Building Technology

Plan, Build, Operate

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Preamble

Content

2.5.2 Chemical process industry

The chemical process industry covers all industrial activities from the extraction of raw materials to the conversion of raw materials into the corresponding basic and special chemicals. Each chemical has its own value chain, with meticulous material and component selection being a prerequisite for materials requirements planner, designers and installers. The demanding environmental conditions in most industrial plants, the pursuit of efficiency and the guidelines for the responsible use of chemicals, place high demands on piping systems in terms of occupational safety, compliance with environmental standards, reliability and maintenance.

GI.6
Chemical process industry
1. Chemical extraction from natural resources
2. Chemical production/ commerce
3. Chemicals in commerce

Chemical extraction from natural resources

Mining and mineral processing

The mining and mineral processing industry is one of the largest consumers of water and chemicals in harsh environments with challenging installation, reliability and corrosion resistance requirements. The products of GF Piping Systems are used in the distribution units of the mines as well as in various process steps from iron ore smelting to hydrometallurgy.

Oil and gas industry

The design of the water circuits in the oil and gas industry is complex and demanding. In order to increase process performance and increase the efficiency of water treatment, many chemical additives are used. New developments in offshore systems and hydraulic fracturing technologies are increasingly relying on the plastic piping systems of GF Piping Systems due to the low weight of the pipelines, the modular installation and long service life in harsh environments.

Chemical production and commerce

Petrochemicals

Petrochemicals are the building blocks of many everyday objects. Their value chain is growing as new equipment becomes necessary due to rising standards of living in emerging economies and increasing urbanization. The industrial processing facilities for oleofins, aromatics and synthesis gas utilize highly complex piping systems for water and chemicals which are used as process additives or catalysts and in various chemical injection devices.

Fertilizers

Fertilizer plants play an important role in the global chemical industry as the demand for food production in industrial agriculture increases constantly. Fertilizer plants provide an excellent platform for monetisation ammonia gas in the form of nitrogen-based fertilizers. They are nodal point in the value chain of most industrial mineral acids worldwide, such as sulfuric acid and phosphoric acid.

2.3 Planning phases in detail

Ideally, the planning phases can be broken down in detail (without claim to completeness) as follows.
This ideal type representation includes further aspects, for example, the selection procedure of the bidders and the call for tenders are not presented here in detail. The reason is that the positioning of these facets is widely depending on the planning process used. These are controlled by country-specific regulations, the local building standards that must be taken into account, the country-specific practices and the dimension and complexity of the construction project.

GII.4
Planning phases in detail

Plan	Idea/Concept	**Strategic planning** • Determining needs, objectives, framework requirements • Defining solution strategies
		Preliminary studies • Defining procedure and organisational form • Verifying feasibility • Defining the project
	Project planning	**Feasibility analysis/construction project** • Optimising the design • Optimising efficiency • Defining schedules **Approval procedure** • Approving project, costs, schedules
Build	Realisation	**Design** • Implementing the building according to planning, contracts and functional specification **Putting into operation** • Taking over the building, putting it into operation • Repairing construction defects
Operate	Operation/ Resources Management/ Preservation	**Operation** • ensure the operation is safe, optimise **Monitoring, installation, maintenance** • Monitoring the building’s condition • Ensure to proceed with maintenance task **Maintenance, Repair** • Maintaining the value of the building’s fabric • Maintain sustained usage

3.3 BIM – From an information standard to a building code

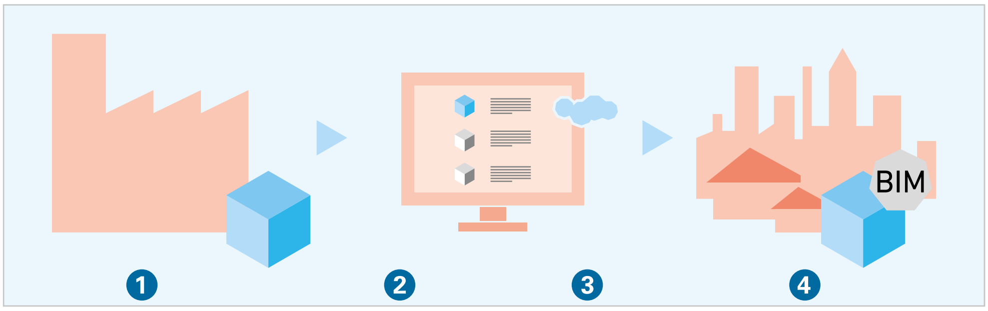
Projects implemented on an international level show that the utilisation of building information models (BIM methods) is indisputably responsible for improving quality and efficiency.

The availability of information on systems and products, including all data and properties that are relevant for the decision on what product to use, is of paramount importance for the success of construction projects. This definitely requires “laborious tasks” for all stakeholders in the planning process.

In the course of digitisation, the construction products will also be digitised: In the future, these construction products will be available as standardised BIM data and can be considered for the geometric and technical planning in the building models.

The digital data are part of the product, like the packaging or the accessories, but with the benefit, once they have been developed and are available on the platform, they can be used multiple times.

Principle: Build digitally first - then real.



GII.5
From the real to the digital construction product

1. Digitalisation
2. Provisioning
3. Linkage
4. Automatisation

From an international perspective, the process of providing BIM data is already in progress. Local industries, coupled with national political bodies, are driving the implementation forward and rolling out the “red carpet” for their industry (GB, NO, USA, etc.). Now the question arises as to what speed and efficiency the construction sector or industry will be able to keep up, take the necessary steps, adapt the tried and tested methods, and to put service benefits in the market.

+ **When speaking of Building Information Modeling (BIM), this does not mean to simply switch from the traditional 2D design to intelligent 3D planning, but rather it refers to the linking of the value chain: The transformation of an entire economic sector into the digital age is imminent.**

The rational transfer of real products and their often poorly structured product data into digital products plays an important role for both local and international manufacturers. However, at the same time this transfer presents a great challenge.

In some countries, **BIM libraries** have already made a significant contribution to realising the potential of digitisation for greater efficiency and added value. Everyone, from the builders, designers, architects, engineers, contractors, as well as the many smaller, medium and large component manufacturers can benefit from this development.

4.2 Prevention

In order to ensure a high drinking water quality up to the tap, rethinking the distribution of drinking water is necessary. Until a few years ago, the drinking water installation was considered maintenance-free. Today, increasingly new installation concepts and preventive measures are required during use. These measures prophylactically promote the drinking water quality in the installation and thus ensure a high level of drinking water hygiene.

