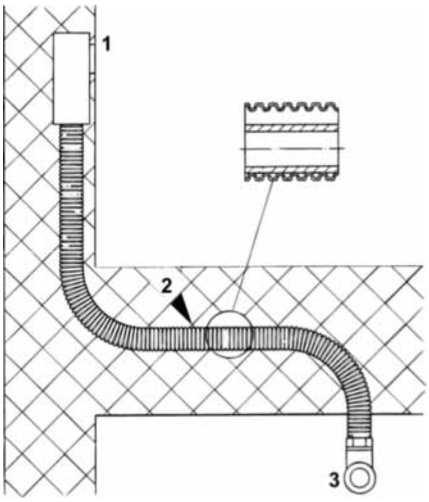
2 Valve connection without housing



1 Valve connection with housing



Valve connections in walls without reinforcement can be either with or without housing.



1 Valve connection with housing
2 Pipe
3 Distributor

Flooring or wall without reinforcement

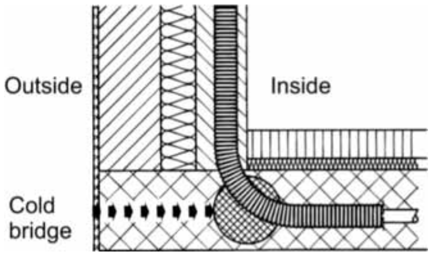
Concrete wall or floor with reinforcement

Frost-proof pipe laying

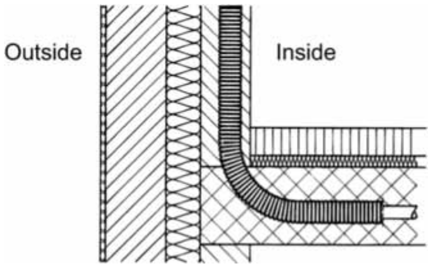
An important factor to remember when laying frost-proof sanitary installations in heated buildings is where the pipes are placed in the structural design of the building. Generally, the temperature will be above 0 °C, but if this factor is ignored, there is a real danger of the pipes freezing if there is water stagnation.

Drain pipes which are liable to freeze if the temperature drops below 0 °C. Ice formation in water sinks is not a problem for our INSTAFLEX pipes.

Certain areas of the structural design, e.g. peripheral area of basement floors, garages, driveways, etc. can reach temperatures below 0 °C. Make sure pipes are laid in **frost-free** areas of the building to prevent risk of freezing.



Wrong
Incorrect solution. The pipe risks freezing because of the cold bridge.



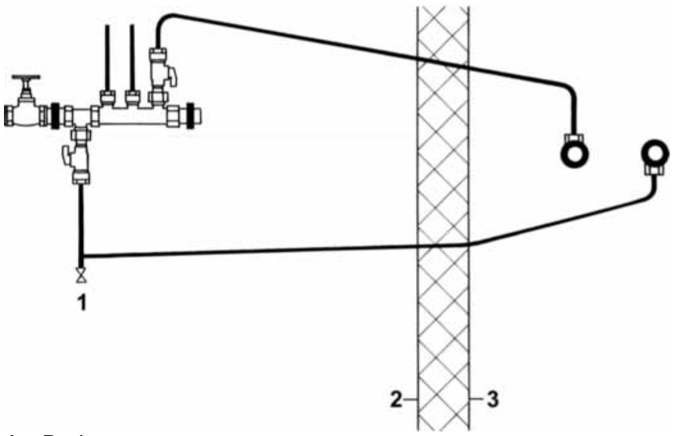
Right
The correct solution. The pipe is laid in a warm area.

Drainage

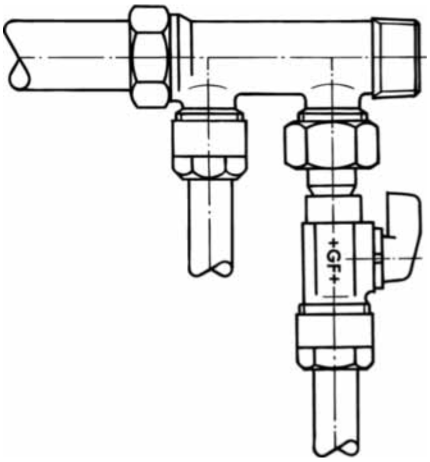
Pipelines which are only used intermittently and which are exposed to risk of frost, e.g. pipes to unheated side rooms, gardens, outdoor courtyards, must be equipped with shut-off and drain valves.

For pipes which are liable to freeze, drainage can be warranted by laying the respective pipeline as a single supply pipe with negative slope along its entire length to the outlet valve or to the pipe connection.

If stub lines have been laid instead, drain the pipes by blowing them out with compressed air or by suction.



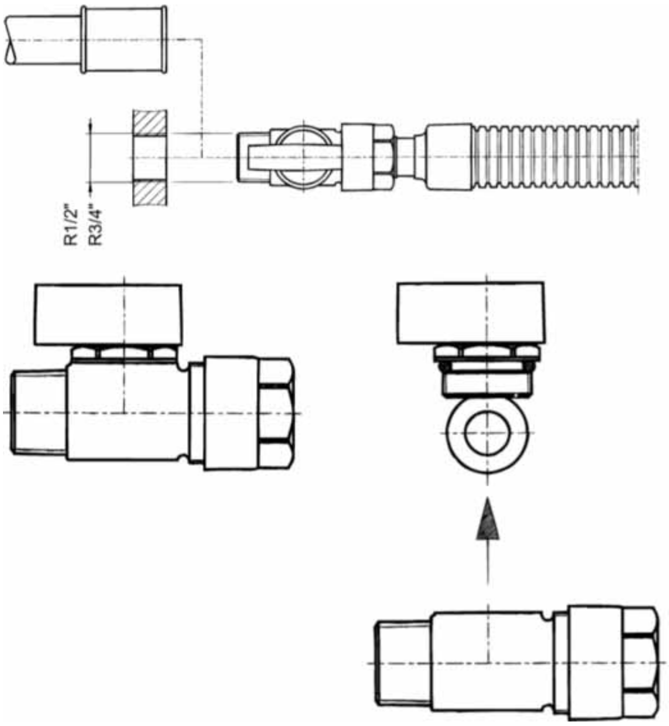
1 Drainage
2 Inside
3 Outside



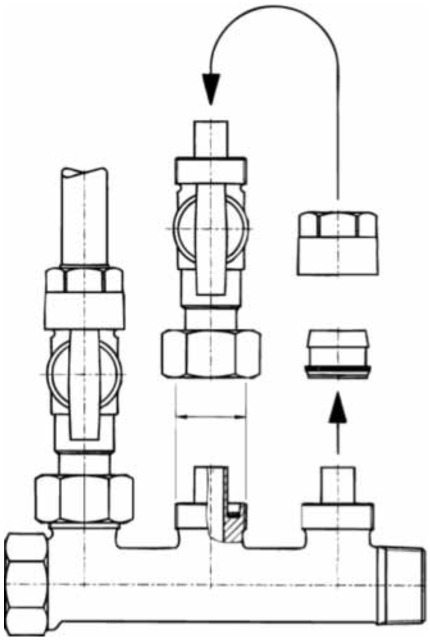
Distributor with valve

Metal valves

1. Transition with external thread



2. Transition to compression fitting

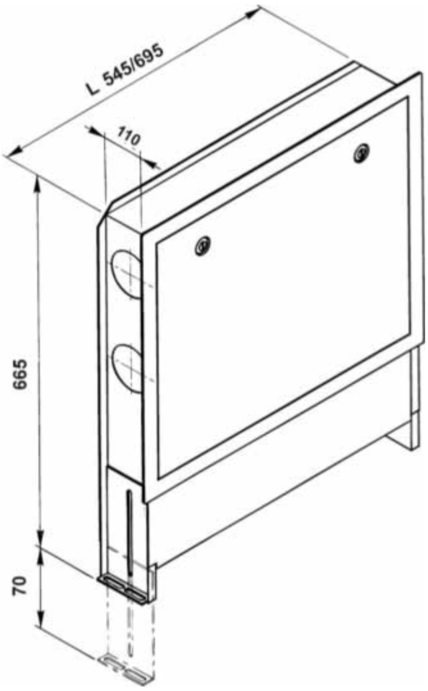


Connections to INSTAFLEX compression fittings (e.g. manifold).
Loosen the union nut and the compression ferrule of the compression fitting and put them on the adaptor. Screw the adaptor with the gasket on the free compression fitting.

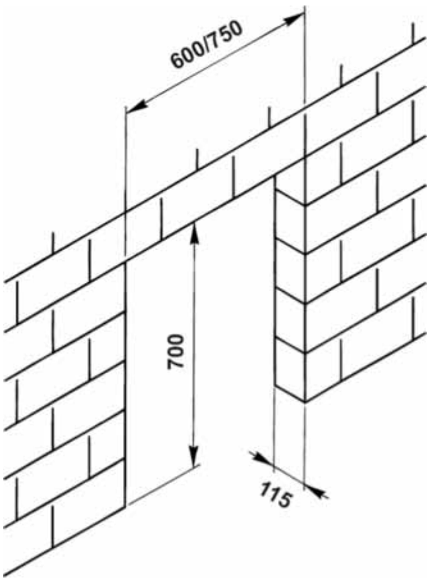
Manifold service cabinets/Installation aids

Dimensions

Pipe guide



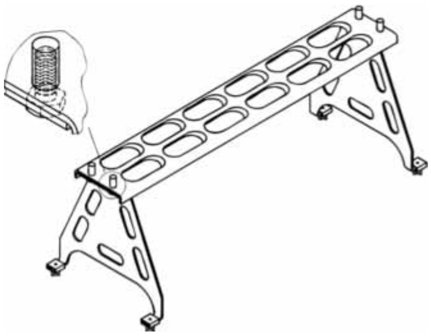
Service cabinet

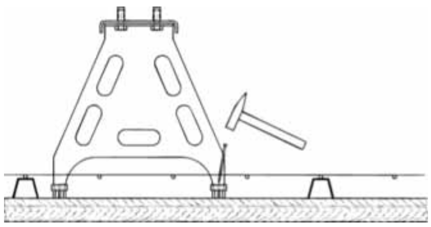


Wall recess

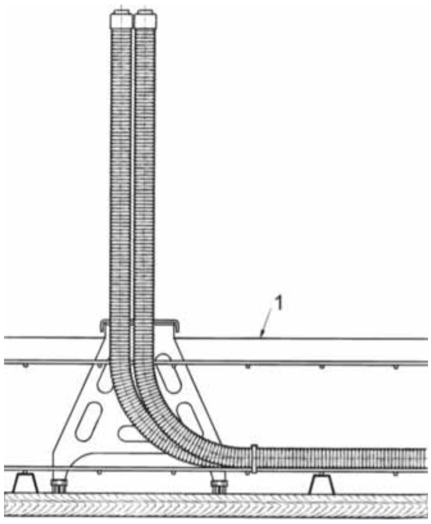
Pipeline assembly


Screw the carrier and pipe guide together.


Protect screw thread with cap.

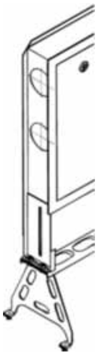

Nail the complete pipe guide onto the formwork.

Service cabinet assembly after pouring the rough concrete floor

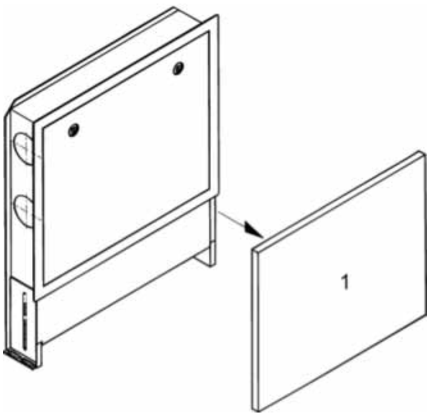


1 Top of concrete floor
Lay the pipes on the reinforcement and conduct them upward through the pipe guide.

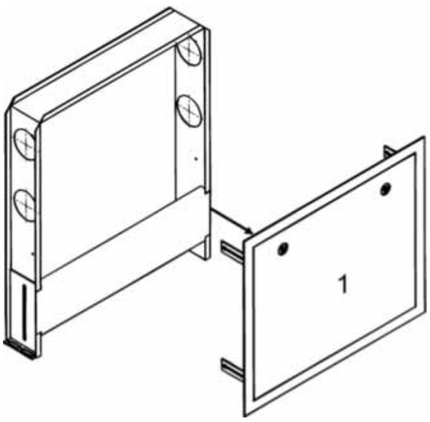

After pouring the concrete, remove the thread covering. Place the service cabinet on the pipe guide and bolt down.



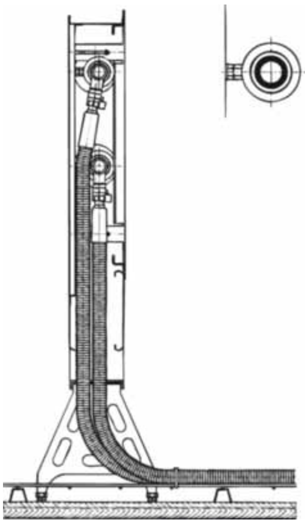
The service cabinet can be offset to the pipe guide by ±15 mm.



1 Packaging cardboard
Remove the packaging cardboard from the service cabinet.

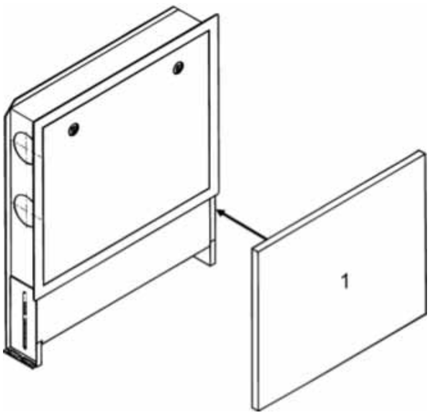


1 Cover frame with door
Dismantle the cover frame with door from the service cabinet.

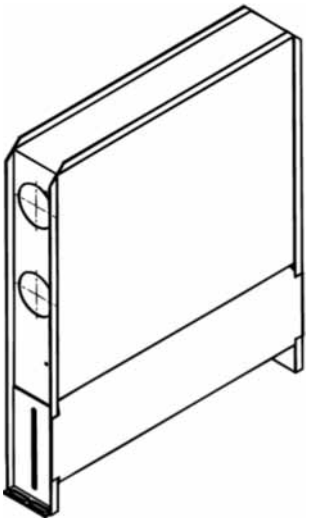


Pipe bracket with M8 thread

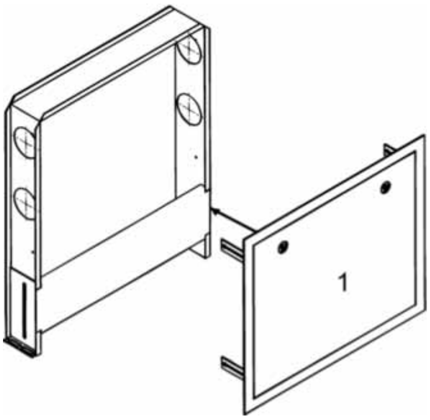
The rest of the fastening materials are enclosed.
Attention:
First mount the manifold in the service cabinet and connect the pipes, only then attach the valve connections.



1 Packaging cardboard
Put the packaging cardboard in the cabinet.

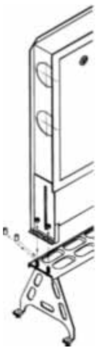


The packaging cardboard protects the cabinet and its contents during construction.

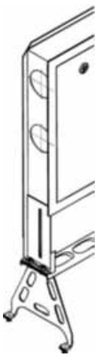


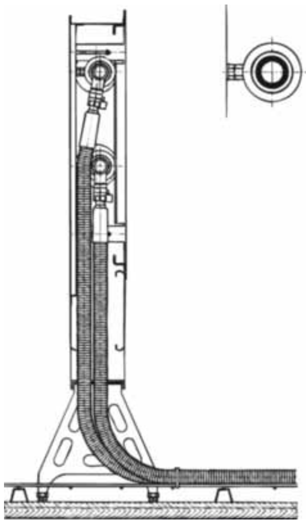
1 Cover frame with door
Reinsert the varnished cover frame with door in final assembly.

Service cabinet assembly before pouring the rough concrete floor



Place the pre-assembled service cabinet on the pipe guide and fasten it.

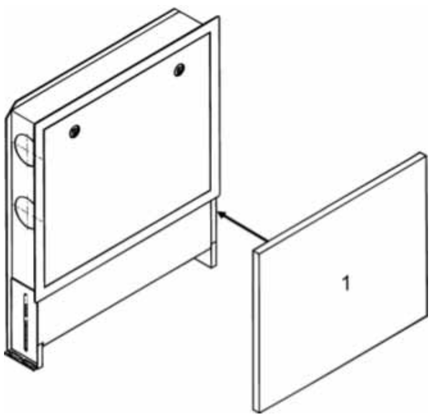




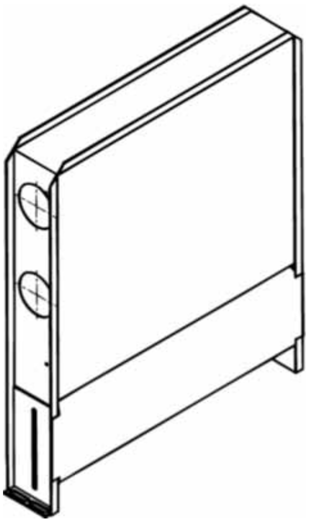
Attention:
First fuse the pipes to the manifold before attaching the pipe connections.

Lay the pipes on the reinforcement. Conduct the pipes through the pipe guide into the service cabinet and connect to manifold.

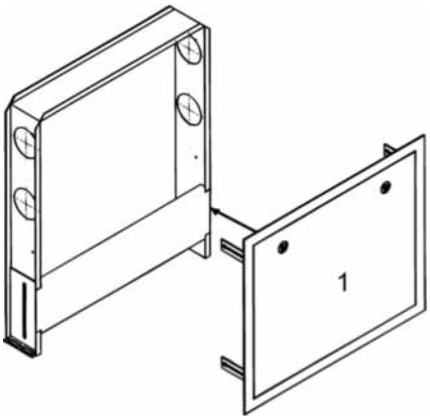
Attention:
Before connecting the pipes to the manifold, fit long protective pipe sleeves on the pipe up to the lettering.



1 Packaging cardboard
Put the packaging cardboard in the cabinet.

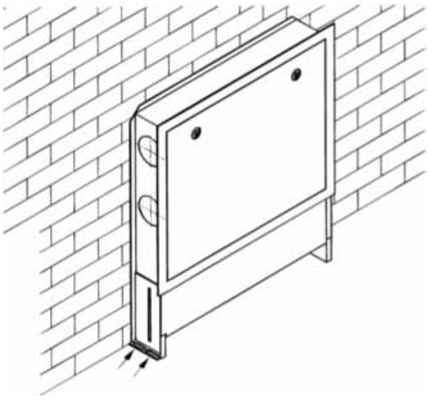


The packaging cardboard
protects the cabinet and its
contents during construction.

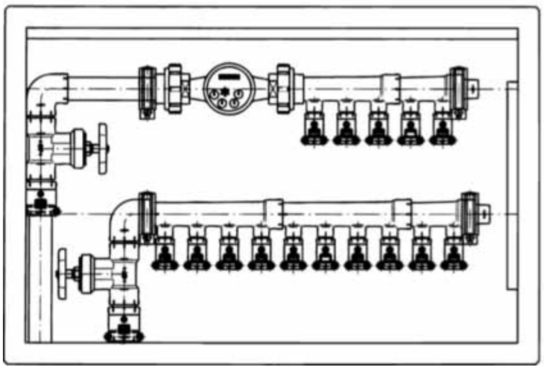


1 Cover frame with door
Reinsert the varnished cover frame with
door in final assembly.

Service cabinet assembly on the rough concrete floor

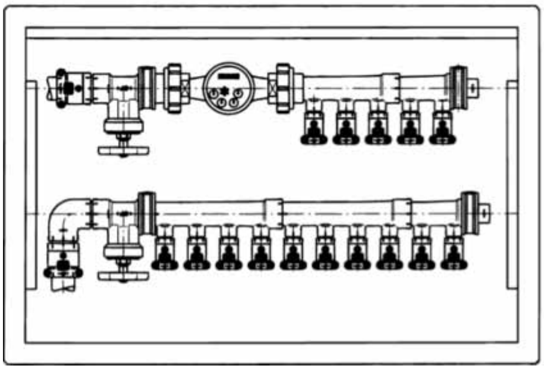


Mount the service cabinet on the rough
concrete floor and fasten. Assemble the
pipes as described above.

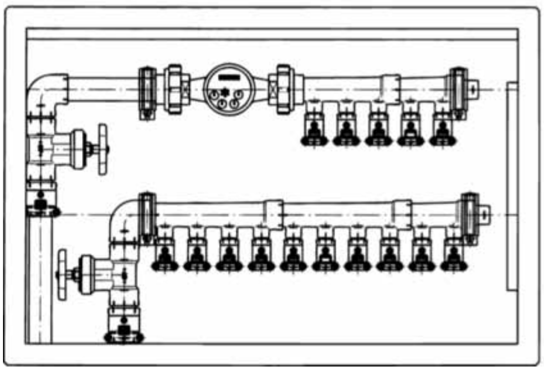


Manifold arrangement with and without water meter, access from top or side possible.
The fastening rails are individually adjustable.

Manifold arrangement in cabinet

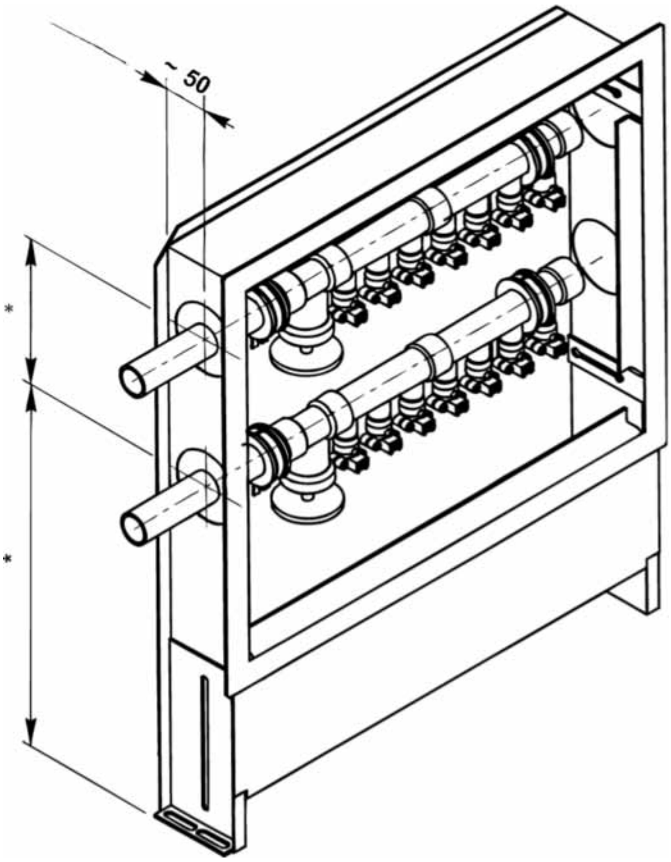


Manifold arrangement with and without water meter, access only from below, valves horizontal

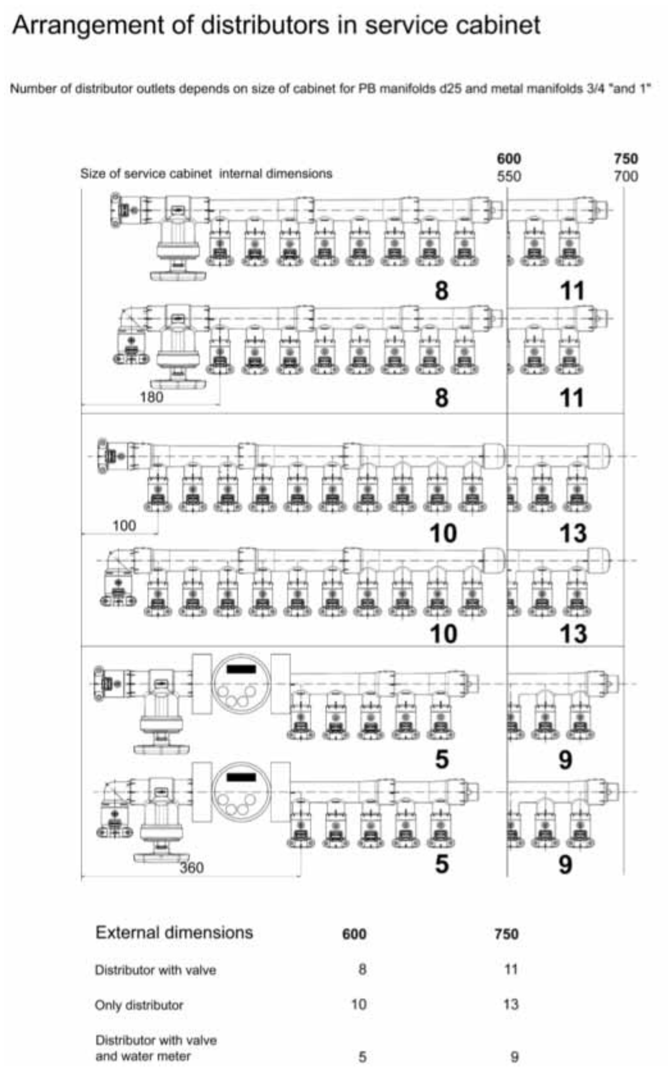


Manifold arrangement with and without water meter, access from below, valves vertical

Installation dimensions



* Variable opening of side wall



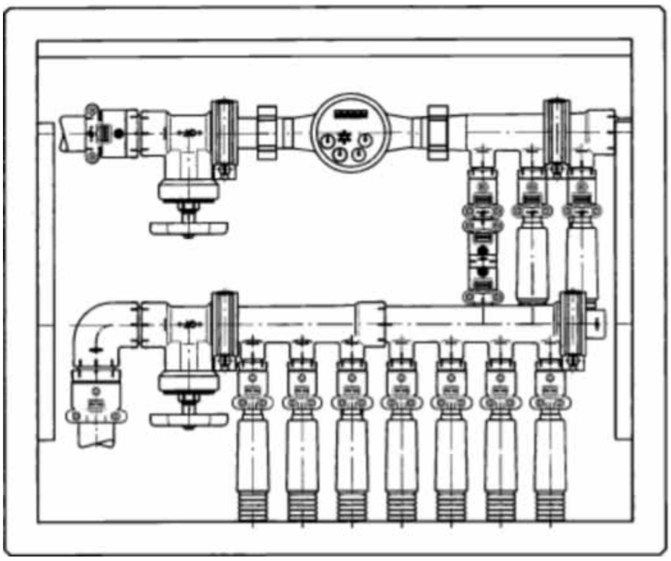
Example:
Manifold 5x with hot water meter and valvel
Solution = cabinet size 600 mm

Number of distributor outlets in cabinet

Cabinet size

600	780	
7	9	Distributor with valve
5	8	Distributor with valve and water meter
9	12	Distributor only

Replacing a pipe in the service cabinet



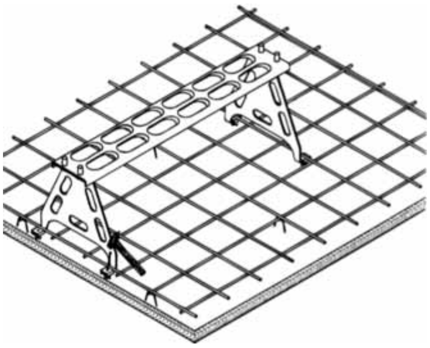
Cut off the pipe to be replaced about 5 cm below the distributor outlet.
Replace the pipe by pulling a new pipe in. Join the pipes afterwards with the electrofusion socket.

If the pipe is exchanged, the corresponding pipeline is recognisable.

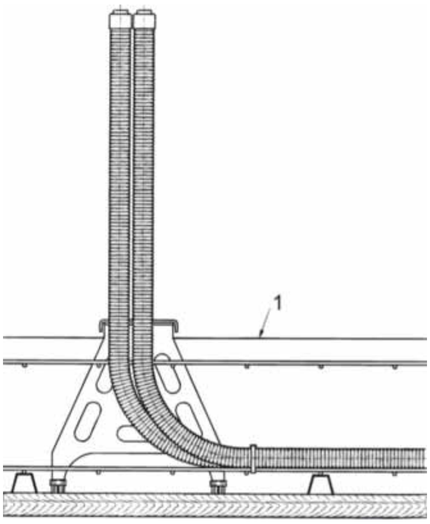
Write the consumer on the sleeve.

Laying INSTAFLEX pipes in rough concrete floor

Carriers
Fasten the service cabinet carrier on the formwork.

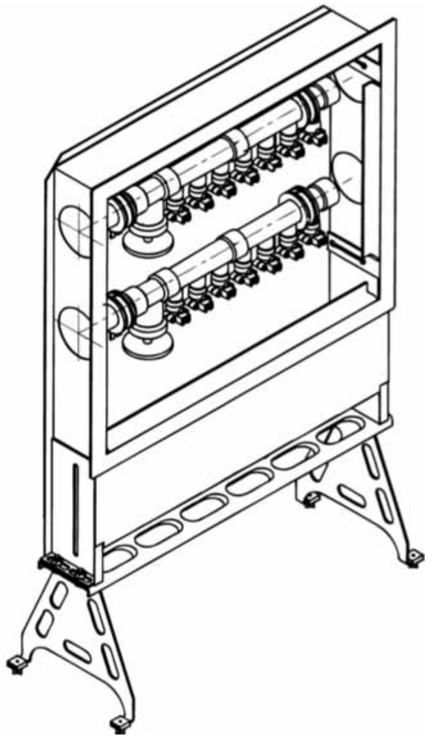


Lay the pipes on the reinforcement and conduct them upward through the carrier.



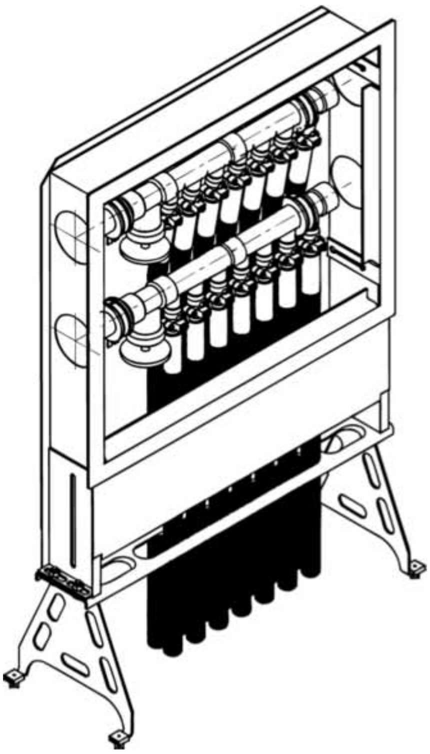
1 Top of concrete floor

Place the pre-assembled service cabinet on the carrier and fasten.

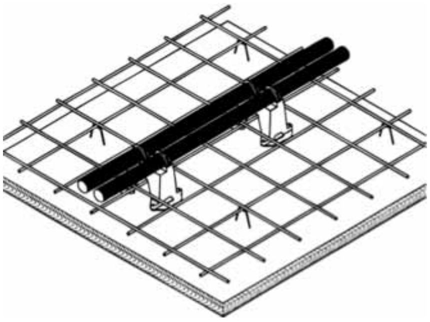


Conduct the pipe into the service cabinet and shorten the protective sleeve with the corresponding cutter for protective sleeves. Attach the protective sleeve (sleeve can be written on). Connect the pipe to the manifold (compression or fusion jointing).

Attention:
First fuse the pipes to the manifold before attaching the valve connections.

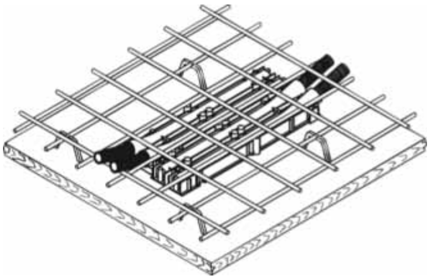


Pipe support d16/d20
Damage can be avoided by using pipe support elements in the concrete floor, thus lifting the pipes from the reinforcement underneath.



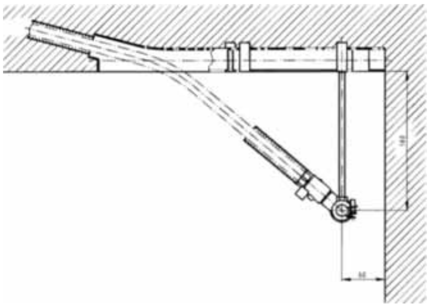
Formwork box d16/d20/d25
If you wish to conduct the pipes downward through the concrete floor, we recommend using a formwork box.

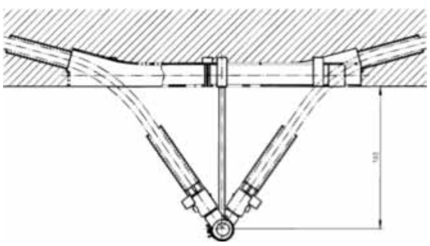
Install the formwork box directly under the formwork reinforcement.



Pipes in d16 and d20 can be pushed directly into the formwork box with the protection sleeve. However, d25 pipes can only be inserted without protective sleeve. Several formwork boxes can be laid side by side, 45 mm apart, in the same or opposite direction. Nail the formwork box to the formwork directly underneath the reinforcement with the enclosed nails.

After removing the floor formwork, the pipe can be connected downward to the manifold. The manifold fastening is similar to manifold fastening in the formwork duct.



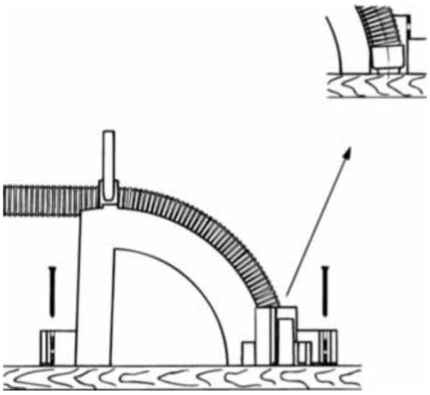


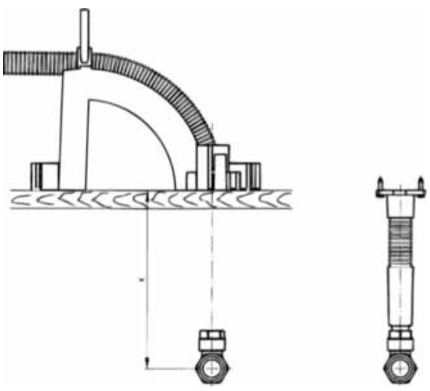
Formwork duct

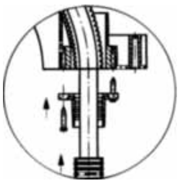
Close off the pipe ends with the sleeve (red/green) enclosed in the packaging. Put the pipe (d16 or d20) in the guide and attach it with the clip. Several guides can be used side by side, 45 m apart, in the same or opposite direction.

After removing the formwork for the floor slab, pull the required length (x) of the medium-conveying pipe up to the manifold.
Then attach the protective sleeve with the corresponding coupling.

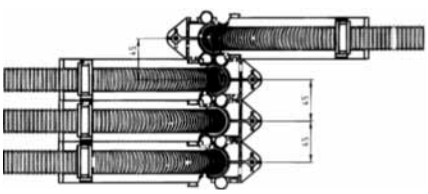
Fasten the manifold by putting M8 metal dowels in the provided openings. Then secure the manifold with INSTAFLEX pipe brackets and M8 threaded bolts.

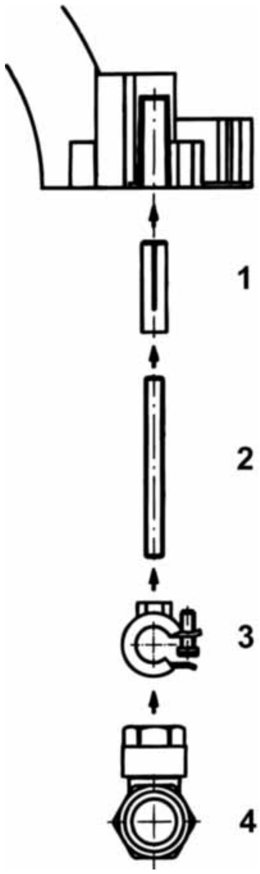






Coupling
d16 = article no.
760 853 316
d20 = article no.
760 853 753

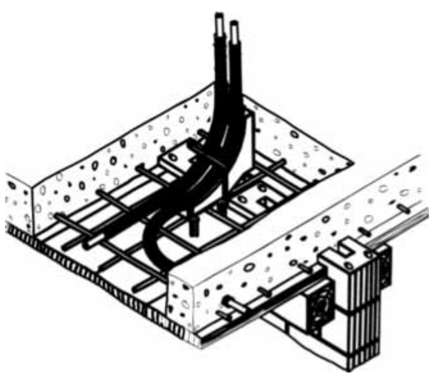




1 Metal dowel M8
2 Threaded bolt M8
3 Pipe bracket
4 Distributor

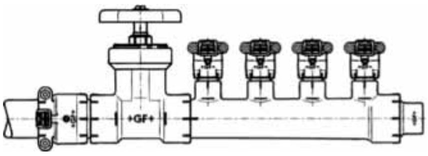
Pipe support

Pipes (d16, d20) are laid in the pipe support and fastened with clips. A reinforcement rod (diameter 10) can be inserted in the pipe support to provide additional support for the pipes upward. Several pipe supports can be positioned side by side, keeping a distance of 45 mm between them.

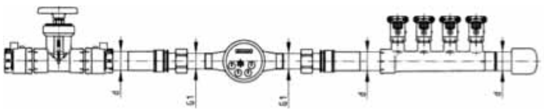


Manifold prefabrication

Multistory manifold

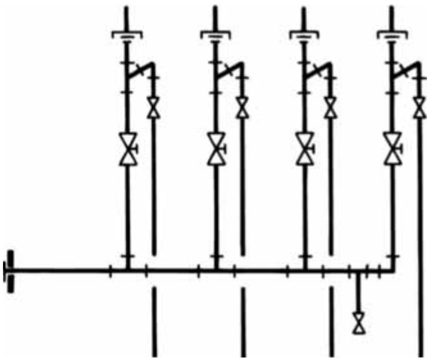


A multistory manifold consists of INSTAFLEX valve with electrofusion union and a multi-distributor with electrofusion unions.



A second version consists of an INSTAFLEX valve with surface-mounted water meter and a multi-distributor. The transitions are made with water meter unions.

Basement manifold

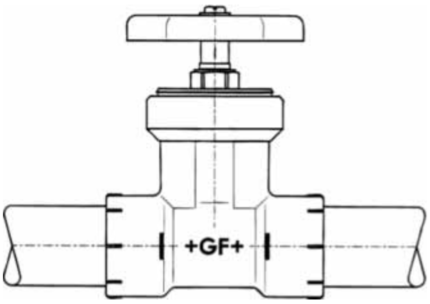


A basement manifold includes shut-off and drain valves as well as threaded outlets. Inlet is with a flanged connection.

Precise pre-fabrication enables optimal on-site working!

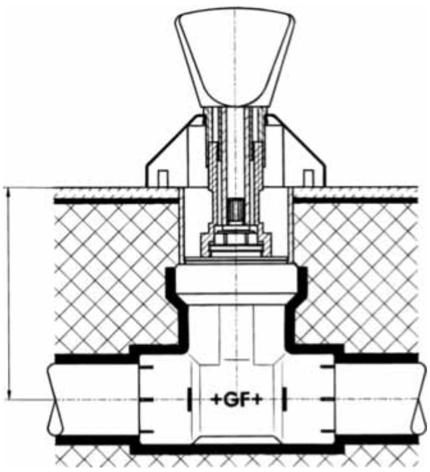
PB valve product description

The valve is designed as a «straight-seat valve», but with full passage, which means it also corresponds to an «angle-seat valve».



Valve with handwheel operation, d20 to d32

Attention:
Do not use the valve with handwheel operation as an outlet or drain valve.



If the valve bonnet is designed appropriately, it can be operated with handwheel or with a commercially available in-wall actuator.

In-wall actuators from H. and F. Grohe, Hansa, and others can be used.

The valve is constructed according to a gate design with direct sealing of the sliding tongue in the valve body. This means the medium can flow in any direction. If the passage cross-section is fully opened with a non-rising valve spindle, it has the characteristic of a free flow valve. Therefore, flow velocities up to maximum 5 m/s* are permitted. Because the valve actuation is 90° to the flow direction, it can be used as a **leg shut-off** as well as an **in-wall valve**. In both cases, the valve bonnet can be replaced.

*per DVGW DIN 1988

Valve with handwheel operation, d40 to d63

Valves with drainage are designed with $^1/_4$" thread on both sides so conventional drain valves can be fitted. The thread insert is rotatable, so the outlet spigot can always be turned in the desired direction, independent of the installation situation.

Technical data for PB valves d20 - d63

- Flow values (see Pipe Network Dimensions)
- Seals
  The seals used are made of ethylene-propylene-di-ene-rubber (**EPDM**) and comply with KTW recommendations (Plastics in Drinking Water) and are approved for a constant operating temperature of 90°C. Short-term peaks up to 120°C are possible.
  Attention:
  In combination with oils, the use of EPDM is conditional.
- Noise behaviour
  The INSTAFLEX valve satisfies the requirements of **DIN 52218**. It is therefore considered a low-noise valve and assigned to **valve group 1**.
  $\mathbf{L}_{AG}$ < 20 dB (A)

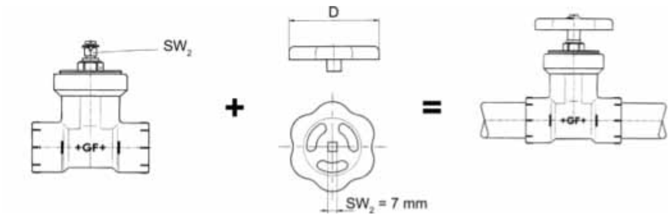
Test certificate number of the DIBt-Berlin PA-IX 7010/I

Assembly and installation instructions

1. Branch/Distributor valve

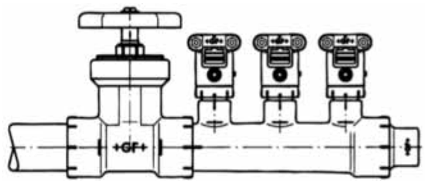
For on-wall installation with handwheel operation, the valve can be used as branch shut-off as well as distribution shut-off.

The valves are fitted with a grey handwheel. The supplied discs (red/green) serve to identify hot or cold water.



Fuse the pipes and/or distributor directly into the valve body as specified in the fusion instructions.

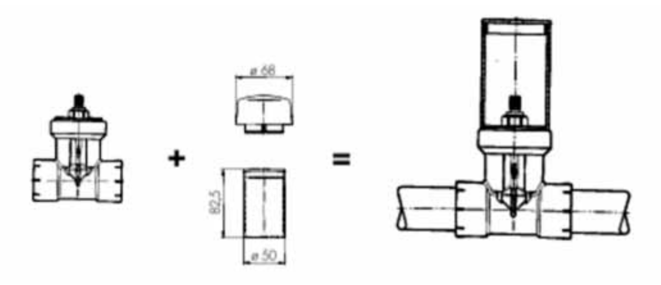
The valve is fused similar to fittings with the INSTAFLEX fusion machine.



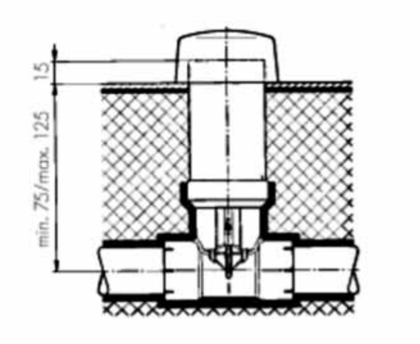
2. Concealed (in-wall) valve without direct operation

For in-wall valves make sure the valve body is not damaged by external effects (masonry). This also applies to the INSTAFLEX pipe.

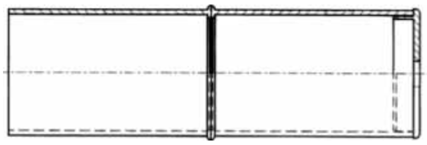
Before installing the valve, place the protective sleeve of the in-wall assembly on the valve. The installation depth of the valve in the wall is between 75 and 125 mm.



Cut off the sleeve 15 mm overlapping the finished wall and put the chrome cap on.

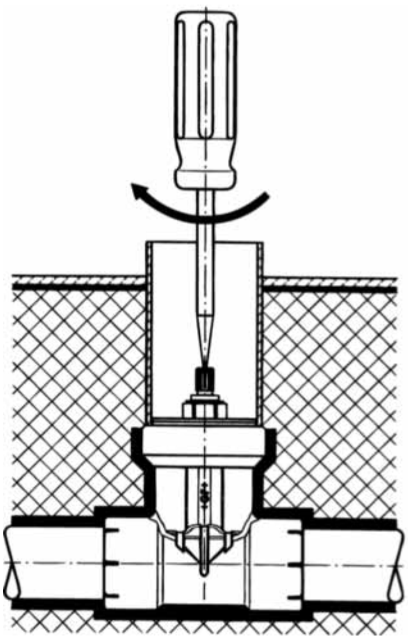


If the installation depth is greater than 125 mm, lengthen the sleeve. This can be done by fusing two sleeves together.



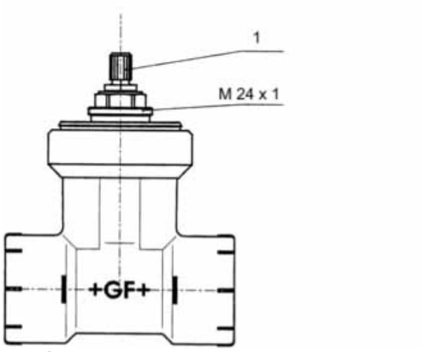
Protection against external damage,
e.g. casing or insulation

The valve is operated with a screwdriver.



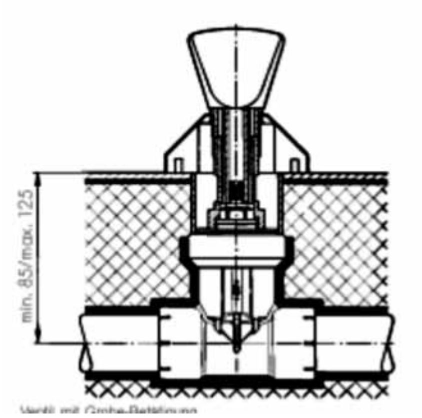
3. In-wall valve for direct operation

For in-wall valves with direct operation, the valve body has been designed to accept conventional actuators from diverse manufacturers (Hansa, Grohe, etc.). The valve bonnet has a valve spindle with a grooved toothing of 8 x 20 teeth and a fastening screw M24 x 1.



1 Grooved toothing ø 8 x 20 teeth

Before installing the valve, put the protective sleeve of the in-wall assembly on the valve. The installation depth depends on the actuating element used.

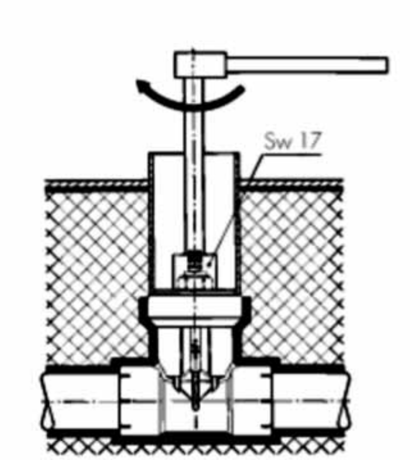


Cut off the sleeve flush with the finished wall. Then mount the actuating element according to the manufacturer's instructions.

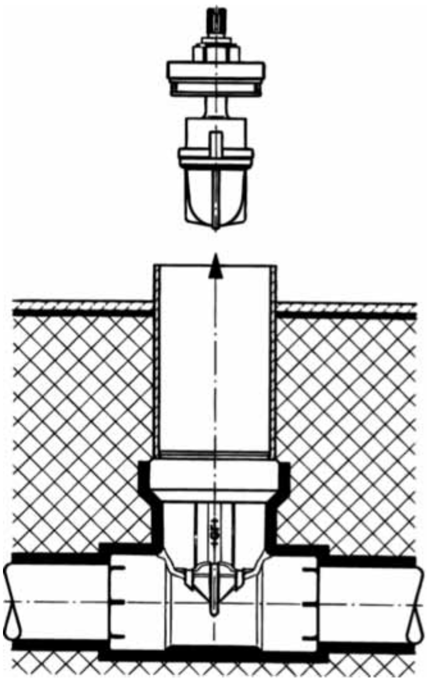
The installation depth varies depending on the type of actuating element. Generally it is between 85 and 125 mm.

4. Replacing the bonnet

The valve bonnet can be replaced in-wall through the protective sleeve. Before dismantling the valve bonnet, remove the cover or the actuating element. Dismantle the valve bonnet with a hexagon socket spanner 17 w/a.

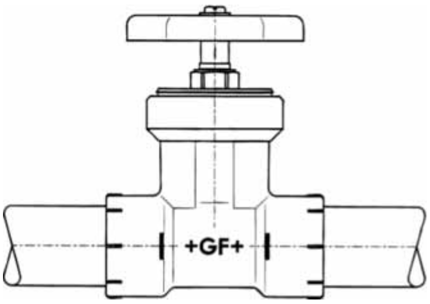


See also the manufacturer's assembly instructions.



Applications

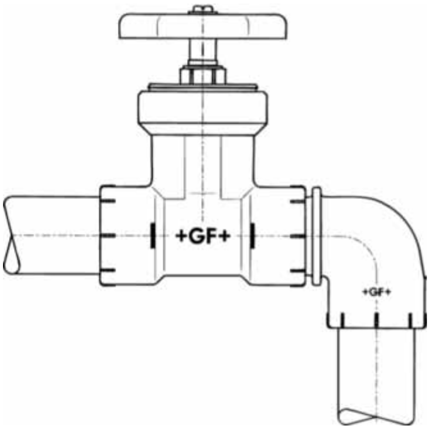
1. Arrangement as a branch shut-off d20 to d63



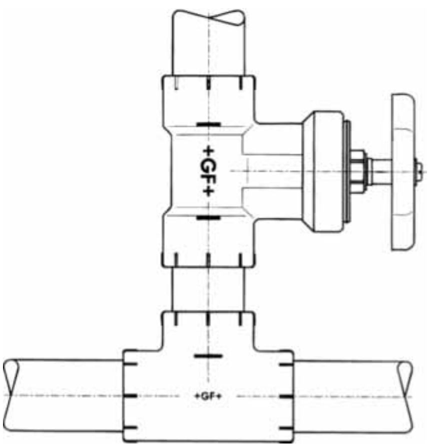
Branch valve horizontal

All valves are available in a socket fusion or electrofusion version.

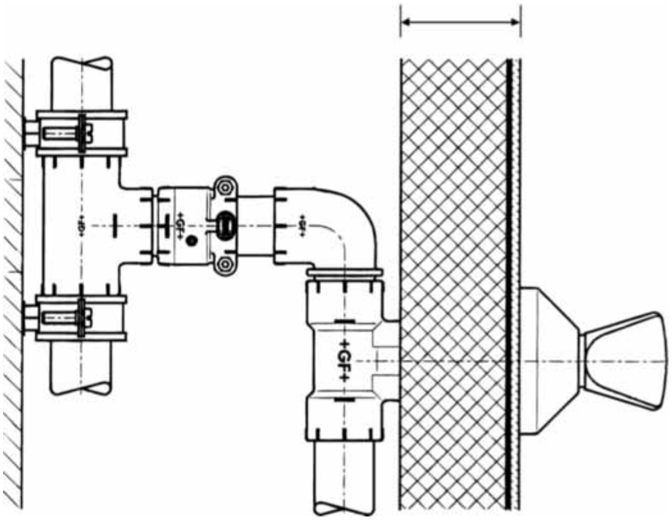
- No restrictions in installation
- Vertical and horizontal installation
- Hanging or standing bonnet
- Any flow direction
- In-wall or on-wall installation
- Pipes, manifolds and fittings can be directly fused in



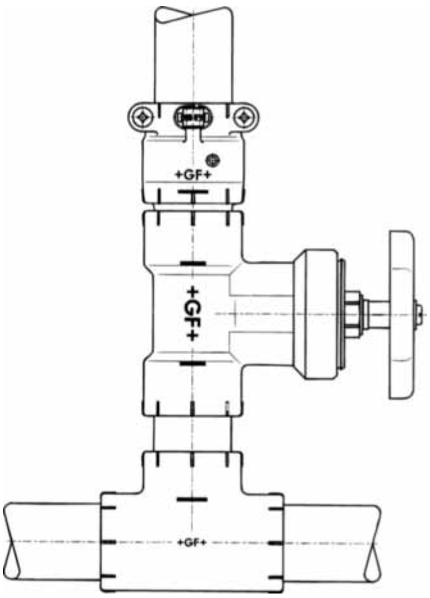
Branch valve with fused-in fitting



Vertical branch valve

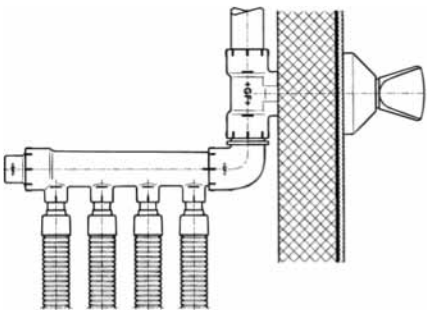


Branch valve with riser pipe outlet, in-wall assembly including fastening

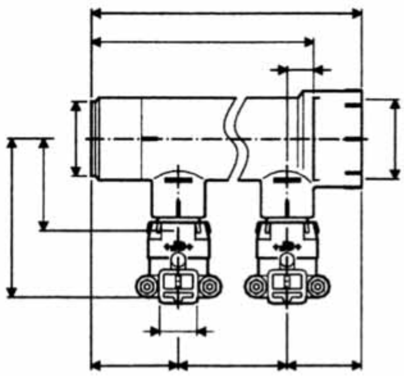


Branch valve with electrofusion adaptor, e.g. for riser pipes

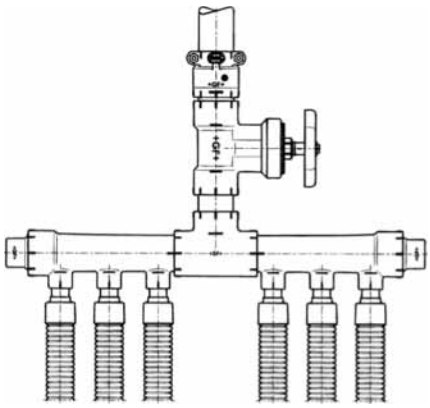
2. Arrangement with PB manifold d25/d32



In-wall valve with manifold in the pipeline shaft

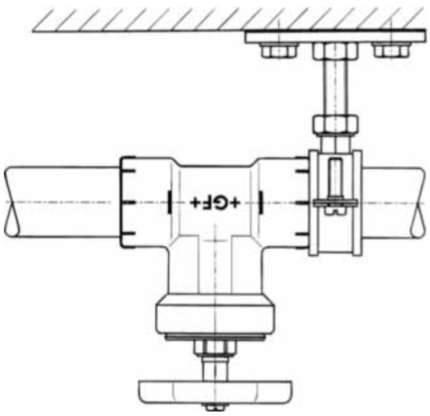


Valve with several distributors

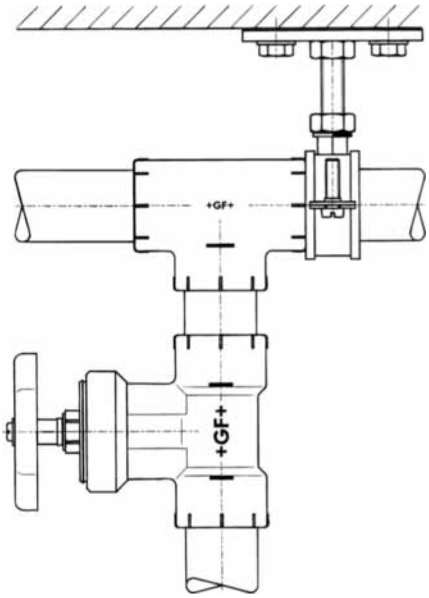


Valve with handwheel, electrofusion adaptor, double manifold

3. Fastening with branch assembly d20 to d63



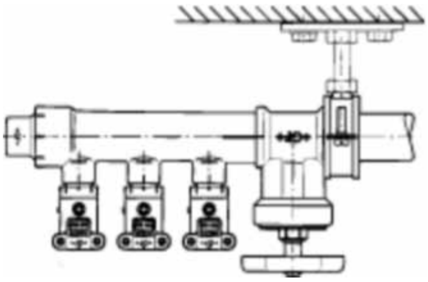
When fastening the valve, make sure that the forces which occur from valve operation are not transferred to the pipeline. Instead, the forces should be deflected via the fastening, which is why a double-sided fastening with two pipe brackets is preferred.
The valve can thus also be used as a **fixed point**.



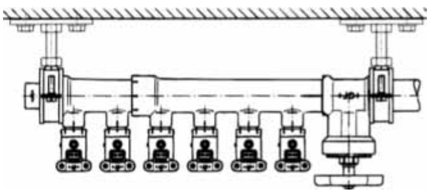
Fastening with conventional pipe brackets

See also the INSTAFLEX product catalogue.

4. Fastening with PB manifold d25

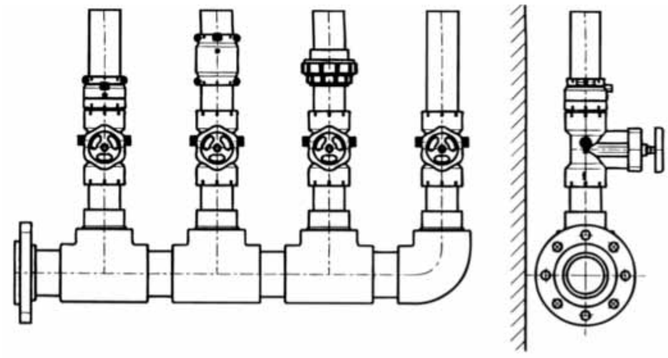


When used with a manifold, the fastening arrangement depends on the number of distributor outlets.

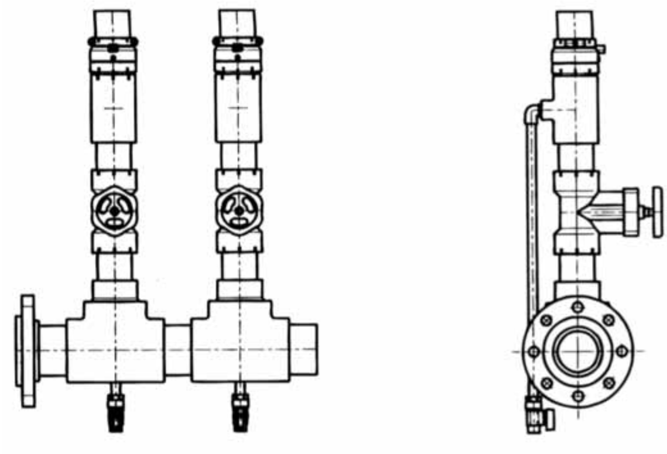


If you are using a short manifold with up to three distributor outlets, it can be fastened to the valve. However, if there are several outlets on the manifold, a separate manifold fastener should be used.

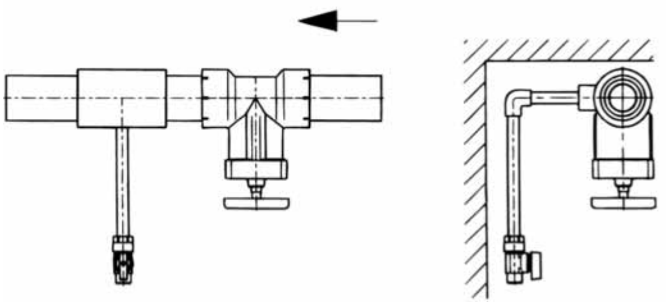
Application examples for PB valves in basement distribution



Basement manifold with INSTAFLEX valves up to d63, with drain valve and various pipe connections



Basement manifold with INSTAFLEX valves without drainage. Drainage is done separately.



Branch shut-off with INSTAFLEX valves without drainage. Drainage is done separately.
– application with thermal insulation throughout.

Valve adaptor unions

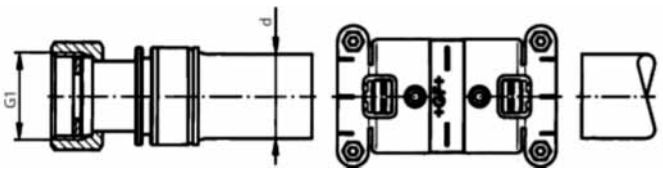
With the **INSTAFLEX valve adaptor union**, durable and leak-proof connections to manifold valves, shut-off valves, return check valves and metal safety groups with external thread for pipe unions (G) can be made.

The external threads of **metal** pipe unions differ however from the external threads of **plastic** pipe unions by one thread dimension.

Example:
Union DN25

- Metal 1"
  Thread **G1½"**
- Plastic (polybutene) d32
  Thread **G 2"**

The jump in dimensions in the union thread (G) is related to the different mechanical stability of the materials (metal/plastic).



The INSTAFLEX valve adaptor union consists of an **intermediate ring**, a **coupling nut** and a **flange sleeve**. The intermediate ring serves to bridge the diameter of the different union threads (G_1 - G). The other two parts are required for socket fusion with seal.

Adaptor union for electrofusion

Special features:

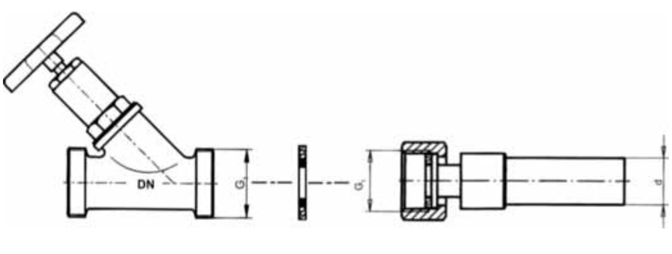
Easy assembly – no special tools required.
Economical in use – much less time and effort necessary.

Technical data

The valve adaptor union consists of a PB flange sleeve with groove and O-ring, a brass coupling nut and a brass intermediate ring (nickel-plated). The design is therefore quite similar to an INSTAFLEX adaptor union.

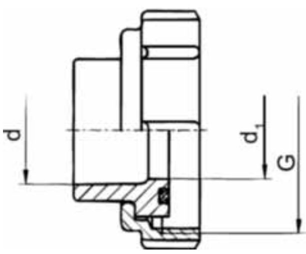
The dimensions are adapted to commercially available angle seat valves and manifold valves as well as safety valves.

For thread (G_1)-pipe (d) combinations that do not fit, a reducer may be welded in to compensate the discrepancy, see Applications.



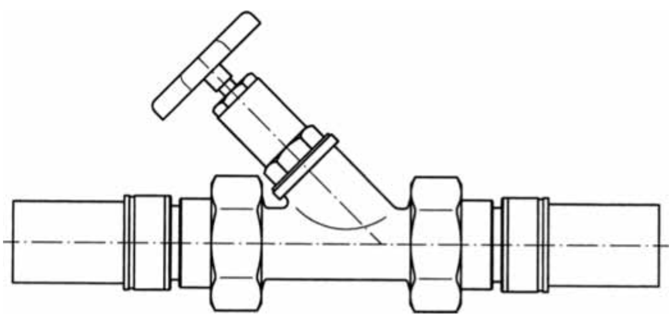
DN	d	G_1
12	16	¾"
15	20	¾"
15	20	1"
20	25	¾"
20	25	1"
20	25	1¼"
25	32	1"
25	32	1¼"
25	32	1½"
32	40	1¼"
32	40	1½"
32	40	2"
40	50	1¾"
40	50	2¼"
50	63	2⅜"
50	63	2¾"

For special applications (see Applications) you can use the brass coupling nut with the PB flange sleeve as direct connection.

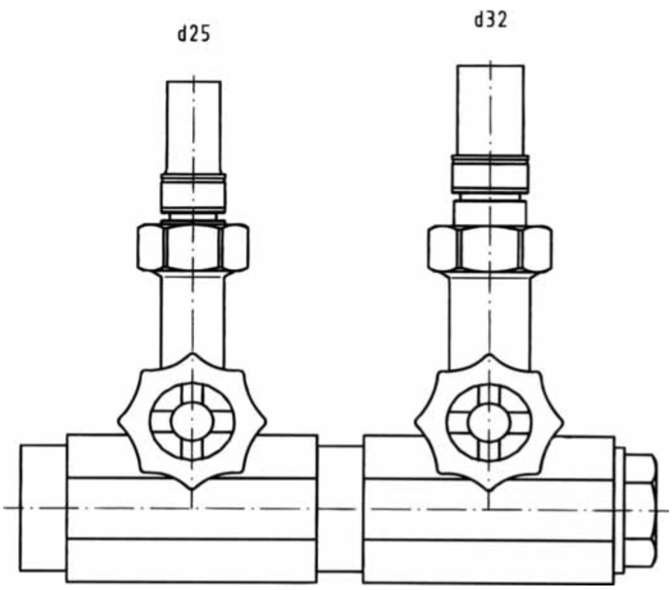


d	G	d_1
16	1	13
20	1¼	16
25	1½	21
32	2	28
40	2½	36
50	2¾	45
63	3¼	57

Applications

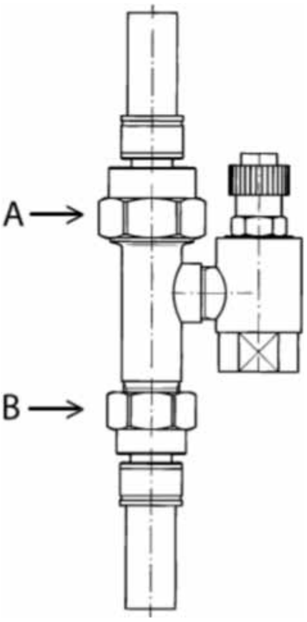


Connection of an angle seat valve with two valve adaptor unions



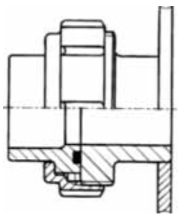
Connection of manifold valves with the valve adaptor union

Changes in diameter can be compensated by welding in reducers.



Connection of a safety group with valve adaptor union and adaptor union with pipe internal thread (Rp thread)

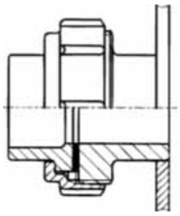
Example:
A d25 - G1 ¼
B d25 - Rp ¾



Tank connections

Direct connection with coupling nut and flange sleeve **with** groove and O-ring.

Make sure the O-ring seal of the flange sleeve lies flat on whole surface.



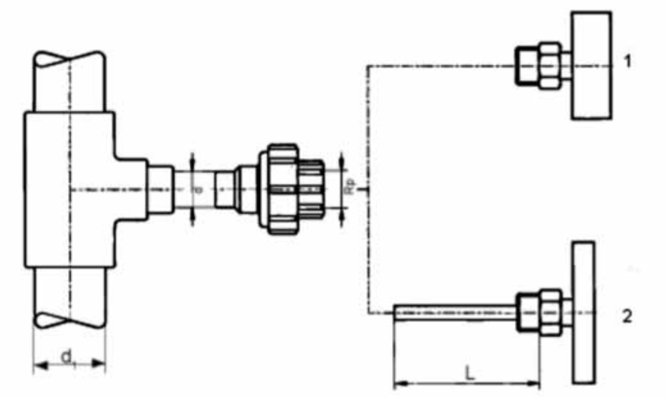
Connections to tanks and valves (filter, pressure reducing valve (PRV))

Direct connection with coupling nut and flange sleeve **without** groove and O-ring.

- only for use with cold water
- sealed with soft rubber gasket

Attention:
This connection **is not an INSTAFLEX system connection** and is therefore **not tested and approved as such.**

Adaptor union for pressure gauge and thermometer



1 Pressure gauge
2 Thermometer

d	Rp
20	½
25	¾
32	1

The length (L) of the immersion sleeve depends on the pipe dimension.

The maximum diameter (d) of the immersion sleeve is 12 mm.

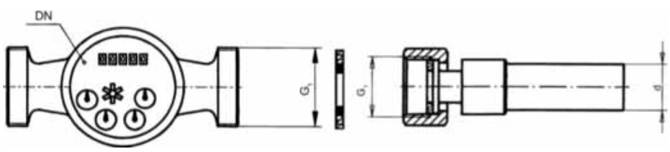
d1	L(mm)
25	≈ 70
32	≈ 70 - 80
40	≈ 90 - 110
50	≈ 100 - 120
63	≈ 110 - 140
75	≈ 150 - 190
90	≈ 170 - 210
100	≈ 180 - 240

Thermometers and pressure gauges can be installed safely in piping systems with the help of adaptor unions.

Water meter union

The **INSTAFLEX water meter union** is the ideal connector between conventional water meters and the INSTAFLEX shut-off valve or distributor. Easy and rational assembly facilitates your work.

Adaptor union for electrofusion



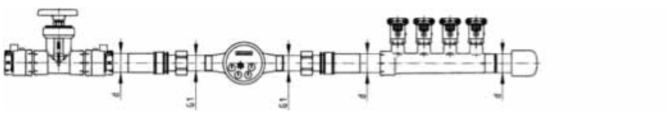
DN	-	G_1
15 (½)	-	¾
20 (¾)	-	1
20(¾)	-	1

G_1	-	d
¾	-	25
1	-	25
1	-	25

Union with socket or spigot

Application tip

The adaptor union is equipped with a flat-sealing thread on one side and a PB flange sleeve (socket) on the other. You can combine diverse dimensions with the available union versions.



Pre-assembled unit with INSTAFLEX valve, water meter, INSTAFLEX manifold and electrofusion adaptors

Drain valves

Connect the drain valve so that its use does not damage the INSTAFLEX pipe.

Always fasten the drain valve directly with a pipe bracket!

Hot water heater

Boiler

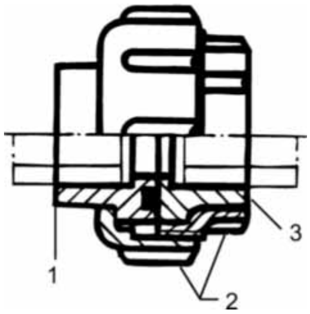
Practical and user-friendly connecting elements make it easier to connect hot water boilers (HW boiler).

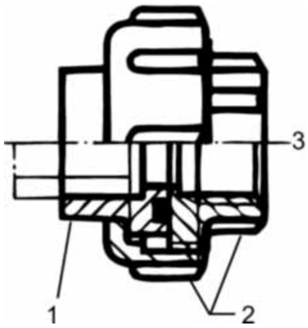
Connect the **safety group** with valve or polybutene adaptor unions depending on the design.

A non-ferrous T-piece is preferred at the **cold water boiler** (CW boiler) inlet so the drain valve can be connected directly. The supply line is connected via an adaptor union with external thread.

The **HW boiler** outlet and the **circulation line** are connected via an adaptor union with internal thread to the boiler.

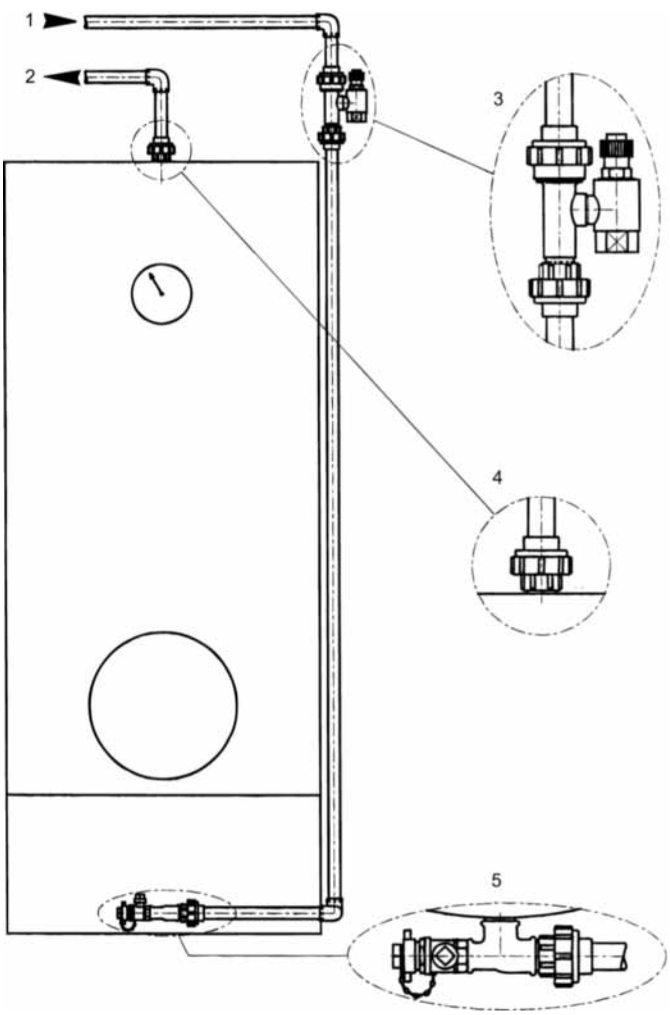
The adaptor unions represent a fast, easy and safe connection technology for boilers and equipment. The INSTAFLEX union offers maximum safety thanks to its perfected design.





1 PB	**1** PB
2 MS	**2** MS
3 PB	**3** Internal thread

The actual connection thread is a metal thread for all unions. This is also true for unions with two weld-on ends.



1 CW inlet
2 HW outlet
3 Safety group
4 Boiler outlet, circulation connection
5 Boiler inlet

Basement distribution and riser pipes

Temperature-related changes in length
When planning and installing basement distribution piping and riser pipes with INSTAFLEX pipes and fittings, it is important to remember temperature-related changes in length, in addition to the structural requirements.

According to the basic laws of physics, all pipe materials expand when heated and contract when cooled. This material behaviour must be taken into consideration when installing drinking water pipes.

The temperature-related change in length occurs with a change in the ambient and operating temperatures. In assembly, this pertains to:

1. Pipeline installation

2. Rigid installation

For **visible** runs of INSTAFLEX pipes, a straight pipeline is achieved with the use of carriers.

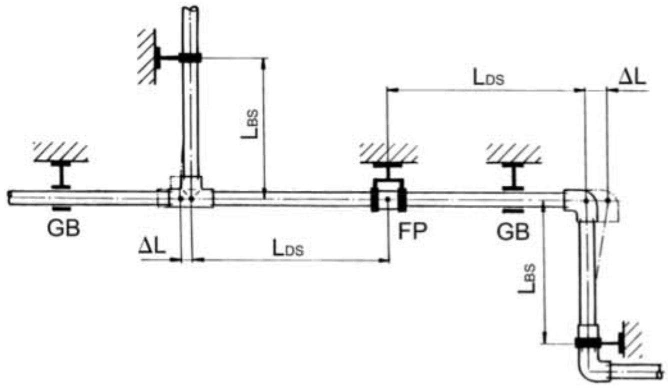
Pipeline installation with flexible sections

With the flexible pipes from INSTAFLEX, temperature-related changes in length in a drinking water pipeline can be absorbed in **short flexible sections.**

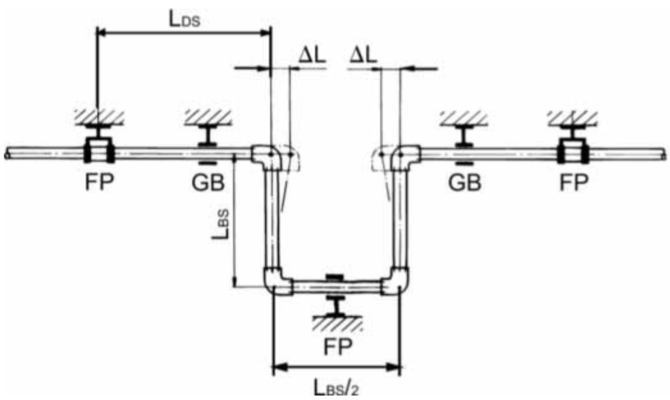
To prevent pipeline deflection, pipe carriers should not be used in the area of the flexible section. You can use flexible sections or expansion compensators in a number of ways:

I. Classic arrangement of flexible sections

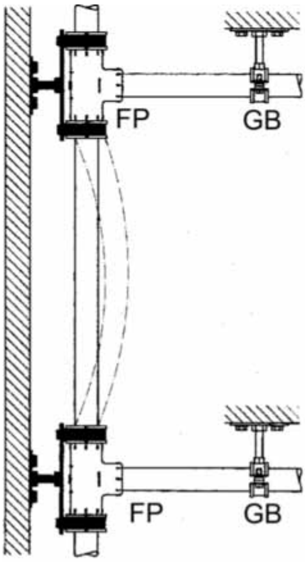
ΔL = Temperature-related changes in length
L_{DS} = Length of the expansion loop
FP = Fixed point
GB = Sliding fastener
L_{BS} = Length of flexible section



II. Expansion bend



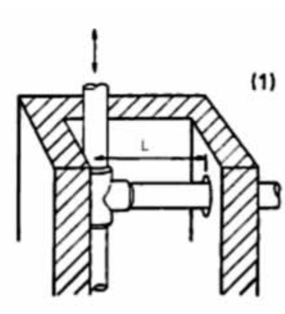
III. Flexible section with lateral yield of pipe

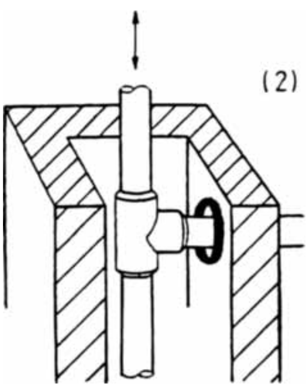


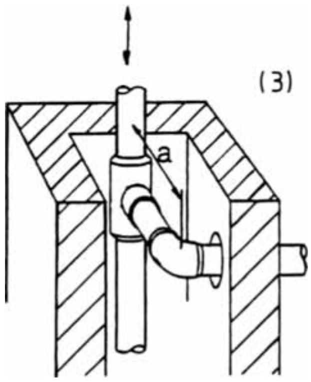
IV. Flexible sections in shafts

If pipes run off from the riser mains in shafts of multistory installations, make sure that the branch can rebound to take up the changes in length in the riser. There are 3 ways to do this:

- favourable positioning of the riser in the shaft (1)
- a large enough hole in the wall for the branch line (2)
- building an expansion loop (3)

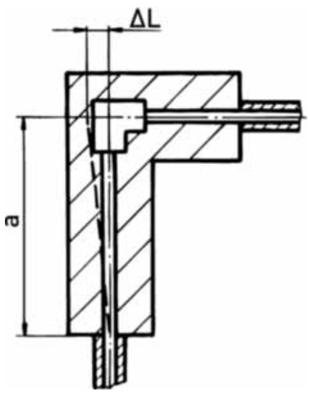


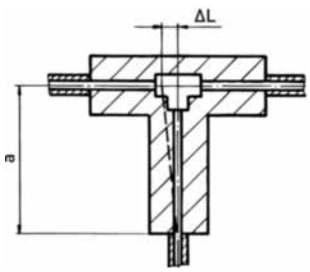




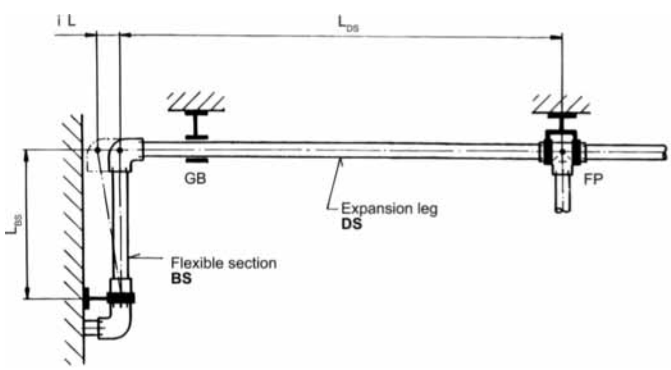
V. Flexible sections for in-wall installations

If the entire pipeline is installed in-wall, it must be insulated according to the applicable guidelines with commercially available insulating materials. Envelop the flexible section with elastic material (mineral wool, foam or similar) so that changes in length are not hindered. In most cases, the required insulation thickness is sufficient for the thermal expansion.





Graphic determination of flexible section length



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INSTAFLEX PB pipe

Temperature-related changes in length Δ l are determined from the temperature difference Δ ϑ and the expansion loop length L_{DS}.

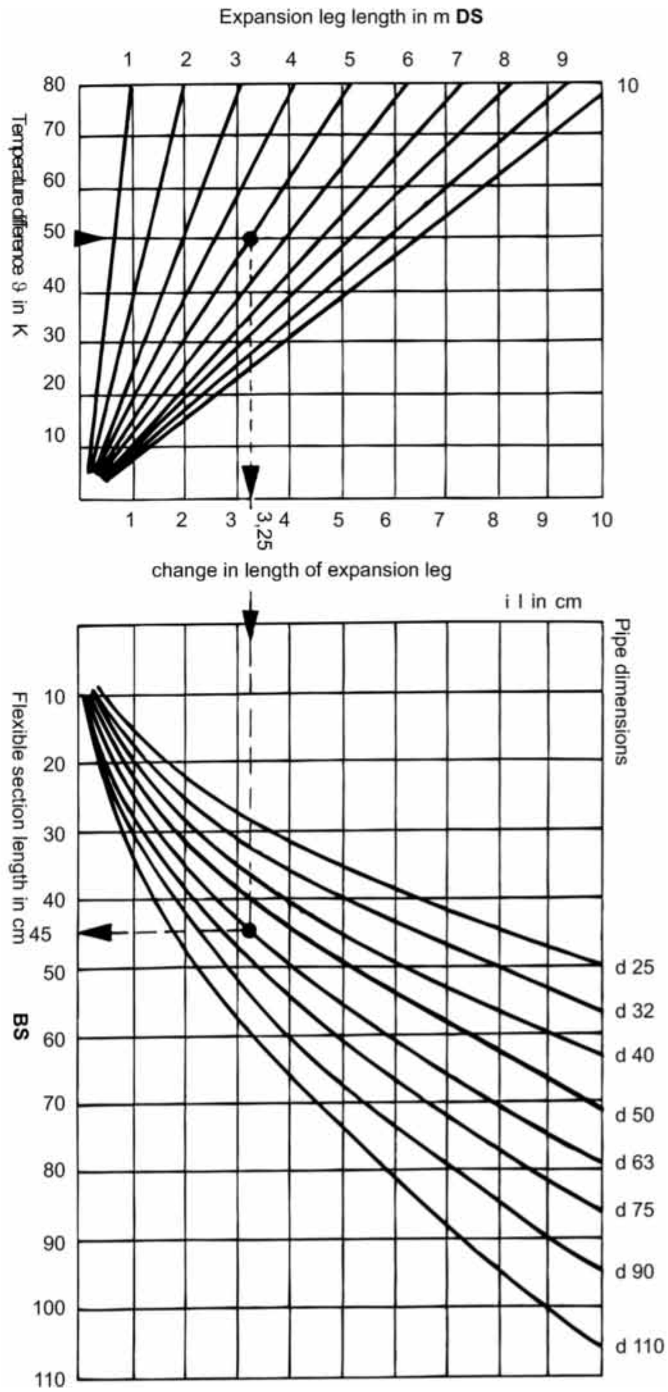
The flexible section length L_{BS} is determined from the change in length Δ l and the pipe outer diameter d.

Example:

L_{DS} = 5 m
Δ ϑ = 50 K
d_a = 63 mm

L_{BS} = 45 cm
See diagram below.

Diagram to determine length of flexible section



Calculating the flexible section length

Calculating the change in length ΔL

The temperature-related change in length is calculated with the following formula:

$$\Delta L = \alpha \times L \times \Delta T$$

ΔL	=	Temperature-related change in length [mm]
α	=	Coefficient of linear expansion [mm/mK]
L	=	Length of pipeline [m]
ΔT	=	Temperature difference [K]

INSTAFLEX pipes
α = 0.13 mm/mK corresponds to 1.3×10^{-4} mm/mmK

Calculating the flexible section length
Calculate the minimum length of the flexible section using the following formula:

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

Definition of symbols:

d_a	=	pipe outer diameter (mm)
ΔL	=	change in length (mm)
E_{cm}	=	average bend-creep module
σ_b	=	permissible bending stress

Calculation example:
The length of the pipeline is 5 m. The temperature-related change in length of this pipe section has to be taken up with a flexible section. The temperature difference between the installation temperature and the maximum operating temperature is 50 K. For this calculatation, PB pipe 63 x 5.8 mm with an outer diameter of 63 mm is used.

Determining the flexible section length:
ΔL = α x L x ΔT
ΔL = 0.13 (mm/mK) x 5 m x 50 K
ΔL = 32.5 mm change in length

To determine the required length of the flexible section more easily, the diagram for flexible section length determination can be used.

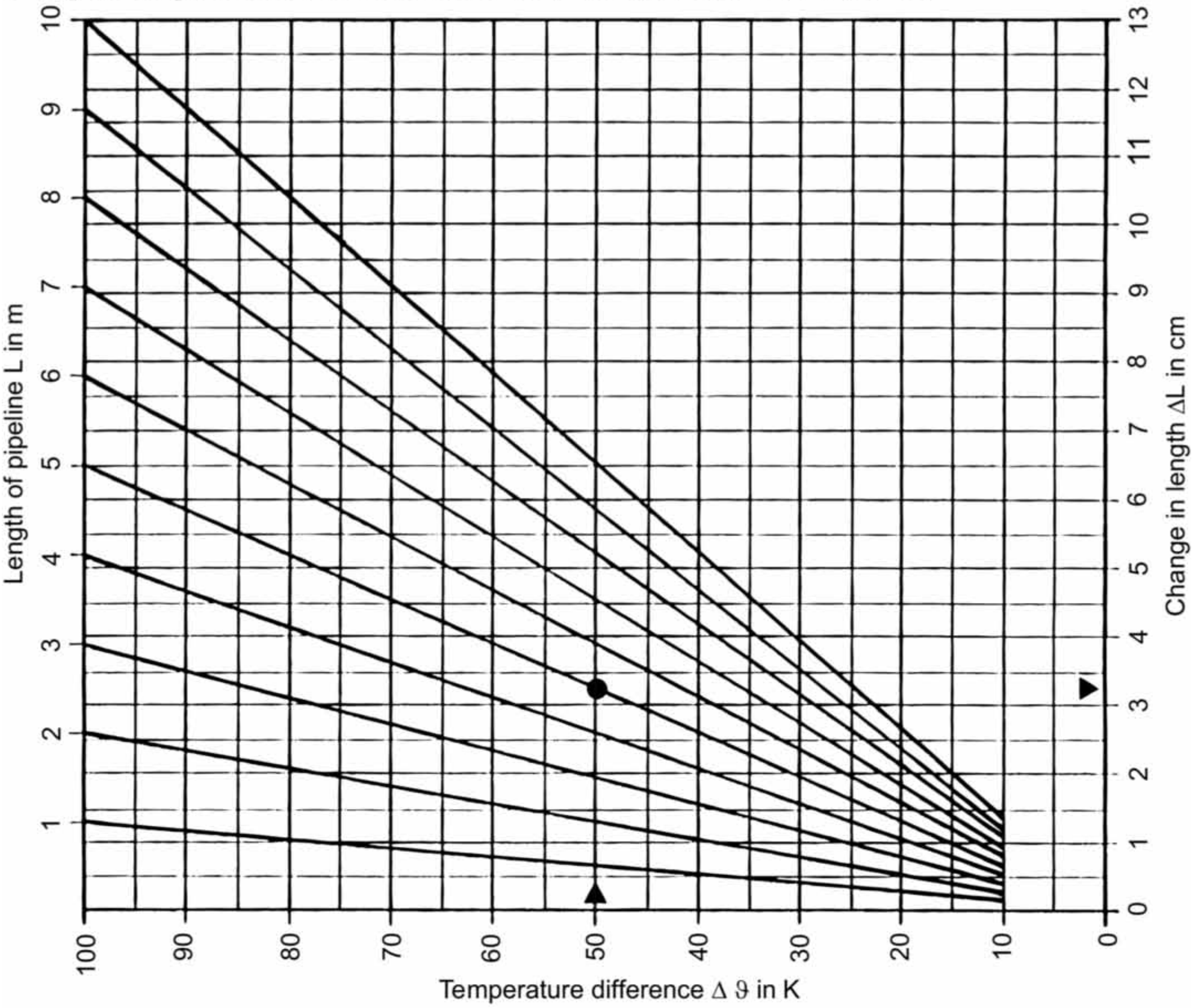
L_{BS} = 45 cm length of flexible section

If we compare this data with the data for a metal pipe in the same dimension, we see that the flexible section for the metal pipe must be much larger. The reason for this is the significantly higher material constant C for metal pipes than for a polybutene pipe.

Temperature-related change in length ΔL [cm] for INSTAFLEX PB pipe

Pipeline	Temperature difference Δ [K]									
[m]	**10**	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**100**
0.1	0.01	0.03	0.04	0.05	0.07	0.08	0.09	0.10	0.12	0.13
0.2	0.03	0.05	0.08	0.10	0.13	0.16	0.18	0.20	0.23	0.26
0.3	0.04	0.08	0.12	0.16	0.20	0.23	0.27	0.31	0.35	0.39
0.4	0.05	0.10	0.16	0.21	0.26	0.31	0.36	0.42	0.47	0.52
0.5	0.06	0.13	0.20	0.26	0.33	0.39	0.46	0.52	0.59	0.65
0.6	0.08	0.16	0.23	0.31	0.39	0.47	0.55	0.62	0.70	0.78
0.7	0.09	0.18	0.27	0.36	0.46	0.55	0.64	0.73	0.82	0.91
0.8	0.10	0.21	0.31	0.42	0.52	0.62	0.73	0.83	0.94	1.04
0.9	0.12	0.23	0.35	0.47	0.59	0.70	0.82	0.94	1.05	1.17
1.0	0.13	0.26	0.39	0.52	0.65	0.78	0.91	1.04	1.17	1.30
2.0	0.26	0.52	0.78	1.04	1.30	1.56	1.82	2.08	2.34	2.60
3.0	0.39	0.78	1.17	1.56	1.95	2.34	2.73	3.12	3.51	3.90
4.0	0.52	1.04	1.56	2.08	2.60	3.12	3.64	4.16	4.68	5.20
5.0	0.65	1.30	1.95	2.60	3.25	3.90	4.55	5.20	5.85	6.50
6.0	0.78	1.56	2.34	3.12	3.90	4.68	5.46	6.24	7.02	7.80
7.0	0.91	1.82	2.73	3.64	4.55	5.46	6.37	7.28	8.19	9.10
8.0	1.04	2.08	3.12	4.16	5.20	6.24	7.28	8.32	9.36	10.40
9.0	1.17	2.34	3.51	4.68	5.85	7.02	8.19	9.36	10.53	11.70
10.0	1.30	2.60	3.90	5.20	6.50	7.80	9.10	10.40	11.70	13.00

Change in length due to thermal effects in ΔL in cm for INSTAFLEX PB PIPE



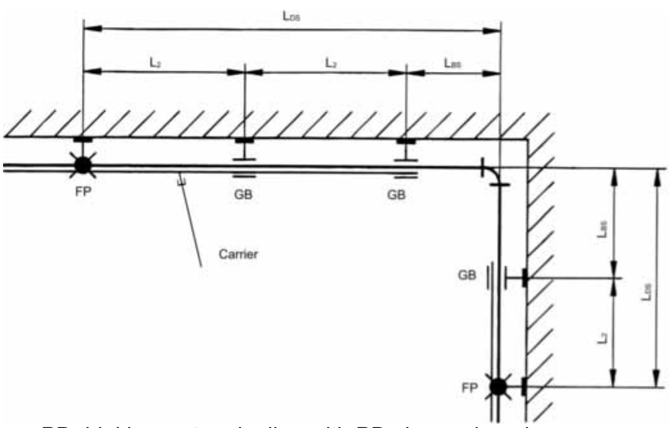
Arrangement and spacing of pipe brackets in flexible section installation

Place the pipe brackets so that the changes in length are not hindered. Make sure that the pipes can rebound in holes through walls and floors. For longer pipelines you can divide up the length changes with fixed points in order to absorb them better.

Table to determine pipe bracket spacing

	PB pipe					
Pipe dim.	Cold water pipeline under 20 °C			Hot water pipeline over 20 °C		
	without carriers	with carriers		without carriers	with carriers	
d x s	L_1 [cm]	L_2 [m]	Pipe bracket	L_1 [cm]	L_2 [m]	Pipe bracket
16 x 2.2	50			35		
20 x 2.8	60	ca. 1.5 - 2 m	0.5 m	40	ca. 1.5 - 2 m	0.25 m
25 x 2.3	70			45		
32 x 3.0	80			50		
40 x 3.7	80	ca. 1.5 - 2 m	0.75 m	50	ca. 1.5 - 2 m	0.5 m
50 x 4.6	100			60		
63 x 5.8	125			75		
75 x 6.8	150			90		
90 x 8.2	180	ca. 1.5 - 2 m	0.75 m	110	ca. 1.5 - 2 m	0.5 m
110 x 10.0	200			130		
125 x 11.4	200			150		
160 x 14.6	200	2 m	0.75 m	190	ca. 2 m	0.5 m
225 x 20.5	200			190		

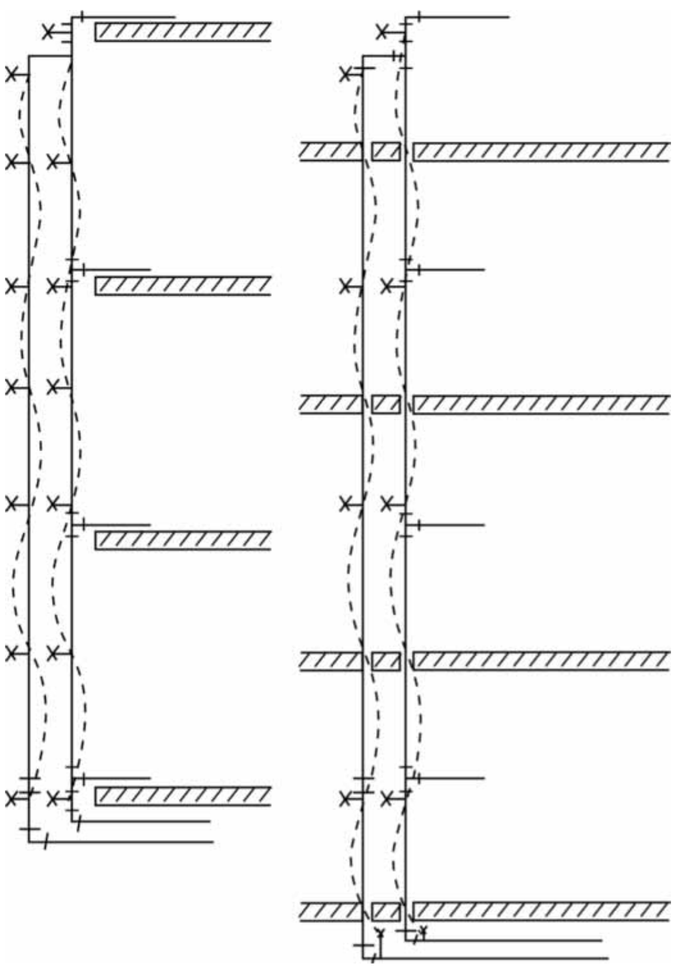
Individual fixed point spacing depending on building situation.
There are no carriers for d90 to d110 in the INSTAFLEX product range.



PB drinking water pipeline with PB pipe and carrier
FB = Fixed point
GB = Sliding fastener

As illustrated above, carriers are not used in the area of the flexible section so that the deflection is not hindered.

Fastening technology for riser pipes in shafts



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Requirements:

- Use suitable pipe fastening to ensure that a fixed point is created at the bottom and top T-piece (floor outlet).
  Definition of fixed point:
  Fastening which prevents axial movement of the pipe and the pipe bracket in any direction (traction forces).
- Position the pipe fastening directly at each floor outlet (above or below the T-piece).
- If the floor outlet is at midway height of the room (ca. 0.4 m), one pipe fastening per floor is enough.
- If the T-piece is located at the height of the top edge of floor, a second fastening is required.
- Only use flexible insulation (e.g. Armaflex, glass or mineral wool or similar) for HW riser pipes.