The following measures are recommended for successful prevention, from designing through installation to use:

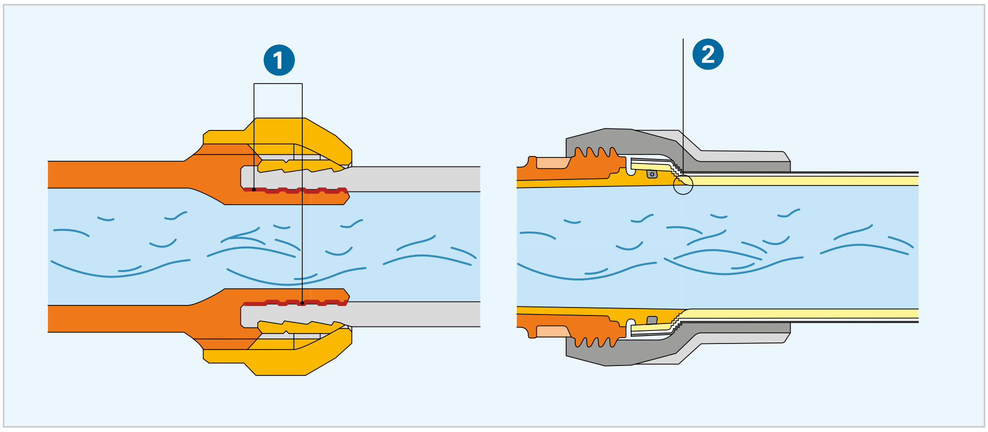
- Installation concept, fittings and pipe system without dead spaces
- Setting the proper drinking water temperature
- Ensuring hydraulic balancing
- All taps must be flushed regularly
- Preventing the formation of limestone, biofilm and corrosion

Installation concept, fittings and pipe system without dead spaces

A piping system inside a building generally entails the risk of microbial contamination, since the drinking water comes into intensive contact with the system's surfaces (unfavourable ratio of the surface to the drinking water). Unused pipe installation sections are at particular risk. They lead to long **stagnation times** of drinking water and provide an ideal habitat for bacteria. The following precautions provide a remedy:

☑ Disconnect unused installation sections.
☑ Empty and shut off all taps used infrequently.
☑ Those pipes used only seasonally require special attention (used only in the summer or only in the winter time).
☑ When converting rooms: If necessary, remove, drain and close the taps.

Even dead spaces – that is to say, those pipes filled with water and cavities hardly ever flushed – harbour dangers and should be avoided: Bacteria multiply very well in these dead spaces. Dead spaces can be found especially in connections of pipe installation systems and sealing points of fittings.



GII.17
Pipe connections without dead space

1 Dead space
2 Sealing edge, no dead space (this example shows a clamping connection with JRG Sanipex MT)

Ensuring the correct drinking water temperature

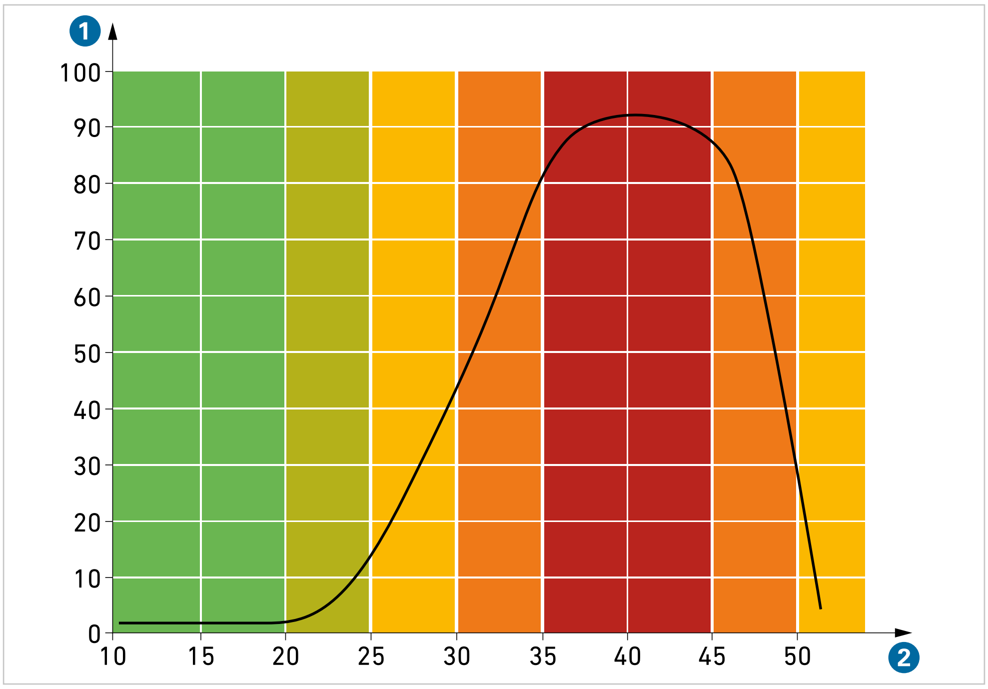
Bacteria multiply more or less depending on the **water temperature**. Therefore, the temperature of the water in a drinking water installation is of great importance.

+ The temperatures of cold water must be below 25°C. This will keep the risk of microbial contamination low. However, the temperatures of hot water should always be above 50°C.

Legionella multiply particularly in the temperature range between 25°C to 50°C. At 37°C, the growth rate reaches its maximum: At these temperatures, the number of legionella doubles within three hours.

To ensure the correct water temperature, compliance with the following conditions is mandatory:

- ☑ The cold and hot water installation requires 100% thermal insulation.
- ☑ The control of the hot water circulation must ensure the heat is distributed evenly, the hydraulic balancing must be given.
- ☑ At elevated cold water temperatures, cold water circulation is recommended, but at least one suitable flushing device must be installed.
- ☑ In the cold water distribution, flushing of the pipes must be carried out at least every 72 hours or they must be automatically flushed.
- ☑ The hot water volume of the storage tank must be changed daily to keep stagnation times in the critical temperature range between 25°C and 50°C. The temperature of the storage tank must never drop below 50°C.



GII.18
Temperature-dependent legionella growth

The critical range is between 25 und 50°C.