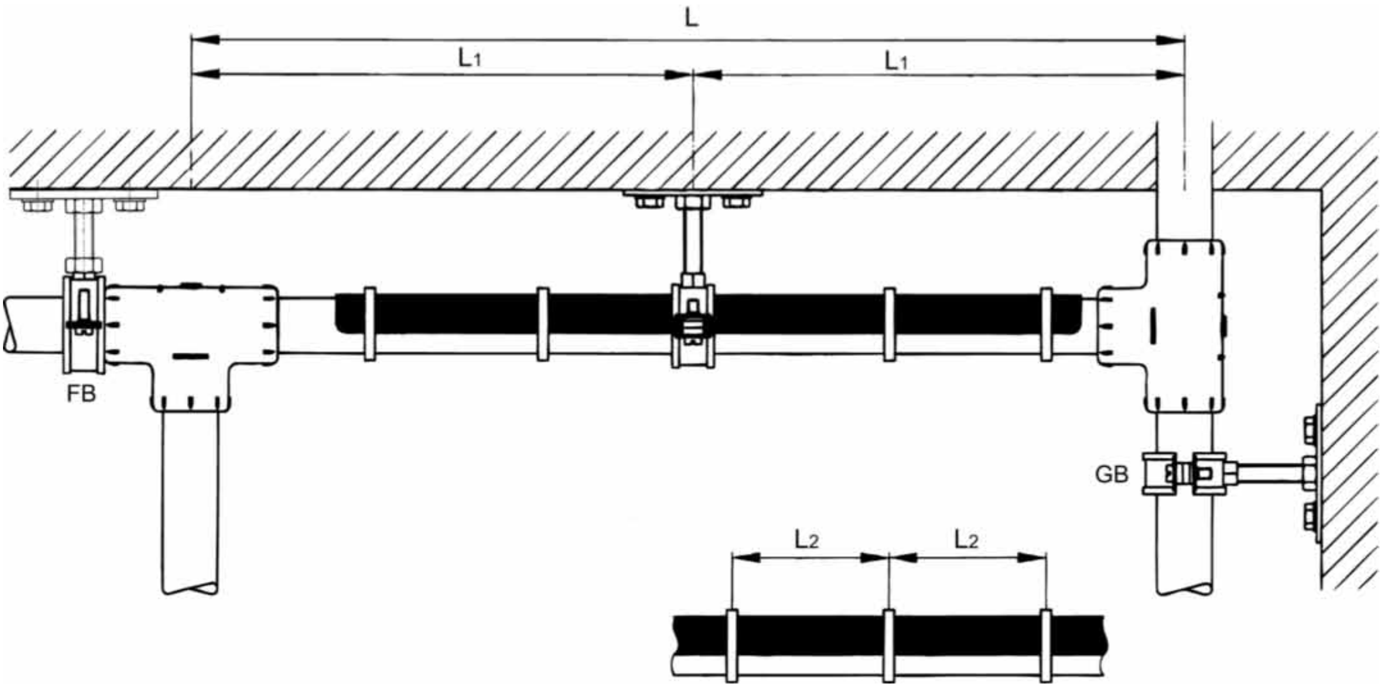
Experience (based on testing and practice):
Thanks to their flexibility, hot water INSTAFLEX pipes bend out freely without large axial thrust forces. You can support this free movement by using flexible insulation wherever possible. The insulation also protects against mechanical damage.

Basic principle:
Riser pipes in shafts enable absorbing the thermal expansion by letting the INSTAFLEX pipes «bend out» at the floor height. This lateral bending has no negative effects on the polybutene material, regardless whether one, two or more pipe fastenings are used.

Rigid installation - laying pipelines without pipe expansion

A rigid installation is a straight pipeline between two fixed points in which the pipe cannot move laterally. The temperature-related change in length is absorbed in the INSTAFLEX pipe. The thermal expansion forces of the pipe are transferred via the fixed point to the structure.

For **INSTAFLEX pipes** rigid installation is only possible with pipe carriers. The forces which act on the fixed point depend on the pipe cross-section, the temperature difference and the pipe material. They are however much higher than for installations with flexible sections, which is why you need additional support fixtures at greater wall and floor spacing.



Use of carriers in fixed point installations

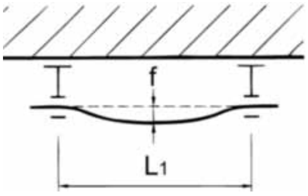
If lateral movement of the INSTAFLEX pipes is not desired, you can install the INSTAFLEX pipes with clip carriers. The pipe is ca. 60 % enclosed by the carrier and pipe deflection is prevented. The temperature-related change in length is also reduced. INSTAFLEX pipe installations with clip carriers have to overlap 25 cm so that a temperature-related change in length is possible.

Arrangement and spacing of pipe brackets in rigid installations

Pipe dim. d mm	Fixed point spacing L	Fast.spacing L_1 CW	Pipe binder spacing L_2 CW	Fast.spacing L_1 HW	Pipe binder spacing L_2 HW
16/20/25	individual depending on building site	1.5 - 2.0 m	0.5 m	1.5 - 2.0 m	0.25 m
32/40/50 63/75/90/110		1.5 - 2.0 m	0.75 m	1.5 - 2.0 m	0.5 m

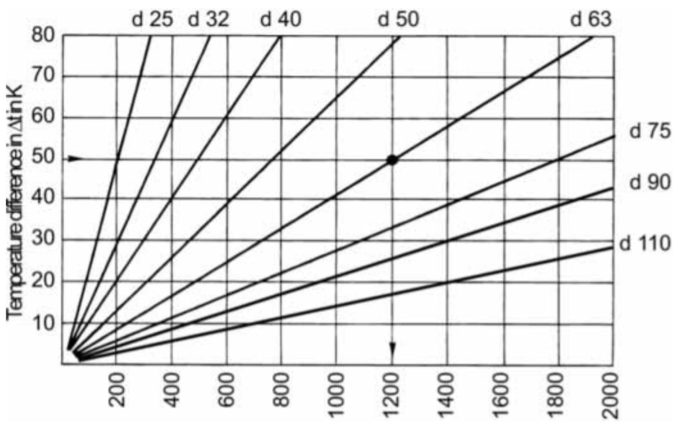
Deflection of straight PB hot water pipes [mm]

Support spacing	d							
L_1 in mm	40	50	63	75	90	110	125	160
500	2.5							
600	3.5	3.0						
750	6.0	4.5	3.5					
900	9.0	6.5	5.0	4.5				
1100		11.0	8.0	6.5	5.5			
1300			11.5	9.0	7.5	6.0		
1500				13.0	10.0	8.0	7.0	
1700					12.0	9.0	8.0	6.5
1900						10.5	9.0	7.0



There are no pipe carriers for d90 and d110 in the INSTAFLEX product range.

Expansion forces at the fixed points due to differences in temperature



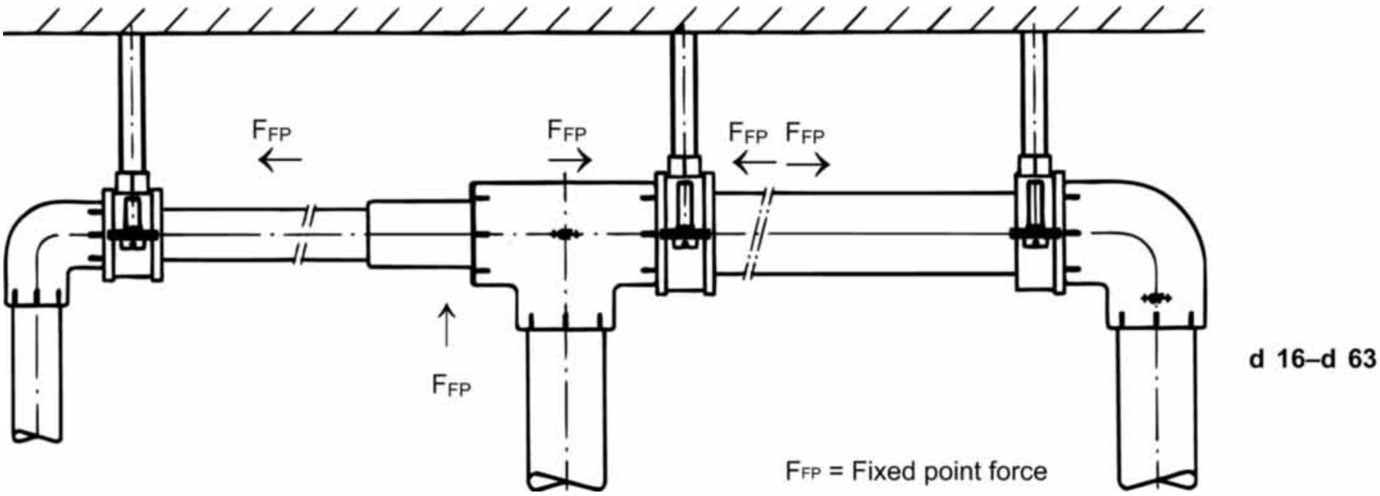
Pipe expansion force F_R in N
In rigid assemblies, the expansion forces which occur are transferred from the fixed points to the building structure.

Example:
The temperature difference between the installation temperature and the operating temperature is 50 K. The INSTAFLEX pipe used in this example has d63 dimension.
The expansion force taken from the above diagram is therefore 1200 N.

F_{FP}= fixed point force
F_R= pipe exansion force
F_R = F_{FP} = 1200 N

More information on how to calculate the expansion forces can be found in the section "linear expansion".

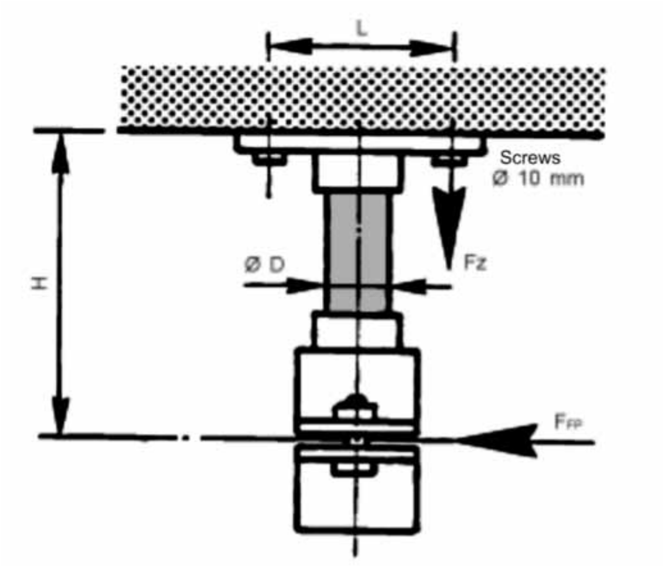
The expansion forces that initially occur in rigid assemblies convert in time to tensile forces. This conversion depends on the load caused by the change in temperature. It is therefore important when designing fixed points to remember that not only expansion forces but also tensile forces need to be absorbed.



For pipelines which are reduced two or more dimensions in the passage, the reduction point should be fastened with a fixed point.

Calculating the fixed point fastening

$F_Z = (F_{FP} \times H) / (L \times X)$



D	= diameter of fastening
H	= distance between wall or floor and pipeline
L	= distance between screws
X	= number of screws subject to tensile load
F_{FP}	= fixed point forces (N)
F_Z	= screw or dowel retention force (N)

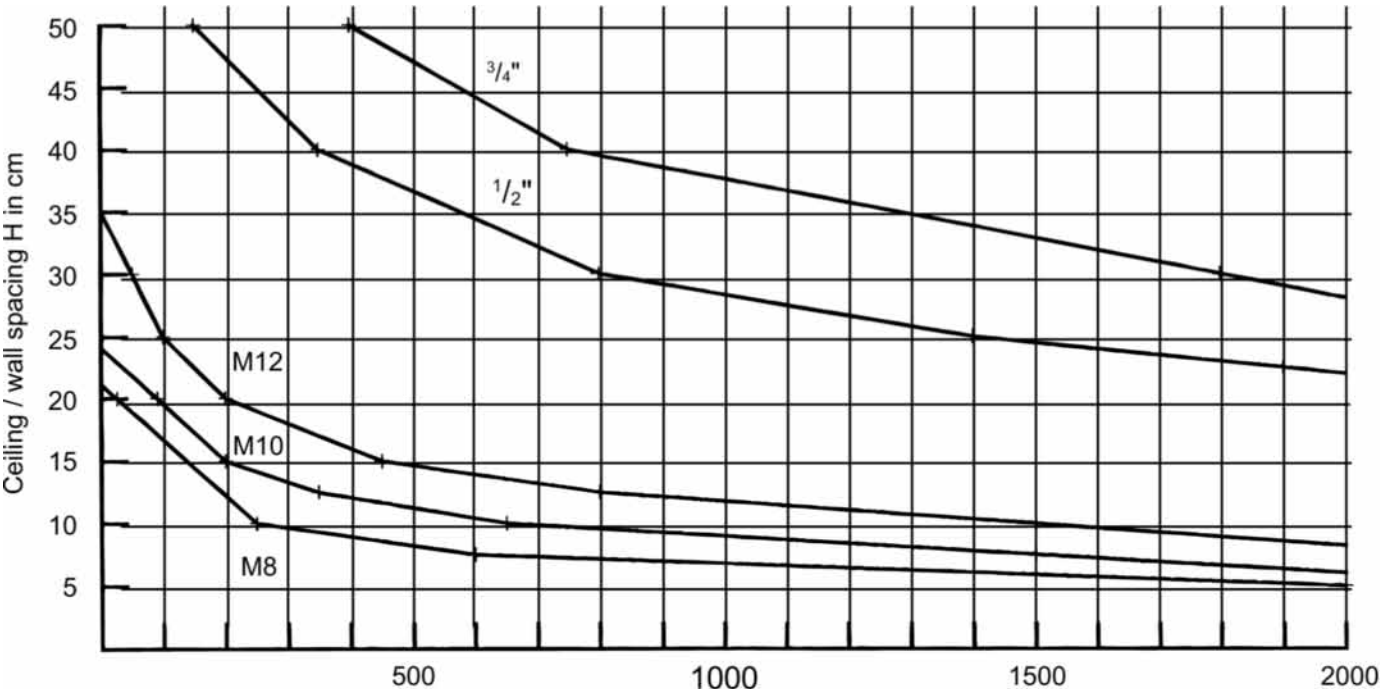
2-hole base plate
x = 1

4-hole base plate
x = 2

Example:
F_Z= (1200 N x 20 cm) / (12 cm x 2) = 1000 N

Retention force per screw
F_Z = 1000 N

Choice of fastener diameter (D) of pipe bracket on base plate

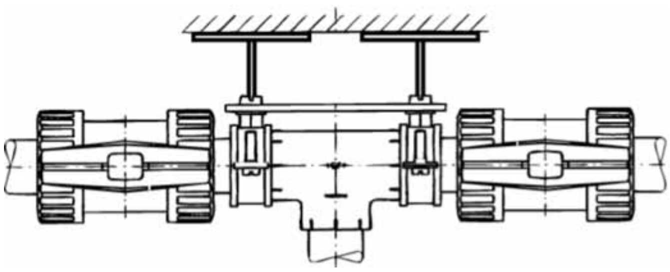


The diameters given in the diagram are reference values, based on a deflection of ca. 5 mm.
For a more precise calculation, please see the pipe bracket manufacturer's data.

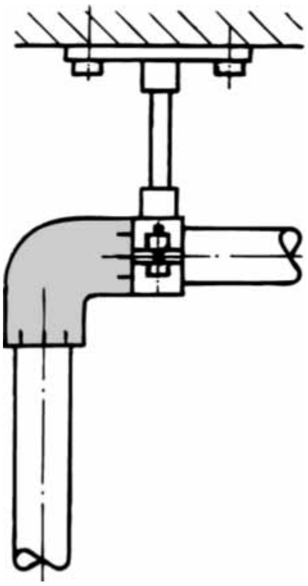
Realising fixed points and sliding fasteners

Arrangement of fixed points «FP»
Fixed points direct temperature-related expansions in the pipeline in a desired direction. Fixed points should always be arranged at a fitting and supported on both sides.

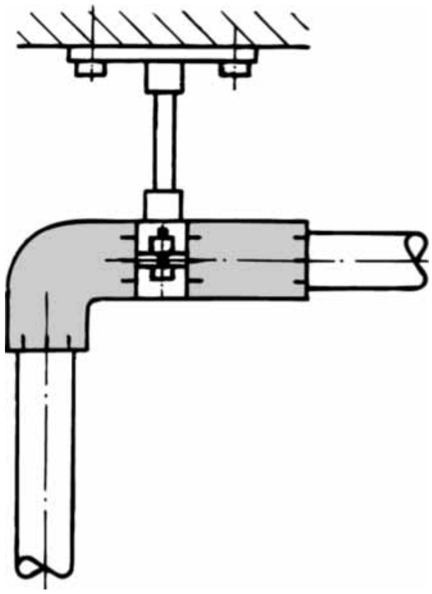
Some installation examples of fixed points:



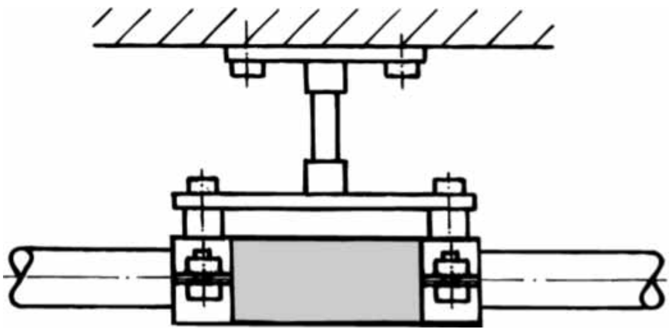
up to d63



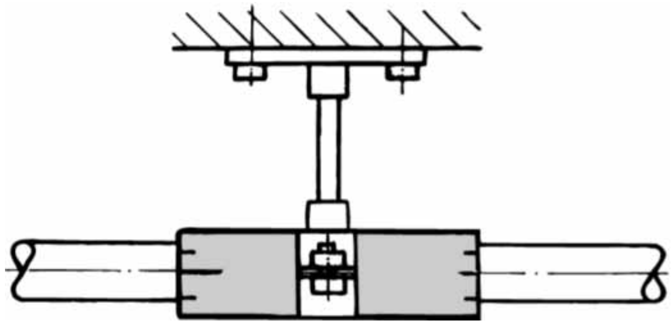
up to d63



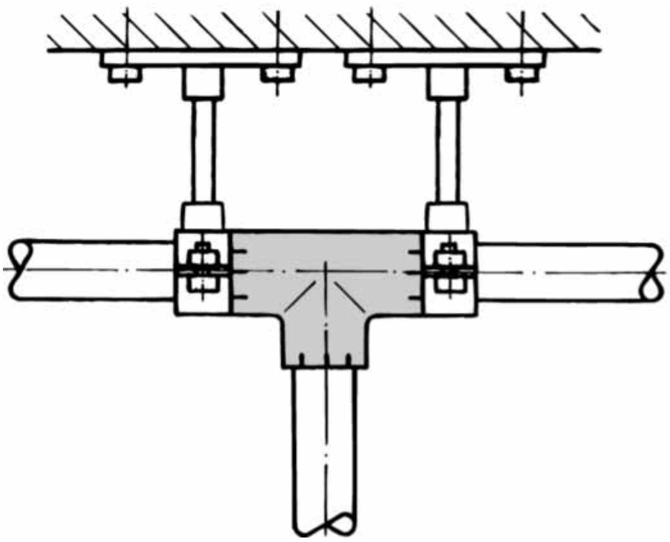
from d75



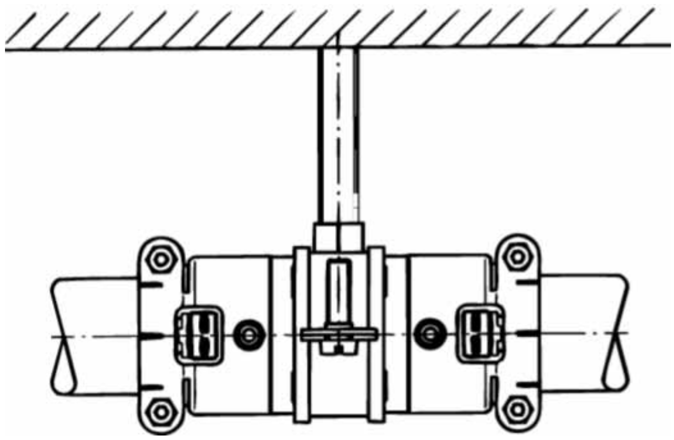
up to d63



from d75



from d75



Fixed point with half of an electrofusion socket
Supplied on request.

If you use metal valves up to d63, we recommend fastening them with 2 pipe brackets.

If you use metal valves d75 and larger, fasten the valves directly on the fitting.

Fixed point layout for rigid installation of INSTAFLEX hot water pipes d16 to d63

Distance to floor in cm	d25	d32	d40	d50	d63
to 10	M8	M8	M10	M10	½ "
to 15	M10	½ "	½ "	½ "	½ "
to 20	½ "	½ "	½ "	½ "	½ "
to 25	½ "	½ "	½ "	½ "	½ "
to 30	½ "	½ "	½ "	½ "	¾ "
to 35	½ "	½ "	½ "	¾ "	¾ "
to 40	½ "	½ "	¾ "	¾ "	¾ "
to 45	½ "	¾ "	¾ "	¾ "	¾ "
to 50	½ "	¾ "	¾ "	¾ "	¾ "

For dimensions ≥ d75 contact our technical support.

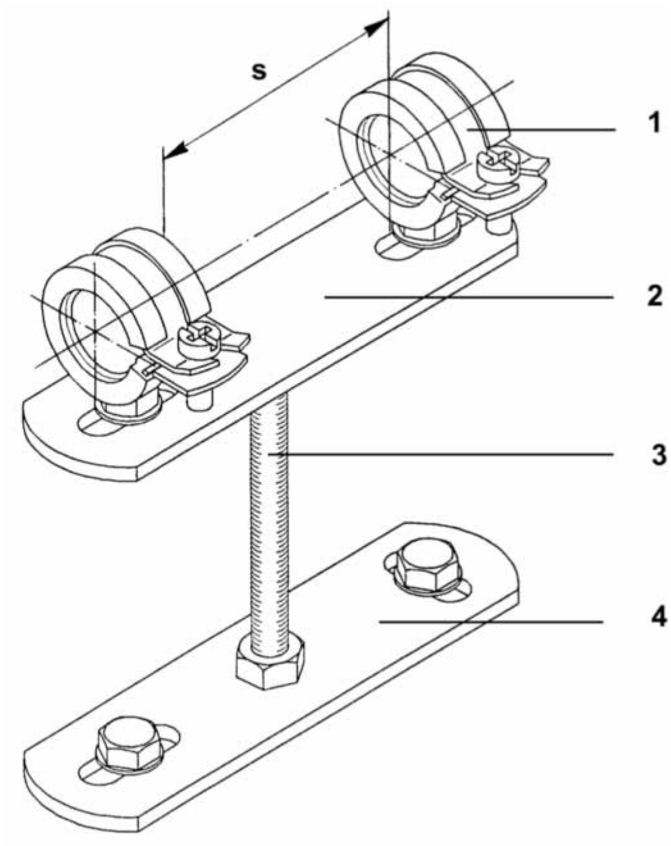
Basics:

Due to the low expansion forces of PB, conventional pipe brackets with rubber linings up to d63 are sufficient. They should always be tightened firmly.

Recommendations:

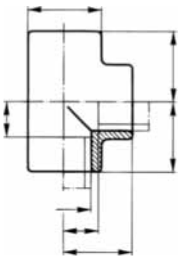
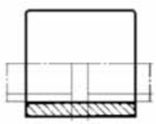
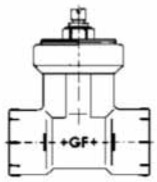
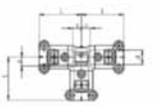
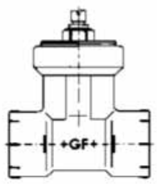
- Always install visible and horizontal pipelines with carriers
- Always fasten INSTAFLEX pipelines tightly with pipe brackets with rubber linings and threaded rods (min. M8)
- Place sockets, valves, etc. directly at a pipe bracket so there is no interruption in the carrier
- Always mount clip carriers flush
- Other carriers should always overlap ca. 25 cm and be tied with zip ties
- For long pipelines, we recommend first aligning the pipe brackets with a string

Fixed point configuration



1 Pipe bracket
2 Carrier plate
3 Threaded rod
4 Base plate

Selecting a carrier plate (Table 1)

			Pipe dimension d							
			d16	d20	d25	d32	d40	d50	d63	d75
			Carrier plate no.							
Socket Fusion Fittings	T equal, T red.		1	1	2	2	2	3	3	4
	Socket		1	1	1	1	1	1	1	2
	PB valves			2	2	2	3	3	4	
Electrofusion Fittings	T equal, T red.		2	3	3	3	4	4	4	
	Socket		1	1	2	2	2	2	3	4

Determining the pipe bracket spacing (Table 2)

Carrier plate no.	1	2	3	4
Pipe bracket spacing s	33 - 63	64 - 94	97 - 125	132 - 162

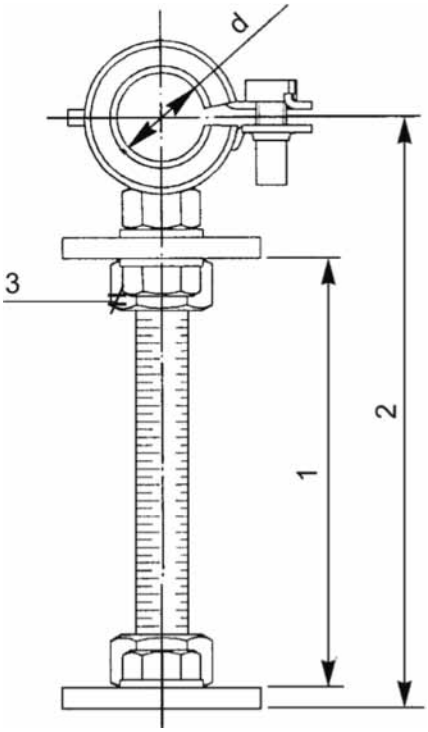
Example:
A fixed point needs to be installed at the T-piece d40. In Table 1 we see that the carrier plate no. 2 is required. In Table 2 a pipe bracket spacing between 64 - 94 mm is given for carrier plate no. 2.

Selecting the threaded rod

INSTAFLEX pipe dimension

Distance to floor		d16	d20	d25	d32	d40	d50	d63
	10 cm	M10	M10	M10	M10	M10	M10	½ "
	15 cm	M10	M10	M10	½ "	½ "	½ "	½ "
	20 cm	M10	½ "	½ "	½ "	½ "	½ "	½ "
	25 cm	½ "	½ "	½ "	½ "	½ "	½ "	½ "
	30 cm	½ "	½ "	½ "	½ "	½ "	½ "	¾ "
	35 cm	½ "	½ "	½ "	½ "	½ "	¾ "	¾ "
	40 cm	½ "	½ "	½ "	½ "	½ "	¾ "	¾ "

Please note that all the data given in these tables is based on a temperature difference of 60 K.



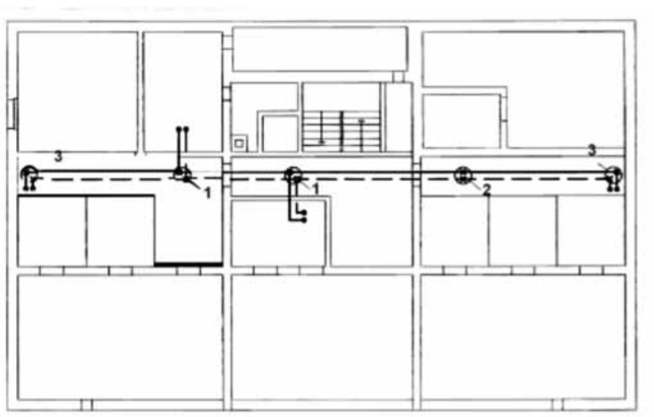
1 Length of threaded rod L
2 Centre distance A
3 Reducer M10 - ½"

1 = 2 - x

		x	
for threaded rod		**M10**	**½ "**
Pipe bracket diameter d	16	27	49
	20	31	53
	25	33	55
	32	38	60
	40	42	64
	50	46	68
	63	53	75
	75	60	82

Rigid installation

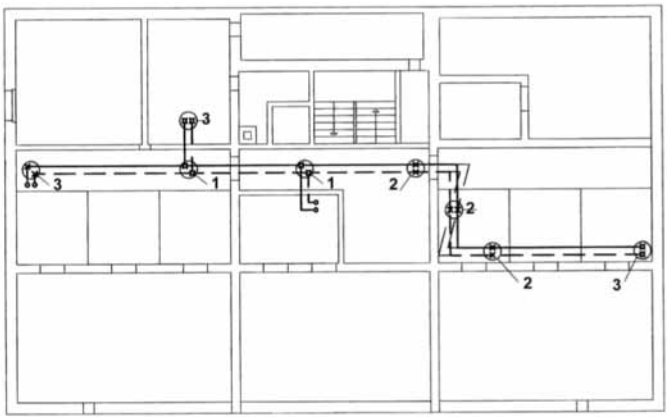
The three floor plans below show possible placement of fixed points.



1 on T-piece
2 on pipeline
3 on change in direction

For basement distribution, only use rigid installation with carriers and position the fixed points at branches and in the pipeline.

Rigid installation and flexible sections

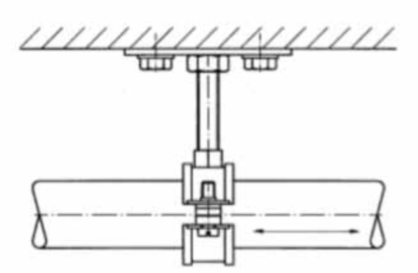


Pipes from basement manifolds can be installed rigid in some places and with flexible sections in others. Position the fixed points at branches and in the pipeline.

Attention:
Do not install any carriers in the area of flexible sections or else the deflection of the pipeline will be hindered.

Sliding fastener (GB)
Sliding fasteners enable the pipeline to move in the axial direction. Avoid jamming.
Only use pipe brackets and fastening materials which satisfy the following conditions:

- suitable for plastic pipes
- noise insulating bracket lining available
  Select the size of the pipe bracket according to the pipe dimension to ensure smooth sliding during operation and to prevent the bracket lining from being pulled out.



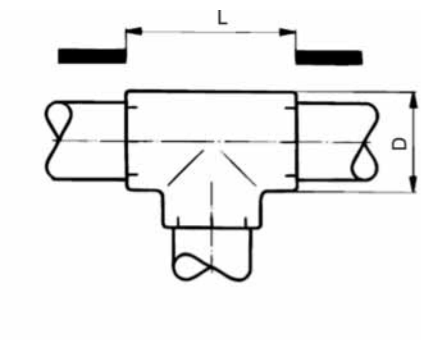
Pipe bracket diameters and spacing for INSTAFLEX fittings

INSTAFLEX pipes

d16	
d20	
d25	
d32	
d40	Pipe diameter corresponds
d50	to pipe bracket diameter
d63	
d75	
d90	
d110	

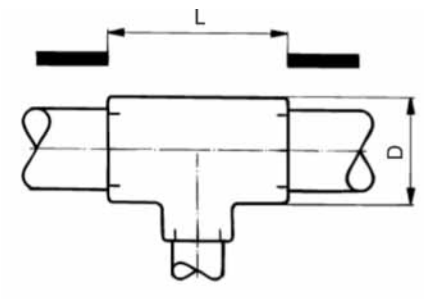
INSTAFLEX fittings with socket fusion joints

T 90° equal



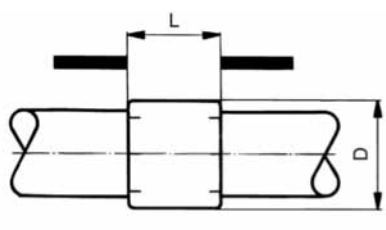
Dimension	D	L
16	22	50
20	26	56
25	32	64
32	40	76
40	51	88
50	64	102
63	81	124
75	91	150
90	112	176
110	132	210

T 90° reduced



Dimension	D	L
20-16-20	26	56
20-16-16	26	56
20-20-16	26	56
25-16-25	32	64
25-20-25	32	64
25-20-20	32	64
25-25-20	32	64
32-16-32	40	76
32-20-32	40	76
32-25-32	40	76
40-16-40	51	88
40-25-40	51	88
50-16-50	64	102
50-25-50	64	102
63-16-63	81	124
63-25-63	81	124

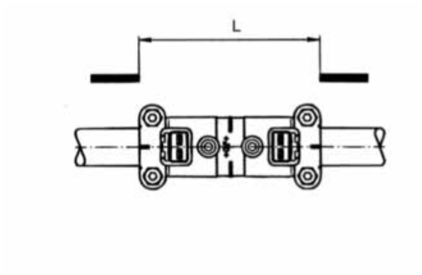
Socket



Dimension	D	L
16	22	33
20	26	33
25	32	39
32	40	43
40	51	48
50	64	54
63	81	60
75	91	69
90	110	80
110	133	94

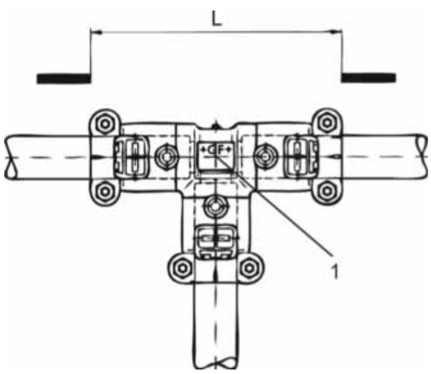
INSTAFLEX fittings with electrofusion joints

Socket



Dimension	L
16	76
20	80
25	85
32	85
40	95
50	99
63	102
75	134
90	147
110	160

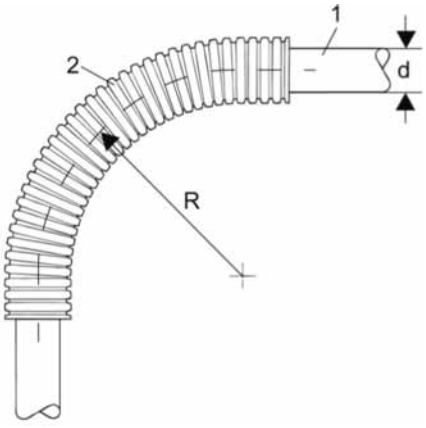
T 90° equal
T 90° reduced



Dimension	L
16	94
20	108
25	116
32	120
40	138
50	156
63	1172
75	224
90	254
110	292

Bending radius for PB pipes

INSTAFLEX pipes d16, d20 and d25 are always bent **cold**. A minimum bending radius is required for bending which is compatible with the material.

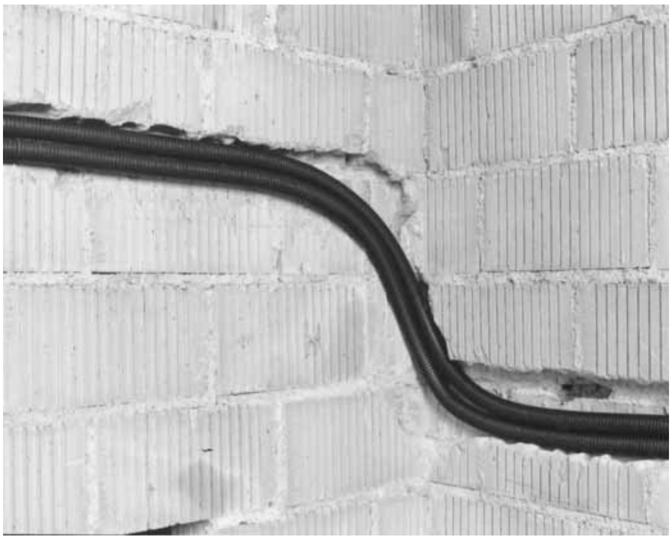


INSTAFLEX pipes	With bending tool (90 °) 5xd		By hand (90 °) 10xd	
Pipe dimension	Bending radius R mm	Radian measure B mm	Bending radius R mm	Radian measure B mm
16	80	125	128	201
20	100	157	160	251

INSTAFLEX pipes	With bending tool (90 °) 8xd		By hand (90 °) 10xd	
Pipe dimension	Bending radius R mm	Radian measure B mm	Bending radius R mm	Radian measure B mm
25	200	314	250	392
32	256	402		

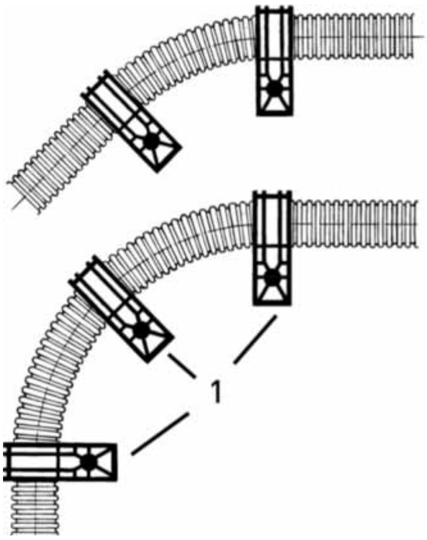
INSTAFLEX pipes	With bending tool (90°) 35xd at **+10 °C**	
Pipe dimension	Bending radius R mm	Radian measure B mm
40	1400	2198
50	1750	2748
63	2205	3462
75	2625	4121
90	3150	4946
110	3850	6045

INSTAFLEX pipes	With bending tool (90°) 20xd at **+20 °C**	
Pipe dimension	Bending radius R mm	Radian measure B mm
40	800	1256
50	1000	1570
63	1260	1978
75	1500	2355
90	1800	2826
110	2200	3454

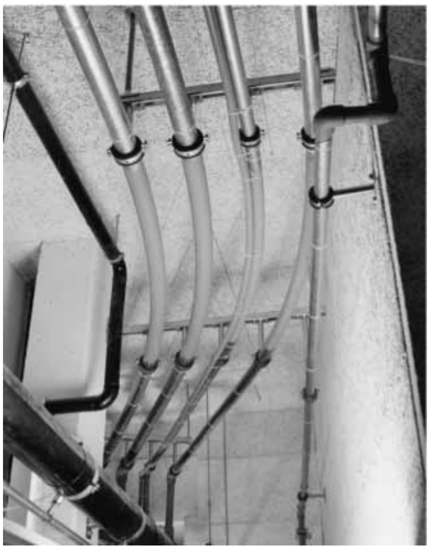


Make certain that the minimum bending radius is kept when transitioning from the floor to the wall.

- The minimum bending radius refers to the pipe centre.
- You may not go below the minimum bending radius.
- Ensure that there are no dents or compressions after the bending process.
- **Hot bending of PB pipes is prohibited.**
- Commercially available pipe bends can be used to bend the pipes. It is important that the bending radii given here are adhered to and that the pipe is not damaged or buckled.
- The given temperatures only pertain to the bending process.
- From dimension d40 and up, you may not subject the pipes to a pressure test immediately after bending. The waiting time for a pipe temperature of 10 °C is 48 hours. At a pipe temperature of 20 °C the waiting time is 18 hours.
- If the pipes are only briefly bent, e.g. to insert them in a shaft, the pipes may be bent with a bending radius of at least 15xd at an ambient temperature of 10 °C. For an ambient temperature of 20 °C the minimum short-term bending radius is 9xd.



1 Pipe fastening in bending area
d16 R = 130 mm
d20 R = 160 mm
d25 R = 200 mm



Linear expansion

It is a law of nature that all solid bodies expand to some degree when heated and they contract again when cooled.
A rod with an **original length L_0** exhibits a **change in length ΔL** when heated by a **temperature difference Δϑ**.

The temperature-related **coefficient of linear expansion α** indicates the lengthening value at a temperature increase of 1 K for a 1 m rod.

ΔL	= Temperature-related change in length
L	= Pipe length

The average linear expansion coefficent for:

INSTAFLEX PB pipes

α = 0.13 mm / mK ≙ 1.3 x 10^{-4}mm/mm K

The temperature-related change in length is calculated with the following formula:
ΔL = α x L x Δϑ

Pipeline calculations

Determining the pipe expansion forces in a «rigid installation»

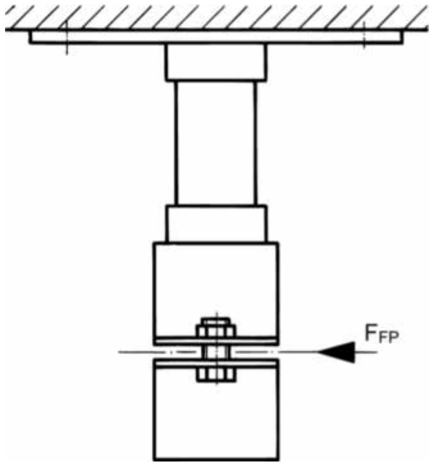
$F_R = A_R \times E \times \varepsilon$

Under the load condition, thermal expansion is **ε = α x Δϑ** .

Determining the fixed point forces in a flexible section installation

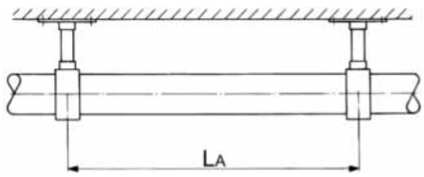
$$F_R = \frac{12 \times \Delta L \times E \times J_R}{L_{BS}^{3}}$$

$$J_R = \left(da^4 - di^4\right) \times \frac{\pi}{64}$$



Determining the pipe support distances

$$L_A = 0{,}916 \times \sqrt[3]{\frac{E \times J_R}{q}}$$



Determining the bending stress

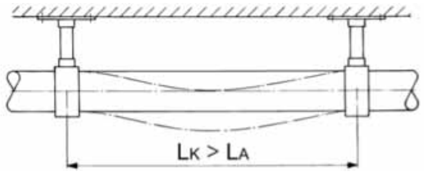
$$\delta_B = \frac{q \times L_A^{2}}{8 \times W_R}$$

$$W_R = \frac{\left(da^4 - di^4\right)}{da} \times \frac{\pi}{32}$$

Determining the allowed unsupported length for fixed clamped pipe sections

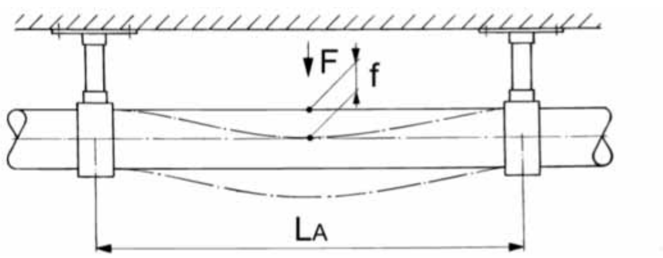
$$L_K = 3{,}17 \times \frac{\sqrt{J_R}}{5 \times A_R}$$

L_K with minimum safety factor of **S_K = 2**
L_K greater than L_A



When you lay pipelines so that axial expansion is not possible, you should compare the determined pipe support distance L_A with the allowed unsupported length L_K, i.e.
L_A may not be larger than L_K.

α	Coefficient of linear expansion	m/mK mm/mmKN
F_R	Expansion force of pipe	N
ΔL	Change in length of the expansion loop	mm
E	Elasticity modulus	N/mm^2
ε	Prevented change in length, calculation of the prevented change in length always only on **one** meter pipe length	
A_R	Pipe ring surface	mm^2
L_{BS}	Length of flexible section	mm
J_R	Torque of inertia of pipe	mm^4
L_A	Distance between pipe supports	mm
q	Distributed load, weight of pipe incl. content	N/mm
W_R	Resisting torque of pipe	mm^3
L_K	Permitted unsupported length	mm
da	Pipe outer diameter	mm
di	Pipe inner diameter	mm
$\Delta\vartheta$	Temperature difference	K
δ_B	Bending stress	N/mm^2



Sagging ε of freely suspended pipe

$$f = \frac{F \times L_A^{\ 3}}{48 \times E \times J_R}$$

F	Load	N
L	Length of pipe	mm
σa	Axial stress	N/mm^2

Axial stress from prevented change in length

$$\alpha a = \frac{\Delta L \times E}{L}$$

Calculation example:

Pipe expansion force F_R / Fixed point force F_{FP}

Selected pipe dimension: 63 x 5.8
Elasticity modulus: 450 N/mm^2
α: 0.13 mm/mK
Δψ: 50 K

1. Pipe expansion force F :

$$F_R = A_R \times E \times \varepsilon$$

$$= \frac{\left(d_a^2 - d_i^2\right) \times \pi}{4} \times E \times \alpha \times \Delta\psi$$

$$F_R = \frac{\left(63^2 mm^2 - 51.4^2 mm^2\right) \times \pi}{4} \times 450 \frac{N}{mm^2} \times 0.13 \frac{mm}{m\,K} \times 50K$$

$$F_R = 3047N$$

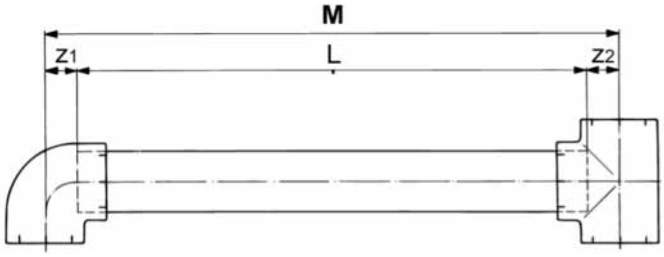
Pipe expansion force = fixed point force	Type of pipe	Ratio factor	Dimension
F_{FP} = F_R = 3047 N	INSTAFLEX PB pipe	1.0	d63 x 5.8
F_{FP}= F_R= 8814 N	PE-X pipe	2.9	d63 x 8.6
F_{FP} = F_R= 12462 N	PP-R pipe	4.1	d63 x 10.5
F_{FP} = F_R= 17446 N	PVC-C pipe	5.7	d63 x 7.1
F_{FP} = F_R= 52576 N	Composite pipe	17.3	ø 50 x 4
F_{FP} = F_R = 81808 N	Steel pipe	26.9	2" (60, 3/53)
F_{FP}= F_R= 35286 N	Copper pipe	11.6	ø 54 x 2
F_{FP} = F_R= 58290 N	Stainless steel pipe	19.1	ø 54 x 2

The pipe expansion forces or fixed point forces are much lower for INSTAFLEX PB pipes than for other materials. See table above.

z-dimension installation method

Introduction

The z-dimension and standard measurement procedures are at the core of the GF Piping Systems installation method. The z-dimension is the design dimension used by installers. With this, it is easy to calculate the exact pipe length between fittings and/or valves.
Determining and using the z-dimension is based on the fundamental principle:
Standard measurement
Centre - Centre = M

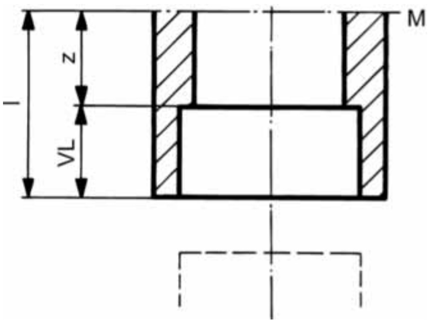


This method, which is the foundation for efficient planning, work preparation and pre-fabrication, makes work easier and saves the enterprising installer time and money:
With Georg Fischer, you:

- can pre-fabricate sections
- use materials, labour and machinery efficiently
- reduce assembly time
- adapt to the construction progress
- are not dependent on construction deadlines
- have better conditions for carrying out external projects
- have better conditions for carrying out renovations
- work more precisely with less effort
- are ensured consistent quality

Measurements on the fitting
Socket

Fitting with inner jointing end:



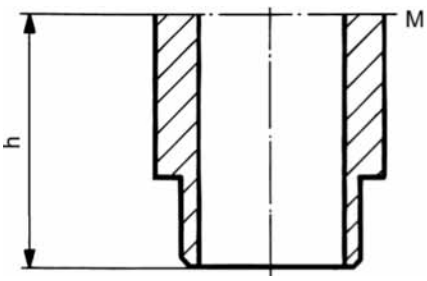
l	Overall length of fitting with socket
h	Overall length of fitting with spigot
z	z-dimension
VL	Length of joint

z = l - VL

The z-dimension is calculated as the difference from the overall length l and the jointing length VL.

Spigot

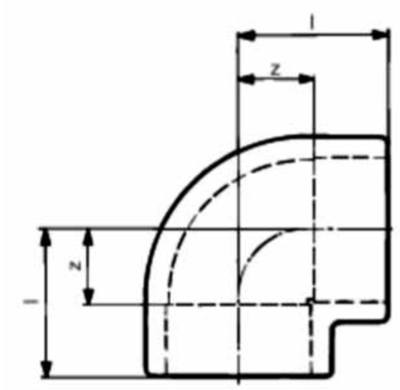
Fitting with outer jointing end:



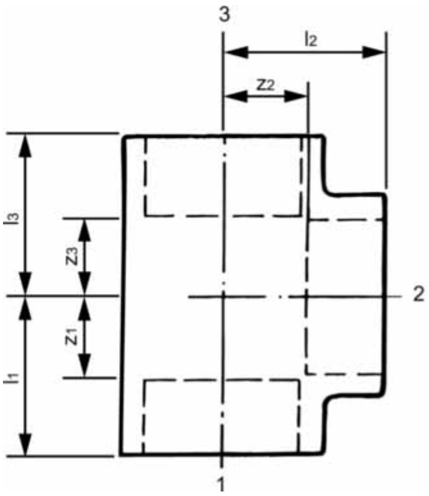
h = Overall height of fitting

Inner jointing ends are referred to in the following as **sockets** and outer joints as **spigots**.

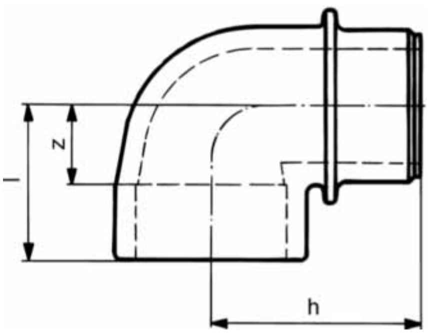
Elbow 90° with two inner jointing ends (sockets):



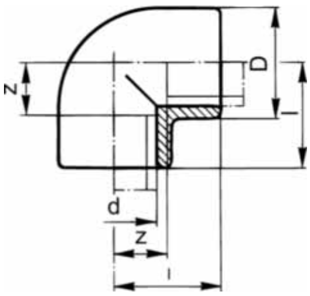
T-piece equal on all sides, or reduced in outlet or passage:



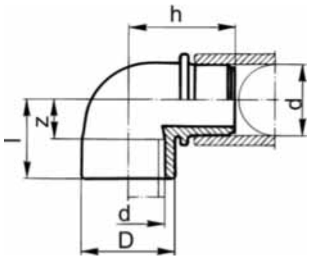
Elbow 90° with inner and outer jointing ends (socket - spigot):



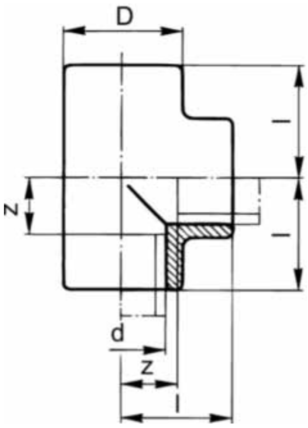
z-dimension for socket fusion fittings



Elbow 90°



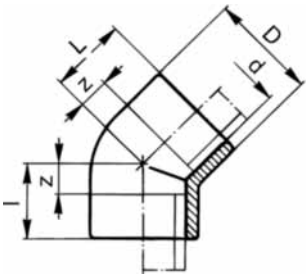
Elbow 90° socket -spigot



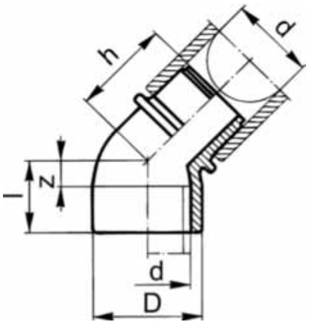
T-equal 90°

Dimension	Measurements			
d	**z**	**h**	**l**	**D**
16	**10**	34	25	22
20	**13**	36	28	26
25	**14**	44	32	32
32	**18**	50	38	40
40	**22**	58	44	51
50	**26**	70	51	64
63	**34**	82	62	81
75	**44**	-	75	91
90	**52**	-	88	112
110	**63**	-	105	132

All measurements in mm

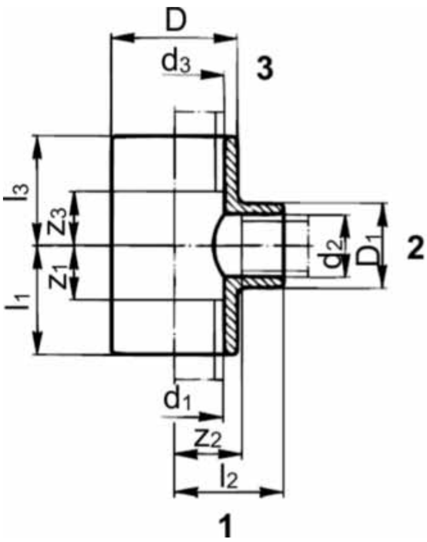


Elbow 45°



Elbow 45° socket - spigot

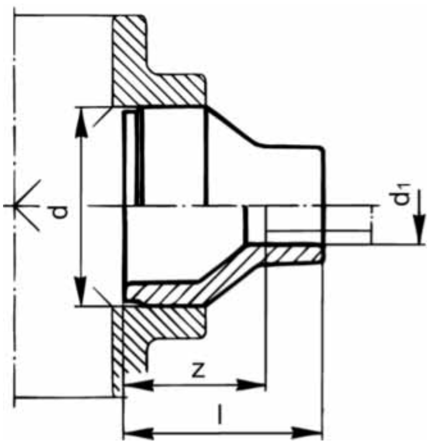
Dimension	**Measurements**			
d	**z**	**h**	**l**	**D**
16	**6**	29	21	22
20	**7**	30	22	26
25	**7**	35	25	32
32	**10**	40	30	40
40	**12**	46	34	51
50	**14**	53	39	64
63	**17**	62	45	81
75	**20**	-	51	92
90	**22**	-	58	109
110	**26**	-	68	134

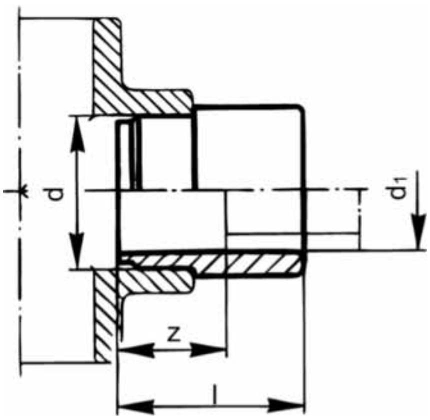


T-red. 90°

Dimension	**Measurements**					
$\mathbf{d}_1$-d_2-d_3	$\mathbf{z}_1/z_3$	$\mathbf{z}_2$	$\mathbf{l}_{1/3}$	$\mathbf{l}_2$	**D**	$\mathbf{D}_1$
20-16-20	13	13	28	28	26	22
20-16-16	13	13	28	28	26	2
20-20-16	13	13	28	28	26	26
25-16-25	14	17	32	32	32	26
25-20-25	14	17	32	32	32	26
25-20-20	14/17	17	32	32	32	26
25-25-20	14	17	32	32	32	32
32-16-32	18	23	38	38	40	26
32-20-32	18	23	38	38	40	26
32-25-32	18	20	38	38	40	32
40-25-40	22	26	44	44	51	34
50-25-50	26	33	51	51	64	34
63-25-63	34	44	62	62	81	34

Reducers

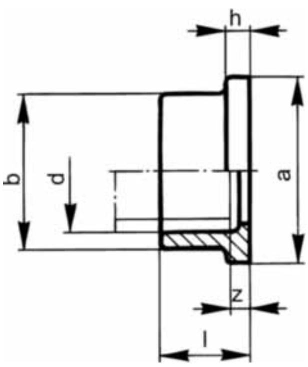




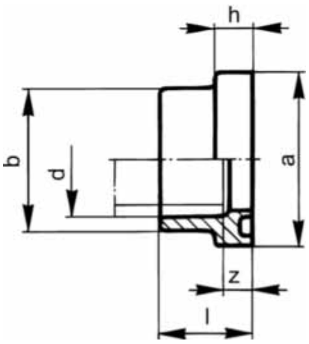
+GF+

Dimension	Measurements	
d - d_1	**z**	**l**
20-16	**15**	30
25-16	**18**	33
25-20	**18**	33
32-20	**25**	40
32-25	**22**	40
40-20	**27**	42
40-25	**24**	42
40-32	**22**	42
50-20	**40**	55
50-25	**37**	55
50-32	**35**	55
50-40	**33**	55
63-20	**43**	58
63-25	**40**	58
63-32	**38**	58
63-40	**36**	58
63-50	**33**	58
75-63	**39**	67
90-63	**46**	74
90-75	**43**	74
110-63	**58**	86
110-75	**55**	86
110-90	**50**	86

Flange adaptor



Flange adaptor flat

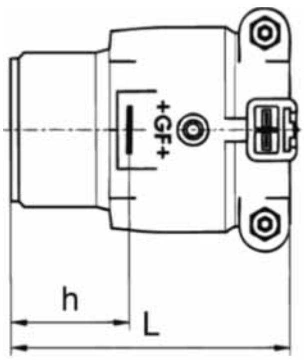


Flange adaptor with groove

Dimension	flat		with groove	
d	**z**	**l**	**z**	**l**
16	**5**	20	**8**	23
20	**5**	20	**8**	23
25	**5**	23	**8**	26
32	**5**	25	**8**	28
40	**5**	27	**10**	32
50	**5**	30	**10**	35
63	**5**	33	**10**	38
75	**4**	35	**9**	40
90	**6**	42	**11**	47
110	**7**	49	**13**	55

All the fittings not listed here and other dimensions can be found in the INSTAFLEX products catalogue or price list.

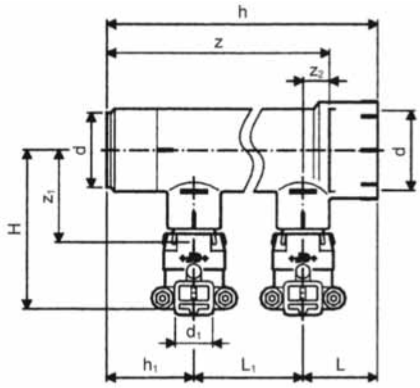
Electrofusion adaptor



Spigot for socket fusion

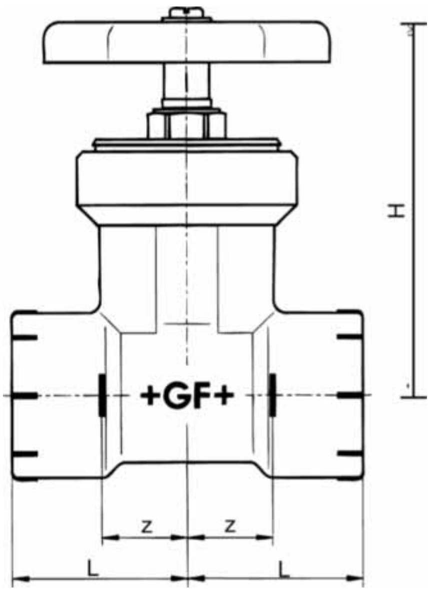
Dimension d	h	L
16	23	60
20	22	61
25	25	67
32	29	71
40	32	79
50	36	85
63	43	94

Polybutene manifold



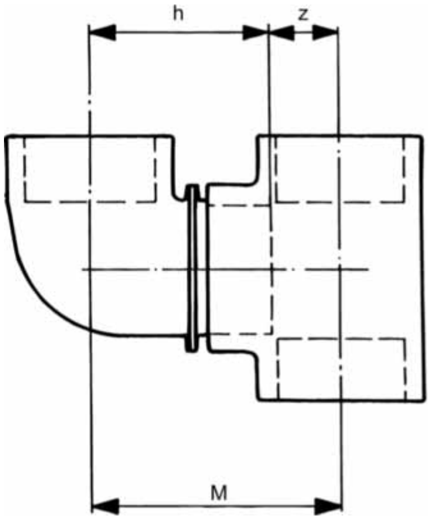
d-d 1		L	L 1	h	h 1	H	z	z 1	z 2
25-16	1-fold	31	-	63	32	60	**45**	**36**	**13**
25-20	1-fold	39	-	78	39	64	**60**	**35**	**21**
25-16	2-fold	31	45	108	32	60	**90**	**36**	**13**
25-16	3-fold	31	45	153	32	60	**135**	**36**	**13**
25-16	4-fold	31	45	198	32	60	**180**	**36**	**13**

Polybutene valve

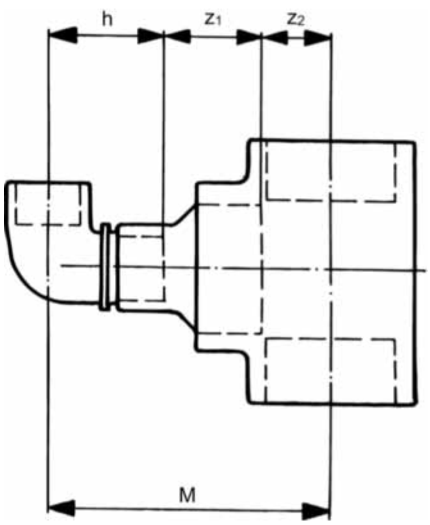


Dimension d	L	z	H
20	40	**25**	86
25	40	**22**	86
32	43	**23**	91
40	55	**33**	155
50	60	**35**	155
63	75	**47**	155

Application examples
(M as fixed or variable measurement)



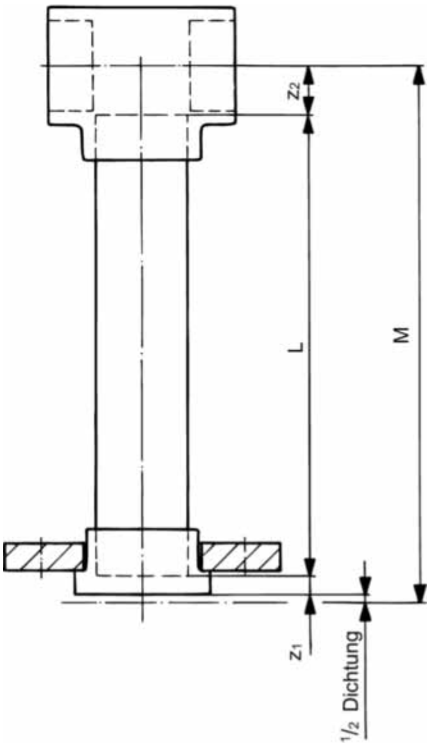
The direct joining of two fittings (socket/spigot) results in a **dimension-related measurement «M».**



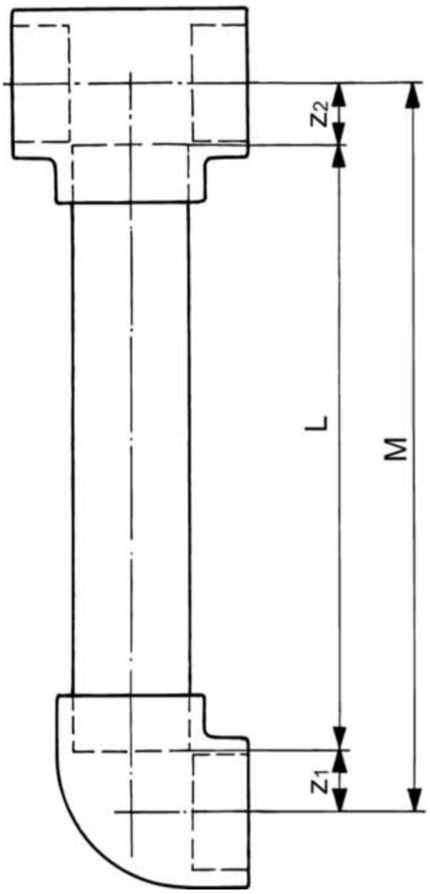
Example:
Elbow 90° socket - spigot d25
h = 44 mm
Reducer: d63 - d25
z_1= 40 mm
Tee d63 equal
z_2 = 34 mm

M = h + z1 + z2
M = 44 mm + 40 mm + 34 mm
M = 118 mm

You will find the z-dimension in the corresponding INSTAFLEX product range.

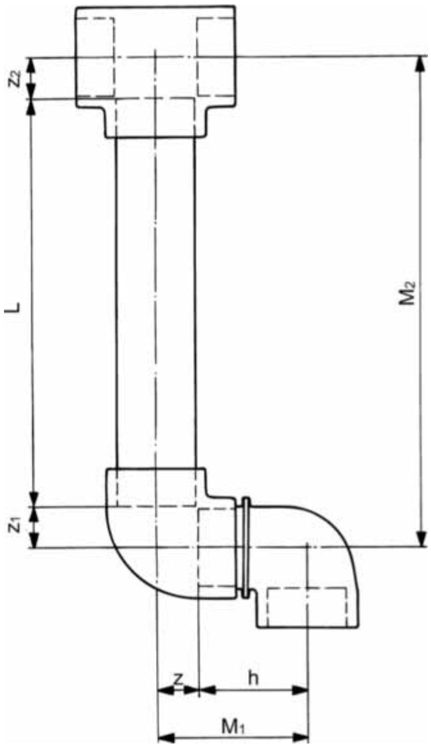


$M = L + z_1 + z_2 + ½$ seal
$L = M - z_1 - z_2 - ½$ seal

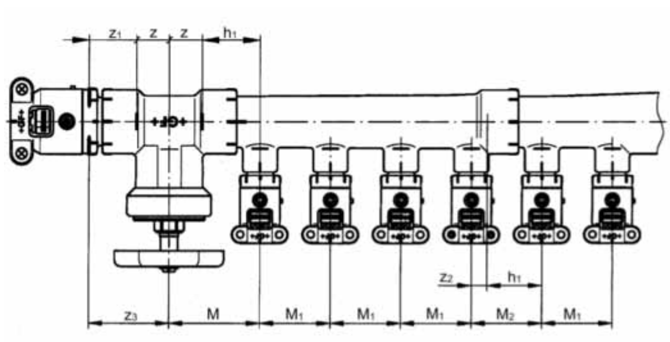


«M» is the system-related distance between two axes. The calculated measurement is achieved with two fittings and a pipe section with the length L.

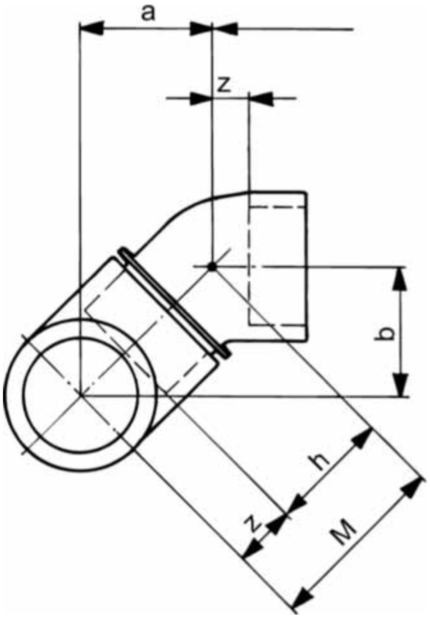
$M = L + z_1 + z_2$
$L = M - (z_1 + z_2)$



$M_1 = h + z$
$M_2 = L + z_1 + z_2$
$L = M_2 - z_1 - z_2$



$z_3 = z_1 + z$
$M = z + h_1$
M_1 (for d16) = 45 mm
$M_2 = z_2 + h_1$
M_2 = 13 mm + 32 mm = 45 mm

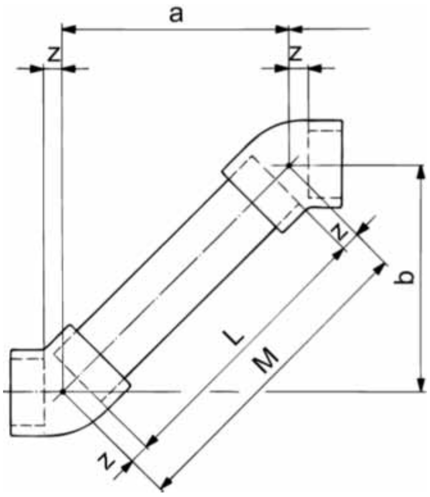


On angular joints, the measurements a and b can be calculated with the measurement «M» (M = z + h) and the corresponding factors for the angular degrees.

Elbow 45°
M = h + z
a or b = M x 0.707

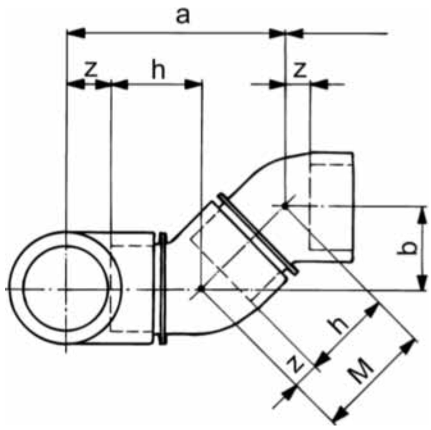
Example:
Tee d63 equal + Elbow 45° socket - spigot d63
z = 34 mm h = 62 mm

M = h + z
M = 62 mm + 34 mm = 96 mm
a = 96 mm x 0.707 = 68 mm



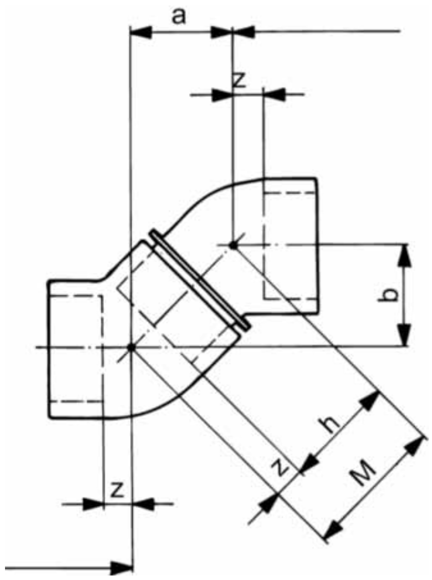
Elbow 45°
M = a or b x 1.414
M = L + 2z
L = M - 2z

Example:
Elbow 45° d63
M = 2 m
M = L + 2z
L = M - 2z
L = 2 m - 2 x 17 mm = 1.96 m
a = M/1.414 = 2 m /1.414 = 1.41 m



Elbow 45°
M = h + z
b = M x 0.707
a = M x 0.707 + (z_1 + h_1

Example:
Elbow 45° socket - spigot d63
z = 17 mm
h = 62 mm
M = h + z
M = 62 mm + 17 mm = 79 mm
b = 79 mm x 0.707 = 56 mm
a = 79 mm x 0.707 + 34 mm + 62 mm = 152 mm



Elbow 45 °
M = z + h
a or b = M x 0.707

Example:
Elbow 45° socket - spigot d63
z = 17 mm
Elbow socket - spigot 45° d63
h = 62 mm
M = z + h
M = 17 mm + 62 mm = 79 mm
a = M x 0.707

a = 79 mm x 0.707 = 56 mm

Piping diagram

When using the GF Piping Systems installation method, pipe plans and floor plans are not suitable if you want to prepare and install the piping system rapidly.

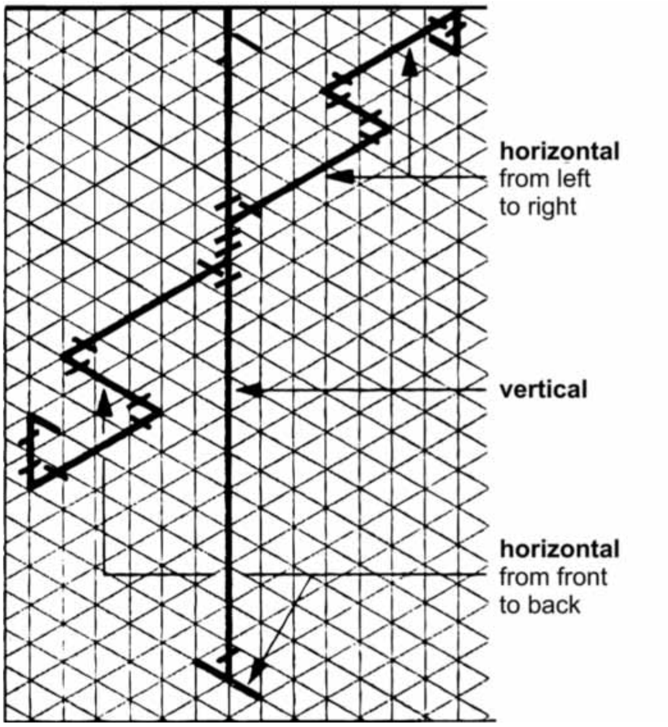
The run of the pipeline should be illustrated as plainly and clearly as possible. The sketches can be done right on the building site itself.

This type of illustration makes it possible to draw the diagrams quickly on location or according to a plan. You require no further tools, such as ruler, triangle, etc. The planned pipe system and all the required fittings, valves, etc. is always easy to see.

Piping diagram 30° (space drawing)
is deliberately not drawn to scale, so long pipe sections may be drawn shorter and short pipe sections longer.

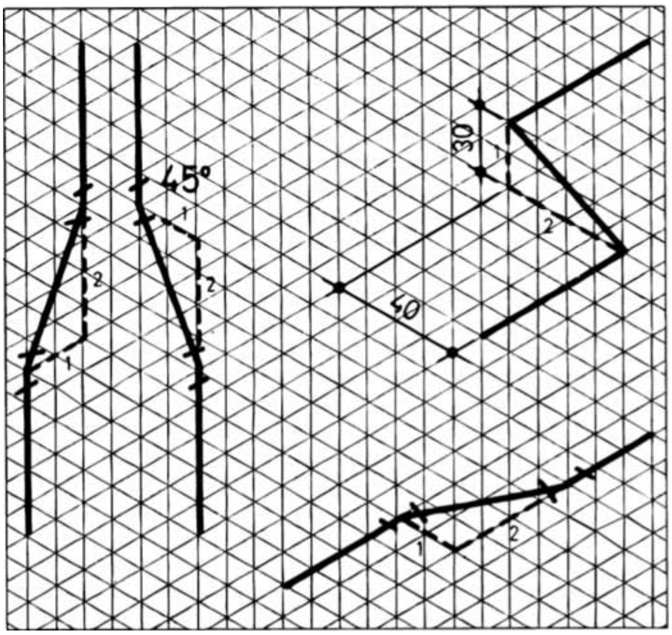
In this way, you can draw extensive piping systems on one A4 sheet of paper.

Draw pipelines which run at right angles to one another as follows:



These changes in direction from pipelines which run diagonally to one other are drawn in a 2:1 or 1:2 ratio regardless of the angles and dimensions. You can show the change in direction more exactly by drawing in a triangle. The deviation is specified by indicating the type of fittings (catalogue number or elbow) or the dimensions.

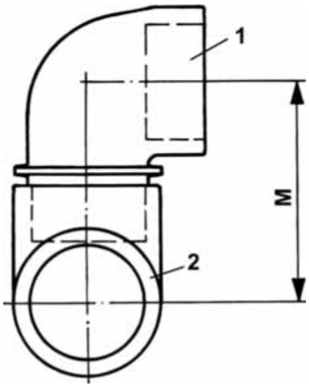
Fitting or sealing points are marked with a small horizontal line and valves with the respective standard symbols.



Fitting combinations

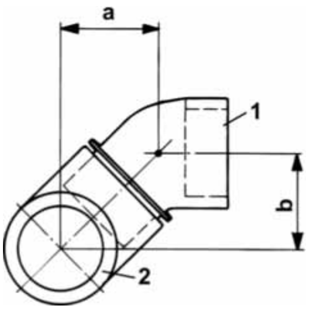
Fittings with socket fusion joints

All dimensions in mm



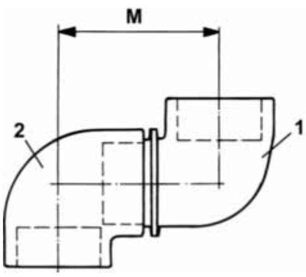
1 Elbow 90°
2 Socket - Spigot

Dimension d	**M**
16	44
20	49
25	58
32	68
40	80
50	96
63	116



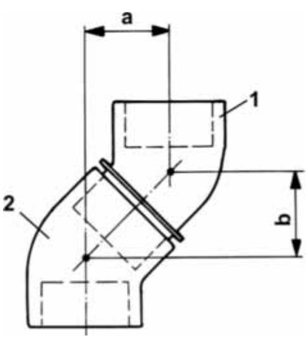
1= Elbow 45°, Socket - Spigot
2= Elbow 90°, T-piece equal

Dimension d	**a/b**
16	27
20	30
25	35
32	41
40	48
50	56
63	68



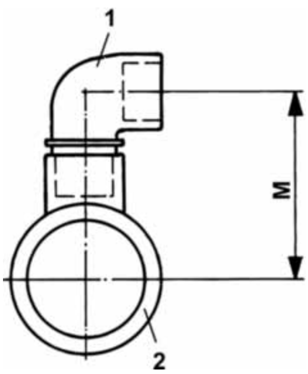
1 Elbow 90°, Socket - Spigot
2 Elbow 90°

Dimension d	**M**
16	44
20	49
25	58
32	68
40	80
50	96
63	116



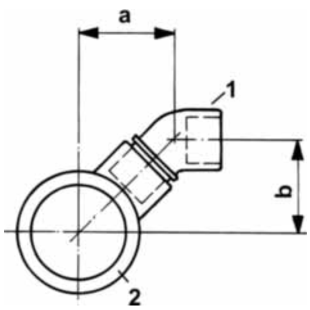
1 Elbow 45°, Socket - Spigot
2 Elbow 45°

Dimension d	**a/b**
16	27
20	30
25	35
32	41
40	48
50	56
63	68



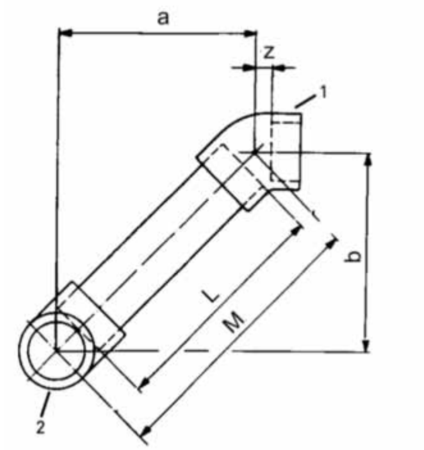
1 Elbow 90°, Socket - Spigot
2 T-piece reduced

Dimension d	**M min.**
20-16-20	47
20-20-16	49
25-16-25	51
25-20-25	53
25-25-20	58
32-16-32	57
32-20-32	59
32-25-32	64
40-16-40	63
40-25-40	70
50-16-50	70
50-25-50	77
63-16-63	81
63-25-63	88



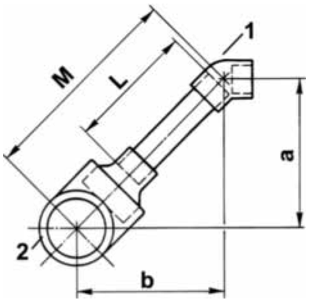
1 Elbow 45°, Socket - Spigot
2 T-piece reduced

Dimension d	**M min.**	**a/b**
20-16-20	42	30
20-20-16	43	30
25-16-25	46	32
25-20-25	47	33
25-25-20	49	35
32-16-32	52	37
32-20-32	53	37
32-25-32	55	39
40-16-40	58	41
40-25-40	61	43
50-16-50	65	46
50-25-50	68	48
63-16-63	76	54
63-25-63	79	56



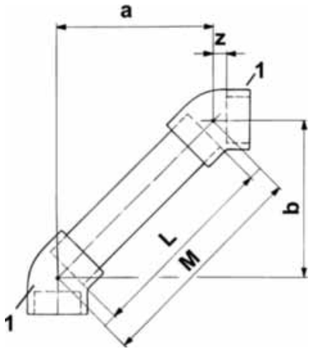
1 Elbow 45°
2 T-piece equal

Dimension d	a/b	M min.	L
16	39	55	39
20	42	60	40
25	47	66	45
32	55	78	50
40	64	90	56
50	71	100	60
63	85	120	69
75	99	140	76
90	117	165	91
110	138	195	106



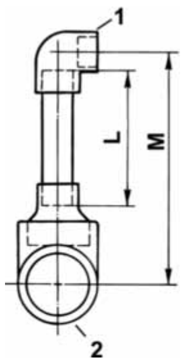
1 Elbow 45°
2 T-piece equal / Reducer

Dimension d	a/b	M min.	L
20-16	52	73	39
25-16	54	77	39
25-20	55	78	39
32-25	66	94	47
40-32	74	105	51
50-40	92	130	59
63-50	103	145	64
75-63	120	170	70
90-75	138	195	81
110-90	163	230	96



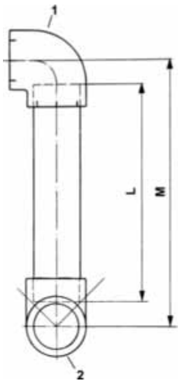
1 + **2** Elbow 45°

Dimension d	a/b	M min.	L
16	35	50	38
20	37	52	38
25	42	60	46
32	50	70	50
40	57	80	56
50	60	85	57
63	71	100	66
75	85	120	80
90	95	135	91
110	113	160	108



1 Elbow 90°
2 T-piece equal / Reducer

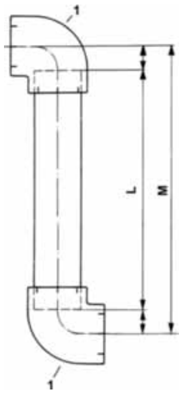
Dimension d	M min.	L
20-16	78	40
25-16	82	40
25-20	85	40
32-25	102	48
40-32	115	53
50-40	140	59
63-50	160	67
75-63	195	78
90-75	225	88
110-90	270	106



1 Elbow 90°
2 T-piece equal

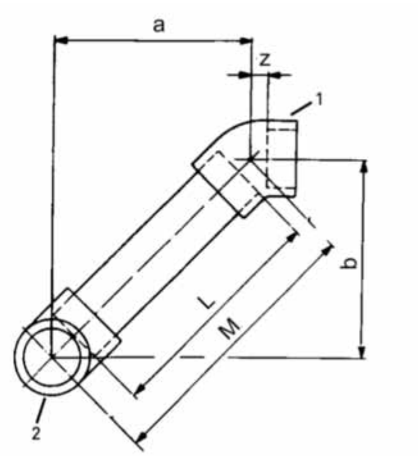
Dimension d	M min.	L
16	60	40
20	66	40
25	76	48
32	88	52
40	100	56
50	115	63
63	140	72
75	165	77
90	195	91
110	230	104

Pipe lengths for defined distance between axes



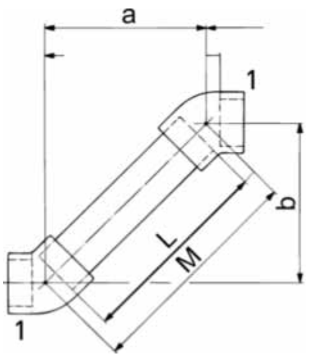
1 + **2** Elbow 90°

	Dimension d									
	16	**20**	**25**	**32**	**40**	**50**	**63**	**75**	**90**	**110**
	Pipe length L									
80	60	54	52	44	-	-	-	-	-	-
100	80	74	72	64	56	-	-	-	-	-
120	100	94	92	84	76	68	-	-	-	-
150	130	124	122	114	106	98	82	-	-	-
180	160	154	152	144	136	128	112	92	-	-
210	190	184	182	174	166	158	142	122	106	-
250	230	224	222	214	206	198	182	162	146	124



1 Elbow 45°
2 T-piece equal

	Dimension d										
	16	**20**	**25**	**32**	**40**	**50**	**63**	**75**	**90**	**110**	
	Pipe length L										**M**
80	97	93	92	85	79	73	-	-	-	-	113
100	125	121	120	113	107	101	90	-	-	-	141
120	154	150	149	142	136	130	119	106	-	-	170
150	196	192	191	184	178	172	161	148	138	123	212
180	238	234	233	226	220	214	203	190	180	165	254
210	281	277	276	269	263	157	246	233	223	208	297
250	337	333	332	325	319	313	302	289	279	264	353



1 + **2** Elbow 45°

	Dimension d										
	16	20	25	32	40	50	63	75	90	110	
	Pipe length L										M
80	1011	99	99	93	89	85	79	-	-	-	113
100	129	127	127	121	117	113	107	101	97	-	141
120	158	156	156	150	146	142	136	130	126	118	170
150	200	198	198	192	188	184	178	172	168	160	212
180	242	240	240	234	230	226	220	214	210	202	254
210	285	283	283	277	273	269	263	257	253	245	297
250	341	339	339	333	329	325	319	313	309	301	353

Design and hydraulic pressure losses of piping systems (CH, D, A, UK)

Design and hydraulic pressure losses of piping systems (CH, D, A, UK)

General

Basics for determining pressure loss

The basics for determining the pressure loss in INSTAFLEX piping systems are derived from the guidelines or technical regulations for drinking water installations in the respective countries.
Local regulations should always be observed. Moreover, the national preface of EN-806-T3 must be adhered to.

Guidelines or technical regulations for drinking water systems

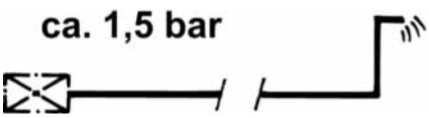
Country	Guideline or Technical Regulations
Switzerland	SVGW/W3 2000, EN 806-3
Germany	DVGW/DIN 1988, TRWI Part 3, EN 806-3
Austria	ÖVGW/ÖNORM B 2531 Part 2, EN 806-3
England	C.I.B.S.E. Guide 4, BS 6700:2006, EN 806-3

In our experience, the simplified INSTAFLEX calculation method can be used for residential buildings with standard installations up to pipe dimension d50 (DN 40). For large buildings, such as hospitals, schools, hotels, etc. or for pipe diameters >d50 you should always perform a pressure loss calculation.

Simplified calculation method for pressure loss in piping systems

Determining the pipe diameters is the basis for the simplified method of calculating the pressure loss.

An approximation for determining pipe diameters in multistory distribution and riser pipes can be found in **Table 1**. Experience has shown that this simplified calculation is sufficiently accurate for standard installations of pipe dimensions d16-d50 (DN 40) in residential buildings.



By dimensioning the pipe diameters correctly, you can safely assume that a pressure loss of 1.5 bar will not be exceeded. This applies to the whole installation, starting at the water meter or pressure reducing valve to the last tapping point.

Determining the pipe diameter

The pipe diameter is determined with Tables 1 and 2 in the following. To calculate the pipe diameter, you need the load values (LV) of the individual sections, which correspond to the specifically calculated flow rates, flow strengths or load values of valves and appliances. For more information, please see the guidelines or technical regulations.

1 Load value (LV) corresponds to 0.1 l/s

The overall load value of a section is obtained by adding up the individual load values allocated to the sections.

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Table 1: Load values (LV) and pipe diameters for INSTAFLEX pipes and fittings

1* Max. number LV	3	4	5	8	25	55	180	500	1100
2 ** largest single LV			4	5					
Pipe ø d_a x s	16 x 2.2			20 x 2.8	25 x 2.3	32 x 2.9	40 x 3.7	50 x 4.6	63 x 5.8
Pipe ø d_i	11.6			14.4	20.4	26.2	32.6	40.8	51.4
Max. pipe length [m]	9	5	4						
Pipe content [l/m]	0.10			0.16	0.33	0.53	0.83	1.31	2.07
Valves	½"			½"	¾"	1"	1¼"	1½"	2"

Details to Table 1:
1* Max. number LV – The flow rate may not be larger than the sum of the equipment connected.
2** largest single LV – There may be no single user with a greater flow rate.

Application

The load units (LU) for the same appliance may differ from country to country. To determine the pipe diameter with Table 1, use the load values (LV) listed in Table 2. Simultaneity has already been taken into consideration in this calculation method.

Table 2: Load values per connection

Intended use: ½" connections	Flow rate per connection		Number of load values per connection LV
	[l/s]	[l/min]	
Hand basin, wash trough, wash-stand, bidet, toilet tank, soda machine	0.1	6	1
Kitchen sink, sink, water tap for balcony and terrace, hand shower set, household dishwasher, laundry room sink	0.2	12	2
Shower	0.3	18	3
Industrial sink, stand and wall sink, bathtub, washing machine up to 6 kg, automatic urinal flushing, kitchen spray head	0.4	24	4
Water tap for garden and garage	0.5	30	5
Intended use: ¾" connections			
-Industrial sink, bathtub -Shower, water tap for garden and garage	0.8	48	8

Calculation formulae

Determining pressure loss in pipes

$$\Delta p_R = \frac{\lambda \cdot l \cdot \rho \cdot v^2 \cdot 100}{2 \cdot d_i} [\text{mbar}]$$

Δp = Pressure loss [mbar]
ζ = Loss coefficient (Zeta value) for fittings
λ = Loss coefficient (Lamda value) for pipes

The resistance λ is a ratio. It depends on the Reynolds number (Re) and the roughness of the pipe. For rough estimations you can assume λ = 0.025. Up to Re = 2300 the flow in a straight pipe with smooth walls will be laminar. In the laminar range, the resistance value is:

λ = 64 /RE

l = Length of pipe [m]
d_i = Pipe inner ø (d-2s) [mm] *1
p = specific weight of water at:

18 ºC	=	998.5kg/m³
60 ºC	=	983.2 kg/m³
80 ºC	=	971.8 kg/m³

v = Flow velocity [m/s]

$$v = \frac{\dot{V} \cdot 4000}{d_i^2 \cdot \pi}$$

$\dot{V}$ = Flow rate $[l/s]$

*[1] also for fitting calculations
*[2] calculation basis for fittings and pipes

Thermophysical properties of water

	Density ρ [kg/m³]	Kinematic viscosity [m²/s]
10 °C	999.6	1.31 x 10-6
60 °C	983.2	0.52 x 10-6
80 °C	971.8	0.37 x 10-6

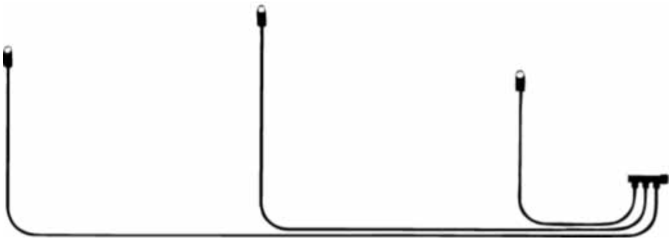
Multistory distribution

Piping systems and pressure loss calculation for multistory distribution

The flow-dependent pressure loss in multistory distribution pipes is determined with the **Tables 2 to 4**. Decisive for pressure loss calculation is only the «least favourable hydraulic flow path».

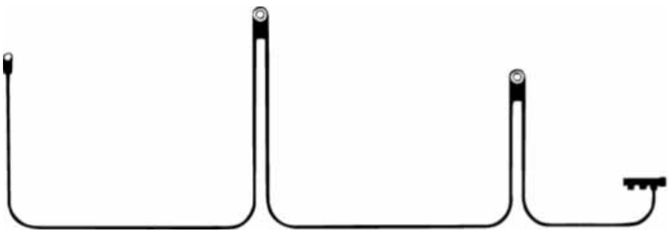
The load values (LV) for valves and appliances can be found in Table 2.

Single pipeline



Single pipelines supply only one water tapping point each. The pressure loss values can be taken directly from Tables 3 and 4.

Continuous lines



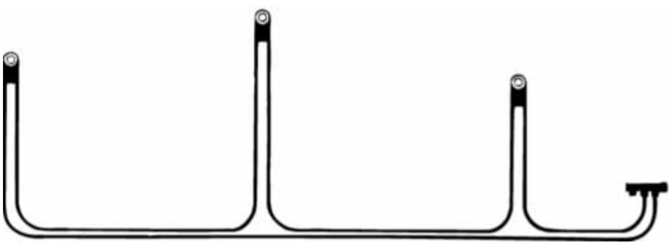
Continuous lines supply several water tapping points from the manifold. Because the tapping points are connected in series, the pressure losses are added up.

If you place the valve with the largest load unit at the beginning of the continuous line, the pressure loss will be much lower than in the reverse order.

The pressure loss in continuous lines is calculated with the peak flow. This calculation allows for reduced simultaneity, which means that not all the tapping points along the flow path are used at the same time and over the same period.

The **peak flow rate (s)** is determined with the help of the corresponding simultaneity diagrams or calculation formulae, as well as the information in the respective technical regulations and the sum of the load units.
See **Table 2** and **Diagram 1** in this chapter.

Ring mains



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Ring mains supply several tapping points from the manifold. The difference to the continuous line is, however, that the tapping point is supplied with water from two sides.

In ring mains there is about 70 % less pressure loss than in continuous lines. For purposes of calculating the pressure loss, you should nevertheless view a ring mains as a continuous line with only one feed. Then when you multiply the calculated pressure loss by **0.3**, you will get the result for pressure loss in the ring mains.

Pressure losses in pipe loops

The pressure loss values in the following Tables 3 and 4 show the individual resistances for direction changes, valve connections and manifolds.