1 Legionella growth rate (%)
2 Drinking water temperature (°C)

Materials and jointing technology

1 Plastics

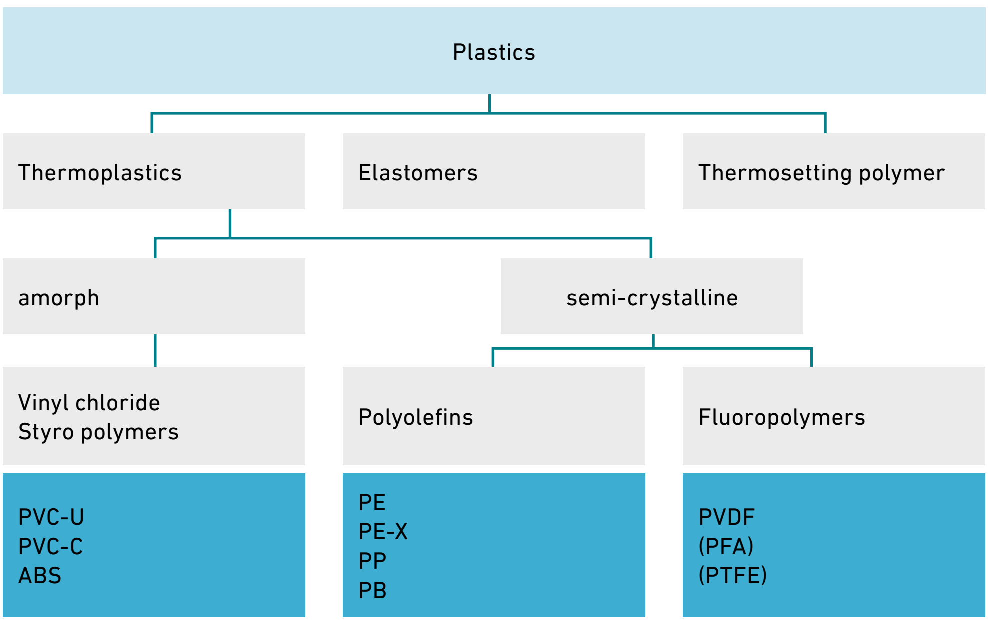
1.1 History

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

1.2 Structure and properties

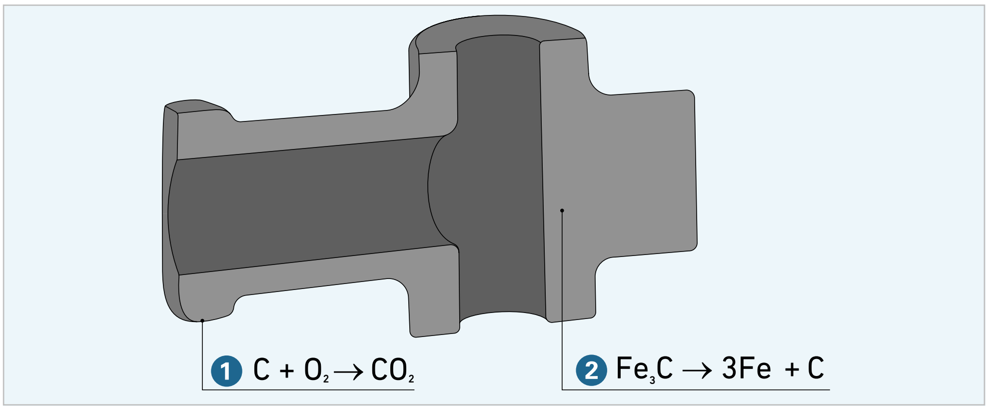
Polymers are organic compounds that are obtained either by the conversion of natural products (e.g. natural rubber, cellulose), or by synthesis from petroleum derivatives. Polymer chains, together with additives such as stabilisers and processing aids, produce the actual material – referred to as plastic.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

In piping system construction, mainly thermoplastics are used, which are processed into fittings and pipes with a technical processes referred to as **injection moulding** and **extrusion**. Elastomers are used as sealing material in screw, flange and plug-in connectors. For example, thermosetting polymer are used as insulation foams or in glass-fibre reinforced liners.



GIII.1
Materials for pipelines – Overview

From a chemical point of view, this change is as follows:



GIII.17
Processes in the casting during tempering; micrograph

Black malleable iron

Black malleable iron is annealed in an inert atmosphere (inert gas or vacuum) and has a uniform structure with a higher carbon content. The production of black malleable iron proceeds similarly. However, a neutral (low-oxygen) atmosphere is used. As a result, the carbon in the boundary region cannot oxidise. Tempering coal forms, which has an effect on the properties of malleable cast iron depending on the cooling rate.

Use

Malleable is mainly used in vehicle manufacturing, for example, producing connecting rods and steering columns. However, this material is also used in the building industry for fittings and locks or in the installation technology for fitting and valves.

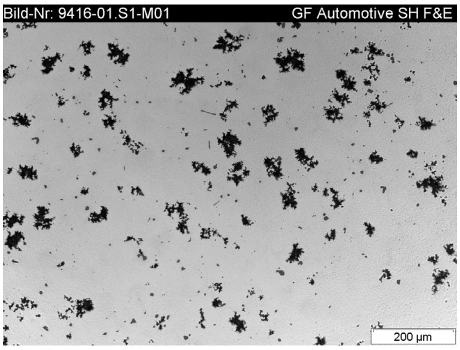
Economics

The production and processing of cast iron materials is economically priced. For economic profitability, malleable cast iron requires the production in series.

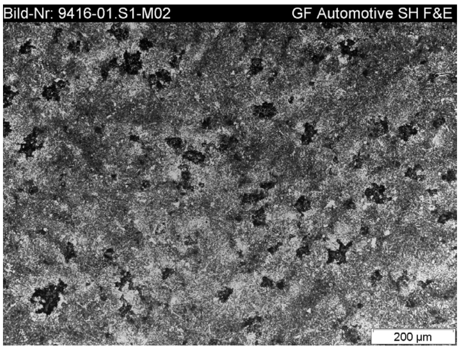
Ecology and recycling

In order to produce from natural resources, a very high energy consumption is required. When extracting cast iron from recycled material, this energy consumption is much lower. The dusts and fumes generated during the manufacture of metals causes a strong environmental impact. However, complex exhaust gas treatment plants can lower this adverse effect to an environmentally acceptable level. Iron materials are recycled almost 100%. By remelting the cast materials, they can be fed into the production process and reused without any loss of quality.

GIII.19
Black malleable iron, micrograph (unetched)



GIII.18
Black malleable iron, micrograph (etched)



4.4 Protection against corrosion and formation of scale

A drinking water installation always consists of several different **materials**. Therefore, not only the pipe material used must be taken into consideration – even if it has the largest share of the water-wetted surface – but also the materials of all other components integrated into the system must be considered.

In an installation the following materials can be part of the various components, such as:

- Pipe installations made of different plastics
  - for example: PB, PP, PE-X, Multi-layer composites, copper or stainless steel
- Pipe connectors made of plastics, copper, brass, gunmetal or stainless steel
- Gaskets made of different elastomer materials
- Shut-off valves made of plastics, brass, gunmetal or stainless steel
- DWH heaters made of stainless steel, copper, steel (coated or enamelled) or steel storage tanks with plastics in the continuous flow principle
- Circulation pumps
  - for example, housings made of gunmetal, rotors made of stainless steel, gaskets made of elastomers
- Brass sanitary fittings with ceramic washers or elastomer seals

4.4.1 Corrosion

+ **Corrosion is the reaction of a metallic material with its environment, which causes a measurable change in the material and can lead to an impairment of the function of a mechanical component or the whole system. In most cases, this is an electrochemical reaction, but in some cases it may also be a metal-related chemical or physical reaction. (DIN EN ISO 8044)**

Corrosion can occur in drinking water installations when using **metallic materials** or may be caused by the degradations (decomposition of chemical compounds) in **plastic materials**. Corrosion can adversely affect the function of the installation and its components, cause malfunctions and also lead to considerable damage, which eventually necessitates extensive repair.