Table 3: Pressure loss for INSTAFLEX pipe loops d16 x 2.2, Loop length 1 - 9 m

V	V	Loop length l [m]										
		1	1.5	2	2.5	3	4	5	6	7	8	9
[l/s]	[m/s]	Pressure loss in pipe loops [mbar]										
0.07	0.7	17	21	24	28	31	38	45	52	57	66	72
0.10	0.9	32	38	45	51	57	70	83	96	109	121	134
0.13	1.2	54	64	74	84	94	114	134	154	174	194	214
0.15	1.4	72	85	98	111	124	150	177	203	229	255	281
0.20	1.9	129	150	172	194	216	259	303	346	390	433	477
0.22	2.1	156	182	208	234	259	311	363	415	467	518	570
0.25	2.4	200	232	265	297	329	394	459	524	589	653	718
0.30	2.8	274	319	364	409	454	544	634	723	813	903	993
0.35	3.3	375	434	494	553	612	731	850	969	1088	1206	1325
0.40	3.8	490	566	642	717	793	944	1096	1247	1398	1549	1700
0.50	4.7	746	860	973	1087	1200	1428	1655	1882			

d16 x 2.2, Loop length 10 - 20 m

V	V	Loop length l [m]										
		10	11	12	13	14	15	16	17	18	19	20
[l/s]	[m/s]	Pressure loss in pipe loop [mbar]										
0.07	0.7	79	86	93	100	107	114	121	128	135	141	148
0.10	0.9	147	160	173	185	198	211	224	237	249	262	275
0.13	1.2	234	254	274	294	314	334	354	374	394	414	434
0.15	1.4	307	333	359	385	411	438	464	490	516	542	568
0.20	1.9	520	564	607	651	694	738	781	825	868	912	955
0.22	2.1	622	674	726	777	829	881	933	985	1036	1088	1140
0.25	2.4	783	848	913	977	1042	1107	1172	1237	1301	1366	1434
0.30	2.8	1083	1173	1263	1353	1443	1533	1622	1712	1802	1892	1982
0.35	3.3	1444	1563	1682	1800	1919						
0.40	3.8	1852	2003									
0.50	4.7											

Table 4: Pressure loss for INSTAFLEX pipe loops
d20 x 2.8, Loop length 1 - 9 m

V	V	Loop length l [m]										
		1	1.5	2	2.5	3	4	5	6	7	8	9
[l/s]	[m/s]	Pressure loss in pipe loop [mbar]										
0.07	0.4	6	8	9	10	11	14	16	19	21	24	26
0.10	0.6	12	14	17	19	21	26	31	35	40	44	49
0.13	0.8	20	24	27	31	35	42	49	57	64	71	78
0.15	0.9	26	31	36	40	45	54	64	73	82	91	101
0.20	1.2	46	53	61	69	76	92	107	123	138	153	169
0.22	1.4	55	64	73	82	91	110	128	146	165	183	201
0.25	1.5	70	81	93	104	116	138	161	184	207	230	252
0.30	1.8	100	115	131	147	163	194	226	258	289	321	352
0.35	2.1	134	155	176	196	217	259	300	342	384	425	467
0.40	2.5	174	200	226	253	279	332	385	438	491	544	597
0.50	3.1	268	307	347	386	426	505	584	663	742	821	900
0.60	3.7	384	439	494	549	604	714	824	934	1045	1155	1265
0.70	4.3	516	589	661	734	807	953	1099	1245	1391	1536	1682
0.80	4.9	666	759	852	946	1039	1225	1411	1597	1783	1969	

d20 x 2.8, Loop length 10 - 20 m

V	V	Loop length l [m]										
		10	11	12	13	14	15	16	17	18	19	20
[l/s]	[m/s	Pressure loss in pipe loop [mbar]										
0.07	0.4	29	31	34	36	39	41	44	46	49	51	54
0.10	0.6	54	58	63	67	72	77	81	86	90	95	100
0.13	0.8	86	93	100	108	115	122	130	137	144	151	159
0.15	0.9	110	119	129	138	147	157	166	175	184	194	203
0.20	1.2	184	200	215	230	246	261	277	292	307	323	338
0.22	1.4	220	238	256	274	293	311	329	348	366	384	403
0.25	1.5	275	298	321	344	366	389	412	435	458	480	503
0.30	1.8	384	416	447	479	510	542	574	605	637	668	700
0.35	2.1	508	550	592	633	675	716	758	800	841	883	924
0.40	2.5	650	703	755	808	861	914	967	1020	1073	1126	1179
0.50	3.1	980	1059	1138	1217	1296	1375	1454	1533	1612	1691	1171
0.60	3.7	1375	1485	1705	1815	1925						
0.70	4.3	1828	1974									
0.80	4.9											

SVGW Norm

C H

Excerpts from guidelines and norms
SVGW Guideline W 3

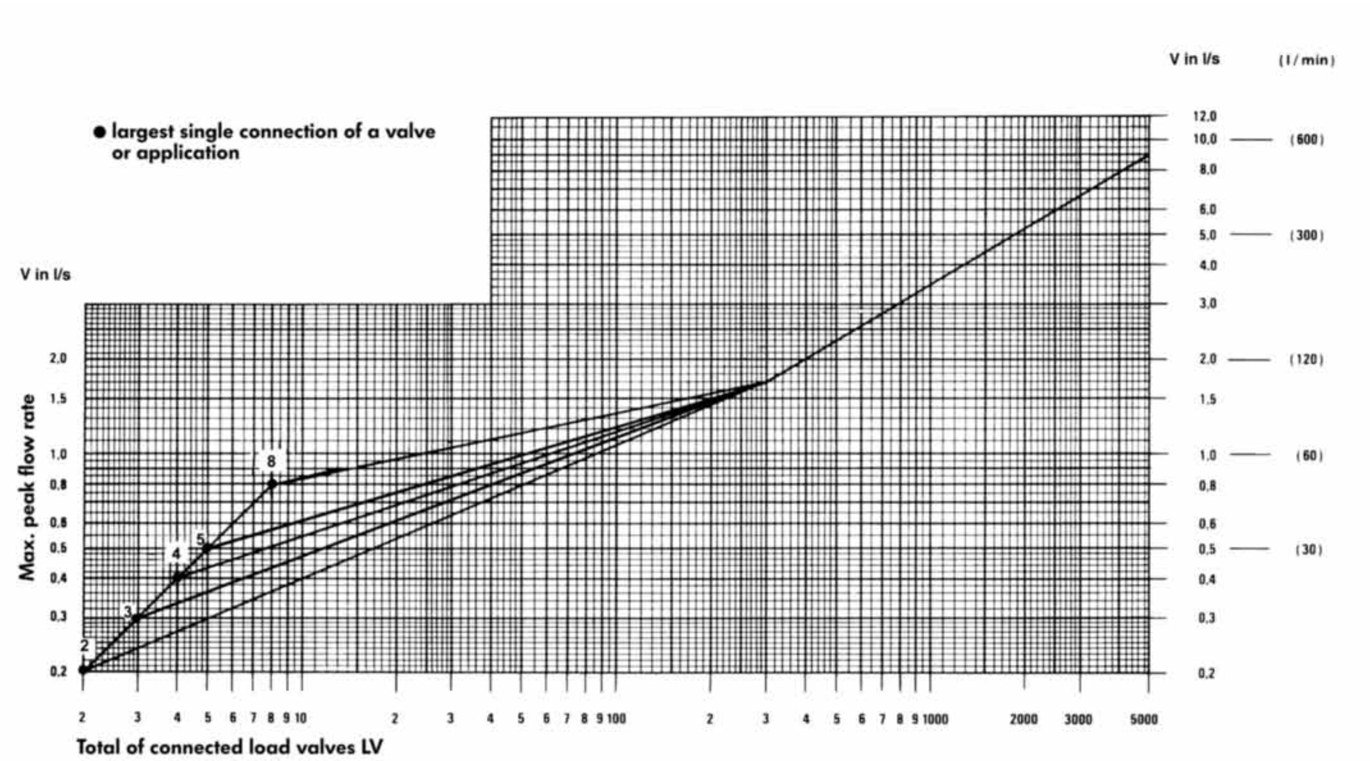
Guideline W 3 is the basis for dimensioning pipe networks and for determining the pressure loss in the scope of the SVGW.

Basic principles of W 3:

- If the static pressure of the system is under 2 bar, calculations must be furnished that a flow pressure of at least 1 bar is guaranteed at each tapping point.
- The static pressure at the tapping point may not exceed 5 bar.
- The maximum permissible pressure loss for the entire system after the water meter or pressure reducing valve may not exceed 1.5 bar.

Tables 1 and 2 contain the LV for valve and appliance connections, as well as the diagram to determine the peak flow in relation to the load value of a complete pipeline.

Diagram 1



Distribution pipelines

Determining pressure loss in polybutene (PB) distribution pipelinesin the pipe dimensions d25 x 2.3 / d32 x 2.9 / d40 x 3.7 / d50 x 4.6 / d63 x 5.8 / d75 x 6.8 / d90 x 8.2 und d110 x 10.

Pressure loss Δp_{VL}in distribution pipelines is determined by adding the individual pressure losses Δp_{TS} in the different network sections.

To determine the pressure loss, you must calculate the peak flow rate V_s in the respective sections, taking the overall load value (LV) and the respective simultaneity factor into consideration. The overall LV can be found in **Table 2**.

The maximum peak flow rate is found with the help of **Diagram 1**. In the appendix to this chapter you will find the pressure loss and flow velocity tables. From these and with the value for the maximum peak flow rate you can find the pressure loss per dimension in the table.

For the next calculation step you will need the length of the pipe per dimension and the equivalent pipe lengths of the fittings (Tables 11, 12 and 13 in the Appendix). These values are added up and multiplied by the pressure loss determined from Table 1.

Alternatively, and for large fitting diameters, you can use the formula below, with which you can calculate the pressure loss for fittings:

$$\Delta p_{fi} = \zeta \times \frac{\rho}{2} \times W^2$$

Δp_{fi}	=	Pressure loss for fitting [mbar]
ζ	=	Zeta value for fitting
p	=	Density [kg/m3]
w	=	Flow velocity [m/s]

Example:

ζ Elbow 90º = 0,7

ρ = 999.7 kg/m³

w = 0.5 m/s

$$\Delta p_{fi} = 0.7 \times \frac{999.7 \frac{\mathrm{kg}}{\mathrm{m}^3}}{2} \times 0.5^2 \frac{\mathrm{m}^2}{\mathrm{s}^2}$$

ΔP_{fi} = 87.5 Pa = 0.87 mbar

Converting the fitting pressure loss in pipe meters
Proceed as follows:

From the table:
The pressure loss of dimension d125 mm with a flow velocity w = 0.5 m/s is **0.266 mbar/m**.

$$\frac{0.87\mathrm{mbar}}{0.266 \frac{\mathrm{mbar}}{\mathrm{m}}} = 3.27\mathrm{m}$$

Diagram 1

Peak flow rate [l/s] as a function of total connected load values for standard installations. The size of the pipeline required to transport the medium to the consumer is calculated from Diagram 1.

Complete installation

Pressure loss in the complete installation and adjustment of the pressure reducing valve

The pressure loss of the complete installation is composed of the pressure loss for the multistory level ΔP_{ST} and the pressure loss for the distribution pipeline ΔP_{VL}.

Only the multistory level pipeline and the distribution pipeline with the largest pressure loss are needed for this.

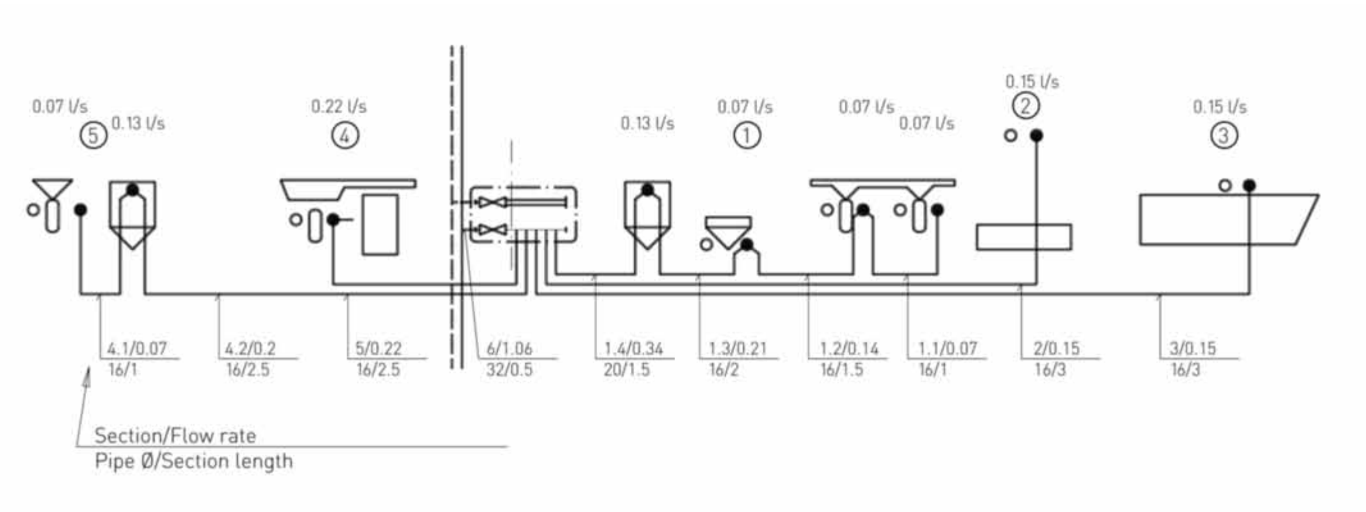
The total pressure loss $\Delta P_{Inst.}$ pertains to the pipe system after the water meter or the pressure reducing valve up to the last water tapping point.

To set the pressure reducing valve, add the required flow pressure at the farthest tap and the geodesic difference in height between the pressure reducing valve and the highest tapping point to the total pressure loss $\Delta P_{Inst.}$.

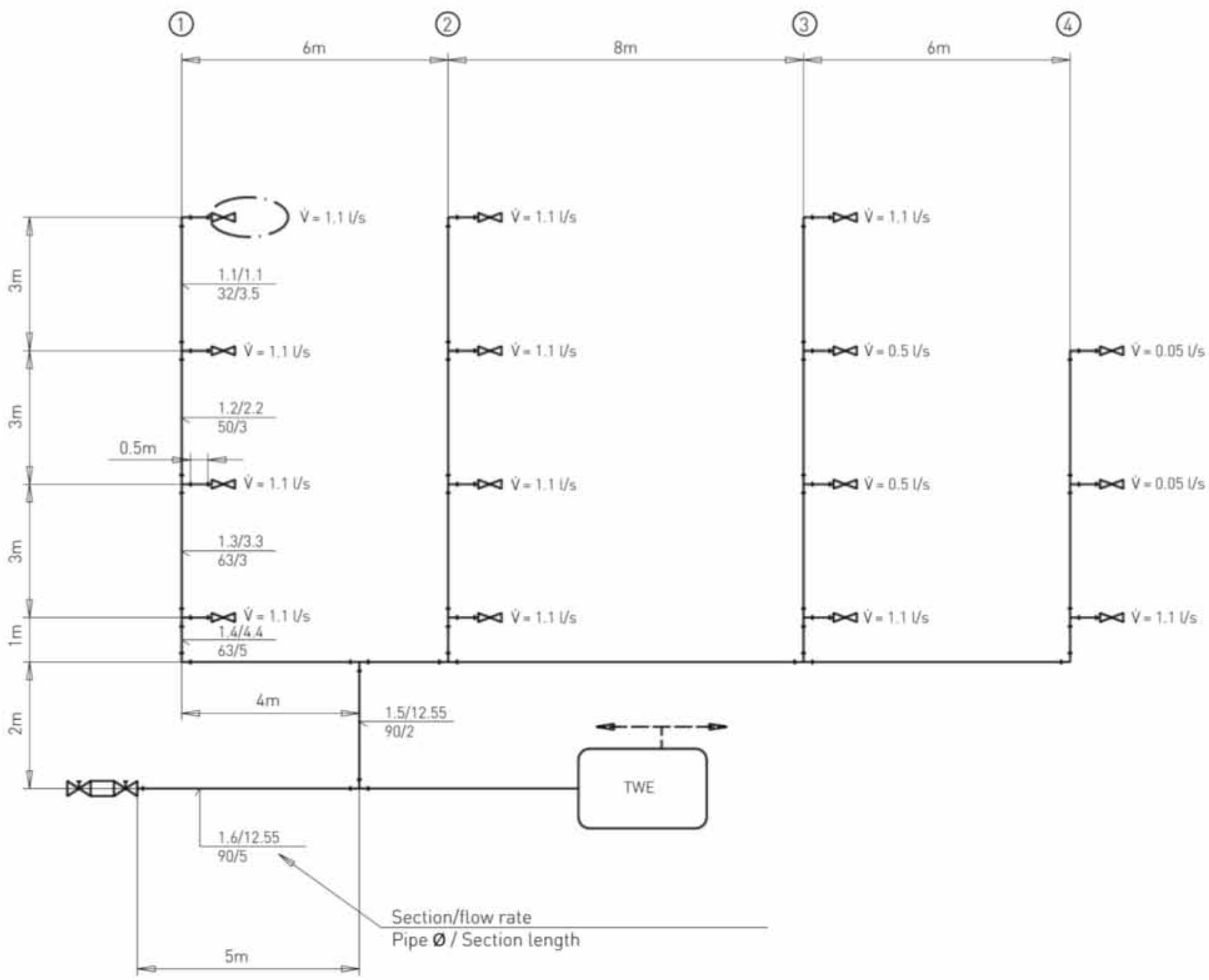
Calculation examples

Calculation example 1: according to SVGW Guideline W 3

Multistory level distribution



Distribution and riser pipes



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Form

Job reference:				Worker:							Date Name Sheet
Information from the drawing:				**Pressure loss calculations:**							**Comments**
1	2	3	4	5	6	7	8	9	10	11	
Section	k BE	fs l/s	Length TS m	Nom-∅ pipe d	i p Pipe- mbar/m	Fitting-allowance m	Σ Pipe length m	i p TS mbar			
Total pressure loss for line no. ______ **Δ p** ______ **mbar**											**GF Piping Systems**

Explanation

Col. 3 from Col. 2 and resp. simultaneity diagram

Col. 5 from Col. 2 and Table 1

Col. 6 from Table 5 and Col. 3

Col 7 from Table 4

Col. 8 from Col. 4 and 7

Col. 9 from Col. 6 and 8

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Job reference: Multi storey distribution system				Worker: xxxxxxxxxx xxxxxxxx							Date xxxxx	Name xxxxxx	Sheet xx
Information from the drawing:				**Pressure loss calculations:**							**Comments**		**Explanation**
1	2	3	4	5	6	7	8	9	10	11			
Section	k BE	fs l/s	Length TS m	Nom-∅ pipe d	i p Pipe- mbar/m	Fitting- allowance m	Σ Pipe length m	i p TS mbar			Column 9 calculated from Table 2 "Pressure losses for pipe looops d16"		
1.1	1	0.10	1.0	16x2.2	-	-	-	32.0					
1.2	2	0.20	1.5	16x2.2	-	-	-	150.0			Column 3 calculated with simultaneity diagram from SVGW - W3d		
1.3	3	0.24	2.0	16x2.2	-	-	-	246.0					
1.4	4	0.27	1.5	16x2.2	-	-	-	267.0					
								Ł	695.0		Line 1		
2	3	0.30	3.0	16x2.2	-	-	-	454.0	454.0		Line 2		
3	4	0.40	3.0	16x2.2	-	-	-	793.0	793.0		Line 3		
4	4	0.40	2.5	16x2.2	-	-	-	717.0	717.0		Line 4		
5.1	1	0.10	1.0	16x2.2	-	-	-	32.0					
5.2	2	0.20	2.5	16x2.2	-	-	-	194.0					
								Ł	226.0		Line 5		
Total pressure loss for line no. 3				**Δ p_{ST} = 793.0 mbar**							**GF Piping Systems**		

Explanation:

Col. 5 from Col. 2 and Table 1

Col 7 from Table 4

Col. 9 from Col. 6 and 8

Col. 3 from Col. 2 and resp. simultaneity diagram

Col. 6 from Table 5 and Col. 3

Col. 8 from Col. 4 and 7

ÖNORM B 2531, Part 2 ÖVGW

The ÖNORM B 2531, Part 2 forms the basis for pressure loss determination in the scope of **ÖVGW**.

Table 8 shows the **flow strengths Q** and the corresponding **load values (LV)** for valves and appliances.

1 LV = 16 x Q^2

Simultaneity is determined with the formula. Z stands for the sum of all the **LV** assigned to a section.

$$Q_G = 0.25 \times \sqrt{Z}$$

Table 5: Flow strengths Q and load values LV at commonly found types of tapping points

Type of tapping point	**LU per INSTAFLEX**	**Q* [l/s]**	LV
Outlet valve NW 10	2.5	0.250	1.00
Outlet valve NW 15	4.0	0.400	2.50
Outlet valve NW 20	10.0	1.000	16.00
Outlet valve NW 25	15.0	1.500	36.00
Toilet tank, bidet, urinal, etc.	1.25	0.125	0.25
Tap for hand basin, sink, etc.	1.75	0.175	0.50
Tap for kitchen sink	2.5	0.250	1.00
Tap for household dishwasher, washing machine	2.5	0.250	1.00
Spray head NW 10 (hand)	1.75	0.175	0.50
Spray head NW 15	2.5	0.250	1.00
Tap for bathtub, incl. spray head	4.0	0.400	2.50
Continuous-flow heater to 17.4 kW [1)]	1.75	0.175	0.50
Continuous-flow heater to 22.6 kW [2)]	2.5	0.250	1.00
Flsuhing valve NW 15	6.0	0.600	6.00
Flushing valve NW 20	8.0	0.800	11.00
Tap for industrial dishwasher and washing machine	4.0	0.400	2.50

[1)]formerly 250 kcal/min
[2)]formerly 325 kcal/min

* Total flow strength, hot and cold water combined

DIN 1988 TRWI, Part 3 DVGW

D

DIN 1988 TRWI, Part 3 forms the basis for dimensioning and calculating piping systems in the scope of **D VGW**.

Table 6 shows the reference values for **minimum flow pressures** and **calculation flow rates** V_R at commonly used drinking water taps.

Diagram 2 provides information on the peak flow rate V_s*) in relation to the total flow k V_R for diverse types of buildings.

*) Simultaneity

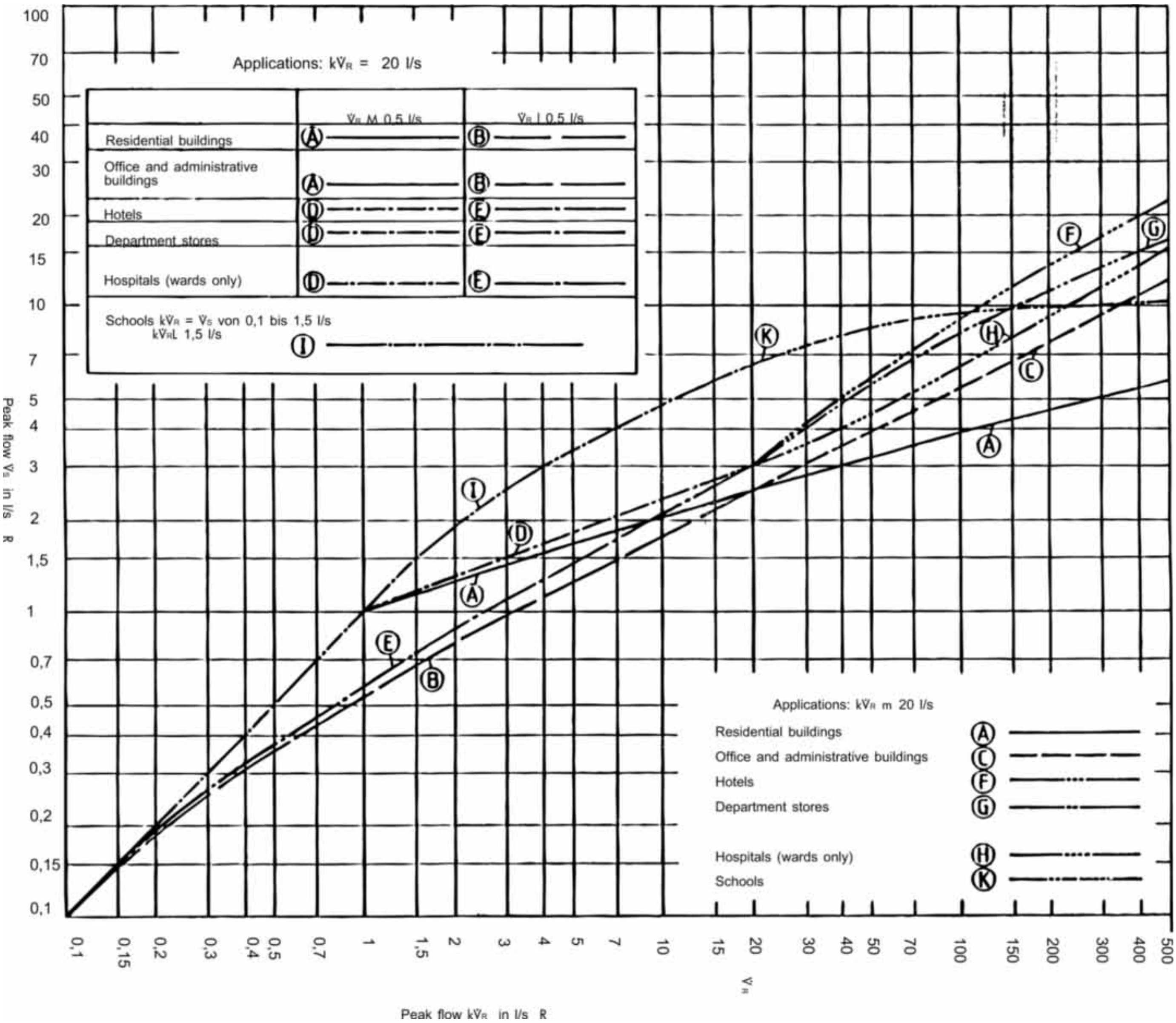
Table 6: Reference values for minimum flow pressures and calculation flow rates at commonly used drinking water taps.

Minimum flow pressure P min Fl [bar]	Type of drinking water tap		Calculated flow when tapping: Mixed water *) $\dot{V}_R$ cold [l/s]	$\dot{V}_R$ hot [l/s]	only cold or heated drinking water $\dot{V}_R$ [l/s]
	Outlet valve				
0.5	without aerator **)	DN 15	-	-	0.30
0.5		DN 20	-	-	0.50
0.5		DN 25	-	-	1.00
1.0	with aerator	DN 10	-	-	0.15
		DN 15	-	-	0.15
1.0	Spray head for cleaning	DN 15	0.10	0.10	0.20
1.2	Flushing valve per DIN 3265 Part 1	DN 15	-	-	0.70
1.2	Flushing valve per DIN 3265 Part 1	DN 20	-	-	1.00
0.4	Flushing valve per DIN 3265 Part 1	DN 25	-	-	1.00
1.0	Flushing valve for urinals	DN 15	-	-	0.30
1.0	Household dishwasher	DN 15	-	-	0.15
1.0	Household dishwasher	DN 15	-	-	0.25
1.0	Mixing taps for shower basin	DN 15	0.15	0.15	-
1.0	Bathtub	DN 15	0.15	0.15	-
1.0	Kitchen sink	DN 15	0.07	0.07	-
1.0	Wash basin	DN 15	0.07	0.07	-
1.0	Bidet	DN 15	0.07	0.07	-
1.0	Mixing taps	DN 20	0.30	0.30	-
0.5	Toilet tank per DIN 19 542	DN 15	-	-	0.13
1.0	Electric, open-end water heater	DN 15	-	-	0.10 ***)

*) The calculated flow rates for tapping mixed water are based on a cold water temperature of 15 ºC and hot water temperature of 60 ºC.
**) For outlet valves without aerator and with hose union, the pressure loss in the hose line (up to 10 m length) and in the connected appliance (e.g. lawn sprinkler) is taken overall into consideration in the minimum flow pressure. In this case the minimum flow pressure increases 1.0 bar to 1.5 bar.
***) with fully opened throttle screw.

Note: The pipe diameters of taps and appliances not included in the table which are of the similar type with larger flows or minimum flow pressures than given should be dimensioned according to the manufacturer's data.

Diagram 2


Applications: kV̇R = 20 l/s
V̇R M 0,5 l/s
V̇R L 0,5 l/s
Residential buildings
Office and administrative buildings
Hotels
Department stores
Hospitals (wards only)
Schools kV̇R = V̇S von 0,1 bis 1,5 l/s
kV̇RL 1,5 l/s
Applications: kV̇R m 20 l/s
Residential buildings
Office and administrative buildings
Hotels
Department stores
Hospitals (wards only)
Schools
Peak flow V̇S in l/s R
Peak flow kV̇R in l/s R

Peak flow rate Vs in relation to total flow

Table 7: Flow velocity

Pipeline section	Max. flow velocity for flow duration	
	m **15 min [m/s]**	L **15 min [m/s]**
House service connections	2	2
For use with low pressure loss valves (gates/angle seat valve)	5	2
For use of valves with increased pressure loss (straight seal valve)	2.5	2
Circulation line	-	0.5

Recommended max. flow velocity:

PB = 5.0 m/s

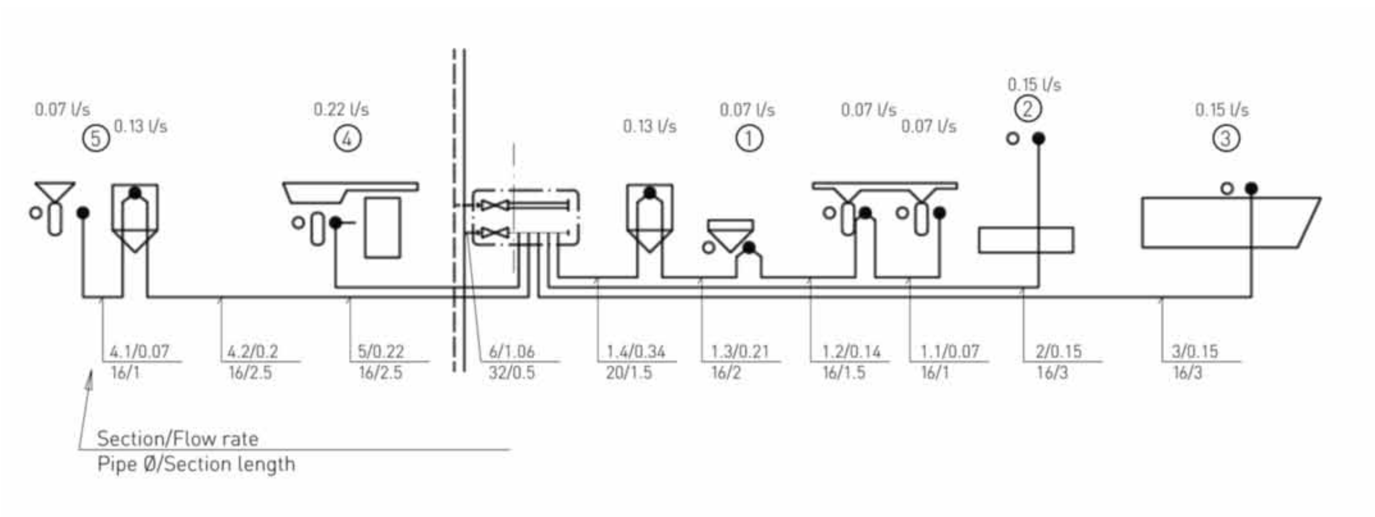
Cu = 2.5 m/s

galv. steel = 2.0 m/s

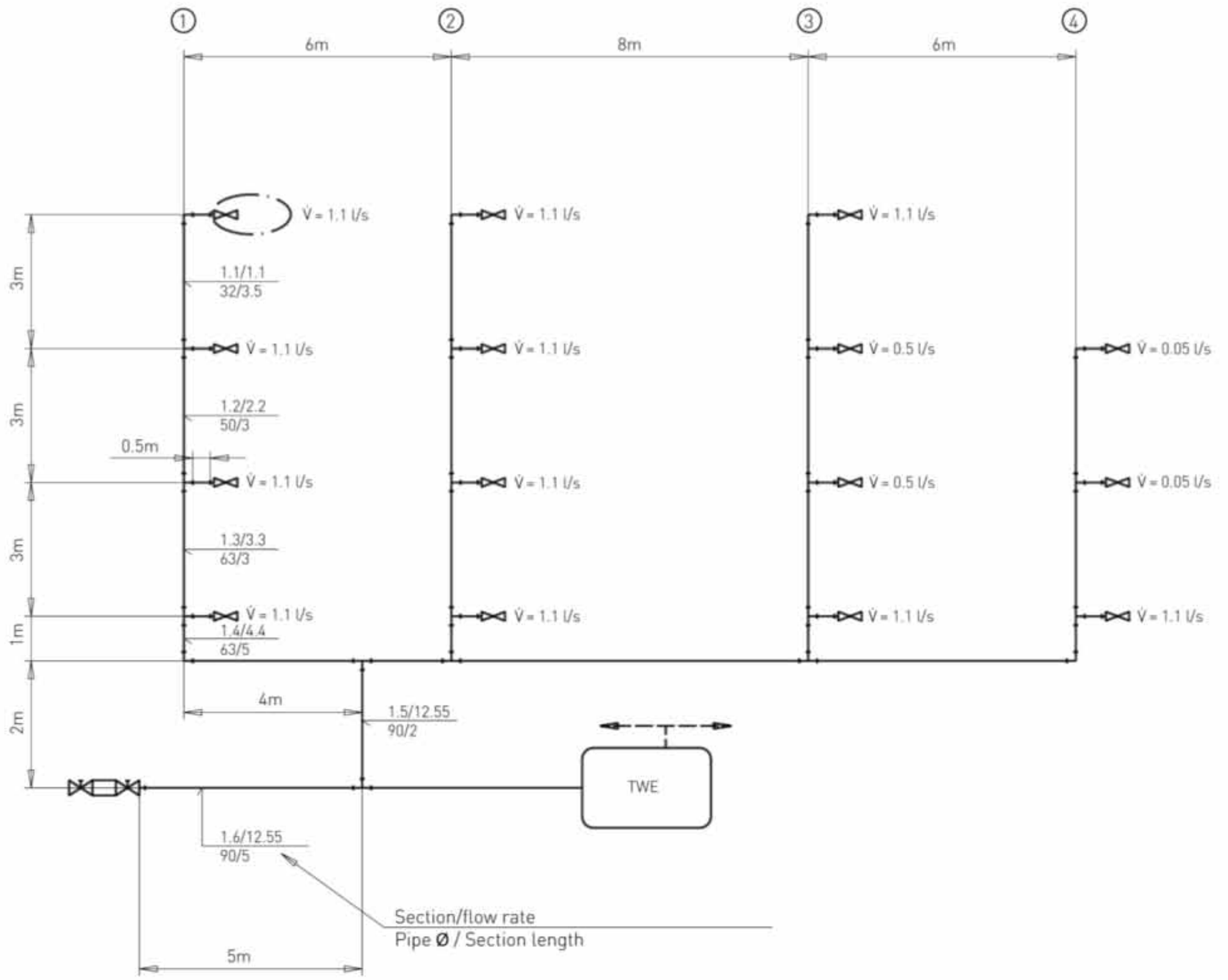
Calculation example 2: based on DVGW

Based on DVGW Germany, Technical Regulations DIN 1988 TRWI

Multistory level distribution



Distribution and riser pipes



Job reference: Multi storey distribution system	Worker: xxxxxxxxxx xxxxxxxx	Date xxxxx	Name xxxxxx	Sheet xx

Information from the drawing:				Pressure loss calculations:							Comments
1	2	3	4	5	6	7	8	9	10	11	
Section	k BE	fs l/s	Length TS m	Nom-∅ pipe d	i p Pipe- mbar/m	Fitting-allowance m	Σ Pipe length m	i p TS mbar			
Valve	11	0.58	-	DN20	-	-	-	11.0			Valve: INSTAFLEX 6211; DN20
1.1	11	0.58	3.5	d25	19.2	1.8	5.3	101.8			
1.2	22	0.85	3.0	d25	38.2	-	3.0	114.6			
1.3	33	1.05	3.0	d25	56.0	-	3.0	168.0			
1.4	44	1.20	5.0	d25	21.9	2.3	7.3	159.9			
1.5	141	2.10	2.0	d25	20.2	1.8	3.8	76.8			Column 3 calculated from Table 12,
1.6	214	2.55	5.0	d25	28.7	1.6	6.6	189.4			residential building DIN 1988, Part 3

Explanation

- Col. 3 from Col. 2 and resp. simultaneity diagram
- Col. 5 from Col. 2 and Table 1
- Col. 6 from Table 5 and Col. 3
- Col 7 from Table 4
- Col. 8 from Col. 4 and 7
- Col. 9 from Col. 6 and 8

Total pressure loss for line no. _______1___________ Δp_{VL} = ___821.5_________ mbar

GF Piping Systems

Job reference: Multi storey distribution system				Worker: xxxxxxxxxx xxxxxxxx							Date xxxxx / Name xxxxxx	Sheet xx
Information from the drawing:				**Pressure loss calculations:**							**Comments**	**Explanation**
1	2	3	4	5	6	7	8	9	10	11		
Section	k BE	fs l/s	Length TS m	Nom-∅ pipe d	i p Pipe- mbar/m	Fitting- allowance m	Σ Pipe length m	i p TS mbar			Column 3 calculated with simultaneity diagram according to DIN 1988, Part 3	Col. 5 from Col. 2 and Table 1; Col 7 from Table 4; Col. 9 from Col. 6 and 8
1.1	0.7	0.07	1.0	16x2.2	-	-	-	17.0			Column 9 calculated from Table 2 "Pressure losses for pipe loops d16"	
1.2	1.4	0.14	1.5	16x2.2	-	-	-	75.0				
1.3	2.1	0.19	2.0	16x2.2	-	-	-	158.0				
1.4	3.4	0.28	1.5	16x2.2	-	-	-	284.0				
								Ł	534.0		Line 1	
2	1.5	0.15	3.0	16x2.2	-	-	-	124.0	124.0		Line 2	
3	1.5	0.15	3.0	16x2.2	-	-	-	124.0	124.0		Line 3	
4	2.2	0.22	2.5	16x2.2	-	-	-	234.0	234.0		Line 4	Col. 3 from Col. 2 and resp. simultaneity diagram; Col. 6 from Table 5 and Col. 3; Col. 8 from Col. 4 and 7
5.1	0.7	0.07	1.0	16x2.2	-	-	-	17.0				
5.2	2.0	0.18	2.5	16x2.2	-	-	-	161.0				
								Ł	178.0		Line 5	
Total pressure loss for line no. 1 Δp_{ST} = 534.0 mbar											**GF Piping Systems**	

Excerpt of guidelines and norms in United Kingdom

U K

The Water Regulations Guide, C.I.B.S.E Guide C4 and British Standard BS 6700:2006 form the basis of pipe dimensioning and pressure loss determination in Great Britain and Northern Ireland.

Permission to use the BS 6700:2006 excerpts has been granted by BSI. British Standards are available in PDF format or hardcopy from BSI Online Shop www.bsi-group.com/shop or directly from BSI Customer Services Tel: +44 (0)20 8996 9001, Email: cservices@bsigroup.com (only paper).

Table 8 establishes the recommended flow rate values for the tapping points (hot and cold water).

Table 8:

Tap	Flow rate [l/s]	
	Design value	Minimum value
WC toilet tank (filled in 2 minutes)	0.13	0.05
WC rinsing channel (every WC) (see Note 2)	0.15	0.10
Urinal flushing (individual settings)	0.004	0.002
Wash basin	0.15	0.10
Hand wash basin (pillar valve)	0.10	0.07
Hand wash basin (spray or Mix spray valve)	0.05	0.03
Bidet	0.20	0.10
Bathtub (G ¾)	0.30	0.20
Bathtub (G 1)	0.60	0.40
Shower (see Note 3)	0.20	0.10
Sink (G ½)	0.20	0.10
Sink (G ¾)	0.30	0.20
Sink (G 1)	0.60	0.40
Washing machine (see Note 1)	0.20	0.15
Dishwasher (see Note 1)	0.15	0.10
Urinal flushing automatic	1.5 max.	1.2 min.
Urinal tank	0.3 max.	0.15 min.

Note 1: Please contact the manufacturer for details on the required flow rate if washing machines and dishwashers are used for more than one household.

Note 2: WC rinsing channels are recommended if the expected use is more than once a minute.

Note 3: The flow rate for showers depends on the type. For more information, contact the manufacturer.

In general, hot and cold water installations are designed and installed so that the required flow rate for every valve opened can be found in **Table 8**. This also pertains to every opened valve assembly whose total consumption does not exceed 0.3 l/s.

For simultaneous output, the flow rate for each opened valve should not be less than the value shown in **Table 8.**

Load units are factors which take into account the valve flow velocity, the duration of use and frequency of use. The number of each tapping point from Table P1, including the pipe length, must be multiplied by the load units from **Table 9**.

Table 9:

Type of tap	Load units (LU)
WC toilet tank	2
Wash basin ½ - DN15	1.5 - 3
Bathtub ¾ - DN25	10
Bathtub 1	22
Shower	3
Outlet valve	3
Outlet valve	5
Washing machine or dishwasher ½ - DN15	3

Note 1: WC toilet tanks with single or double flushing have the same load units.

Note 2: The load units of wash basins refer to wash basins with pillar valves. The larger load units are found in school and office situations because in these places there are peak usage times. If spray valves are installed, a simultaneous consumption of 0.04 l/s is assumed.

Note 3: Urinal flushing tanks have a very low consumption and are usually ignored.

Note 4: Tapping points for industrial applications or with peak usage times should be calculated so that 100 % of the flow is added to the simultaneous consumption.

Polybutene pipe dimensions can be calculated with the help of Table 1 by using the maximum number of load units.

Note: For approximate pipe dimensions, 1 LU from Table 9 equals 3 consumption units (DU/LU).

Table 10 Pressure loss per meter INSTAFLEX pipe (per C.I.B.S.E. C4 2007) for water at 20 °C

		Pipe dimension [mm]										
		Flow rate [l/s]										
Pressure loss [Pa/m]	Velocity [m/s]	**16**	**20**	**25**	**32**	**40**	**50**	**63**	**75**	**90**	**110**	Velocity [m/s]
0.1					0.001	0.000	0.006	0.016	0.033	0.068	0.139	
0.2					0.002	0.005	0.012	0.032	0.066	0.114	0.168	
0.3				0.001	0.003	0.007	0.019	0.048	0.095	0.122	0.215	
0.4				0.001	0.004	0.010	0.025	0.065	0.095	0.145	0.255	
0.5				0.002	0.005	0.012	0.031	0.079	0.100	0.166	0.292	0.05
0.6				0.002	0.006	0.015	0.038	0.079	0.112	0.185	0.325	
0.7			0.001	0.002	0.007	0.017	0.044	0.079	0.122	0.203	0.356	
0.8			0.001	0.003	0.008	0.020	0.051	0.081	0.133	0.220	0.385	
0.9			0.001	0.003	0.010	0.023	0.057	0.087	0.142	0.236	0.412	
1.0			0.001	0.004	0.011	0.025	0.063	0.092	0.152	0.251	0.439	
1.5			0.002	0.006	0.016	0.038	0.063	0.118	0.193	0.319	0.556	
2.0		0.001	0.003	0.008	0.022	0.050	0.073	0.140	0.229	0.378	0.657	

2.5		0.001	0.004	0.010	0.027	0.050	0.083	0.160	0.261	0.430	0.748	
3.0		0.001	0.004	0.012	0.033	0.050	0.093	0.178	0.291	0.478	0.831	
3.5		0.001	0.005	0.014	0.039	0.053	0.102	0.195	0.318	0.523	0.908	0.15
4.0		0.002	0.006	0.016	0.040	0.058	0.110	0.211	0.344	0.565	0.981	
4.5		0.002	0.007	0.018	0.040	0.062	0.118	0.227	0.396	0.605	1.040	
5.0		0.002	0.008	0.020	0.040	0.066	0.126	0.241	0.392	0.643	1.110	
5.5		0.003	0.008	0.022	0.040	0.070	0.133	0.255	0.414	0.680	1.170	
6.0		0.003	0.009	0.024	0.041	0.074	0.140	0.268	0.436	0.715	1.230	
6.5		0.003	0.010	0.026	0.043	0.078	0.147	0.281	0.457	0.748	1.290	
7.0		0.003	0.011	0.028	0.045	0.081	0.154	0.294	0.477	0.781	1.350	
7.5		0.004	0.012	0.030	0.047	0.085	0.160	0.306	0.496	0.813	1.400	
8.0		0.004	0.012	0.031	0.049	0.088	0.166	0.317	0.515	0.843	1..50	
8.5		0.004	0.013	0.031	0.051	0.091	0.172	0.329	0.533	0.873	1.510	
9.0		0.005	0.014	0.031	0.053	0.094	0.178	0.340	0.551	0.902	1.560	
9.5		0.005	0.015	0.031	0.054	0.098	0.184	0.351	0.569	0.931	1.600	
10.0	0.05	0.005	0.016	0.031	0.056	0.101	0.190	0.362	0.586	0.958	1.650	0.30
12.5		0.007	0.020	0.031	0.064	0.115	0.216	0.411	0.666	0.108	1.880	
15.0		0.008	0.024	0.035	0.072	0.128	0.240	0.457	0.739	1.200	2.080	
17.5		0.009	0.025	0.039	0.079	0.140	0.263	0.499	0.807	1.310	2.270	
20.0		0.011	0.025	0.042	0.085	0.151	0.284	0.539	0.872	1.420	2.450	
22.5		0.012	0.025	0.045	0.091	0.162	0.304	0.577	0.932	1.520	2.620	
25.0		0.014	0.025	0.048	0.097	0.173	0.323	0.613	0.990	1.610	2.780	
27.5		0.015	0.026	0.051	0.103	0.182	0.342	0.647	1.040	1.700	2.930	
30.0		0.016	0.028	0.053	0.108	0.192	0.359	0.680	1.090	1.790	3.080	0.50
32.5	0.15	0.018	0.029	0.056	0.113	0.201	0.376	0.712	1.140	1.870	3.220	
35.0		0.019	0.030	0.059	0.118	0.210	0.393	0.743	1.190	1.950	3.360	
37.5		0.019	0.032	0.061	0.123	0.219	0.408	0.773	1.240	2.030	3.490	
40.0		0.019	0.033	0.063	0.128	0.227	0.424	0.801	1.290	2.100	3.620	
42.5		0.019	0.034	0.066	0.133	0.235	0.439	0.830	1.330	2.170	3.740	

		Pipe dimension [mm]										
		Flow rate [l/s]										
Pressure loss [Pa/m]	Velocity [m/s]	**16**	**20**	**25**	**32**	**40**	**50**	**63**	**75**	**90**	**110**	Velocity [m/s]
45.0		0.019	0.035	0.068	0.137	0.243	0.454	0.857	1.380	2.250	3.860	
47.5		0.019	0.036	0.070	0.142	0.251	0.468	0.884	1.420	2.320	3.980	
50.0		0.019	0.038	0.072	0.146	0.258	0.482	0.910	1.460	2.380	4.100	
52.5		0.019	0.039	0.075	0.150	0.266	0.495	0.935	1.500	2.450	4.210	
55.0		0.019	0.040	0.077	0.154	0.273	0.509	0.961	1.540	2.510	4.320	
57.5		0.019	0.041	0.079	0.158	0.280	0.522	0.985	1.580	2.580	4.430	
60.0		0.020	0.042	0.081	0.162	0.287	0.535	1.000	1.620	2.640	4.540	
62.5		0.020	0.043	0.083	0.166	0.284	0.547	1.030	1.660	2.700	4.640	
65.0		0.021	0.044	0.085	0.170	0.300	0.560	1.050	1.700	2.760	4.750	
67.5		0.021	0.045	0.086	0.174	0.307	0.572	1.070	1.730	2.820	4.850	
70.0		0.022	0.046	0.088	0.177	0.314	0.584	1.100	1.770	2.880	4.950	

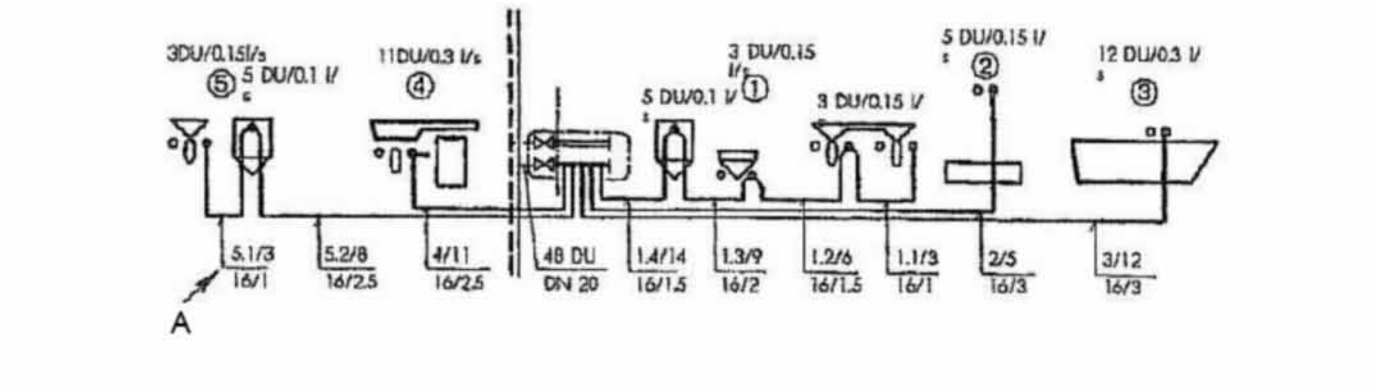
72.5		0.022	0.047	0.090	0.181	0.320	0.596	1.120	1.800	2.940	5.040	
75.0		0.023	0.048	0.092	0.185	3.260	0.607	1.140	1.840	2.990	5.140	
77.5		0.023	0.049	0.094	0.188	0.332	0.619	1.160	1.870	3.050	5.230	
80.0		0.024	0.050	0.096	0.192	0.339	0.630	1.180	1.910	3.100	5.330	
82.5		0.024	0.051	0.097	0.195	0.345	0.641	1.200	1.940	3.160	5.420	
85.0		0.025	0.052	0.099	0.199	0.351	0.652	1.220	1.970	3.210	5.510	
87.5		0.025	0.053	0.101	0.202	0.356	0.663	1.240	2.010	3.260	5.600	
90.0		0.025	0.054	0.102	0.205	0.362	0.674	1.260	2.040	3.310	5.690	
92.5		0.026	0.054	0.104	0.209	0.368	0.680	1.280	2.070	3.360	5.780	
95.0		0.026	0.055	0.106	0.212	0.374	0.700	1.300	2.100	3.420	5.860	
97.5		0.027	0.056	0.107	0.215	0.379	0.710	1.320	2.130	3.470	5.950	
100		0.027	0.057	0.109	0.218	0.385	0.720	1.340	2.160	3.510	6.030	1.00
120		0.030	0.063	0.121	0.242	0.427	0.790	1.490	2.390	3.890	6.670	
140		0.033	0.070	0.133	0.265	0.466	0.870	1.620	2.610	4.240	7.270	
160	0.30	0.036	0.075	0.143	0.286	0.503	0.930	1.750	2.810	4.570	7.820	
180		0.039	0.081	0.153	0.306	0.538	1.000	1.870	3.000	4.870	8.350	
200		0.041	0.086	0.163	3.250	0.571	1.050	1.980	3.180	5.170	8.850	1.50
220		0.044	0.091	0.172	0.343	0.603	1.110	2.090	3.360	5.450	9.330	
240		0.046	0.095	0.181	0.360	0.633	1.170	2.190	3.520	5.720	9.780	
260		0.048	0.100	0.189	0.377	0.662	1.220	2.300	3.680	5.970	10.200	
280		0.050	0.104	0.198	0.393	0.690	1.270	2.390	3.840	6.220	10.600	
300		0.052	0.109	0.206	0.409	0.718	1.320	2.490	3.990	6.470	11.000	
320		0.054	0.113	0.213	0.424	0.744	1.370	2.580	4.130	6.700	11.400	
340		0.056	0.117	0.221	0.439	0.770	1.420	2.660	4.270	6.930	11.800	
360		0.058	0.121	0.228	0.454	0.795	1.470	2.750	4.410	7.150	12.200	2.00
380	0.50	0.060	0.124	0.236	4.680	0.820	1.510	2.830	4.550	7.360	12.500	
400		0.062	0.128	0.243	0.481	0.844	1.550	2.920	4.680	7.570	12.900	
420		0.064	0.132	0.249	0.495	0.867	1.600	3.000	4.800	7.780	13.300	
440		0.066	0.135	0.256	0.508	0.890	1.640	3.070	4.930	7.980	13.600	
460		0.067	0.139	0.263	0.521	0.913	1.680	3.150	5.050	8.180	13.900	
480		0.069	0.142	0.269	0.534	0.935	1.720	3.230	5.170	8.370	14.300	
500		0.071	0.146	0.275	0.546	0.956	1.760	3.300	5.290	8.560	14.600	

		Pipe dimension [mm] Flow rate [l/s]										
Pressure loss [Pa/m]	Velocity [m/s]	16	20	25	32	40	50	63	75	90	110	Velocity [m/s]
520		0.072	0.149	0.282	0.558	0.977	1.800	3.370	5.400	8.750	14.900	
540		0.074	0.152	0.288	0.570	0.998	1.840	3.440	5.520	8.930	15.200	
560		0.076	0.156	0.294	0.582	1.010	1.880	3.510	5.630	9.110	15.500	
580		0.077	0.159	0.300	0.594	1.030	1.910	3.580	5.740	9.280	15.800	
600		0.079	0.162	0.305	0.605	1.050	1.950	3.650	5.850	9.460	16.100	
620		0.080	0.165	0.311	0.616	1.070	1.990	3.720	5.950	9.630	16.400	
640		0.082	0.168	0.317	0.627	1.090	2.020	3.780	6.060	9.800	16.700	
660		0.083	0.171	0.322	0.638	1.110	2.060	3.850	6.160	9.960	17.000	
680		0.085	0.174	0.328	0.649	1.130	2.090	3.910	6.260	10.100	17.200	
700		0.086	0.177	0.333	0.660	1.150	2.120	3.970	6.360	10.200	17.500	
720		0.087	0.180	0.339	0.670	1.170	2.160	4.040	6.460	10.400	17.800	
740		0.089	0.182	0.344	0.681	1.190	2.190	4.100	6.560	10.600	18.100	
760		0.090	0.185	0.349	0.691	1.200	2.220	4.160	6.650	10.700	18.300	3.00
780		0.091	0.188	0.354	0.701	1.220	2.250	4.220	6.750	10.900	18.600	
800		0.093	0.191	0.359	0.711	1.240	2.290	4.280	6.840	11.000	18.800	
820		0.094	0.193	0.364	0.721	1.260	2.320	4.330	6.940	11.200	19.100	
840		0.095	0.196	0.369	0.731	1.270	2.350	4.390	7.030	11.300	19.300	
860		0.097	0.199	0.374	0.740	1.290	2.380	4.450	7.120	11.500	19.600	
880		0.098	0.201	0.379	0.750	1.310	2.410	4.510	7.210	11.600	19.800	
900		0.099	0.204	0.384	0.759	1.320	2.440	4.560	7.300	11.800	20.100	
920		0.101	0.207	0.389	0.769	1.340	2.470	4.620	7.390	11.900	20.300	
940		0.102	0.209	0.394	0.778	1.350	2.500	4.670	7.470	12.000	20.600	
960		0.103	0.212	0.398	0.787	1.370	2.530	4.730	7.560	12.000	20.800	
980		0.104	0.214	0.403	0.796	1.390	2.560	4.780	7.650	12.300	21.000	
1000		0.106	0.217	0.408	0.805	1.400	2.590	4.830	7.730	12.400	21.300	
1100		0.112	0.229	0.430	0.849	1.480	2.730	5.090	8.140	13.100	22.400	
1200	1.00	0.117	0.240	0.451	0.891	1.550	2.860	5.340	8.540	13.700	23.500	
1300		0.123	0.251	0.472	0.932	1.620	2.990	5.580	8.920	14.400	24.500	
1400		0.128	0.262	0.492	0.971	1.690	3.110	5.810	9.280	14.900	25.500	
1500		0.133	0.272	0.511	1.000	1.760	3.230	6.030	9.640	15.500	26.500	
1600		1.380	0.282	0.530	1.040	1.820	3.350	6.250	9.980	16.100	27.400	
1700		1.430	0.292	0.548	1.080	1.880	3.460	6.460	10.300	16.600	28.300	
1800		0.148	0.302	0.566	1.110	1.940	3.570	6.660	10.300	17.100	29.200	
1900		0.152	0.311	0.584	1.150	2.00	3.680	6.860	10.900	17.600	30.000	
2000		0.157	0.320	0.600	1.180	2.060	3.780	7.050	11.200	18.100	30.900	

Calculation example 3: based on BS6700:2006 and Water Regulations Guide

According to BS 6700:2006 and Water Regulations Guide

Multistory level distribution



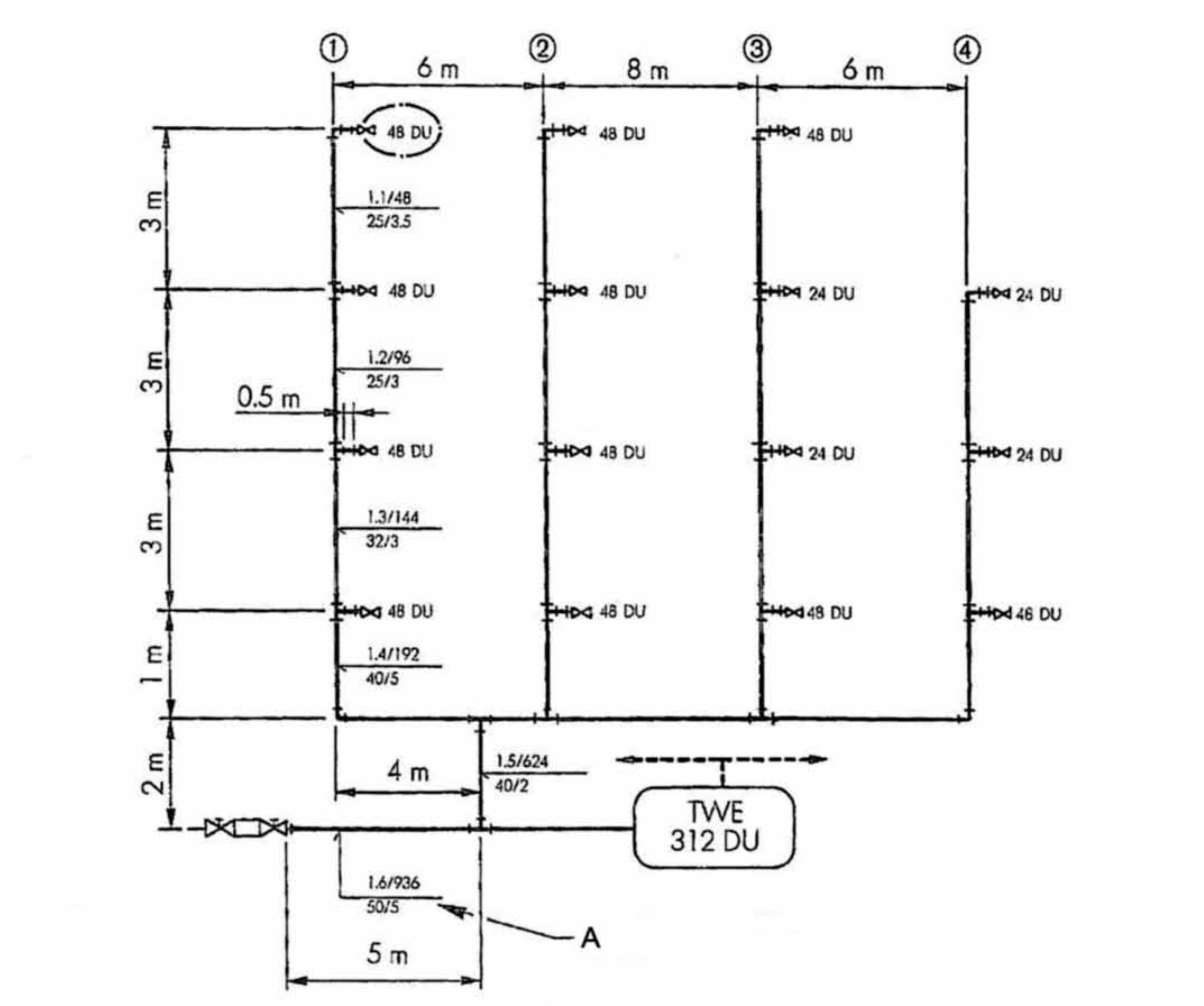
Section / Number DU (LV)

Pipe ø / Section length

DU = shower
LV = load value

1 load unit equals 3 DU (LV)

Distribution and riser pipes



Section / Number DU (LV)
Pipe ø / Section length

Job reference: Distribution and riser systems				Worker: xxxxxxxxxx xxxxxxxx						
Information from the drawing:				**Pressure loss calculations:**						
1	2	3	4	5	6	7	8	9	10	11
Section	k BE	fs l/s	Length TS m	Nom-∅ pipe d	i p Pipe- mbar/m	Fitting-allowance m	Σ Pipe length m	i p TS mbar		
Valve	16(48)	0.3		DN20				240	240	
1.1	16(48)	0.3	3.5	25	580	0.6	4.1	2378	2618	
1.2	32(96)	0.4	3	25	970	-	3.0	2910	5528	
1.3	48(144)	0.7	3	32	780	-	3.0	2340	7868	
1.4	64(192)	0.9	5	40	450	1	6.0	2700	10568	
1.5	208(624)	2.1	2	40	2010	4.6	6.6	13266	23834	
1.6	312(936)	2.8	5	50	1150	2.3	7.3	8395	32229	

Total pressure loss for line no. 1 Δ p = 32'229 mbar

Date: xxxxx Name: xxxxxx Sheet: xx

Comments

Valve: see below. Pressure loss see table

Col. 1: pipe section from drawing

Col. 2: determination of the BE from drawing or specific table

Col. 3: determination of the Vs from drawing or specific table (for small BE's) or diagram (for bigger BE's)

Col. 4: pipe length from drawing or specific table

Col. 5: pipe size from drawing or specific table

Col. 6: include pressure loss per meter from specific table

Col. 7: determination of fitting addition from specific table

Col. 8: calculate pipe lengths (col. 4 and 7)

Col. 9: calculate pressure loss by multiplying of col. 6 with col. 8)

Col. 10: calculate the total pressure loss for each section by adding of col. 9 for each section

Explanation

Col. 5 from Col. 2 and Table 1

Col 7 from Table 4

Col. 9 from Col. 6 and 8

Col. 3 from Col. 2 and resp. simultaneity diagram

Col. 6 from Table 5 and Col. 3

Col. 8 from Col. 4 and 7

GF Piping Systems

Job reference:				Worker:							Date Name Sheet
Information from the drawing:				**Pressure loss calculations:**							**Comments**
1	2	3	4	5	6	7	8	9	10	11	
Section	k BE	fs l/s	Length TS m	Nom-∅ pipe d	i p Pipe- mbar/m	Fitting- allowance m	Σ Pipe length m	i p TS mbar			
Total pressure loss for line no. ______________ **Δ p =** __________ **mbar**											**GF Piping Systems**

Comments

Valve: see below. Pressure loss see table

Col. 1: pipe section from drawing

Col. 2: determination of the BE from drawing or specific table

Col. 3: determination of the Vs from drawing or specific table (for small BE's) or diagram (for bigger BE's)

Col. 4: pipe length from drawing or specific table

Col. 5: pipe size from drawing or specific table

Col. 6: include pressure loss per meter from specific table

Col. 7: determination of fitting addition from specific table

Col. 8: calculate pipe lengths (col. 4 and 7)

Col. 9: calculate pressure loss by multiplying of col. 6 with col. 8)

Col. 10: calculate the total pressure loss for each TS by adding of col. 9 for each TS

Explanation

	Col. 5 from Col. 2 and Table 1	Col 7 from Table 4	Col. 9 from Col. 6 and 8
Col. 3 from Col. 2 and resp. simultaneity diagram		Col. 6 from Table 5 and Col. 3	Col. 8 from Col. 4 and 7

Appendix

Tables and diagrams for pipeline dimensioning and pressure loss calculation

Pipe data

Pipe dimension [mm]	Wall thickness [mm]	Inner diameter [mm]	Water quantity [l/m]	Rod length [m]	Pipe weight (empty) [kg/m]	Pipe weight with 20 ºC water[kg/m]
16	2	11.6	0.10	5.8	0.0088	0.1088
20	2.8	14.4	0.16	5.8	0.141	0.301
25	2.3	20.4	0.33	5.8	0.152	0.482
32	2.9	26.2	0.53	5.8	0.254	0.784
40	3.7	32.6	0.83	5.8	0.392	1.222
50	4.6	40.8	1.31	5.8	0.610	1.920
63	5.8	51.4	2.07	5.8	0.969	3.039
75	6.8	61.4	2.96	5.8	1.354	4.314
90	8.2	73.6	4.25	5.8	1.960	6.210
110	10.0	90.0	6.36	5.8	2.920	9.280
125	11.40	102.20	8.20	5.8	3.95	12.10
160	14.60	130.80	13.40	5.8	6.46	19.86
225	20.50	184.00	26.60	5.8	12.70	39.30

Pressure loss and flow velocity

**INSTAFLEX PB pipes per DIN 16968 and DIN 16969.
Pipe series S 3.2 (ISO 4065)**

Pipe frictional pressure drop R and calculated flow velocity v in relation to peak flow rate V_s

Peak flow rate V_s	**PB pipe DN12/d16 x 2.8 di=11.6 mm V=0.16 l/m**		**PB pipe DN15/d20 x 2.8 di=14.4 mm V=0.16 l/m**	
[l/s]	**R [mbar/m]**	**v [m/s]**	**R [mbar/m]**	**v [m/s]**
0.01	0.3	0.1	0.1	0.1
0.02	0.8	0.2	0.3	0.1
0.03	1.6	0.3	0.6	0.2
0.04	2.6	0.4	0.9	0.2
0.05	3.9	0.5	1.4	0.3
0.06	5.3	0.6	1.9	0.4
0.07	6.9	0.7	2.5	0.4
0.08	8.7	0.8	3.1	0.5
0.09	10.7	0.9	3.8	0.6
0.10	12.8	0.9	4.6	0.6
0.15	26.1	1.4	9.3	0.9
0.20	43.5	1.9	15.4	1.2
0.25	64.8	2.4	22.8	1.5
0.30	89.9	2.8	31.6	1.8
0.35	118.8	3.3	41.6	2.1
0.40	151.3	3.8	52.9	2.5
0.45	187.4	4.3	65.4	2.8
0.50	227.2	4.7	79.1	3.1
0.55	270.5	5.2	94.0	3.4
0.60			110.1	3.7
0.65			127.3	4.0
0.70			145.8	4.3
0.75			165.3	4.6
0.80			186.1	4.9
0.85			208.0	5.2
0.90				
0.95				
1.00				
1.05				
1.10				
1.15				
1.20				
1.25				
1.30				

INSTAFLEX PB pipes per DIN 16968 and 16969. Pipe series S 5 (ISO 4065)

Pipe frictional pressure drop R and calculated flow velocity v in relation to peak flow rate V_s

Peak flow rate V_s	PB pipe DN12/d16 x 2.8 di=11.6 mm V=0.16 l/m		PB pipe DN15/d20 x 2.8 di=14.4 mm V=0.16 l/m	
[l/s]	R [mbar/m]	v [m/s]	R [mbar/m]	v [m/s]
0.05	0.3	0.2	0.1	0.1
0.10	0.9	0.3	0.3	0.2
0.15	1.8	0.5	0.6	0.3
0.20	2.9	0.6	0.9	0.4
0.25	4.3	0.8	1.4	0.5
0.30	5.9	0.9	1.9	0.6
0.35	7.8	1.1	2.4	0.7
0.40	9.9	1.2	3.1	0.8
0.45	12.2	1.4	3.8	0.8
0.50	14.7	1.5	4.5	0.9
0.55	17.4	1.7	5.4	1.0
0.60	20.3	1.8	6.3	1.1
0.65	23.5	2.0	7.3	1.2
0.70	26.8	2.1	8.3	1.3
0.75	30.3	2.3	9.4	1.4
0.80	34.1	2.4	10.6	1.5
0.85	38.0	2.6	11.8	1.6
0.90	42.2	2.8	13.0	1.7
0.95	46.5	2.9	14.4	1.8
1.00	51.0	3.1	15.8	1.9
1.05	55.8	3.2	17.2	2.0
1.10	6.7	3.4	18.7	2.1
1.15	65.8	3.5	20.3	2.2
1.20	71.1	3.7	21.9	2.3
1.25	76.6	3.8	23.5	2.4
1.30	82.3	4.0	25.3	2.4
1.35	88.2	4.1	27.1	2.5
1.40	94.2	4.3	28.9	2.6
1.45	100.5	4.4	30.8	2.7
1.50	106.9	4.6	32.8	2.8
1.55	113.5	4.7	34.8	2.9
1.60	120.4	4.9	36.8	3.0
1.65	127.4	5.0	38.9	3.1
1.70			41.1	3.2
1.75			43.3	3.3
1.80			45.6	3.4
1.85			48.0	3.5
1.90			50.4	3.6
1.95			52.8	3.7

2.00			55.3	3.8
2.05			57.9	3.9
2.10			60.5	4.0
2.15			63.1	4.0
2.20			65.8	4.1
2.25			68.6	4.2
2.30			71.4	4.3
2.35			74.3	4.4
2.40			77.2	4.5
2.45			80.2	4.6
2.50			83.2	4.7
2.55			86.3	4.8
2.60			89.5	4.9
2.65			92.7	5.0
2.70			95.9	5.1

Peak flow rate V_s	**DN32/d40 di=32.6 mm V=0.83 l/m**		**DN40/d50 di=40.8 mm V=131 l/m**		**DN50/d63 di=514 mm V=2.07 l/m**		**Peak flow rate Vs**
[l/s]	**R [mbar/m]**	**v [m/s]**	**R [mbar/m]**	**v [m/s]**	**R [mbar/m]**	**v [m/s]**	**[l/s]**
0.1	0.1	0.1	0.0	0	0.0	0.0	5.1
0.2	0.3	0.2	0.1	0.2	0.0	0.1	5.2
0.3	0.6	0.4	0.2	0.2	0.1	0.1	5.3
0.4	1.1	0.5	0.4	0.3	0.1	0.2	5.4
0.5	1.6	0.6	0.5	0.4	0.2	0.2	5.5
0.6	2.1	0.7	0.7	0.5	0.2	0.3	5.6
0.7	2.8	0.8	1.0	0.5	0.3	0.3	5.7
0.8	3.6	1.0	1.2	0.6	0.4	0.4	5.8
0.9	4.4	1.1	1.5	0.7	0.5	0.4	5.9
1.0	5.3	1.2	1.8	0.8	0.6	0.5	6.0
1.1	6.3	1.3	2.1	0.8	0.7	0.5	6.1
1.2	7.3	1.4	2.5	0.9	0.8	0.6	6.2
1.3	8.5	1.6	2.9	1.0	1.0	0.6	6.3
1.4	9.7	1.7	3.3	1.1	1.1	0.7	6.4
1.5	11.0	1.8	3.7	1.1	1.2	0.7	6.5
1.6	12.3	1.9	4.2	1.2	1.4	0.8	6.6
1.7	13.7	2.0	4.6	1.3	1.5	0.8	6.7
1.8	15.2	2.2	5.1	1.4	1.7	0.9	6.8
1.9	16.8	2.3	5.7	1.5	1.9	0.9	6.9
2.0	18.4	2.4	6.2	1.5	2.0	1.0	7.0
2.1	20.1	2.5	6.8	1.6	2.2	1.0	7.1
2.2	21.9	2.6	7.4	1.7	2.4	1.1	7.2
2.3	23.7	2.8	8.0	1.8	2.6	1.1	7.3
2.4	25.6	2.9	8.6	1.8	2.8	1.2	7.4
2.5	27.6	3.0	9.3	1.9	3.1	1.2	7.5
2.6	29.6	3.1	10.0	2.0	3.3	1.3	7.6
2.7	31.7	3.2	10.7	2.1	3.5	1.3	7.7
2.8	33.9	3.4	11.4	2.1	3.7	1.3	7.8
2.9	36.2	3.5	12.2	2.2	4.0	1.4	7.9
3.0	38.5	3.6	12.9	2.3	4.2	1.4	8.0
3.1	40.9	3.7	13.7	2.4	4.5	1.5	8.1
3.2	43.3	3.8	14.5	2.4	4.8	1.5	8.2
3.3	45.8	4.0	15.4	2.5	5.0	1.6	8.3
3.4	48.4	4.1	16.2	2.6	5.3	1.6	8.4
3.5	51.0	4.2	17.1	2.7	5.6	1.7	8.5
3.6	53.7	4.3	18.0	2.8	5.9	1.7	8.6
3.7	56.5	4.4	18.9	2.8	6.2	1.8	8.7
3.8	59.4	4.6	19.9	2.9	6.5	1.8	8.8
3.9	62.3	4.7	20.8	3.0	6.8	1.9	8.9
4.0	65.2	4.8	21.8	3.1	7.1	1.9	9.0
4.1	68.3	4.9	22.8	3.1	7.4	2.0	9.1
4.2	71.4	5.0	23.8	3.2	7.8	2.0	9.2
4.3	74.5	5.2	24.9	3.3	8.1	2.1	9.3

4.4			26.0	3.4	8.5	2.1	9.4
4.5			27.0	3.4	8.8	2.2	9.5
4.6			28.2	3.5	9.2	2.2	9.6
4.7			29.3	3.6	9.5	2.3	9.7
4.8			30.4	3.7	9.9	2.3	9.8
4.9			31.6	3.7	10.3	2.4	9.9
5.0			32.8	3.8	10.7	2.4	10.0

Peak flow rate V_s	**DN40/d50 di=40.8 mm V=1.31 l/m**		**DN50/d63 di=51.4 mm V=2.07 l/m**	
[l/s]	**R [mbar/m]**	**v [m/s]**	**R [mbar/m]**	**v [m/s]**
0.1	34.0	3.9	11.0	2.5
0.2	35.3	4.0	11.4	2.5
0.3	36.5	4.1	11.9	2.6
0.4	37.8	4.1	12.3	2.6
0.5	39.1	4.2	12.7	2.7
0.6	40.4	4.3	13.1	2.7
0.7	41.7	4.4	13.5	2.7
0.8	43.1	4.4	14.0	2.8
0.9	44.5	4.5	14.4	2.8
1.0	45.9	4.6	14.9	2.9
1.1	47.3	4.7	15.3	2.9
1.2	48.7	4.7	15.8	3.0
1.3	50.2	4.8	16.2	3.0
1.4	51.7	4.9	16.7	3.1
1.5	53.2	5.0	17.2	3.1
1.6	54.7	5.0	17.7	3.2
1.7	56.2	5.1	18.2	3.2
1.8			18.7	3.3
1.9			19.2	3.3
2.0			19.7	3.4
2.1			20.2	3.4
2.2			20.7	3.5
2.3			21.3	3.5
2.4			21.8	3.6
2.5			22.3	3.6
2.6			22.9	3.7
2.7			23.5	3.7
2.8			24.0	3.8
2.9			24.6	3.8
3.0			25.2	3.9
3.1			25.7	3.9
3.2			26.3	4.0
3.3			26.9	4.0
3.4			27.5	4.0
3.5			28.1	4.1
3.6			28.7	4.1
3.7			29.4	4.2
3.8			30.0	4.2
3.9			30.6	4.3
4.0			31.2	4.3
4.1			31.9	4.4
4.2			32.5	4.4
4.3			33.2	4.5

4.4			33.9	4.5
4.5			34.5	4.6
4.6			35.2	4.6
4.7			35.9	4.7
4.8			36.6	4.7
4.9			37.3	4.8
5.0			37.9	4.8

Peak flow rate V s	DN65/d75 di=61.2 mm V=2.94 l/m		DN80/d90 di=73.6 mm V=4.25 l/m		DN90/d110 di=90.0 mm V=6.36 l/m	
[l/s]	R [mbar/m]	v [m/s]	R [mbar/m]	v [m/s]	R [mbar/m]	v [m/s]
0.5	0.0	0.2	0.0	0.1	0.0	0.1
1.0	0.3	0.3	0.1	0.2	0.0	0.1
1.5	0.5	0.5	0.2	0.4	0.1	0.2
2.0	0.9	0.7	0.4	0.5	0.2	0.3
2.5	1.3	0.8	0.5	0.6	0.3	0.4
3.0	1.8	1.0	0.8	0.7	0.3	0.5
3.5	2.4	1.2	1.0	0.8	0.4	0.6
4.0	3.1	1.4	1.3	0.9	0.5	0.6
4.5	3.8	1.5	1.6	1.1	0.6	0.7
5.0	4.6	1.7	1.9	1.2	0.7	0.8
5.5	5.4	1.9	2.2	1.3	0.8	0.9
6.0	6.4	2.0	2.6	1.4	0.9	0.9
6.5	7.4	2.2	3.0	1.5	1.0	1.0
7.0	8.4	2.4	3.4	1.6	1.2	1.1
7.5	9.6	2.5	3.9	1.8	1.3	1.2
8.0	10.7	2.7	4.4	1.9	1.4	1.2
8.5	12.0	2.9	4.9	2.0	1.5	1.3
9.0	13.3	3.1	5.4	2.1	1.6	1.4
9.5	14.7	3.2	6.0	2.2	1.7	1.5
10.0	16.2	3.4	6.6	2.4	1.9	1.6
10.5	17.7	3.6	7.2	2.5	2.2	1.7
11.0	19.3	3.7	7.8	2.6	2.5	1.7
11.5	20.9	3.9	8.5	2.7	2.8	1.8
12.0	22.6	4.1	9.2	2.8	3.2	1.9
12.5	24.4	4.2	9.9	2.9	3.5	2.0
13.0	26.2	4.4	10.6	3.1	3.8	2.0
13.5	28.1	4.6	11.4	3.2	4.1	2.1
14.0	30.0	4.8	12.2	3.3	4.4	2.2
14.5	32.1	4.9	13.0	3.4	4.8	2.3
15.0	34.1	5.1	13.8	3.5	5.2	2.4
15.5			14.7	3.6	5.5	2.4
16.0			15.6	3.8	5.8	2.5
16.5			16.5	4.0	6.1	2.6
17.0			17.4	4.1	6.5	2.7
17.5			18.4	4.2	6.8	2.7
18.0			19.4	4.3	7.2	2.8
18.5			20.4	4.4	7.6	2.9
19.0			21.4	4.5	8.0	3.0
19.5			22.4	4.6	8.3	3.1
20.0			23.5	4.7	8.7	3.1
20.5			24.6	4.8	9.1	3.2
21.0			25.7	4.9	9.5	3.3
21.5			26.9	5.1	9.8	3.4

22.0					10.2	3.5
22.5					10.6	3.5
23.0					11.0	3.6
23.5					11.4	3.7
24.0					11.8	3.8
24.5					12.3	3.8
25.0					13.1	3.9
26.0					14.2	4.1
27.0					15.1	4.2
28.0					16.3	4.4
29.0					17.8	4.6
30.0					19.7	4.7

Pressure loss and flow velocity INSTAFLEX

d_1 x s d_2	125 x 11.4 102.2		160 x 14.6 130.8		225 x 20.5 184.0	
Q [l/s]	v [m/s]	dp [mbar/m]	v [m/s]	dp [mbar/m]	v [m/s]	dp [mbar/m]
0.5	0.061	0.007				
0.63	0.077	0.01				
0.08	0.098	0.016	0.060	0.005		
1.0	0.122	0.023	0.074	0.0071		
1.25	0.152	0.034	0.093	0.011		
1.6	0.195	0.053	0.119	0.016	0.060	0.003
2	0.244	0.078	0.149	0.024	0.075	0.005
2.5	0.305	1.116	0.186	0.036	0.094	0.007
3.15	0.384	0.174	0.234	0.054	0.118	0.011
4	0.488	2.266	0.298	0.082	0.150	0.016
5	0.610	0.396	0.372	0.12	0.188	0.024
6.3	0.768	0.598	0.469	0.183	0.237	0.036
8	0.975	0.919	0.595	0.281	0.301	0.055
10	1.219	1.373	0.744	0.419	0.376	0.081
12.5	1.524	2.056	0.930	0.625	0.470	0.121
16	1.95	3.219	1.191	0.976	0.602	0.089
20	2.438	4.836	1.488	1.463	0.752	0.282
25	3.048	7.279	1.861	2.195	0.940	0.422
31.5			2.344	3.347	1.185	0.641
40			2.977	5.188	1.504	0.989
50					1.880	1.486
63					2.369	2.270
80					3.009	3.521

d_i = inner diameter
s = pipe wall thickness
d_a = outer diameter
Q = flow volume [l/s]
v = flow velocity [m/s]
dp = pressure loss [mbar/m]

The table shows calculations for a water temperature of 10 ºC. For higher temperatures, the pressure loss dp must be multiplied with the factor k (see diagram below).

Temperature [ºC]	Factor k
10	1
20	0.958
30	0.925
40	0.896
50	0.878
60	0.580

Pressure loss in fittings

The table below shows the equivalent length of pressure loss in fittings. The equivalent length is the length of a pipe which would produce the same pressure loss as the respective fitting.

Table 11: Equivalent pipe lengths for INSTAFLEX compression fittings

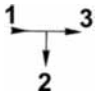
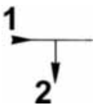
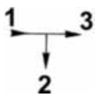
Article	PB pipe dimension «d»									
	16	20	25	32	40	50	63	75		
	Equivalent pipe length [m]									
Adaptors, sockets, couplings	0.7	1.3	1.2	1.4	1.4	1.6	2.0	2.4		
Valve connections/ elbow/bend 90 º	1.3	1.5	4.3							
Valve connections/ T-equal  1-3 1-2	0.9 2.2	1.2 3.0	1.7 4.2							
T-reduced	The loss coefficient of the outlet in the flow direction (1-2 or 1-3) of the T-equal must always be taken into consideration.									
T-adaptor	For outlet 2, only the loss coefficient of the part to be screwed in needs to be considered.									

Table 12: Equivalent pipe lengths for INSTAFLEX electrofusion and socket fusion fittings

Article	PB pipe dimension «d»									
	16	20	25	32	40	50	63	75	90	110
	Equivalent pipe length [m]									
Elbow 90º	0.3	0.4	0.6	0.8	1.0	1.2	1.7	2.1	2.6	3.2
Elbow 45º	0.2	0.3	0.4	0.5	0.7	0.9	1.2	1.5	1.9	2.4
T-equal 	0.6	0.8	1.1	1.5	1.8	2.3	3.2	4.2	5.4	6.6
T-equal 	0.7	0.9	1.2	1.7	2.1	2.7	3.7	4.8	5.9	7.0
T-reduced	The loss coefficient of the outlet in the flow direction (1-2 or 1-3) of the T-equal must always be taken into consideration.									
Not documented are T90º passage, sockets, reducers, unions, due to too low pipe length values.										

Equivalent pipe length ≙ of the pressure loss of the fitting in relation to the given pipe meter with a known flow rate.
Example:
Pipe d16 x 2.2 V = 0.4 l/s=151.3 bar/m
151.3 x 1.3 = pressure loss of a valve connection

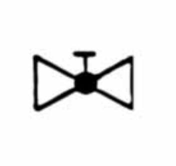
Equivalent pipe lengths for INSTAFLEX BIG fittings

Table 13:

Pipe dimension (DN, mm)		**125**				**160**				**225**			
v [m/s]		**0.5**	**1**	**2**	**3**	**0.5**	**1**	**2**	**3**	**0.5**	**1**	**2**	**3**
	Pressure loss Pipe [mbar/m]	0.266	0.919	3.219	7.279	0.183	0.625	2.195	5.188	0.121	0.422	1.486	3.521
	Loss coef-ficient	Equivalent pipe lengths [m]											
Elbow 90 º	0.7	3.27	3.81	4.35	4.33	4.78	5.60	6.38	6.07	7.23	8.29	9.42	8.94
Elbow 45 º	0.4	1.88	2.18	2.48	2.47	2.73	3.20	3.64	3.47	4.13	4.74	5.38	5.11
T equal	1.3	6.11	7.07	8.07	8.03	8.88	10.40	11.84	11.27	13.43	15.40	17.49	16.61
Reducer													
225-160	0.5	2.35	2.72	3.11	3.09	3.41	4.00	4.55	4.34	5.16	5.92	6.73	6.39
160-125	0.5	2.35	2.72	3.11	3.09	3.41	4.00	4.55	4.34	5.16	5.92	6.73	6.39
125-110	0.5	2.35	2.72	3.11	3.09	3.41	4.00	4.55	4.34	5.16	5.92	6.73	6.39

Pressure loss in INSTAFLEX shut-off valves

Table 14:



Article
PB valve

Flow rate	Pressure loss ω p [mbar]						
	Dimension DN						
[l/s]	12	15	20	25	32	40	50
0.22		5.4	1.0	-			
0.25		6.9	1.6	-			
0.30		10.0	2.4	1.0			
0.35		13.6	3.2	1.4			
0.40		17.7	4.2	1.9			
0.45		22.5	5.3	2.4			
0.50		27.7	6.6	3.0			
0.55		33.6	8.0	3.6			
0.60		40.0	9.5	4.3			
0.65		46.8	11.0	5.0			
0.70		54.4	13.0	5.8	1.6		
0.80		71.0	16.8	7.6	2.1		
0.90		90.0	21.3	9.6	2.6		
1.00		111.0	26.3	12.0	3.3		
1.10		134.2	31.8	14.4	4.0		
1.20			37.8	17.1	4.7		
1.30			44.4	20.1	5.5		
1.40			51.5	23.3	6.4		
1.50			59.0	26.7	7.3	0.9	2.5
1.75			-	36.4	10.0	1.2	3.4
2.00				47.5	13.0	1.6	4.4
2.25				60.2	16.5	2.0	5.6
2.50				74.3	20.4	2.5	6.9
2.75				90.0	24.7	3.0	8.4
3.00				107.0	29.4	3.6	10.0
3.20				121.7	33.4	4.1	11.4
3.40				137.4	37.7	4.6	12.8
3.60				154.0	42.3	5.2	14.4
3.80				171.6	47.1	5.8	16.0
4.00				190.1	52.2	6.4	17.8
4.2					57.5	7.0	19.6
4.4					63.1	7.7	21.5
4.6						8.5	23.5
4.8						9.2	25.6
5.0						10.0	27.7

5.2 5.4 5.6 5.8 6.0						10.8 11.6 12.5 13.4 14.4	30.0 32.4 35.8 37.3 40.0
6.5 7.0 7.5 8.0						16.9 19.5	46.9 54.4 62.4 71.0
8.5 9.0 9.5 10.0							80.2 89.9 100.1 111.0
kv-value		180	370	550	1050	3000	1800
Pipe ø d	16	20	25	32	40	50	63

kv-value = flow coefficient [m³/h]: measurement to select and dimension a valve in order to realise the desired flow of a liquid or gas.

Dimension
d20 to d63
DN15 to DN50

Pressure loss calculation:

$$\Delta p = \left(\frac{\dot{V} \times 60}{kv}\right)^2 \times \rho$$

kv = 550

means a flow rate of 550 l/min with a pressure loss of 1000 mbar

$$\dot{V} = \frac{kv}{60} \times \sqrt{\frac{\Delta P}{\rho}}$$

Example:

$$\Delta p = \left(\frac{\dot{V} \times 60}{kv}\right)^2 \times \rho$$

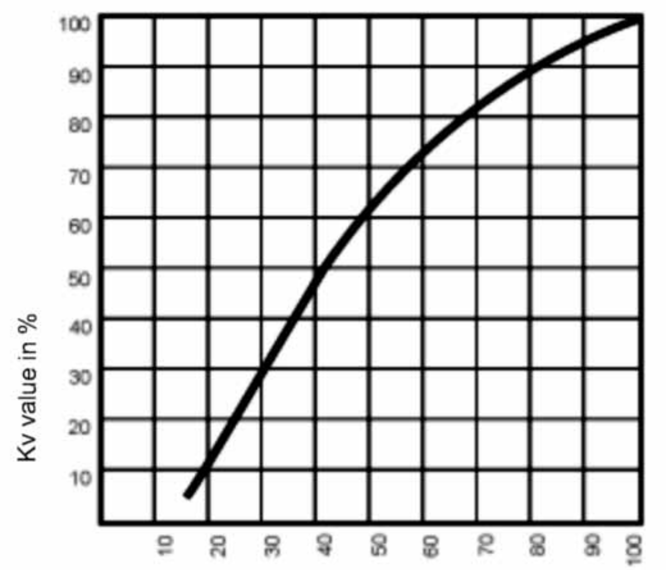
Flow rate V = 2.0 l/s

Pressure loss Δp = 47.5 mbar

ρ of water at 18 ºC = 998.5 kg/m³

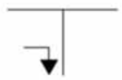
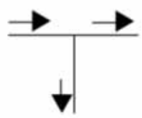
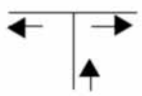
$$= \left(\frac{2.0 \times 60}{550}\right)^2 \times 998.5$$

Flow characteristics



Spindle lift in %
10 % spindle lift corresponds to ½ spindle revolution

Loss coefficient ζ (Zeta) for individual resistances in INSTAFLEX fittings

Individual resistance	Simplified symbol	Loss coefficient* ζ
Change in direction via elbow to 45°		0.4
Change in direction via elbow larger than 45° to 90°		0.7
Flow separation, branch		1.3
Flow separation, branch and passage		1.4
Flow separation		1.5
Polybutene valves 	d20	0.50
	d25	0.55
	d32	0.65
	d40	0.45
	d50	0.15
	d63	0.95

Not documented due to too low values
T 90° passage, sockets, reducer, unions.

For reduced T fittings, the smallest diameter in the flow direction is always relevant for the calculation.

* Reference values according to DIN 1988

INSTAFLEX

Flushing time for INSTAFLEX d 16 x 2.2 and d 20 x 2.8

Table 15:

Pipe length d16 x 2.2						**Water content per m 0.10 l**	
	Flow [l/s]						
Pipe length	0.07	0.10	0.15	0.20	0.25	0.30	0.50
[m]	Flushing time [s]						
2	2.8	2.0	1.3	1.0			
4	5.7	4.0	2.7	2.0	1.6	1.3	
6	8.6	6.0	4.0	3.0	2.4	2.0	1.2
8	11.4	8.0	5.3	4.0	3.2	2.7	1.6
10	14.3	10.0	6.7	5.0	4.0	3.3	2.0
12	17.1	12.0	8.0	6.0	4.8	4.0	2.4
14	20.0	14.0	9.3	7.0	5.6	4.7	2.8
16	22.8	16.0	10.7	8.0	6.4	5.6	3.2
18	25.7	18.0	12.0	9.0	7.2	6.0	3.6
20	28.6	20.0	13.3	10.0	8.0	6.7	4.0
22	31.4	22.0	14.7	11.0	8.8	7.3	4.4
24	34.3	24.0	16.0	12.0	9.6	8.0	4.8
26	37.1	26.0	17.3	13.0	10.4	8.7	5.2
28	40.0	28.0	18.7	14.0	11.2	9.3	5.6
30	42.8	30.0	20.0	15.0	12.0	10.0	6.0

Pipe content «V» per m INSTAFLEX pipe

d16 x 2.2 = 0.10 l/m
d20 x 2.8 = 0.16 l/m
d25 x 2.3 = 0.33 l/m
d32 x 2.9 = 0.53 l/m
d40 x 3.7 = 0.83 l/m
d50 x 4.6 = 1.31 l/m
d63 x 5.8 = 2.07 l/m
d75 x 6.8 = 2.96 l/m
d90 x 8.2 = 4.25 l/m
d110 x 10.0 = 6.36 l/m

*Flushing time is the time in seconds required to completely exchange the pipe content. It serves to calculate the time which the hot water needs to flow from the manifold to the consumer.

Calculation of flushing time «t»

$$t = \frac{V \times L}{\dot{V}}$$

V = Pipe content [l/m]
L = Pipe length [m]
V = Flow [l/s]
t = Flushing time [s]

Example:

(d32)

$$t = \frac{0.53 \frac{\mathrm{l}}{\mathrm{m}} \times 8\mathrm{m}}{0.6 \frac{\mathrm{l}}{\mathrm{s}}}$$

t = 7 s

Flushing time

Table 16:

Pipe length d20 x 2.8						**Water content per m 0.16 l**			
	Flow [l/s]								
Pipe length	0.07	0.10	0.15	0.20	0.25	0.30	0.50	0.60	1.00
[m]	Flushing time [s]								
2	4.6	3.2	2.1	1.6	1.3	1.1			
4	9.1	6.4	4.3	3.2	3.6	2.1	1.3	1.1	
6	13.7	9.6	6.4	4.8	3.8	3.2	1.9	1.6	1.0
8	18.3	12.8	8.5	6.4	5.1	4.3	2.6	2.2	1.3
10	22.8	16.0	10.7	8.0	6.4	5.3	3.2	2.7	1.6
12	27.4	19.2	12.8	9.6	7.7	6.4	3.8	3.2	1.9
14	32.0	22.4	15.0	11.2	9.0	7.5	4.5	3.7	2.2
16	36.6	25.6	17.1	12.8	10.2	8.5	5.1	4.3	2.6
18	41.1	28.8	19.2	14.4	11.5	9.6	5.8	4.8	2.9
20	45.7	32.0	21.3	16.0	12.8	10.7	6.4	5.3	3.2
22	50.3	35.2	23.5	17.6	14.1	11.7	7.0	5.9	3.5
24	54.8	38.4	25.6	19.2	15.4	12.8	7.7	6.4	3.8
26	59.4	41.6	27.7	20.8	16.8	13.8	8.4	6.9	4.2
28	64.0	44.8	29.9	22.4	18.0	15.0	9.0	7.5	4.5
30	68.6	48.0	32.0	24.0	19.2	16.1	9.6	8.0	4.8

Pressure test

Pressure test

Pressure test according to GF Piping Systems factory specification

Remarks on pressure testing

Procedure

1. Build up pressure slowly to 15 bar, let stand for 10 minutes.
2. Reduce pressure to 0 bar, let stand for 5 minutes.
3. Build up pressure slowly to 15 bar, let stand for 10 minutes.
4. Reduce pressure to 0 bar, let stand for 5 minutes.
5. Build up pressure slowly to 15 bar. Close off the system with a shut-off device.
6. Wait 60 minutes, read off the system pressure and enter it in the log.
7. Then reduce to pressure to 3 bar.
8. Wait 90 minutes, read the pressure off the manometer and enter it in the log.

The pressure must be at/above 3 bar at the end of the test.

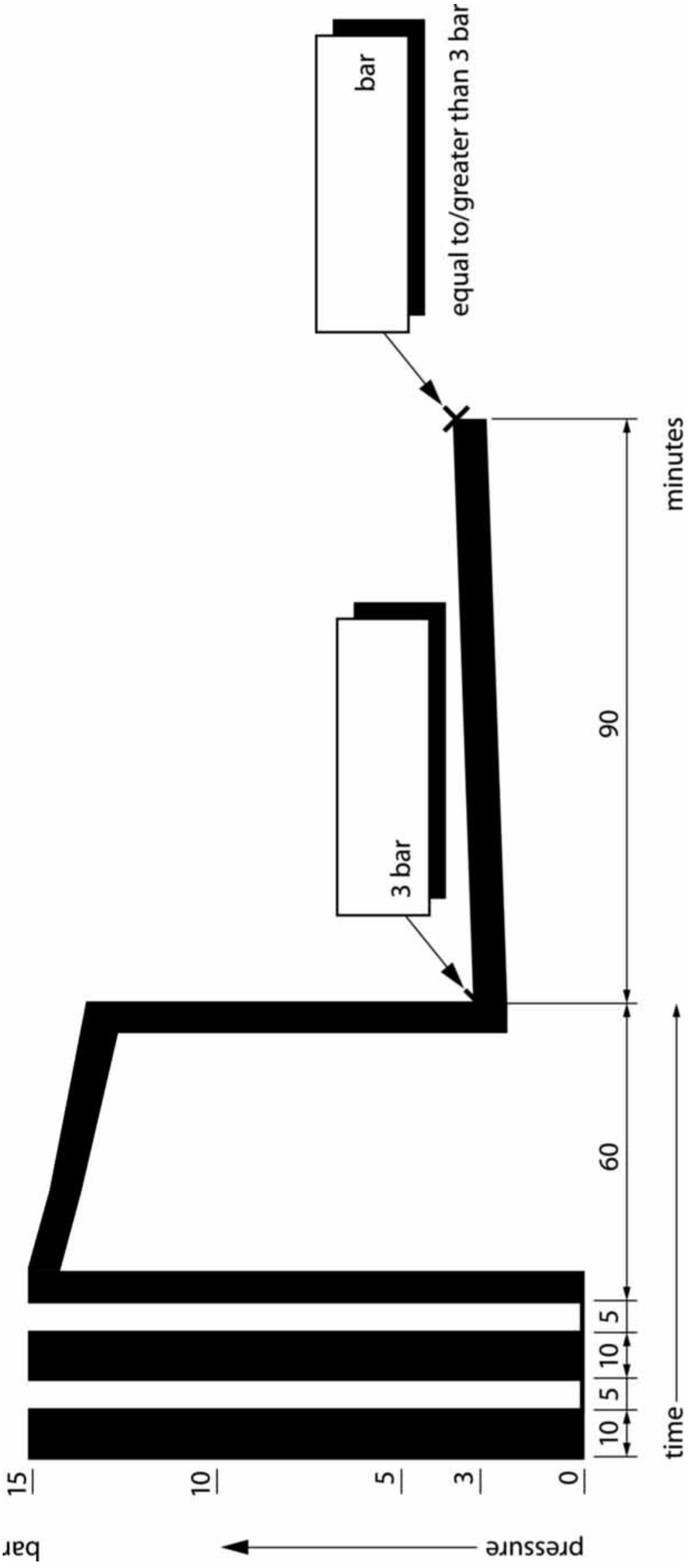
The pressure increase over 3 bar depends on the length of the pipe and the type of installation and is therefore not specified exactly.

The individual distribution circuits for drinking water must be tested separately. Hot and cold water distribution circuits are tested separately, as are CW riser pipes and HW riser pipes including circulation.

To save time, several drinking water distribution circuits can be tested simultaneously.
After building up pressure three times to 15 bar, the system is closed off with a shut-off device and the pressure pump may be removed. The next distribution circuit can be put under pressure in the same manner so that the pressure testing is performed continuously, thus saving time.

Equipment (according to DVGW - DIN 1988)
Use pressure measurement instruments which permit reading pressure variations of **0.1 bar**.

Pressure test protocol of plastic piping systems



Pressure test

Drinking water pipes must be subjected to a pressure test after installing while the pipes are still visible.

The pressure test must be 1.5 times the operating pressure or at least 15 bar.

To ensure correct testing, fill the installation slowly and then de-aerate it again completely. Use calibrated measurement instruments which show pressure changes of 0.1 bar.

Note also that a temperature change of 10 K results in a change in test pressure. Depending on the size of the system, changes of up to 2 bar and more are possible.

The pressure test is composed of two test phases:

1. Preliminary test
2. Main test

Pressure testing is done:

- **immediately** after the last connection for compression jointing
- at the earliest **1 hour** after the last fusion for fusion jointing

Please abide by these Technical Regulations and Pressure Testing Norms:

Germany

Pressure testing according to DVGW / ZVSHK (DIN 1988)

DVGW pressure test according to DIN 1988 - 2 TRWI

Switzerland

Pressure testing according to SVGW Guideline W 3

Pressure test according to ZVSHK

A pressure test is performed with air or inert gases in drinking water installations according to DIN 1988 - 2 (TRWI)

Attention:
If a pressure test with water is not possible or only with an extreme effort, it may be exceptionally performed with oil-free compressed air or with inert gases.