The **corrosion resistance** in flowing waters is generally relatively high, while in stagnation phases the probability of **pitting corrosion** increases. Therefore, in addition to hygienic reasons, it is also important from the point of view of corrosion technology that drinking water installations are always operated according to their intended use.

The **materials** used in a drinking water installation must be corrosion-resistant to the condition of the drinking water that exist at the time of the design. In order to achieve this consistency, **water treatment systems** should not be required for new installations.

The **quality of the drinking water** can be affected by the influence of the material's parameters and the operating conditions when it comes into contact with metallic materials. The resulting corrosion products or the reaction products formed with the ingredients in the water can lead to unacceptable health-related issues and may exceed impermissible values of the drinking water.

TIV.20

Minimum flow pressures and minimum values for the calculation flow of common drinking water supply points (DIN 1988-300)

Type of tap	DN	Minimum flow pressure p_{minFl} [MPa]	Design flow Q_R [l/s]
Drainage valves			
without tap aerator[a]	15	0.05	0.30
	20	0.05	0.50
	20	0.05	1.00
with tab aerator	10	0.10	0.15
	15	0.10	0.15
Mixing tabs[b, c] for			
Shower tub	15	0.10	0.15
Bathtub	15	0.10	0.15
Kitchen sink	15	0.10	0.07
Washbasin	15	0.10	0.07
Bidet	15	0.10	0.07
Household equipment			
Washing machine (acc. to DIN EN 60456)	15	0.05	0.15
Washing machine (acc. to DIN EN 50242)	15	0.05	0.07
Toilet bowl and urinals			
Filling valve for cistern (acc. to DIN EN 14124)	15	0.05	0.13
Flush valve (manually operated) for urinal (acc. to DIN EN 12541)	15	0.10	0.30
Flush valve (electronically operated) for urinal (acc. to DIN EN 15091)	15	0.10	0.30
WC flush valve	20	0.12	1.00

a Without connected equipment (e.g. lawn sprinkler)
b The specified calculation flow must be taken into account for the cold **and** hot water connection.
c Angle valves, for example, as in vanity unit fittings and B-connections for shower and bathtub fittings are to be considered as individual resistors or dealt with in the minimum flow pressure of the tap.

TIV.21

Constants for the peak flow rate

Source: DIN 1988-300

Type of building	Constant A	B	C
Residential building	1.48	0.19	0.94
Inpatient ward room in the hospital	0.75	0.44	0.18
Hotel	0.70	0.48	0.13
School	0.91	0.31	0.38
Administration building	0.91	0.31	0.38
Equipment for assisted living facility, retirement home	1.48	0.19	0.84
Nursing home	1.40	0.14	0.92

TIV.22

Reference values for pressure losses of group DHW heaters

Source: DIN 1988-300

Equipment type	Pressure loss Δp_{TE} [hPa]
Electrical flow DHW heater	
• hydraulically controlled	1000
• electronically controlled	800
Electric or gas storage water heater Nominal volume up to 80 l	200
Gas flow water heater Gas/combination water heater acc. to DIN EN 297, DIN EN 625	800

13 Installation and attachment

There are different options for installing and attaching pipelines:

- Installation using rigid assembly
- Installation using flexible pipe legs
  - If the structural conditions allow for sufficient space in order to assemble the flexible pipe legs, this type of installation should be chosen.

If selecting these two types of installation, special attention must be paid when designing and calculating fixed points and floating points.

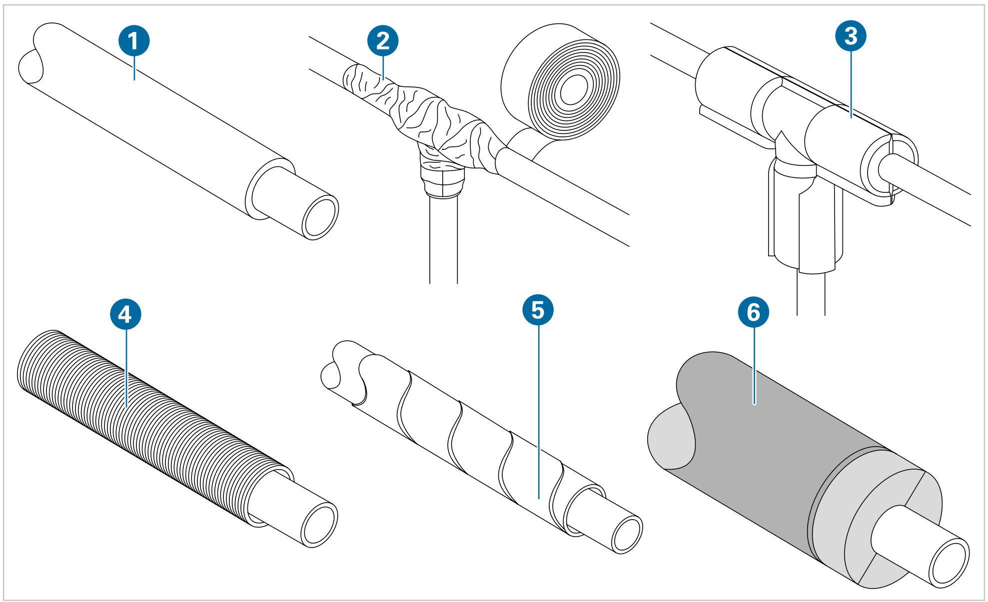
Furthermore, the following types of installation are also available:

- Installation in the building structure
- Installation in the raw concrete ceiling
- Installation on top of a raw concrete ceiling

Permissible installation types
The permissible installation types are product- and material-specific, depending on the **system** used and on the applicable valid **factory specifications**.

13.1 Protection against environmental influences and building materials

Depending on the type of installation, the system, the product- and material-specific properties, pipelines must be protected accordingly.



GIV.56
Safety measures
1 Pre-insulated pipe
2 Pipe with wrapping
3 Half shells
4 Protective conduit
5 Wrapping
6 Sheathing

System components flush-mounted or concealed behind a wall:

☑ In order to absorb thermally induced changes in length, to prevent the transmission of sound, to avoid the formation of condensation, to preclude heat dissipation, heat loss or to heat the medium and to protect from other building material influences, fittings or pipes must be covered with a suitable materials or they must be separated entirely from the structure of the building.