Exceptions are:

- Piping systems that cannot be completely drained and that are at higher risk of corrosion due to the critical triple-point limit of water, material, air.
- Piping systems in which a pressure test cannot be done with water because of frost.
- Prefabrication of piping components in the workshop.
- Piping systems that must be subjected to a pressure test because of the construction progress, but which are not yet connected to the mains.

Pressure testing with air or inert gases is more complicated than pressure testing with water, which is why it needs to be described in detail in the specifications.

Safety regulations, as specified under point 3 of the ZVSHK data sheet, must be observed at all times.

The test is divided into a **strength test** and a **leak test**. See also the corresponding data sheet from ZVSHK D-53757 St. Augustin Pressure Test Protocol, page #.

Leak test:
The leak test is performed before the strength test with a **pressure of 110 mbar**. The test time amounts to **10 minutes per 100 litres pipe volume**.

Strength test:
is performed at increased pressure.
3 bar up to DN50
1 bar above DN50

For plastic piping systems, it is necessary to wait until the steady-state condition is reached before the test time begins. The test time after applying the test pressure is **10 minutes per 100 litres pipe volume**.

Media which can be used for the pressure test:

- compressed air free of oil
- inert gases, e.g. nitrogen, carbon dioxide

Pressure test according to British Standard

Pressure test

The pressure test is based on the guidelines of Schedule 2, Part 4 of the Water Supply (Water Fittings) Regulations 1999, governmental guidelines and recommendations from the water industry.

The complete installation must be subjected to a pressure test after completion, while the pipes are still visible. The internal test pressure for all pipes, fittings and joints must be **1.5 times that of the maximum operating pressure of the installation**.

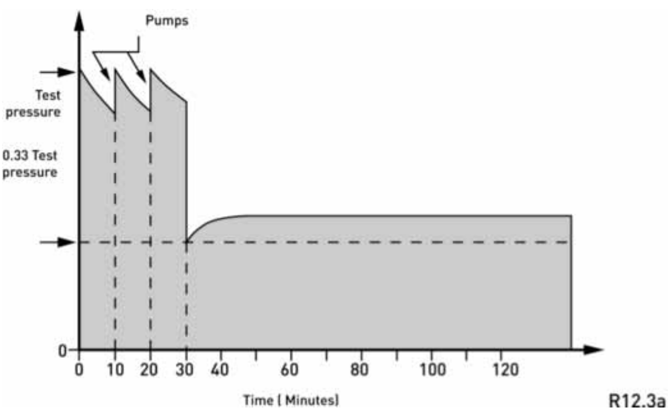
Pressure test

Piping systems laid above ground must be subjected to a pressure test after completion. Underground piping systems should be tested in sections before being filled. If defects become apparent in the test results, they should be rectified and the system then retested.

This condition is met in plastic piping systems when one of the following tests supply satisfactory results.

Test A

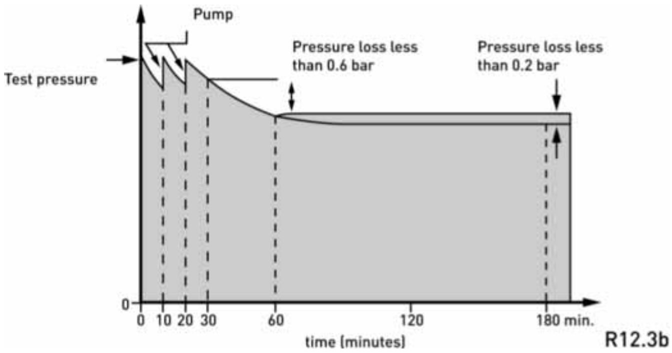
1. Put the whole system under an internal test pressure which is maintained for 30 minutes by continuous pumping. Afterwards, the test is continued without further pumping.
2. The pressure in the system is slowly reduced to one third of the test pressure.
3. The pressure may not fall over the next 90 minutes, which excludes the possibility of leaks. However, if the pressure does fall, this indicates there is a leak. Or according to paragraph 3.1.12.3.4 (Test procedure A) of BS 6700:1997.



R12.3a

Test B

1. Put the whole system under an internal test pressure which is maintained for 30 minutes by continuous pumping. The pressure is noted in the test protocol and the test continued without further pumping.
2. Note whether the pressure loss after another 30 minutes is less than 0.6 bar.
3. If the pressure loss after another 120 minutes is less than 0.2 bar, there are no leaks in the system. Or according to paragraph 3.1.12.3.4 (Test procedure B) of BS 6700:1997.



R12.3b

In systems with plastic piping, the pipes expand with increasing pressure marginally beyond the outer diameter due to their elasticity. When the pumping is stopped, the pressure is reduced, i.e. the pressure cannot be maintained for a longer period of time, as is the case for rigid pipes. The test methods A and B have been developed to counteract this problem. (See diagrams R12.3a and R12.3b).
For more information on pressure testing, refer to BS 6700:1997.

Attention:
Pressure testing with compression joints is done immediately after the last connection has been made. For fusion jointing, you must wait at least one hour.

Pressure test protocol of drinking water application according to ZVSHK

Building project: ______________________________

____

____

Customer represented by: ______________________________

Contractor/responsible
technical expert, represented by: ______________________________

Material of the piping system: ______________________________

Jointing method: ______________________________

System pressure: __________ bar

Ambient temperature ____________ °C. Temperature of test medium ______________ °C

Test medium ☐ Oil-free compressed air ☐ Nitrogen ☐ Carbon dioxide ☐ __________

The drinking water system was tested ☐ as a complete system ☐ in …… sections

All pipelines are closed with metal plugs, caps, shut-off plates or blind plates.
Apparatus, pressure tanks or drinking water heaters are separated from the pipelines.
A visual check of all pipe connections was carried out to see that they have been properly made and installed.

☐ **Leak test**

Test pressure 110 mbar
Test time per 100 litres of pipe volume 10 minutes

Pipes volumes ……………litres Test time .... minutes

Temperature equalisation and a steady-state condition needs to be achieved with plastic materials before the test can begin.

☐ During the testing time no pressure drop was measured.

☐ **Strenght test with raised pressure**

Test pressure m 50 DN max. 3 bar, L 50 DN max. 1 bar

Test time per 100 litres of pipe volume 10 minutes Test time .... minutes

Temperature equalisation and a steady-state condition needs to be achieved with plastics before the test can begin.

☐ During the testing time no pressure drop was measured.

☐ The piping system is tight.

______________________________ ______________________________
Place Date

______________________________ ______________________________
(Customer or representative) (Contractor or representative)

Compressed air applications

Compressed air applications

General

Planning criteria for compressed air pipes

Material selection criteria

National operating conditions

Pressure and temperature specifications, durability, oils additives, medium
See «Planning criteria for compressed air pipes»

Select the material

Dimensioning criteria

Required operating pressure
See «Operating pressure»

Required pipe cross-section, pressure loss
See «Dimensioning»

Select the pipe diameter

Criteria of a compressed air pipe

A compressed air pipeline is an energy line that serves to transport compressed atmospheric air from the compressor to the consumer with as little loss as possible.

Atmospheric air is, chemically speaking, a gaseous mixture which consists of nitrogen (≈ 78 %), oxygen (≈ 21 %) and argon (≈ 1 %) as well as traces of carbon dioxide and other gases.

The compressed air pipeline should conduct compressed air from the compressor to the consumer without reducing

- air quality and
- air volume.

Needlessly high quality demands and unproportional layout increase the price of the compressed air. For this reason it is essential to assess the exact requirements prior to designing the system. The required air quality determines the type of processing and the pipe material of the distribution lines.

Air quality

The application guidelines with the recommended quality grade according to ISO 8573.1 and Pneurop 6611 are based on the classification of

- the particle size,
- the maximum oil content and
- the pressure dew point.

Grade	Maximum particle size	Maximum particle density	Pressure dew point	Maximum oil content	Water content maximum pressure dew point	
	[µm]	[mg/m³]	[°C]	[mg/m³]	ISO 8573.1	Pneurop 6611
1	0.1	0.1	-70	0.01	-70	-40
2	1	1	-40	0.1	-40	-20
3	5	5	-20	1.0	-20	2
4	15	not specified	+3	5.0	+3	10
5	40	10	+7	25.0	+7	-

The pressure dew point determines the highest permissible water content of the air.

- 40 °C ≙ 0.177 g/m³

- 20 °C ≙ 0.88 g/m³

2 °C ≙ 5.57 g/m³

10 °C ≙ 9.36 g/m³

The quality requirements for compressed air depend on the application area. The quality is supplied by the compressor and may not be lessened by the distribution network.

Grades:

1. e.g. photographic industry
2. e.g. aviation
3. e.g. packaging industry
4. e.g. general industry
5. e.g. mining

Air quantity

The required quantity of air is defined by the consumer to be supplied.

Air and therefore energy loss caused by leaks in the distribution piping and the machinery lead to higher than necessary operating costs.

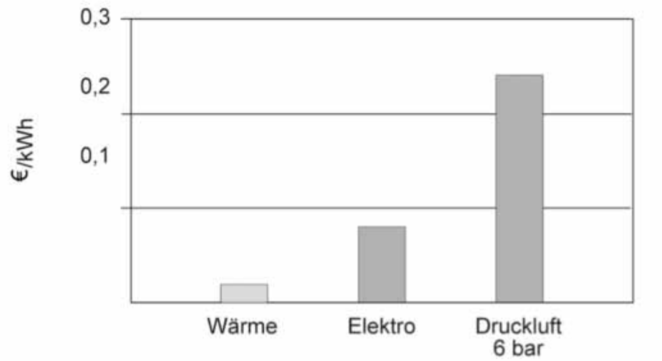
Leaks cannot always be completely eliminated, but they do reduce efficiency and should therefore be kept as minimal as possible.

Economically acceptable losses in the overall system

small networks	max. 5 %
medium networks	max. 7 - 8 %
large industrial networks	15 %

Please follow the national regulations for tank installations.

Compressed air – an expensive form of energy



The leakage in compressed air systems requiring renovation is attributed ≈ 30 % to the network and ≈ 70 % to hoses and tools.

Hole diameter	Air loss **[l/s]** at		Power requirement for compression **[kWh]** at	
[mm]	6 bar	12 bar	6 bar	12 bar
1	1.2	1.8	0.3	1.0
3	11.1	20.8	3.1	12.7
5	30.9	58.5	8.3	33.7
10	123.8	235.2	33.0	132.0

To compress 1 m³ air to 6 bar, 0.075 kWh is needed.

Leakage is best measured by emptying the pressure tank.

$$\dot{V} = \frac{V_B \cdot (p_A - p_E)}{t}$$

V_B = tank volume

p_A = initial pressure

p_E = final pressure

t = measurement time

$\dot{V}$ = Leak volume (l/min)

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Operating pressure

Every consumer of compressed air (machine or tool) requires a specific operating pressure besides air quality and volume.

An operating pressure which is too low, 5 bar instead of 6 bar, reduces the machine's performance by approx. 30 %. Compression which is 1 bar higher generates extra costs of about 10 %.

A large pressure drop between the compressor and the consumer is caused by pipe cross-sections which are too small or by bottlenecks in the pipeline.

The pressure drop between compressor (tank) and consumer should not exceed 0.1 bar (without filter and dryer).

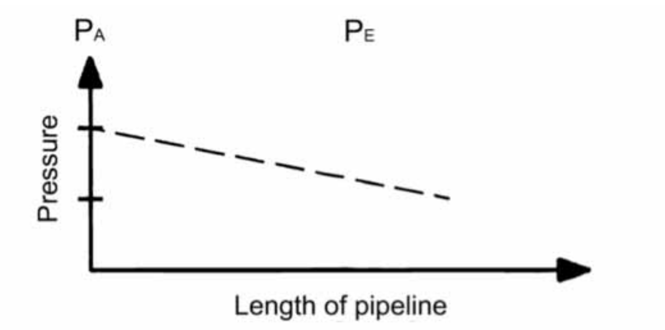
Δp_{system} ≤ 0.1 bar

Definition of pressure:

Pressure	=	Force/Area
p	=	F/A

1 N/m^2 = 1 Pa

Every pipeline offers resistance to air flow. The amount of resistance depends on the surface roughness of the pipe, on the pipe length and the flow velocity.



Operating pressure

Paint spraying	4 bar
Compressed air screwdriver	6 bar
Lorry tyres	8 bar
Hoisting platform	12 bar

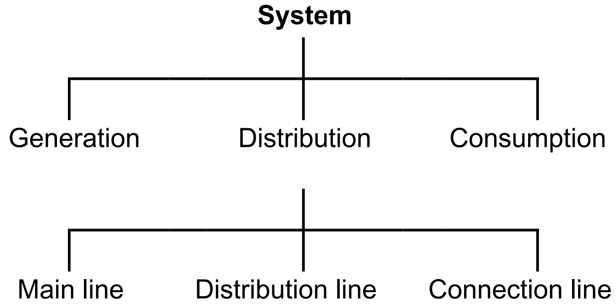
Design of a compressed air pipe

A compressed air system is divided into three segments

- generation
- distribution
- consumption

Distribution, in turn, is divided into

- main line
- distribution line
- connection line



Generation

Modern generators are offered by many manufacturers today as tailor-made complete solutions. The systems take into account the air quality requirements and the volumes required at specific operating pressures and specific times.

Compressed air generation is divided into

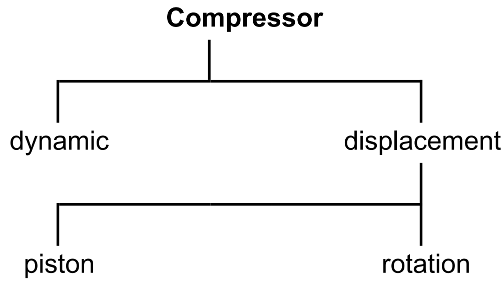
- production
- processing
- storage

Production

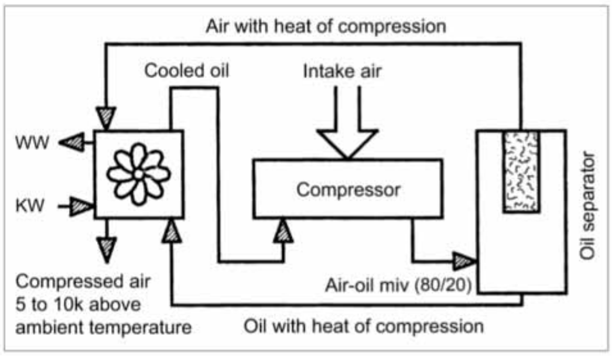
Compressed air is produced in a compressor. Compressors can be classified into two main types: dynamic and positive-displacement.
Positive-displacement compressors are either of the rotary or piston type. In dynamic compressors kinetic energy is converted into pressure energy (e.g. jet engines).

Modern production equipment is equipped today with heat recovery. The electrical energy supplied to a compressor is nearly entirely converted into heat. With optimal heat recovery, up to 90 % of the supplied electrical power can be recovered.

In positive-displacement compressors a volume is pressed together (e.g. air pump).



Principle of production with heat recovery



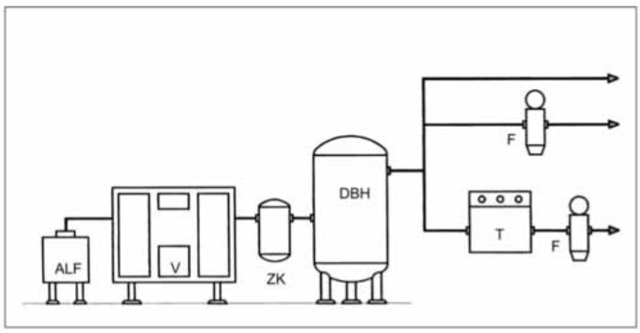
Processing

Depending on the compressed air quality required, a certain type of processing is needed. Processing can take the form of cleaning (filter), drying as well as oil and water separation.

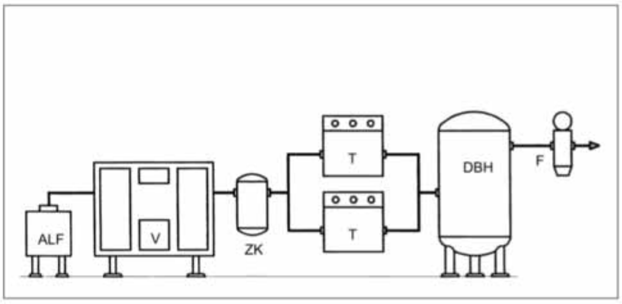
Storage

The pressure reservoir is a buffer station between compressor and distribution network. The pressure vessel can either be placed before or after the processing, depending on whether the same air quality is required for all the consumers or different ones.

Principles of compressed air generation



Distribution of different qualities of compressed air



One quality of compressed air

ALF	=	intake air filter
V	=	compressor
ZK	=	cyclone separator
DBH	=	pressure vessel
F	=	filter
T	=	dryer

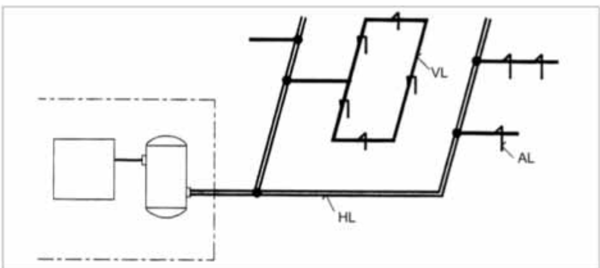
Distribution

The compressed air network is dîvided into

- main line (HL),
- distribution line (VL) and
- connection line (AL).

We recommend separating the pipe network into segments according to the function and usage requirements.

To keep leakage to a minimum, pipe joints should be homogenous and, if possible, not threaded or flange connections. Compression joints for plastic pipes should be vacuum and pressure-tight and without elastomer seals.

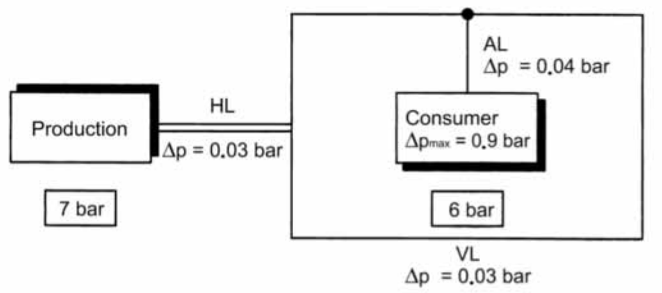


For optimally designed compressed air networks, the pressure drop is as follows

- 0.03 bar for the main line,
- 0.03 bar for the distribution line and
- 0.04 bar for the connection line.

The **total pressure loss** of the system including filter, separator, dryer, service units and connecting hoses should not exceed **0.1 bar**.

$\Delta p_{network} \leq 0.1$ bar



$\Delta p_{total} \leq 1.0$ bar

The pressure drop between the pressure reservoir and the consumer connection should not exceed 0.1 bar.

For an operating pressure at the point of consumption of 6 bar, the generating station should be run with 7 bar.

Main line (HL)

The main line joins the generating station (compressor room) to the distribution network. The main line should be dimensioned so that there is enough reserve for future extensions.

The pressure drop in the main line should not exceed **$\Delta p_{HL} \leq 0.03$ bar**.

Distribution line (VL)

The distribution line distributes the air within a consumer section. It can be designed as a tie or ring line or a ring mains with integrated ties.

In machine shops without specific requirements in regard to compressed air distribution, ring mains are preferred. Lines to machine or equipment aggregate are ideally smaller ring mains. If this is not possible and only a large ring mains can be installed, then it is advisable to use tie lines in this case.
The targeted use of shut-off valves allows shutting off segments for maintenance or extension work.

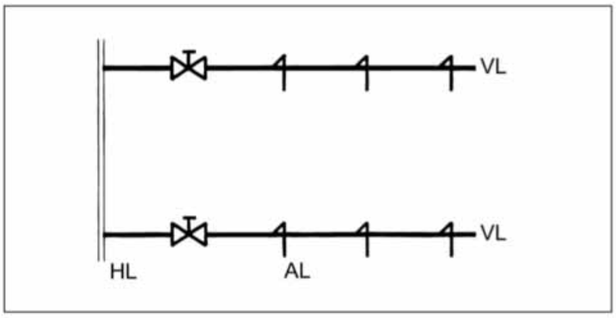
For machine aggregates or assembly lines with specific requirements, individual tie lines can also be used. These are especially practical when production processes and equipment (assembly lines) are frequently rearranged, requiring a different infrastructure.

The pressure drop in the distribution line should not exceed **$\Delta p_{VL} \leq 0.03$ bar**.

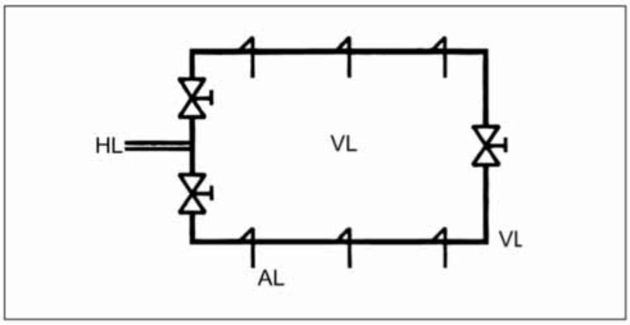
Nominal width (NW) of **HL** or **VL** for a length of up to 100 m and an operating pressure of 6 bar.

Q [l/s], [m³/min]	**DN** [mm]	**PB/PE** **d** [mm]
233/14.0	90	110
135/8.1	75	90
100/5.0	63	75
53.3	50	63
30/1.8	40	50
15/0.9	32	40
10/0.6	25	32

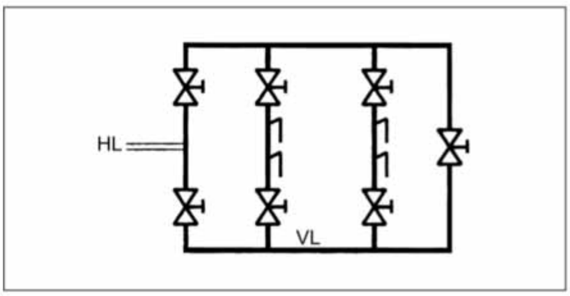
Tie line:



Ring line:



Ring line with tie lines:



Connection line (AL)

The connection line is the connection between the distribution line and the machine or tapping point. The method of connection depends on the air quality. The type of connection to the distribution line depends on the air quality. For air which hasn't been dried, the connection line should be conducted from the top of the distribution line to prevent condensate from exiting with the air. For dried air the connection line can be conducted from the bottom.

Connection lines should always be fitted with a shut-off valve at their end. For single connections, the shut-off can be integrated in the connector fitting. For group connections via a manifold, integrating a separate shut-off in the line is recommended.

When connecting a machine or production unit directly to the distribution line, it is advisable to use a shut-off valve with electric actuator so that when the machine is turned off, the air supply is also interrupted. This prevents air loss due to leaks within the machine.

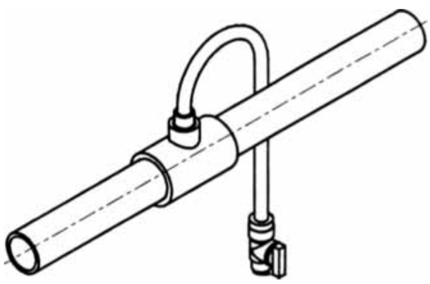
The pressure drop in the connection line should not exceed **$\Delta p_{AL} \leq 0.04$ bar**.

Q [l/s], [m³/min]	**DN** [mm]	**PB** d [mm]
0.42/0.25	**12**	**16**
9.2/0.55	**15**	**20**
L = 10 m/p = 6 bar		

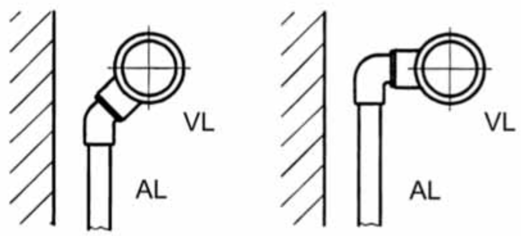
Nominal widths (NW) of the **AL** for a length of 10 m and an operating pressure of 6 bar.

Q [l/s], [m³/min]	**DN** [mm]	**PB** d [mm]
16,6/1	**20**	**25**
33,3/2	**25**	**32**
L = 10 m/p = 6 bar		

Connection for air which hasn't been dried:



Connection for dried air:



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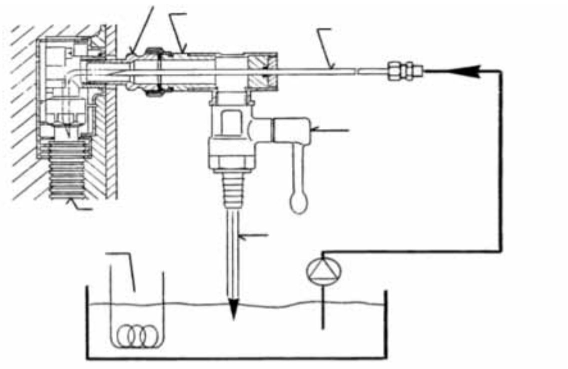
Group connection with shut-off:



Selection of material / selection of system

A compressed air line must be:

- tight
- maintenance-free
- adequately dimensioned

The pipe materials for compressed air lines can be divided into two groups: **metals** and **plastics**.

Metal materials include:

- steel
- copper
- stainless steel

Plastic materials include:

- polybutene (PB)
- polyethylene (PE)
- acrylonitrile-butadiene-styrene (ABS)

Due to steadily increasing demands in terms of the quality of compressed air technology, specifically cleanliness, easier installation and maintenance, plastic piping systems have become more popular for these applications.

There is no one perfect material for compressed air pipes; the specific requirement criteria determine the type of material.

Key criteria for selecting a material:

- location
- pressure/temperature limits
- service life
- safety
- jointing technology
- installation technology
- dimensioning
- product range

Generally, only one pipe system should be used for a compressed air installation, mainly to prevent corrosion problems from the metal systems. Combined systems of plastic and metal are no problem in this regard.

We at GF Piping Systems recommend on the basis of our many years of experience in piping system construction the following materials for compressed air pipelines

- **Polybutene PB and**
- **Polyethylene PE.**

Selection criteria

Place of installation

Polybutene PB

The majority of compressed air networks, **over 80 %**, is installed in factories and production halls or inside buildings. Thus, an ambient temperature of 15 to 25 °C can be assumed. It is however important to note that temperatures in workshops with glass roofs can reach up to 50°C and more with direct sunlight.

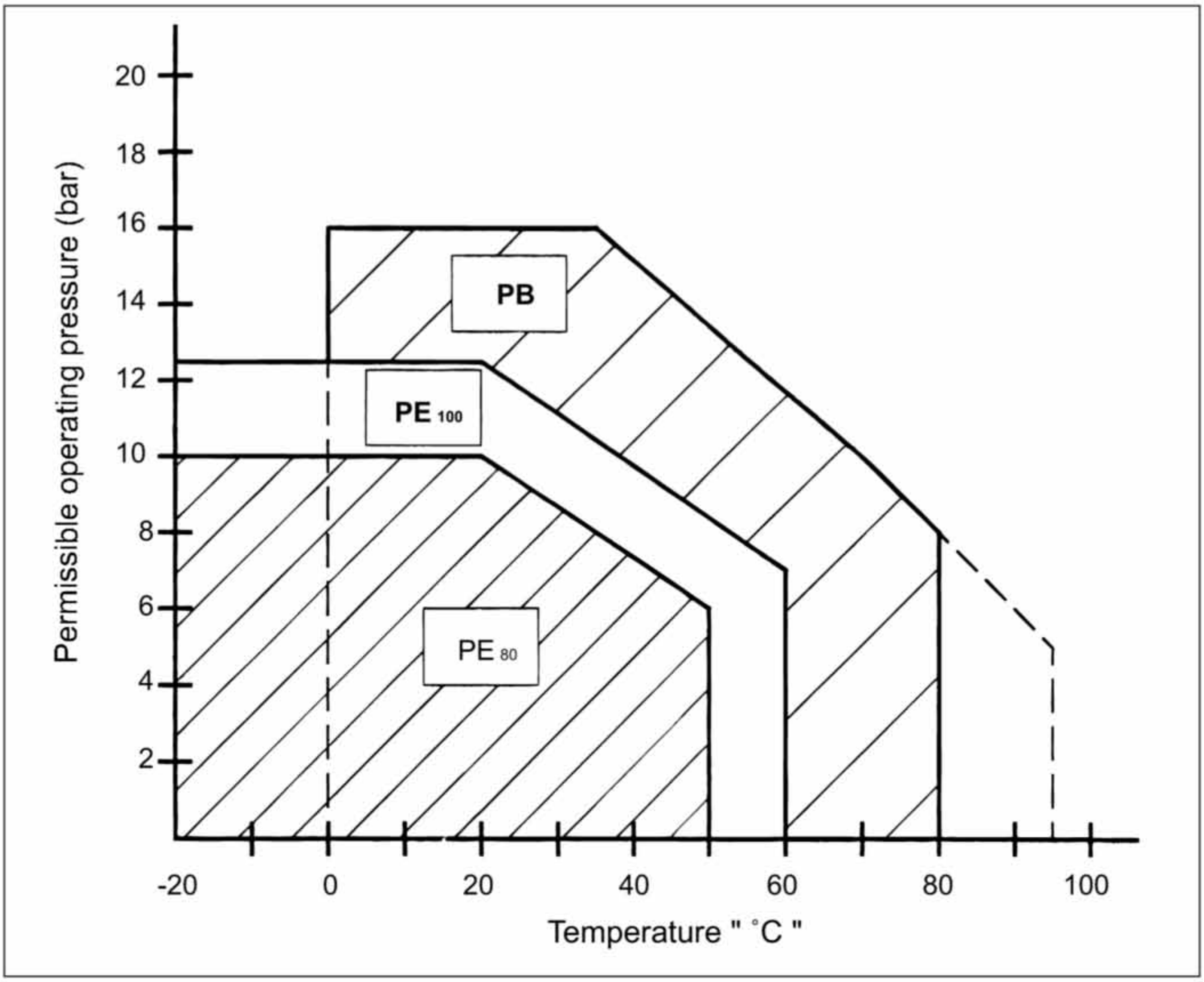
Pressure/temperature limits / Lifetime

Pressure/temperature limits

The diagram below shows the usage limits of the materials we recommend, polybutene (PB) and polyethylene (PE).

Lifetime

The systems' **lifetime** has been calculated for **25 years**, with a **safety factor** of **1.5** for the permissible operating pressure.



The limits were taken from the corresponding creep diagrams for the individual materials.

For PB and PE the **pipe series S5** per **ISO 4065** was taken as the basis. From this, the following pipe dimensions were obtained:

d16	x 2.2
d20	x 2.3
d25	x 2.3
d32	x 2.9
d40	x 3.7
d50	x 4.6
d63	x 5.8
d75	x 6.8
d90	x 8.2
d110	x 10.0

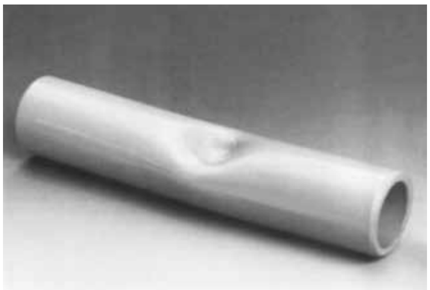
For further calculations of the actual safety factor in relation to the actual operating pressure, see the chapters on Pressure and Distribution.

Safety

Several aspects must be considered under the term «safety», such as

- **fracture behaviour**
- **resistance** to UV radiation and compressor oils
- **corrosion**
- **fire behaviour**

In contrast to water, air can be compressed. This means that there can be explosive decompression if the pipeline is mechanically damaged. Preventing mechanical damage is therefore extremely important so as not to endanger the environment. In compressed air technology and at temperatures below freezing, only plastic materials with **ductile fracture behaviour** should be used for the piping.



Ductile fracture behaviour means that if there is forced damage to a pipe causing explosive decompression (relief of compressed air), the material **will not shatter**. Consequently there is no immediate danger to the environment.

The threshold temperature for ductile fracture behaviour is ≤ -5 °C for polybutene (PB) ≤ -40 °C for polyethylene (PE).

In a compressed air network, traces of compressor oil and condensate are to be expected. To ensure a long service life and reliability, the pipe material must withstand the operation load.

Oil resistance of polybutene (PB) and polyethylene (PE)

Mineral oils, oils that contain esters and oils with components of aromatic amines have, depending on their concentration, a negative effect on the lifetime of plastics.

Attention:

Make sure that you use only oil-free air in INSTAFLEX piping systems for compressed air lines.

The materials PB and PE have the advantage that they are resistant to corrosive attack inside and outside. A damp and corrosive atmosphere will inevitably lead to corrosion on the outside of steel pipes, residual moisture in compressed air will lead to corrosion on the inside.

PB and **PE** piping systems are **corrosion-resistant**, so that the quality of the air conveyed is not impaired.

PB and **PE** are plastics with a **B2 fire classification** according to DIN 4102 (normal flammability).

Under an open flame, PB and PE burn with a bright flame. The fumes smell of wax and paraffin. Because they contain no halogens (chlorine), polyolefins such as PB and PE do not produce toxic or corrosive combustion products, unlike PVC and PVC-C.

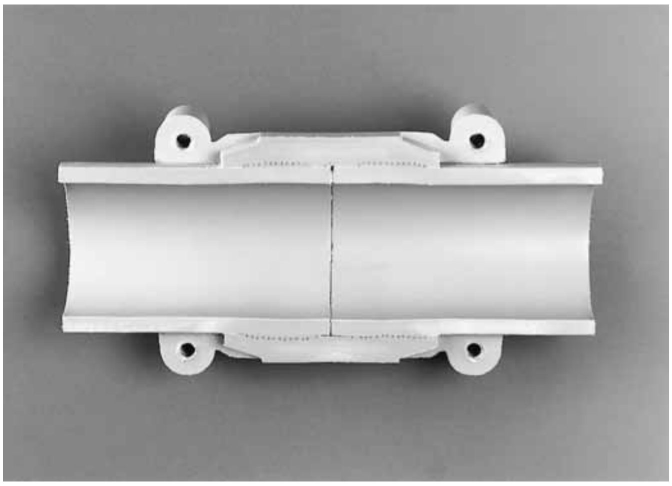
We recommend keeping the distribution network free of oil, if possible, when using polybutene (PB) and/or polyethylene (PE).

Jointing technology

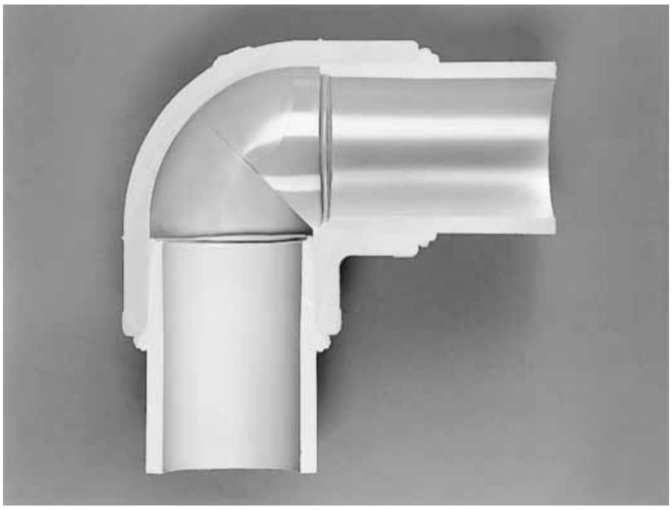
Compressed air networks must be leak-tight to prevent losses and high costs.
Leaks occur primarily at the joints in a compressed air network.

Pipes and fittings should be joined **homogenously**, for example through fusion. A homogenous joint is one in which there is a direct, uniform joining of pipe and fitting, without additives. This type of joint can only be removed by destruction.

Electrofusion, PB and PE:

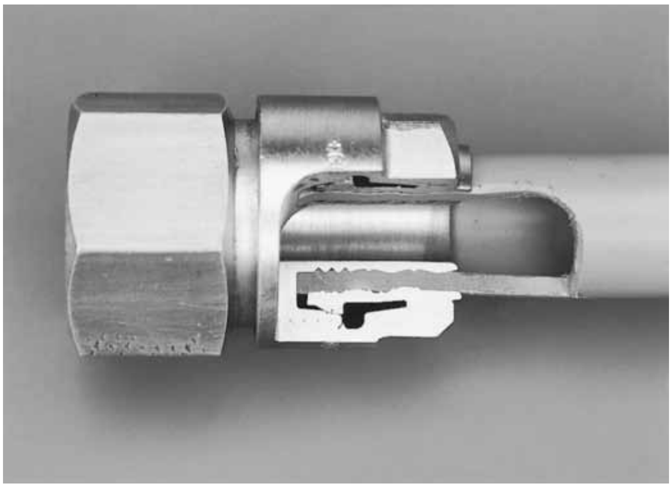


Socket fusion, PB and PE:



Compression joints for plastic pipes should be permanently **pressure and vacuum-tight**. The seal between pipe and fitting should be made **without elastomers.**

The patented **INSTAFLEX compression fitting** for PB pipes creates a durable and tight connection under **DVGW registration** and the required testing according to Worksheet W534.



The connection methods normally found on metal piping systems, such as threaded joints with hemp sealing, press fittings with elastomer seals, unions and flange connections with flat gaskets, lead to leakage after a certain time because of the **«dry»** compressed air generally used today.

In situations where threaded unions or flange connections are unavoidable (tank connections), they should be made so that the seals can be easily replaced.

Vibration

Vibration is the most frequent cause of irregularities in a compressed air system.
It therefore makes sense to use a pipe system which prevents transmission of vibration. Polybutene (PB) pipe systems are flexible compared to metal systems, i.e. they are free of vibration.

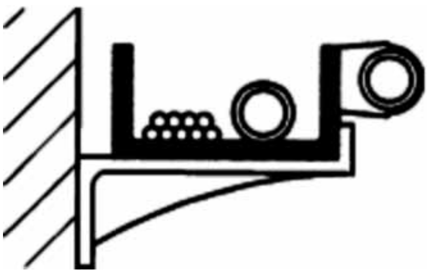
Installation technology

In this case, the installation technology is only discussed under the aspect of «material selection».

The plastics recommended by us, polybutene (PB) and polyethylene (PE), for compressed air applications are **ca. 80% lighter** than steel pipes per DIN 2440, opening up new perspectives for system layout.

Installation is fast and easy thanks to the reduced fastening requirements and rational pre-fabrication - decisive factors for keeping **installation costs low**.

Because the pipes and fittings are so lightweight, compressed air lines can be laid and fastened in existing **cable ducts**.

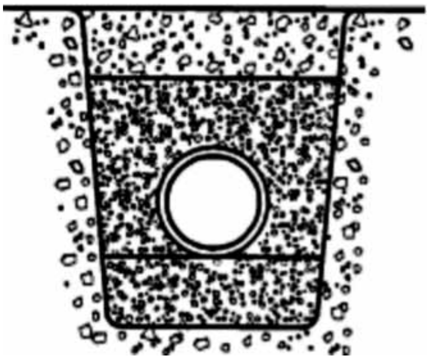


Depending on the pipe dimension, the lines can be secured with **pipe clips** or **cable binders**.

Since plastics do not conduct electricity, the cable duct is a particularly advantageous alternative.

When installing these systems in explosion-proof rooms, the plastic pipes should be statically discharged with the corresponding air humidity.

Plastic pipes are particularly suitable for underground installations because extra corrosion protection is not necessary. The respective installation guidelines (sand bed, etc.) should however be observed.



Dimensioning

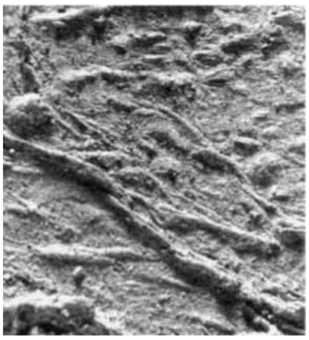
A compressed air line is an **energy line** and should therefore be dimensioned carefully.

If compressed air lines are unknowingly dimensioned according to «water pipeline rules», over 50 % of the energy will be lost before it reaches the consumer.

Polybutene (PB) and **polyethylene (PE)** pipes transport compressed air more economically than steel pipes thanks to their conducive properties. The smooth surface of **plastic pipes** with **k = 0.007** (steel pipe k = 0.15) permits a higher airflow with the same pipe inner cross-section under the same pressure conditions.
k = pipe roughness factor

Surface of a plastic pipe:

Surface of a steel pipe:



Product range

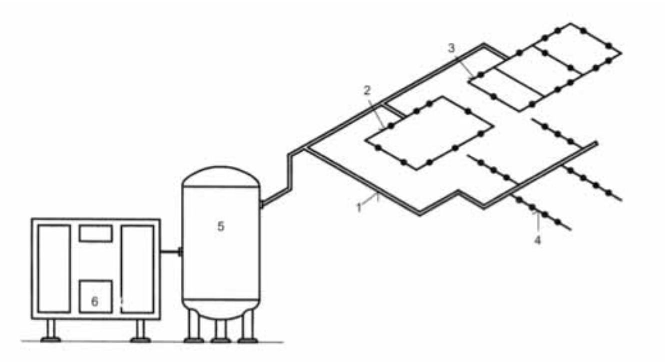
The INSTAFLEX polybutene (PB) piping system is available in a wide range of products: pipes from d16 to d225, in coils and rods, fittings and connecting elements.

The fitter's job is made easier with **electrofusion sockets** and **fittings** as well as the convenient product-coded connections and the handy fusion machine.

Design and installation of pipes

For pipeline planning it is important to know the on-site conditions. Bundling energy lines in or on common carrier elements reduces installation time and costs. Because plastic pipes are approx. 80 % lighter than metal pipes, less fastening is also required.

The first step when planning an installation is to make a schematic, isometric drawing of the system.



1 = main line (HL)
2 = distribution line (VL Ring)
3 = distribution line (VL Ring mains with crossbars)
4 = distribution line (VL branch line)
5 = pressure vessel
6 = compressor

The compressed air lines should be protected against mechanical damage, impact and shock in traffic areas, in the swivel range of heavy loads and similar danger zones.

It should also be remembered that plastic pipes react to temperature changes by expanding or contracting. In compressed air lines, the temperature fluctuations are only in the ambient temperature.

There are two main methods of installing **p olybutene (PB)** and **polyethylene (PE)** pipelines.

1. **Flexible sections or expansion loops**
   Here the temperature-related changes in length are taken into consideration.
2. **Rigid installations**
   Here the pipe must absorb the temperature-related changes in length in itself.

Attention:
Main, distribution and connection lines need to be planned separately.

Main line

We recommend using a rigid assembly for main lines up to d63 (d75). Dimensions d75 and up should be designed with flexible sections or expansion loops.

Fixed points should be selected so that if possible the outlet T is fixed to the distribution line.

A shut-off valve should always be placed at the main pipe outlet as well as at the branches so that individual sections can be turned off without interrupting the whole operation.

Calculating the flexible section:

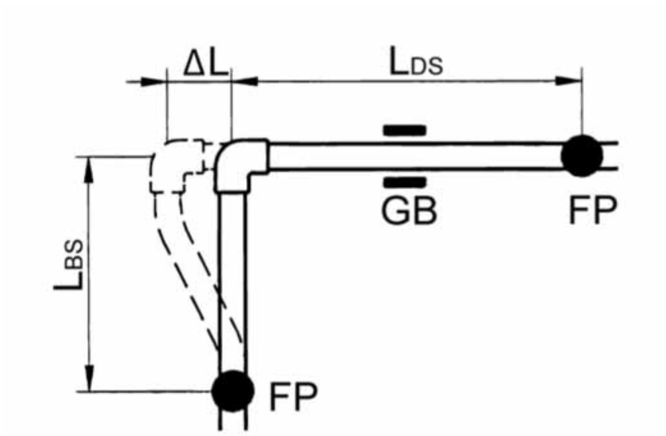
$$L_{BS} = C \cdot \sqrt{\Delta L \cdot d}$$

C for	PB	=	10
	PE	=	27
	St	=	91

ΔL = L_{DS} x α **x $\Delta\vartheta$**

α for	PB	=	0.130 mm/mK
	PE	=	0.200 mm/mK
	St	=	0.012 mm/mK

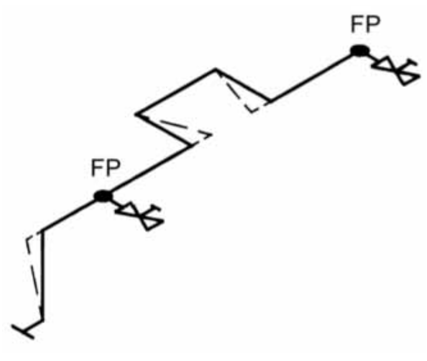
Change in direction:



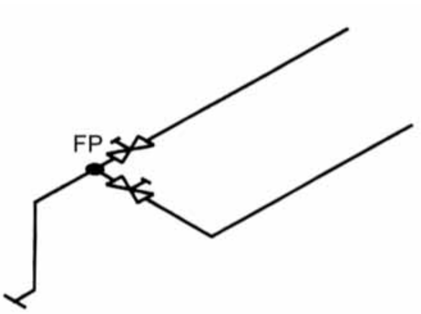
FP = fixed point
GB = sliding fastener

ΔL	= change in length
L_{DS}	= length of expasion leg
L_{BS}	= length of flexible section
α	= thermal expansion coefficient
d	= pipe outer diameter
C	= material constant
Δϑ	= temperature difference

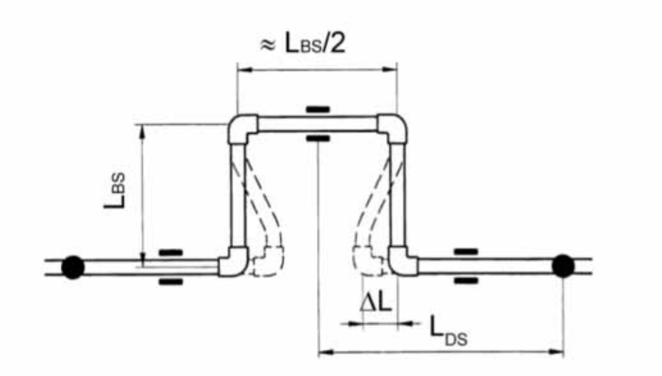
Main line outlets to distribution:



Main line branch:



Expansion loop:



Example:
Flexible section calculation

L_{DS}	=	20 m
$\Delta\vartheta$	=	20 K
Pipe	=	d32

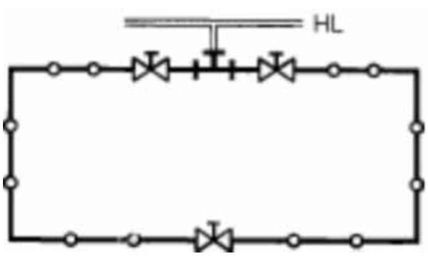
$$L_{BS} = C \cdot \sqrt{L_{BS} \cdot \alpha \cdot \Delta\vartheta \cdot d}$$

L_{BS} for PB	**=**	**32 cm**
L_{BS} for PE	**=**	**108 cm**
L_{BS} for St	**=**	**91 cm**

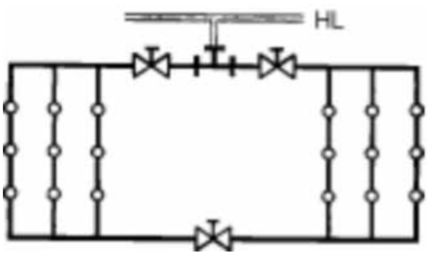
Distribution line

The three main layout designs for distribution lines are:

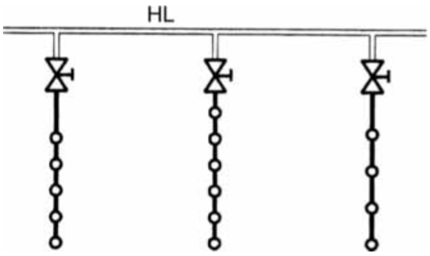
Ring main



Ring main with crossbars



Branch lines

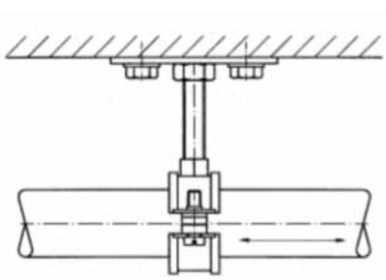


By cleverly placing the shut-off valves, individual sections of the distribution line can be shut down without completely interrupting operation. Dividing the distribution lines (ring and branch lines) must take the actual conditions and requirements into consideration.

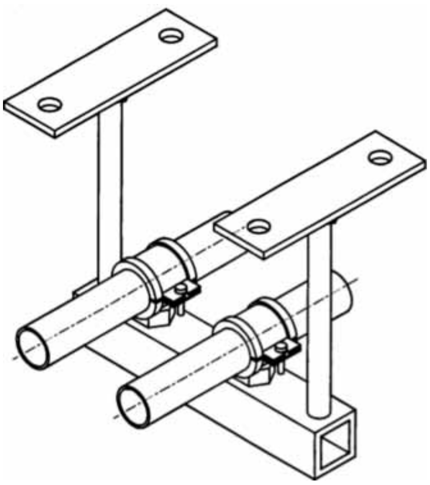
When designing the distribution lines, the existing carrier system of other energy lines can be made use of. Placing the distribution lines in or **on electrical cable ducts** is the easiest and most rational method of installation and because plastic is not electrically conducting, there are no adverse effects.

Fastening methods

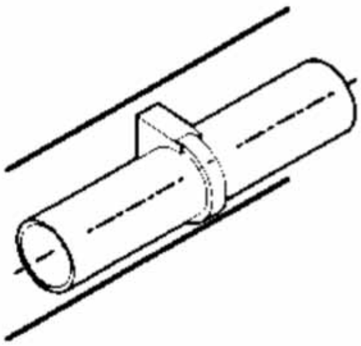
Normal fastening on ceilings, walls or other carriers with pipe brackets:



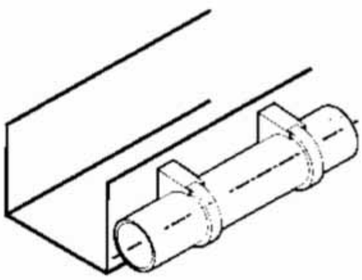
Fastening on pipe runs with brackets:



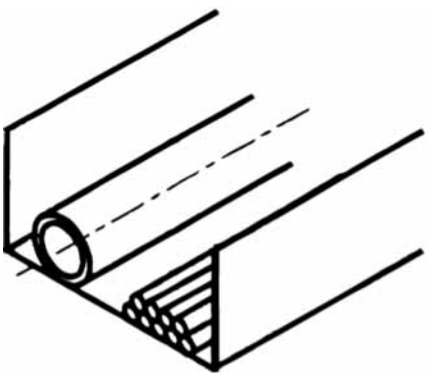
Fastening with pipe clips:



Fastening on cable duct with pipe clips:



Laying in cable duct:



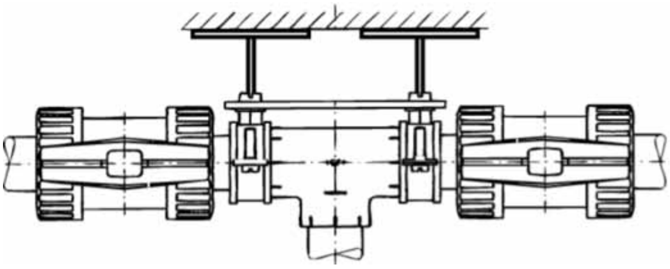
The piping can be fastened in the cable duct with cable ties.

Rigid or flexible assembly

Depending on the installation technology, rigid or flexible, the placement of fixed points is very important.

On **branches** fixed points should be placed, if necessary, as dictated by the local conditions.

On **ring lines** fixed points should be placed at the ring inlet, at shut-off valves and depending on the actual situation also at the crossbar junctions.



Fixed point at ring inlet

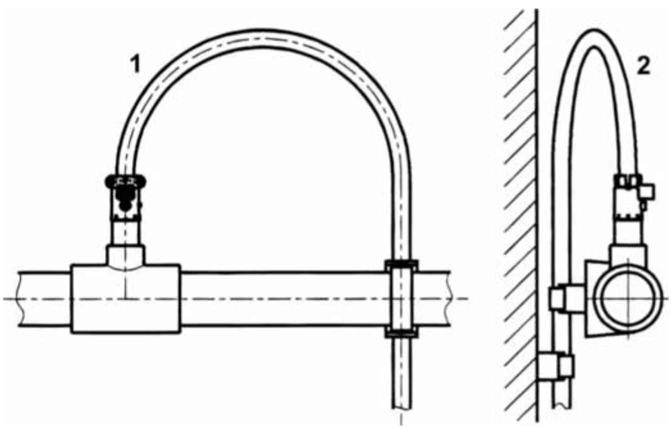
Attention:
Valves or apparatus in the line must be fastened separately.

Connection line

How the connection line (AL) and the distribution line (VL) are connected depends on the air quality and the dimension of the connection line.

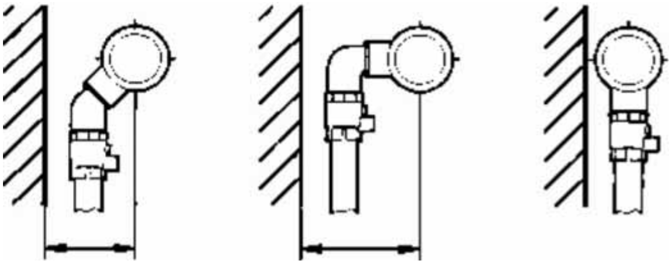
For **wet compressed air** the connection lines should be connected from the top to the distribution line.

For **dry compressed air** the connection lines can be connected to the distribution line as desired.



1 Swan-neck bend with polybutene (PB) pipe Dimension d16 and d20
2 - Tee with electrofusion PB outlet
- Pipe 16 x 2.2 or 20 x 2.8 can be bent into swan neck
- Bending radius min. 8 x d

Attention:
For materials, e.g. PE, the swan neck must be assembled.



Attaching the connection line with d16 or larger

To attach the connection line, we recommend fitting the distribution line outlet with an electrofusion adaptor to make assembly faster and easier.

The joint connection of machines, devices or apparatus at the end of the connection line can be done as a single or multiple connection.

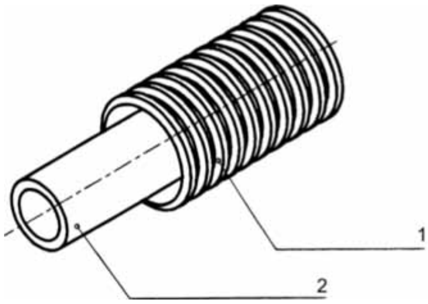
Multiple joint connection

INSTAFLEX valve and manifold:

Non-ferrous manifold with connecting thread G ½", manifold attachment with pipe brackets or clips

If you are laying connection lines in a **non-visible area**, such as in laboratories, training or test facilities, the **INSTAFLEX pipe-in-sleeve system** with **polybutene pipes** offers a big plus. The protective sleeve separates, insulates and protects the medium-conveying pipe from the surrounding building, whether it has been installed in a wall recess or behind a wall panel.

A wide range of connectors with the corresponding assembly and fastening materials are available in the INSTAFLEX programme for this application.

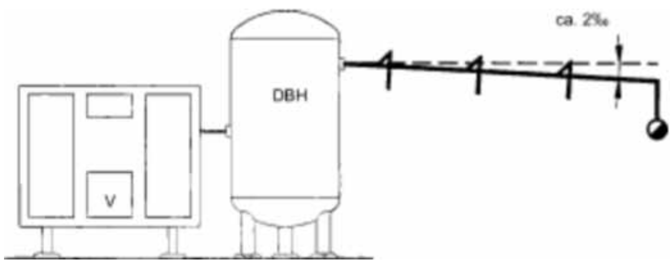


1 Protective sleeve
2 PB medium pipe d16/d20/d25

Special installation cases

In compressed air systems which process the air **without drying**, the main and distribution lines must be laid with a **ca. 2‰ slope** anda condensate drain should be mounted at the end of the line.

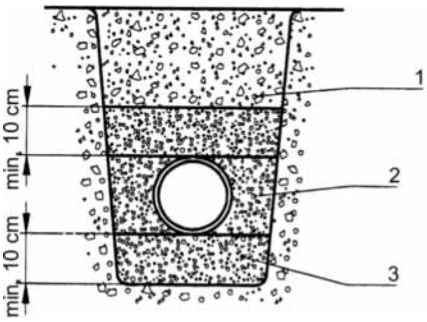
If the system works **with dried compressed air**, the lines can be installed horizontally.



In the ground

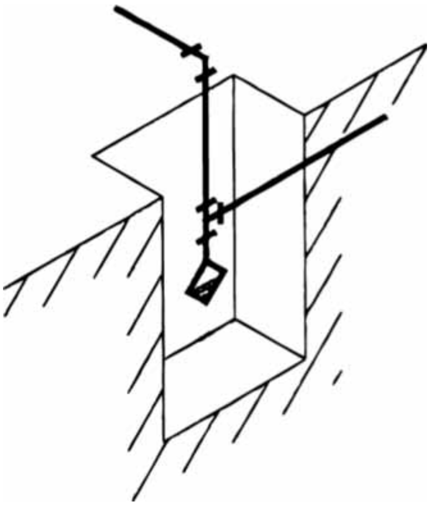
Polybutene (PB) pipes are especially suitable for in-the-ground installations because of their corrosion resistance.

The pipes should be laid at a depth that prevents freezing. Stones and other sharp objects must be removed. The trench bottom should be covered with about 10 cm sand or other fine-grained material. The fill that comes into contact with the pipe should be the same material that was put on the bottom of the trench and should cover the pipe to at least 10 cm, before filling the trench with earth.



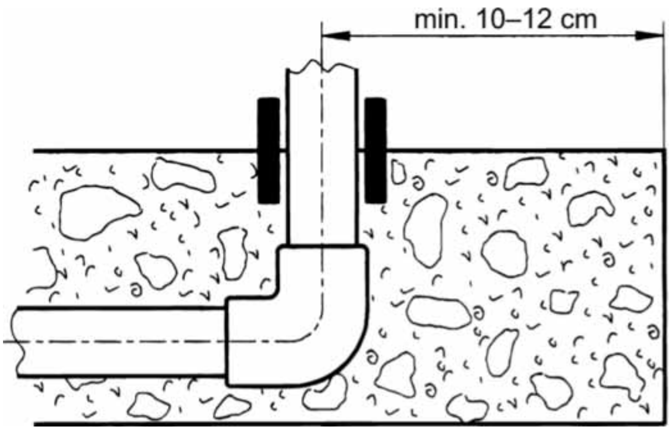
1 Earth
2 Sand
3 Sand

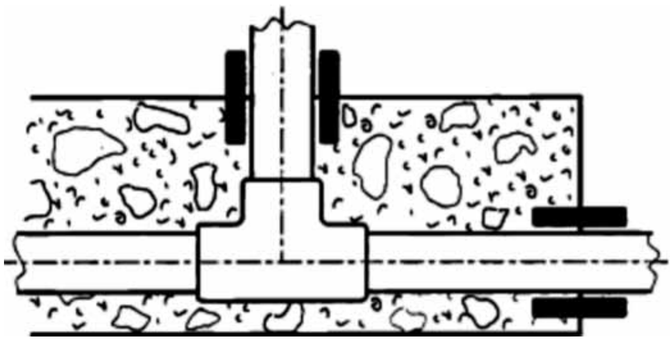
Since condensate might form on pipes laid in the earth, a water trap should be placed at the lowest point.



Duct installation

When laying pipes in ground ducts that are filled with concrete, it is important to ensure that the pipes are completely encased. When inserting or removing the pipes, measures should be taken to protect them from damage.





For floor or wall conduits, the pipe should be separated from the building structure by a sleeve or insulation material. The sleeve should protrude on both sides of the structure.

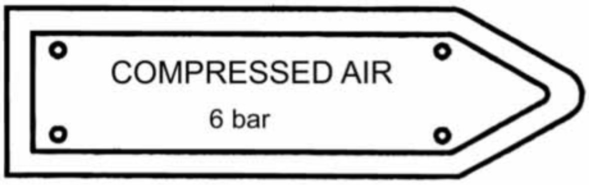
Marking

According to **VEG 1 § 49** and **DIN 2403** pipelines need to be marked. The marking which indicates the type of medium is absolutely essential in the interest of safety and effective fire-fighting.

The marking should be

- at the beginning and the end of the pipeline,
- at branches and lead-throughs
- on valves.

Medium	Group	RAL colour
Water	1	green 6018
Compressed air	**3**	**grey 7001**
Gas	4/5	yellow 1012
Acids	6	orange 2000
Bases	7	violet 4001
Oxygen	0	blue 5015
Steam	2	red 3003


COMPRESSED AIR
6 bar

Dimensioning

The **energy carrier «compressed air line»** must be carefully dimensioned and calculated.

A compressed air pipeline is not the same as a water pipeline.
If a compressed air pipeline were calculated according to the principles for a water pipeline, the energy lost would be ≥ 50 %.

Three factors need to be known in dimensioning:

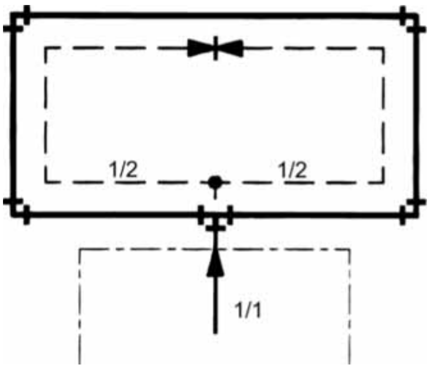
1. System concept
2. Pipe material
3. Total air requirement

System concept

A system consists of a:

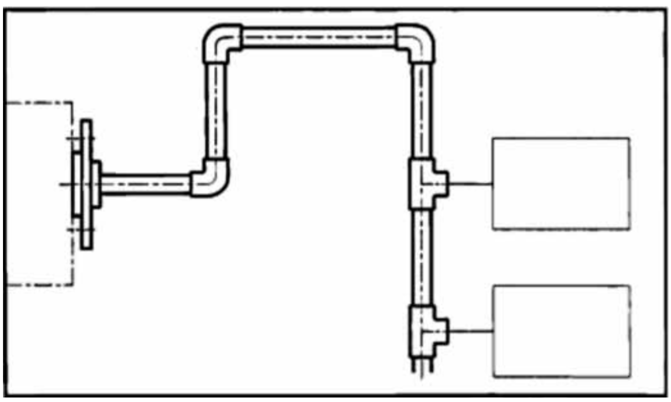
- **connection line**, maximum pressure drop $\Delta p \leq 0.04$ bar for connecting the distribution line and the consumer connection
- **distribution line**, maximum pressure drop $\Delta p \leq 0.03$ bar as a ring mains or branch line

Ring mains have the advantage over branch lines that they have twice the capacity. We recommend them especially when the consumers are fairly evenly distributed.



The ring mains is divided in the middle and calculated with half the nominal length and with half the required air volume, similar to a branch line.

- **Main pipeline**, maximum pressure drop $\Delta p \leq 0.03$ bar connects the pressure reservoir to the distribution line



The entire air volume of the distribution line is collected in the main pipeline.

Main lines are generally not very long. This area should be generously dimensioned and reserves planned in to allow for later extensions and to save costs.

Material

A material must be selected prior to dimensioning because it is a decisive factor in calculating the pressure loss. For instance, the pipe inner surface is an important parameter. Do you want rough as in steel (k = 0.15) or smooth as in plastic (k = 0.007)? The pipe wall thickness (s) in plastic pipes depends on the material strength under temperature load. Under the same application conditions (e.g. 20 °C/16 bar/NW 25) a polybutene pipe has an outer diameter of d32, while a polyethylene pipe has d40 due to the thicker wall required.

Air requirement

The air requirement is determined from the data of the connected machines, devices and apparatus and then added.
However, to prevent overdimensioning the network, the **degree of utilisation** should be figured and taken into account.

We recommend planning in reserves and allowances when calculating the air requirement.

Allowances for:

- Leakage	10 %
- False estimations	10 %
- Reserves	check with operator

Example:
Calculating the total air requirement

Machine number	1	2
Air requirement **V [l/min]**	300	500
Number of machines **n**	2	1
Utilisation degree η **= %**	50	25
Air requirement **V [l/min]**	300	125
Total air requirement	**425 l/min**	

$$V = \dot{V} \times n \times \eta$$

Air requirements plus allowances

V = 600 l/min

Form 1 to calculate the total air requirement, see INSTAFLEX.

INSTAFLEX

Calculation of total air requirement									Form No.1
Tool / machine No:									
Supply pressure P ü									
Air requirements $\dot{V}$(l/min)									
Number of machines n									
Utilization η (%)									
Air required l/min $\boxed{V = \dot{V} \times n \times \eta}$									
(example see page 12.27)	Total air requirment $\boxed{\Sigma \quad}$ **l/min**								
Item: ______	Calculated by: ______								Date: ______ Initials: ______

Pipeline dimensioning

The lengths of the connection, distribution and main lines are determined in the system concept. The fittings used (elbow/T-pieces/etc.) and valves are added according to their equivalent pipe length value.

The pipeline can be pre-dimensioned with the help of **Table 1**.
The maximum flow rate of the diverse pipe diameters at different operating temperatures is based on a pressure loss of 0.03 bar for 100 m pipe.

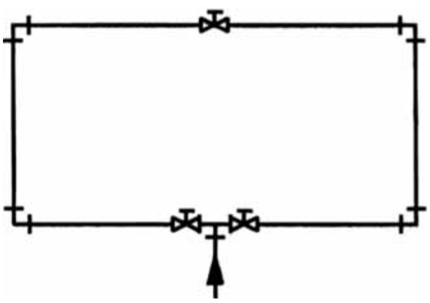
Table 1

Operating pressure [bar]	4	6	8	10	12	16
Pipe ø	Max. flow rate [m³/min]					
16	-	-	-	-	0.10	0.15
20	-	-	-	0.18	0.20	0.25
25	0.20	0.28	0.30	0.34	0.38	0.45
32	0.48	0.55	0.62	0.70	0.75	0.85
40	0.78	0.90	1.00	1.30	1.50	1.70
50	1.40	1.75	2.00	2.20	2.60	3.00
63	2.50	3.25	3.80	4.20	4.60	5.20
75	4.10	5.00	6.00	7.00	7.50	8.20
90	7.00	8.10	9.95	11.00	12.50	14.00
110	11.50	14.00	16.00	18.00	20.00	22.00

Pipe length L	**=**	**100 m**
Pressure loss Δp	**=**	**0.03 bar**

1m³/min ≙ 1000 l/min = 16,7 l/s

Equivalent pipe lengths for fittings, see **Table 2** of the section «Nomogram».



Example:

VL	=	110 m
p	=	0.03 bar
p	=	6.0 bar
V	=	4500 l/min

Distribution line	**d75**	L =	110 m
1 T-piece			2.5 m
4 Elbow 90º			6.0 m
3 Ball valve		ca.	1.6 m
Total length			**120.1 m**

As taken from Table 1 with an operating pressure of 6 bar and an air requirement of 4500 l/min (4.5 m³/min) the pipe diameter is **d75.**

1 bar ≙ 10^5 Pa

Nomogram

The nomogram below is a fast and easy way of calculating the right pipe diameter of compressed air pipelines made of PB and PE-HD.

Procedure:

1. Determine the pipe length [m] **A** and the flow rate [m³/min] B and join them with line **1**.
2. Join the pressure loss [bar] **E** and the operating pressure [bar] **D** with line **2**.
3. Join the two intersection points **1/C** and **2/F** with line **3**.
4. The intersection point of line **3** with **G** shows the pipe dimension.

Example:

L	=	120	m
V	=	4.5	m³/min
Δp	=	0.03	bar
p	=	6	bar

Result: pipe dimension d = 75

Nomogram to determine the pipe diameter for compressed airlines made of PB (PN16) and PE-HD

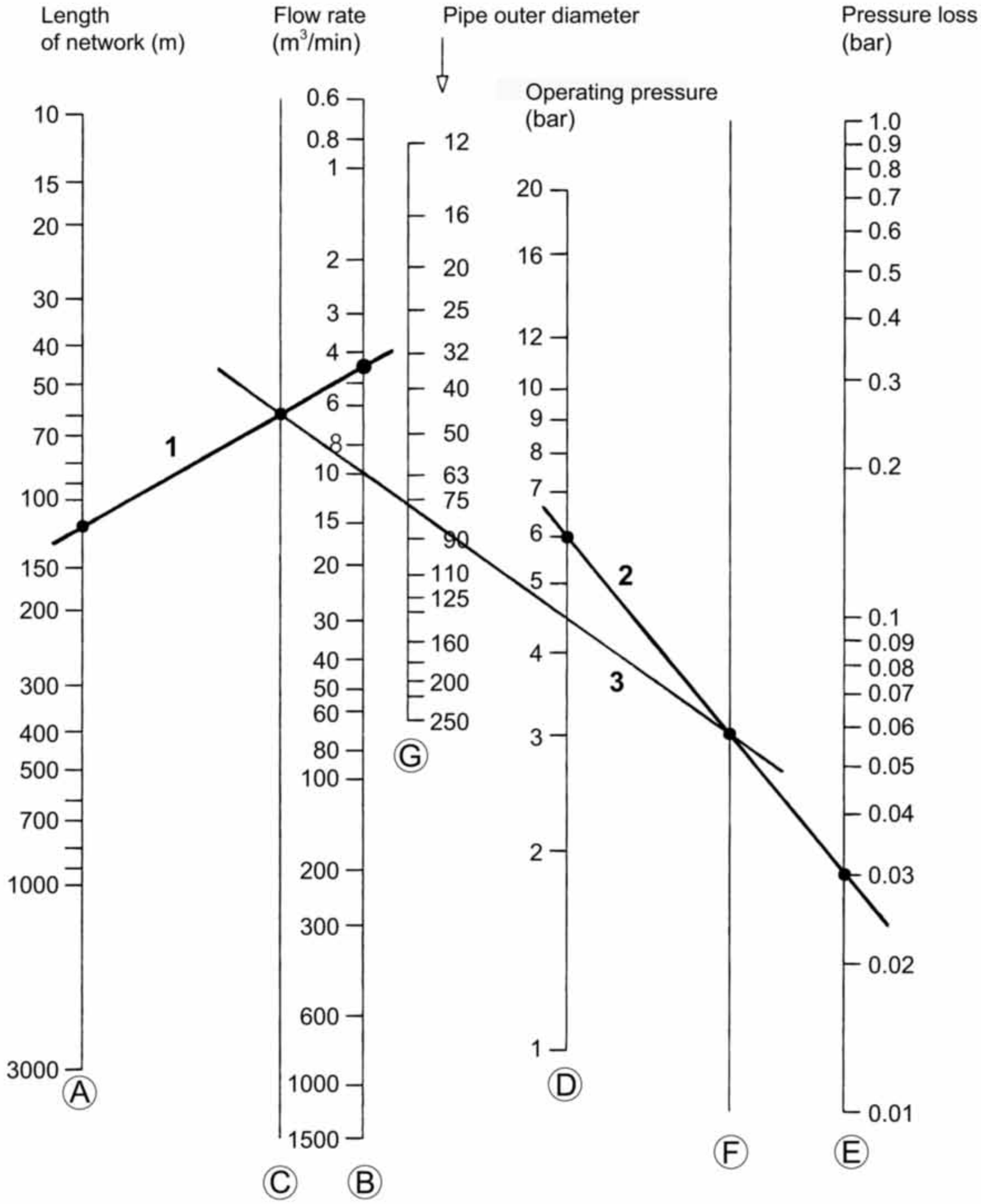
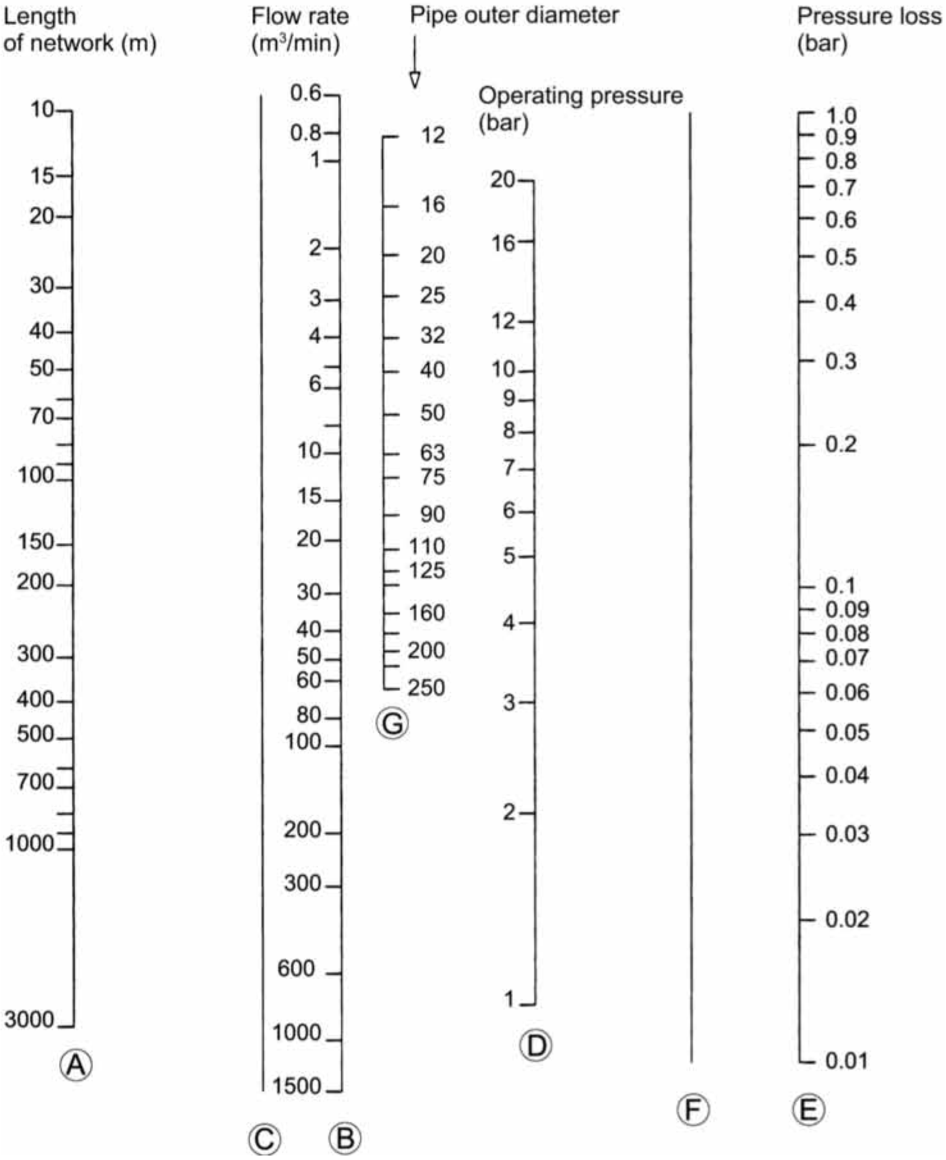


Table 2

Equivalent pipe lengths for plastic fittings and valves (polybutene/polyethylene)

Pipe ø A	16	20	25	32	40	50	63	75	90	110
Fitting Elbow 90º 	0.30	0.40	0.50	0.60	0.80	1.00	1.25	1.50	1.80	2.50
Elbow 45º 	0.15	0.20	0.25	0.30	0.40	0.50	0.60	0.75	0.9	1.25
T-piece passage 	0.10	0.15	0.15	0.20	0.25	0.35	0.45	0.60	0.75	1.00
T-piece branch 	0.50	0.65	0.80	1.00	1.25	1.50	1.90	2.30	2.90	3.50
T-piece separation 	0.65	0.80	1.00	1.25	1.50	1.80	2.10	2.50	3.10	3.80
Reducer 	0.20	0.25	0.30	0.40	0.50	0.70	0.90	1.20	1.50	1.90
Swan-neck outlet 	0.70	0.85	1.00	-	-	-	-	-	-	-
Valves Ball valve/ PB gate 	-	0.16	0.18	0.20	0.24	0.28	0.40	0.52	0.65	0.80
Di-aphragm valve 	-	0.90	1.20	1.60	2.10	2.60	3.30	4.10	5.00	6.20

Nomogram to determine the pipe diameter for compressed airlines made of PB (PN16) and PE-HD (PN10)



Repair of existing systems

For the operator of a compressed air system, the efficiency data of the system are of great importance.

Two factors are predominant:

- pressure loss
- leakage loss

Pressure loss

If dimensions are selected which are too small because of calculation errors or investment cost saving, there will be more pressure loss, thus leading to higher energy costs for supplying the compressed air.

The following example shows the higher energy costs incurred in order to compensate the pressure loss.

Operating pressure	6 bar
Network length	200 m
Flow rate	12 m³/min

DN_R	Pressure drop Δp [bar]	Energy costs EUR p.a.
90	**0.04**	**200.00**
70	0.2	800.00
50	0.86	4400.00

It's easy to calculate how long it takes to recover the somewhat higher investment cost for larger pipes compared to the higher energy costs for the smaller pipeline.

Savings in building costs are rapidly depleted by high lifecycle costs.

Leakage loss

It is important to know where and how much compressed air is lost between the generator and the consumer.

Smaller leaks can usually be located with a leak detector spray, whereas larger leaks are easier to find because of the hissing sound.

The best way of determining the leakage volume is by **draining the pressure reservoir** or **measuring the on-time** of the compressor.

Pressure reservoir draining

The pressure tank (V_B) is filled with a given pressure (p_A) and the time (t) required for the tank pressure to sink to a pressure (p_E) is measured.

Example:

V_B	=	1000	l
p_A	=	8	bar
p_E	=	6	bar
t	=	5	min

$\dot{V}$ = Leakage volume (l/min)

$$\dot{V} = \frac{V_B \cdot (p_A - p_E)}{t}$$

$$\dot{V} = \frac{1000l \cdot (8-6)}{5\,\text{min}} = 400l/\text{min}$$

The shut-off valves at the end of the connection lines are closed so that only the leakage in the single section can be measured.

Warranty

Page

Quality, environmental and social policies

Warranty

Quality, environmental and social policies

Introduction

Quality, environment and social policies are given top priority at the Georg Fischer Corporation. Over 90 percent of the roughly 12,000 persons employed at the end of 2005 work at subsidiaries with quality management systems certified according to international standards, such as ISO 9001. We achieve a competitive edge for ourselves and our customers with a consistent standard of quality tailored to market needs as well as with the continual improvement of our business processes.

Our products are more ecologically efficient; without additional or with less environmental impact in the production and lifecycle phases, our products offer better performance. Plastic piping systems from GF Piping Systems are lightweight to transport, are corrosion resistant and durable. They safeguard our most valuable resource, water, from its source to the end consumer.

Quality assurance at all levels

Improvement process

Your experiences with our products and services help us to continually improve your benefit and to respond quickly to your changing requirements. Our employees are glad to support you with their know-how and their experience.

Customer satisfaction

We offer all this and more:

- Complete systems for a wide variety of applications
- High-quality, reliable products
- Large range of services: customer support and training, fusion machine rental, planning tools
- Compliance with diverse technical regulations: international norms, national and application-specific approvals
- Efficient logistics

Quality is planned, produced and monitored

You can expect comprehensive quality management on all levels.

- Highly productive research and development
- Modern production technology in our plants with integrated quality assurance
- Accredited test lab according to ISO/IEC 17025

An ISO 9001:2000 certified quality management system is a major milestone on the path toward achieving our ultimate goal – customer satisfaction.

Environment

Know-how put to use for a clean environment

Our decades of experience in the field of plastic piping systems are put to the service of a clean environment.

- ABS for environmentally friendly coolants in refrigeration systems
- Pipe-in-sleeve systems for more safety in transporting aggressive fluids
- Better energy balance of plastics compared to alternative pipe materials

Added value for customers

We aim to understand and satisfy our customers' needs for environmentally friendlier products and services. We want to be a competent partner for our environmentally conscious customers.

We achieve this through sustainable product design and production processes, as well as through intensive dialogue with our customers. We strive to know their requirements and to adapt our market performance accordingly.

Environmental management

With our environmental management system we

- deal professionally with environmentally relevant issues,
- control risks and
- continuously evaluate and improve products, processes and services.

ISO 14001 certification is only the beginning. We are committed to continuously evaluating and improving our environmental performance.

Social policies

Statistical data on the diversity, health and safety on the job, employment conditions, training and development of our employees was collected systematically and consolidated for the first time in 2005. This project was overseen by the Corporate Sustainability Officer, who reports in this function directly to the Head of Corporate Development and is therefore a Member of the Executive Committee. The results of this survey were used to formulate the corporate objectives of GF Piping Systems.

Employees
Qualified, well trained and dedicated employees are considered the key to success at GF Piping Systems. Interesting tasks, goal-oriented training activities, fair remuneration and good social benefits are as important as dealing responsibly with employees, especially in a competitive and economically challenging environment.

Further training
The training and personal development programs at GF Piping Systems range from apprenticeship training to courses for employees and managers to seminars for senior management. The goal-oriented development of our employees helps to keep them fit for the future and secures their employment opportunities as well as our competitiveness.

Employee surveys
Georg Fischer periodically surveys the satisfaction of its employees regarding their work conditions. Great importance has also been attached to improving work processes in the corporation through an avidly pursued idea management.

Improvements in work conditions have been implemented at all locations; some of these are, for example, use of lifting equipment, reduction of noise and particle emissions or reduction of hazardous materials.

Symbols and units

Symbols and units

SI units

SI basic units

The International System of Units (SI Units abbreviated from the French) are the seven base units with the corresponding units of measurement and the derived units, i.e. derived with the factor 1.

Measure		**SI base units**	
Name	**Symbol**	**Name**	**Symbol**
Length	l	metre	m
Mass	m	kilogram	kg
Time	t	seconds	s
Electric current	I	ampere	A
Thermodynamic temperature	T	kelvin	K
Amount of substance	n	mole	mol
Luminous intensity	I_n	candela	cd

Internationally defined prefixes

	Prefix		**Factor as**	
Long-scale (UK)	**Name**	**Symbol**	**Power of ten**	**Decimal**
Trillion	exa	E	10^{18}	= 1 000 000 000 000 000 000
Billiard	peta	P	10^{15}	= 1 000 000 000 000 000
Billion	tera	T	10^{12}	= 1 000 000 000 000
Milliard	giga	G	10^{9}	= 1 000 000 000
Million	mega	M	10^{6}	= 1 000 000
Thousand	kilo	k	10^{3}	= 1 000
Hundred	hekto	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
Milliardth	nano	n	10^{-9}	= 0.000 000 001
Billionth	pico	p	10^{-12}	= 0.000 000 000 001
Billiardth	femto	f	10^{-15}	= 0.000 000 000 000 001
Trillionth	atto	a	10^{-18}	= 0.000 000 000 000 000 001

Units

Unit	Symbol	SI unit	Permissible units other than SI	Conversion to the respective SI unit and name	Units and calculations no longer permitted
Length	l	m (metre)			1" (inch) = 0.0254 m 1 sm (sea mile) = 1852 m
Area	A	m² (square metre)			1 b (barn) = 10^{-28} m² 1 a (are) = 10² m² 1 ha (hectare) = 10^{4} m² qm, qdm, qcm, etc. Name permitted, not symbol
Volume	V	m² (cubic metre)	l (litre)	1 l = 10^{-3} m³	
Solid angle	Ω	sr (steradian)		1 sr = 1 m²/m²	1° (quadrant degree) = 3,046 • 10^{-4} sr 1 g (quadrantgon) = 2,467 • 10^{-4} sr
Time	t	s (second)	min (minute) h (hour) d (day)	1 min = 60 s 1 h = 3600 s 1 d = 86400 s	
Frequency	f	Hz (hertz)		1 Hz = 1/s	
Rotational frequency	n	s^{-1}	min^{-1} U/min	1 min^{-1} (1/$_{60}$) s^{-1} 1 U/min = 1 (1/min)	
Velocity	v	m/s	km/h	1 km/h = (1/3.6) m/s	
Acceleration	g	m/s²		Normal gravitational acceleration g_n= 9.80665 m/s²	1 Gal (Gal) = 10^{-2} m/s²
Mass	m	kg (kilogram)	t (tonne)	1 t = 10³ kg	1 q (centner) = 50 kg
Density	ρ	kg/m³	t/m³ kg/l	1t/m³ = 1000 kg/m³ 1kg/l = 1000 kg/m³	
Moment of inertia	J	kg • m²			1 kp • m s² = 9.81 kg • m²
Force	F	N (Newton)		1 N = 1 kg • m/s²	1 dyn (dyn) = 10^{-5} N 1 p (pond) = 9.80665 • 10^{-3} N 1 kp (kilopond) = 9.80665 N
Torque	M	N • m			1 kpm = 9.80665 Nm
Pressure	p	Pa (Pascal)	bar	1 Pa = 1 N/m² 1 bar = 10^{5} Pa	1 atm = 1.01325 bar 1 at = 0.980665 bar 1 Torr = 1.333224 • 10^{-3} bar 1 m WS = 98.0665 • 10^{-3} bar 1 mm Hg = 1,333224 • 10^{-3} bar
Mechanical stress	σ	N/m² Pa		1 N/m² = 1 Pa	1 kp/m² = 9.80665 N/m² 1 kp/cm² = 98.0665 10^{-3} N/m² 1 kp/mm² = 9.80665 • 10^{-6} N/m²

Dynamic viscosity		Pa • s		1 Pa • s = 1 N • s/m²	1 P (poise) = 10^{-1} Pa • s
Kinematic viscosity		m²/s		1 m²/s = 1 Pa • s • m³/kg	1 St (stokes) = 10^{-4} m²/s
Work Energy	W E	J (joule)	eV (electron volt) W • h	1 J = 1 Nm = 1 Ws 1 W • h = 3.6 KJ	1 cal = 4.1868 J 1 kpm = 9.80665 J 1 erg = 10^{-7} J
Quantity of electricity	Q	C (coulomb)		1 C = 1 A • s	
Electric potential difference	U	V (volt)		1 V = 1 W/A	
Electric current	I	A (ampere)			
Electric resistance	R	Ω (ohm)		1 Ω = 1 V/A	1 Ω abs = 1 Ω
Power	P	W (watt)		1 W = 1 J/s = 1 Nm/s 1 W = 1 V • A	1 PS = 735.498 W 1 kcal/h = 1.163 W 1 kpm/s = 10 W
Electric capacitance	C	F (farad)		1 F = 1 C/V	
Magnetic field strength	H	A/m			1 Oe (Oersted) = 79.5775 A/m
Magnetic flux	Φ	Wb (weber)		1 Wb = 1 V • s	1 Mx (Maxwell) = 10^{-8} Wb
Magnetic flux density	B	T (tesla)		1 T = 1 Wb/m²	1 G (Gauss) = 10^{-4} T
Inductance	L	H (henry)		1 H = 1 Wb/A	
Electric conductance	G	S (siemens)		1 S = 1/Ω	
Thermodynamic temperature	T	K (kelvin)		Δ 1 °C = Δ 1 K 0 °C = 273.15 K	
Celsius temperature	t, δ	°C (degree Celsius)		Δ 1 °C = Δ 1 K 0 K = -273.15 °C	
Heat capacity	C	J/K			1 Kcl/grad = 4.1868 10^{-3} J/K 1 Cl (Clausius) = 4.1868 J/K

Conversion tables

Viscosities

Kinematic Viscosity Centistokes Density	Absolute Viscosity Centipoise	Engler degrees	Seconds Saybolt Universal (SSU)	Seconds Redwood 1 (Standard)	Seconds Saybolt Furol	Seconds Ford Cup Nr. 4	Barbey degrees	Seconds Cup Nr. 15	Absolute Viscosity Poise Density 1.0	Kinematic Viscosity m²/s
1.0	1.0	1.0	31	29	--	--	--	--	0.01	1.0×10^{-6}
2.0	2.0	1.1	34	30	--	--	3640	--	0.02	2.0×10^{-6}
3.0	3.0	1.2	35	33	--	--	2426	--	0.03	3.0×10^{-6}
4.0	4.0	1.3	37	35	--	--	1820	--	-	4.0×10^{-6}
5.0	5.0	1.39	42	38	--	--	1300	--	0.05	5.0×10^{-6}
6.0	6.0	1.48	45.5	40.5	--	--	1085	--	0.06	6.0×10^{-6}
7.0	7.0	1.57	48.5	43	--	--	930	--	0.07	7.0×10^{-6}
8.0	8.0	1.65	53	46	--	--	814	--	0.08	8.0×10^{-6}
9.0	9.0	1.74	55	48.5	--	--	723	--	0.09	9.0×10^{-6}
10	10	1.84	59	52	--	--	650	--	0.10	1.0×10^{-5}
20	20	2.9	97	85	15	--	320	--	0.2	2.0×10^{-5}
40	40	5.3	185	163	21	--	159	--	0.4	4.0×10^{-5}
60	60	7.9	280	245	30	18.7	106	5.6	0.6	6.0×10^{-5}
80	80	10.5	370	322	38	25.9	79	6.7	0.8	8.0×10^{-5}
100	100	13.2	472	408	47	32	65	7.4	1.0	1.0×10^{-4}
200	200	26.4	944	816	92	60	32.5	11.2	2.0	2.0×10^{-4}
400	400	52.8	1888	1632	184	111	15.9	18.4	4.0	4.0×10^{-4}
600	600	79.2	2832	2448	276	162	10.6	26.9	6.0	6.0×10^{-4}
800	800	106	3776	3264	368	217	8.1	35	8.0	8.0×10^{-4}
1000	1000	132	7080	4080	460	415	6.6	68	10	1.0×10^{-3}
5000	5000	660	23600	20400	2300	1356	1.23	240	50	5.0×10^{-3}
10000	10000	1320	47200	40800	4600	2713	--	481	100	1.0×10^{-2}
50000	50000	6600	236000	204000	23000	13560	--	2403	500	5.0×10^{-2}

Absolute viscosity (centipoise) = kinematic viscosity (Centistokes) x density
Over 50 centistokes - calculated to SSU at SSU = centistokes x 4.62

Delivery volumes

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	2.78×10^{-4}	3.667	4.404	35.311	9.81×10^{-3}
0.06	1.0	0.017	1.67×10^{-5}	0.220	0.264	2.119	5.89×10^{-4}
3.6	60	1.0	1.00×10^{-3}	13.20	15.853	127.12	3.53×10^{-2}
3600	60000	1000	1.0	13200	15838	127118	35.311
0.2727	4.55	0.076	7.58×10^{-5}	1.0	1.201	9.629	2.67×10^{-3}
0.2272	3.79	0.063	6.31×10^{-5}	0.833	1.0	8.0238	2.23×10^{-3}
0.0283	0.47	0.008	7.86×10^{-6}	0.104	0.125	1.0	2.78×10^{-4}
101.94	1699	28.32	2.83×10^{-2}	373.77	448.8	3600	1.0

gal/min = gallon per minute
1 Imp.gal ≈ 4.55 litre
1 US.gal ≈ 3.79 litre
cu. ft./h = cubic foot per hour
cu. ft./s = cubic foot per second

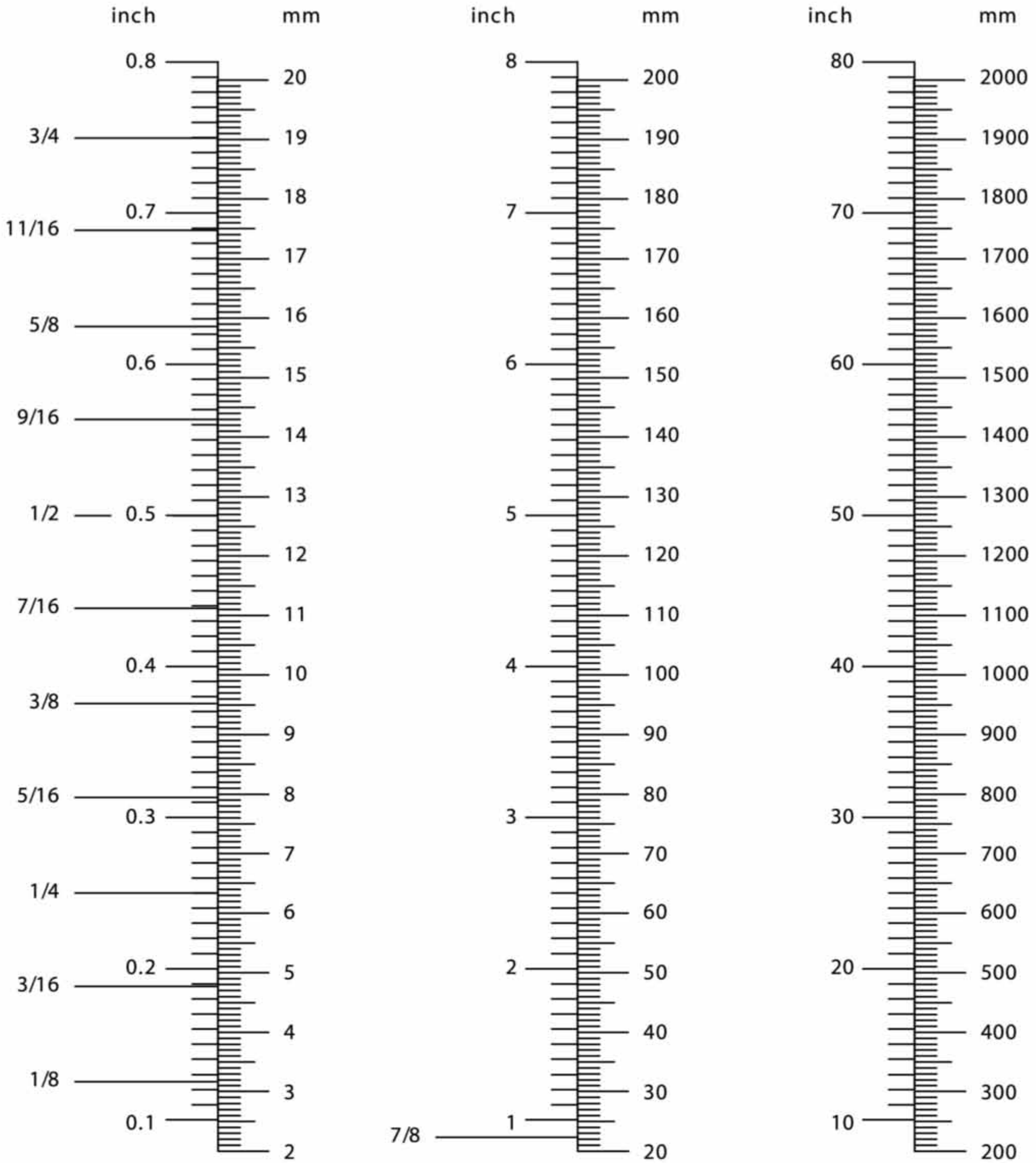
Pressures and pressure heads

bar	kg/cm²	lbf/sq. in.	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	0.0609	2.3067	0.7031	51.715	2.036	6.89
1.0133	1.0332	14.696	1.0	33.889	10.332	760.0	29.921	101.3
0.0299	0.0305	0.4335	0.0295	1.0	0.3048	22.420	0.8827	2.99
0.0981	0.10	1.422	0.0968	3.2808	1.0	73.356	2.896	9.81
13.3×10^{-4}	0.0014	0.0193	13.2×10^{-4}	0.0446	0.0136	1.0	0.0394	0.133
0.0339	0.0345	0.4912	0.0334	1.1329	0.3453	25.40	1.0	3.39
1.0×10^{-5}	10.2×10^{-6}	14.5×10^{-5}	9.87×10^{-6}	3.34×10^{-4}	10.2×10^{-5}	75.0×10^{-4}	29.5×10^{-5}	1.0

kg/cm² = metric atmosphere
lbf/sq. in. = pound (force) per square inch (GB)
atm = international standard atmosphere
mm Hg = millimetre mercury column

Conversion inch/mm

Conversion inch/mm



Materials

ABS	Acrylonitrile-butadiene-styrene
CR	Chloroprene rubber, e.g. Neoprene
EPDM	Ethylene-propylene rubber
FPM	Fluorocarbon rubber, e.g. Viton
Ms	Brass
NBR	Nitrile rubber
NR	Natural rubber
PB	Polybutene
PE	Polyethylene
PE-X	Crosslinked polyethylene
PP	Polypropylene
PTFE	Polytetrafluoroethylene, e.g. Teflon
PVC	Polyvinyl chloride
PVC-C	Polyvinyl chloride post-chlorinated (higher chlorine content)
PVC-U	Polyvinyl chloride unplasticized
PVDF	Polyvinylidene fluoride
TG	Malleable iron
UP-GF	Unsaturated polyester resin, fibreglass reinforced

Measurements and units

Measurements are given in mm or inch and are considered nominal or standard measurements.

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+GF+

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ensure local customer support in over 100 countries.

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