In permanently or periodically damp rooms, in areas subject to aggressive gases or other offensive environment and under uncontrollable environmental influences:

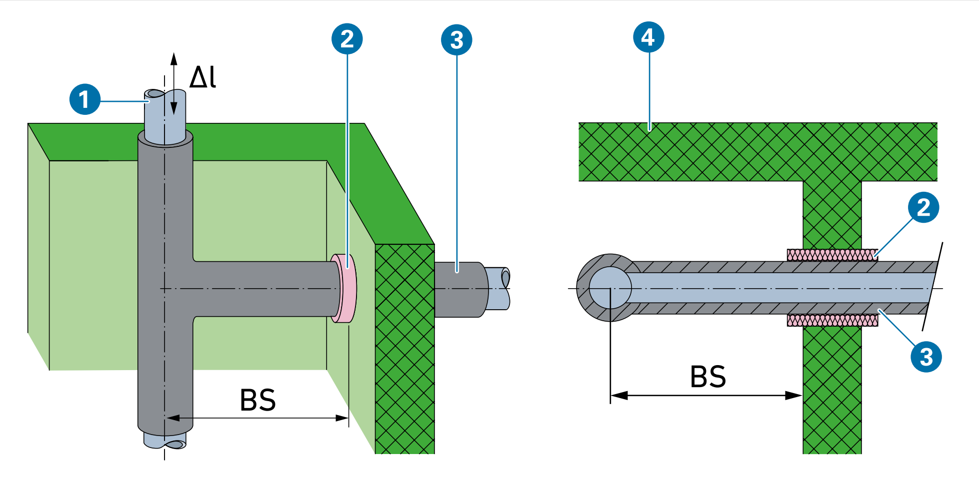
☑ Appropriate precautions must be taken to protect the installation, e.g. by using the following measures:
- Use of suitable anti-corrosion tapes (e.g. supplied by KEBU, Gyso or DENSO)
- Wrapping the pipe with heat-shrinkable materials.

☑ Ensure that pipes and fittings are dry when mounting.

Arrangement of flexible pipe legs inside a pipe shaft

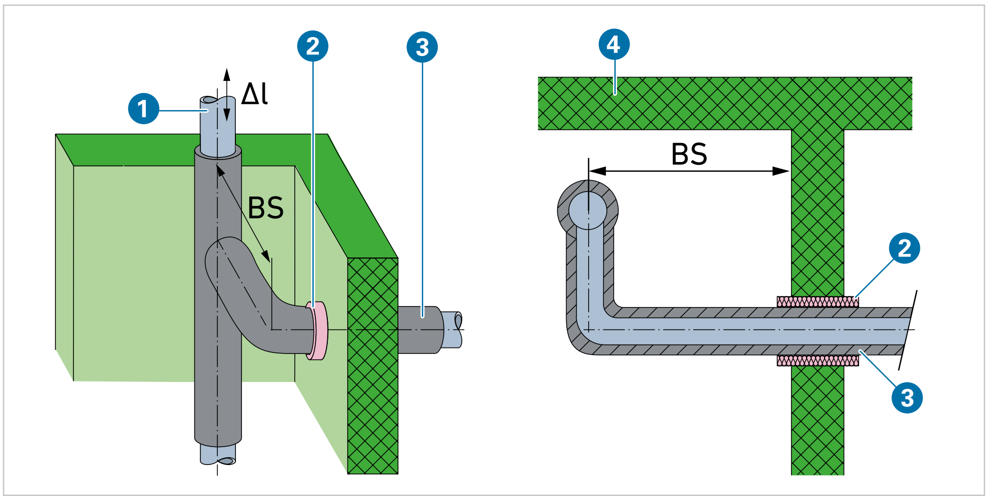
If **riser pipes** are installed inside shafts – required due to branches at individual floors – it must be ensured that the branching pipeline can adequately rebound according to the change of length of the riser pipe. To do this, several options are available:

☑ A soft material shall be used in order to insulate the branches of riser pipes. This will absorb the thermally induced change of length of the riser pipe.



GIV.62
Flexible pipe leg

- 1 Pipe
- 2 Insulation, for expansion (to compensate for the change of length)
- 3 Thermal insulation
- 4 Wall
- BS Flexible pipe leg
- Δl Thermally induced direction of the pipe's expansion



GIV.63
Flexible pipe leg

- 1 Pipe
- 2 Insulation, for expansion (to compensate for the change of length)
- 3 Thermal insulation
- 4 Wall
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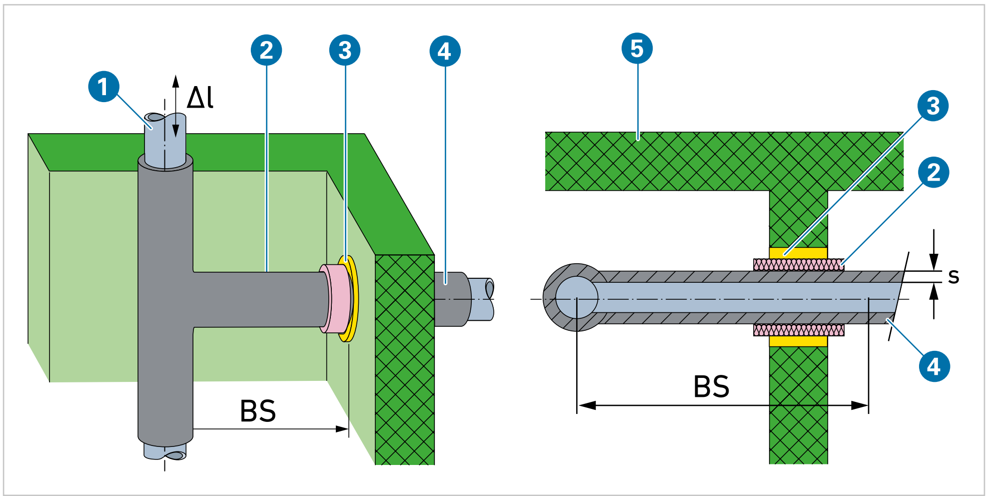
- Δl Thermally induced direction of the pipe's expansion



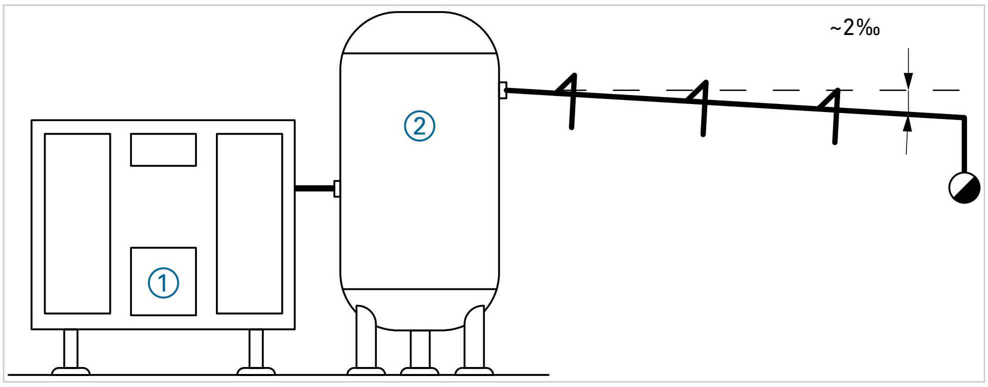
GIV.64
Flexible pipe leg with casing

- 1 Pipe
- 2 Insulation, for elongation
- 3 Casing
- 4 Thermal insulation
- 5 Wall
- BS Flexible pipe leg
- Δl Thermally induced direction of the pipe's expansion

4.5 Special installation cases

4.5.1 Compressed air ductwork without dryers

When installing compressed air ductworks that do not incorporate dryers, the main and distribution pipes must be installed with a gradient of approx. 2 ‰. At the end of the pipeline, a condensate drain must be installed. When installing networks with dry compressed air, the lines can be installed horizontally.



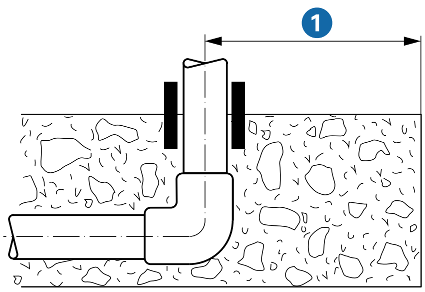
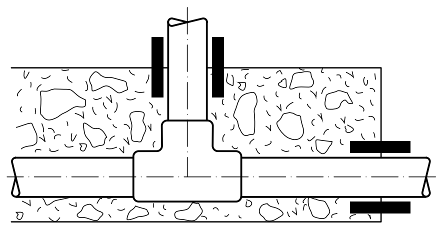
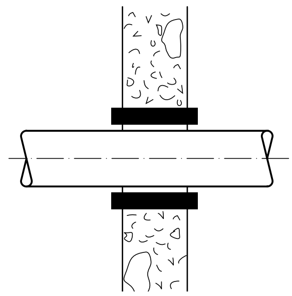
GIV.18
Installation with a gradient of approx. 2‰ and a condensate drain

1. Compressor
2. Pressure vessel

4.5.2 Duct installation

When installing the pipes in **floor ducts** which are closed and filled with concrete, it must be ensured that the pipelines are enclosed in a form-fitting manner. If the pipeline is intended to enter and exit a structure, proper measures must be taken in order to protected the pipes from damage.
If the pipeline must penetrate a **ceiling or wall duct**, a sleeve or insulation material must be used in order to separate the pipe from the surrounding structure. The sleeve must protrude on both sides of the structure.

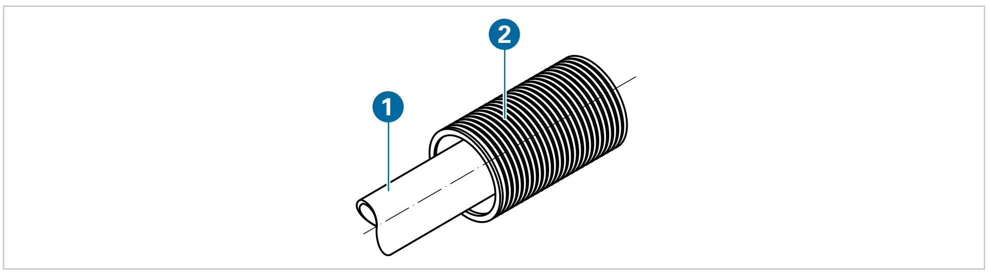
TIV.21 **Duct installation**

Installing in concrete	Protecting the inlet and outlet of the pipelines when installing in concrete	Wall duct with protective jacket
		

1 min. 10–12 cm

4.5.3 Installation in a concealed area

If the installation of the pipelines must be concealed, for example, in laboratories, training and testing rooms, the pipe-in-pipe installation using polybutene (PB) pipes offers another advantage.
Whether the installation is carried out in the wall slot or behind a wall cladding, the protective pipe separates, isolates and protects the medium pipe from the enclosing structure.



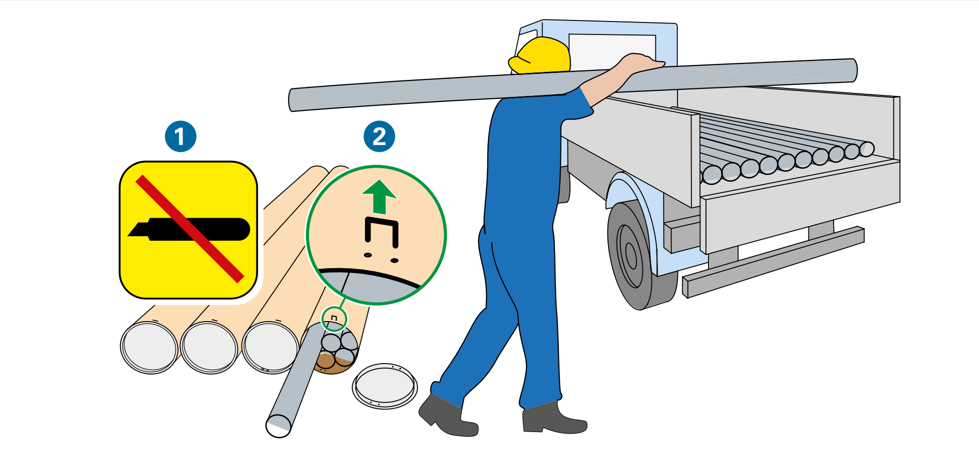
GIV.19
Installation with protective pipe

1. Medium-size pipe
2. Protective pipe

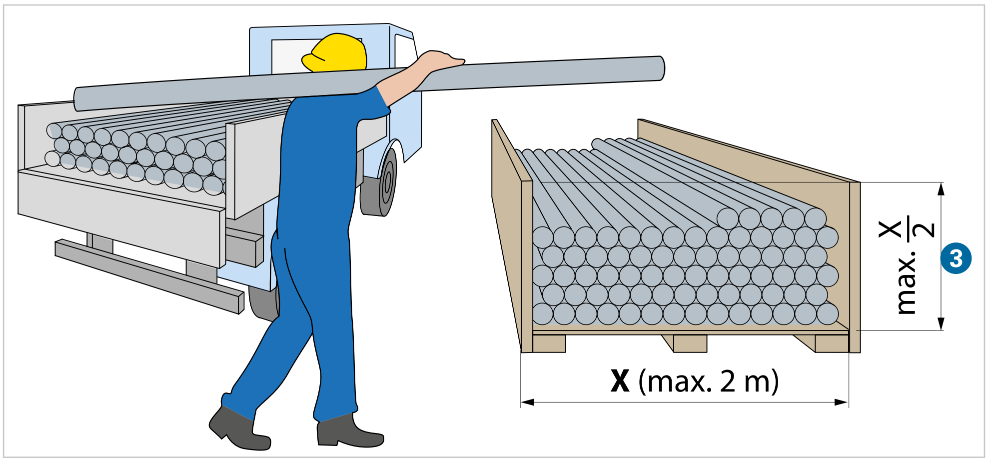
1.5.1 Transport and storage

For hygienic reasons, all openings in pipes, fittings, controls and instruments must be closed until final assembly.

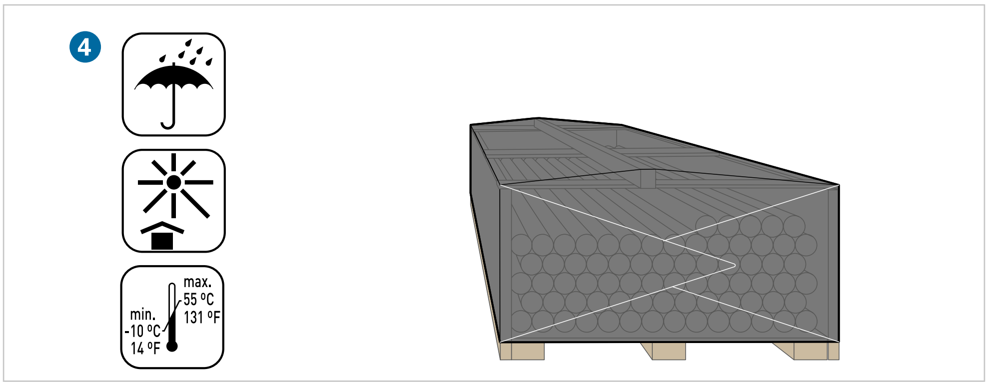
☑ Keep the INSTAFLEX PB pipes and INSTAFLEX fittings in their packaging (sachets or boxes) until they are ready to use.
☑ Ensure to protect the products against external force (shock, impact, vibration, etc.) during transport.
☑ Transport and/or store the products in unopened original packing.



☑ Do not use a knife 1 when opening the tube sleeves.
☑ Ensure to remove all staples 2.



☑ When storing, observe the maximum stacking dimensions 3



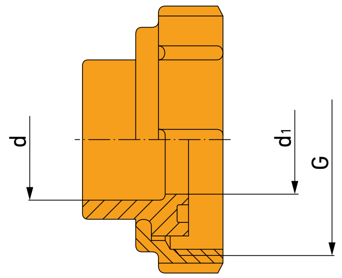
☑ Protect products from dust, dirt, moisture, humidity, rain, rain, sunlight, heat and UV radiation 4 .
- Store only at a temperature range of -10 to 55°C.

☑ Ensure that the products are not damaged by mechanical or thermal influences.
☑ Before proceeding with the assembly, inspect the products for damage that may have occurred during the transport.

Special applications

If special applications are required (see also the applications below), the brass coupling nut with the PB flange adaptor can also be used as a direct connection.

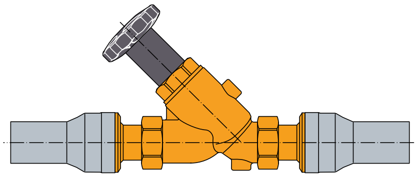
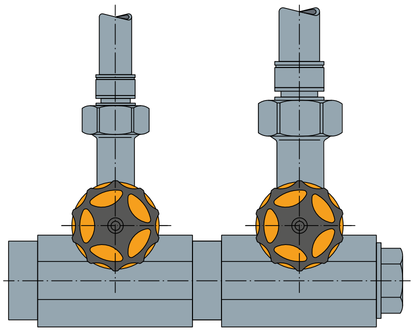
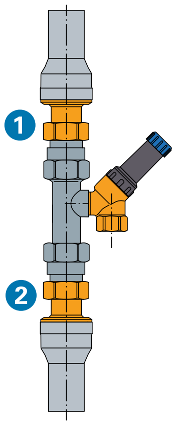
d	16	20	25	32	40	50	63
D	1"	1¼"	1½"	2"	2½"	2¾"	3¼"
d_1	13	16	21	28	36	45	57



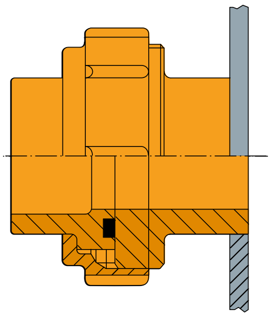
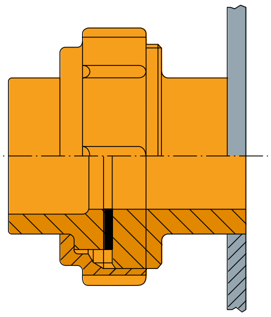
TV.9
Technical data
Brass coupling nut

Applications

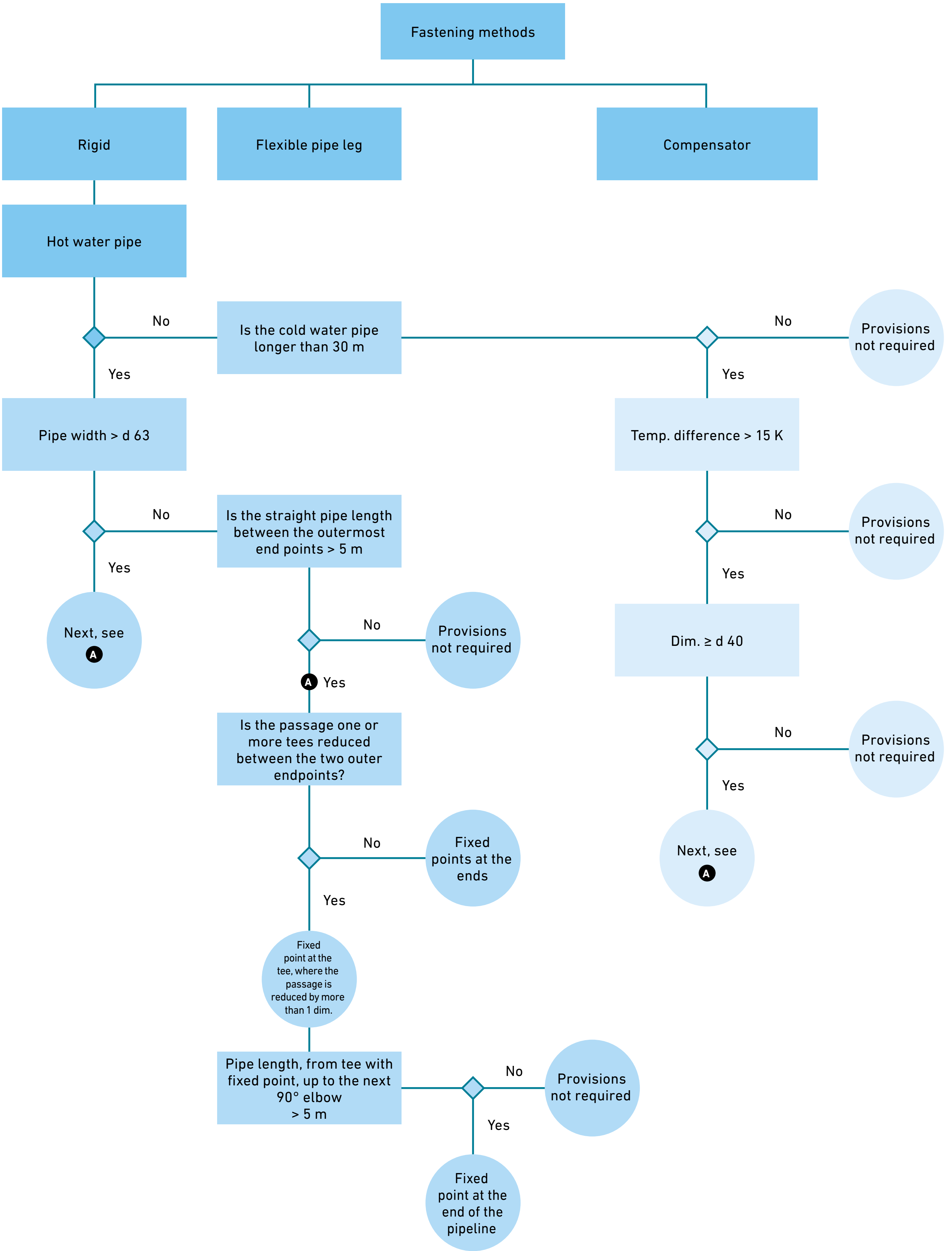
There are various connection options.

How to connect a Y-type valve	How to connect distribution valves	How to connect a safety group
• with two valve adaptor unions	• with valve adaptor union	• with valve adaptor union and adaptor union with $R_p$thread
		
	Changes in diameter can be achieved by adding welded reductions.	Example: 1 d25 – G 11/4" 2 d25 – R_p 3/4"

Direct connections

with coupling nut and flange adaptor with groove and O-ring	with coupling nut and flange adaptor without groove and with flat gasket
	
• for container connections etc. ☑ Ensure the O-ring seal of the flange adaptor seals the entire area.	• for connections to containers and fittings (filter, DRV etc.). ☑ Use only for cold water installations ☑ Use a soft rubber seal ☑ This connection is **not** subject to compliance with the INSTAFLEX system. Therefore, the connection is **not** tested and is **not** permitted.

7.2.1 Procedure on how to determine the fastening type and the fixed point



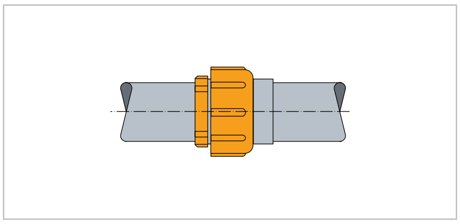
V

Threaded connectors

d16 to d63

These fittings are detachable connections and must not be installed inside the wall.

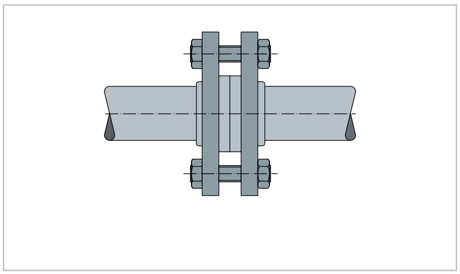
→ Weld the flange adaptors of the threaded connection with the heating element socket weld onto the open pipe ends.



Flange connections

d20 to d110

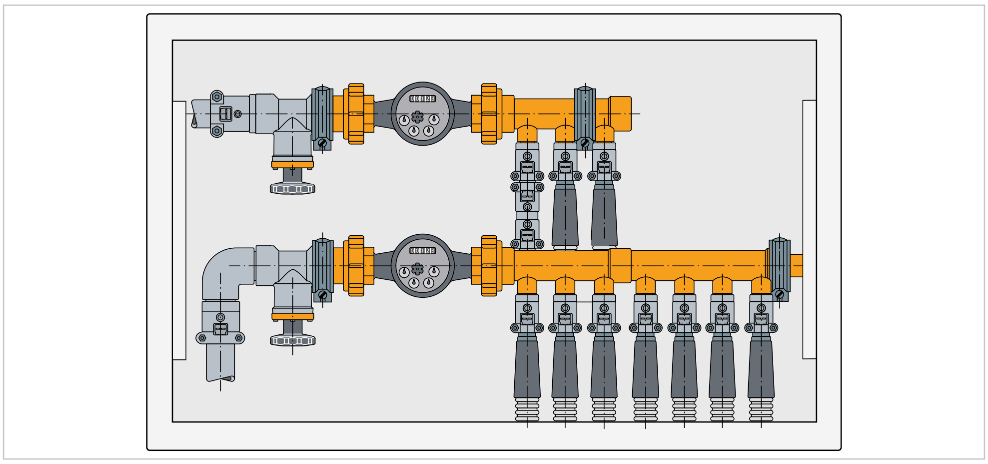
When using a flange connection, the procedure is the same as for a threaded connection.



12.2.2 Replacing pipes inside the distribution box

In order for the corresponding pipeline to be easily recognisable when replacing a pipe:

→ Label the consumer on the protective conduit of the pipeline.
→ Cut off the pipe that must be replaced approx. 5 cm below the distributor outlet.
→ Replace pipe and insert new pipe.
→ Connect the new pipe to the electrofusion socket.



GV.50
Distribution box

5 Thermodynamics

Thermodynamics investigates the behaviour of solids to which heat is added or removed.

5.1 Temperature

The temperature describes a temperature value related to a zero point. This zero point depends on the temperature scale used. Examples are the Kelvin scale, which refers to the lowest possible, the absolute zero, and the Celsius scale, which defines the freezing point of water as the zero point, that is to say 20°C corresponds to 293.15 K.

Size	Designation	Unit of measure	Addition
T	absolute temperature	K	$\{T\} = \{\theta\} + 273{,}15$
θ	Temperature	°C	$\{\theta\} = \{T\} - 273{,}15$

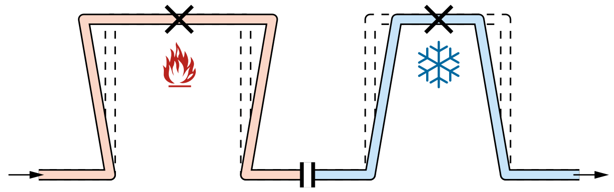
5.2 Expansion of solids

Expansion of solids is calculated according to the following formula:

$$\Delta l = l_1 \cdot \alpha \cdot \Delta T \qquad [\Delta l] = m \cdot \frac{1}{K} \cdot K = m$$

$$l_2 = l_1 \cdot (1 + \alpha \cdot \Delta T) \qquad [l_2] = m$$

Size	Designation	Unit of measure
Δl	Change of length	m
l_1	Initial length	m
l_2	Final length	m
α	Coefficient of linear thermal expansion	K^{-1}
ΔT	Temperature difference	K



GC.11
Length expansion during heating and cooling

TC.20
Coefficient of linear thermal expansion of some solids

Solid	Temperature [°C]	$\alpha \cdot 10^{-5}$ [K^{-1}]
Copper	0 ... 100	16,8
Steel, non-alloy	0 ... 100	11,5
Steel, chromium-nickel-molybdenum	20 ... 100	16,0
Steel, structural steel	0 ... 100	12,0
Reinforced concrete	0 ... 100	14,0
Brass (62% copper)	0 ... 100	18,4
Polyethylene	0 ... 80	150 ... 230
Polyvinyl chloride (PVC hard)	0 ... 100	70,0
Mepla (metal composite pipe)	20 ... 100	26,0