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Criteria for a compressed air line

A compressed air line is an energy line designed to transport compressed atmospheric air with as little loss as possible from the compressor to the point of use.

Physically, atmospheric air is a gas mixture consisting of nitrogen (≈78 %), oxygen (≈21 %) and argon (≈1 %) as well as traces of carbon dioxide and other gases.

Air quality

The quality of the air is defined in the **Pneurop 6611** quality guideline first published in 1984.

The pipework must convey the compressed air from the compressor to the point of use with as little reduction as possible in:

- **the air quality,**
- **the air quantity, and**
- **the operating pressure.**

Excessive quality demands will increase the cost of the compressed air. The air quality requirements are the basis for determining the type of air treatment and the pipework material of the distribution system.

Class	Max. particle size	Max. particle density	Pressure dew point Dew point	Max. oil content
	e	mg/m³	⁰C*	mg/m³
1	0.1	0.1	-40	0.01
2	1	1	-20	0.1
3	5	5	2	1.0
4	40	Not specified	10	5.0
5	Not specified			25.0

* Max. value

The pressure dew point indicates the highest permissible water content of the air.

-40 ⁰C ≙ 0.117 g/m³
-20 ⁰C ≙ 0.88 g/m³
2 ⁰C ≙ 5.57 g/m³
10 ⁰C ≙ 9.36 g/m³

The compressed air quality requirements will depend on the type of application. This quality must be supplied by the unit producing the compressed air and should not be impaired by the distribution network.

Class 1: e.g., photographic industry
Class 2: e.g., aerospace industry
Class 3: e.g., packaging industry
Class 4: e.g., general industrial pur-

Polybutene (PB), as a material for moulding pipes and fittings (couplings, tees, elbows), complies with the KTW recommendations for plastics and drinking water issued by Germany's Federal Health Office. It is also tested in accordance with the rules of the German Association for Gas and Water (DVGW), work sheet W 270.

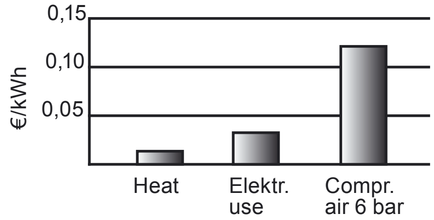
Air quantity

The actual air quantity required will depend on the points of use to be supplied.

Compressed air should flow without loss from the compressor to the point of use. This means that the compressed air network has to be leakproof in order to avoid waste and unnecessary operating costs.

The loss of air – i.e., of energy – through leaks in the distribution network or equipment results in a completely unnecessary increase in the operating costs.

Compressed air is an expensive form of energy.



In neglected compressed air systems, the leakage volume is attributable to ≈30 % to the distribution network and ≈70 % to hoses and tools.

Hole diameter		Air loss in l/s at		Power in kWh required for air compression		Costs for 8000 Bh/a at € 0.10 kWh	
Ø	mm	6 bar	12 bar	6 bar	12 bar	6 bar	12 bar
	1	1.2	1.8	0.3	1.0	245,-	818,-
	3	11.1	20.8	3.1	12.7	2 536,-	10 389,-
	5	30.9	58.5	8.3	33.7	6 790,-	27 569,-
	10	123.8	235.2	33.0	132.0	26 996,-	113 098,-

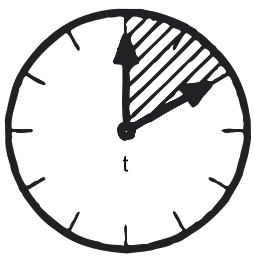
Compressing 1 m³ of air to 6 bar requires 0.075 kWh.

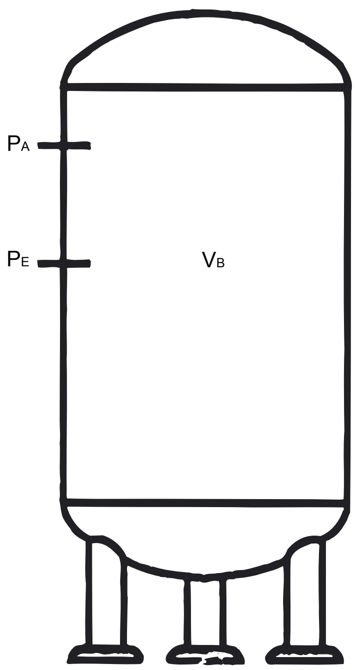
The easiest measurement of leakage loss is carried out by emptying the receiver.

$$\dot{V}_L = \frac{V_B \times (p_A - p_E)}{t}$$

$\dot{V}_L$ = Leakage volume
V_B = Receiver volume
p_A = Initial pressure
p_E = Final pressure
t = Measurement time

$$\dot{V}_L = \frac{500\ l \times (9\ bar - 7\ bar)}{3\ minutes} = \mathbf{333\ l/min}$$





Operating pressure

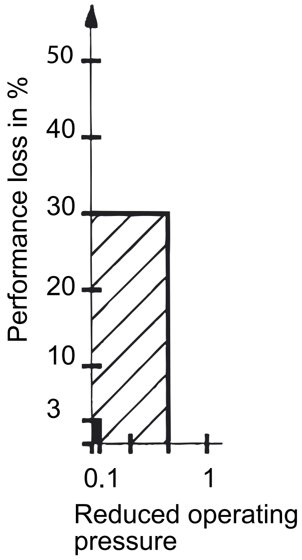
Every compressed air application (machine or tool) requires a specific operating pressure, in addition to the relevant air quality and volume.

If the operating pressure is too low – for instance, 5 bar instead of 6 bar – the performance of the machine or tool will be reduced by some 30 %. An increase in the compression by 1 bar will result in additional costs of around 10 %.

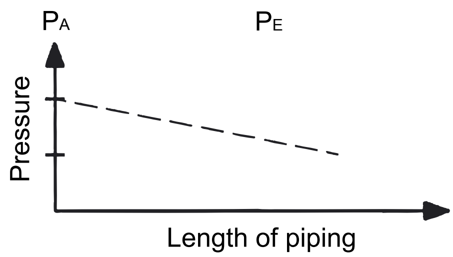
A significant drop in pressure from the compressor to the point of use can be caused if the pipe cross-sections are too small or if the pipe system contains local constrictions.

The pressure loss from the compressor (receiver) to the point of use should not exceed 0.1 bar.

When air flows through a pipe, there is always a certain resistance. The degree of resistance will depend on the surface roughness of the inner walls, the length of the piping, and the flow velocity.



$$\Delta p_{network} \leq 0.1 \text{ bar}$$



Pressure loss

The economic performance of the compressed air system is of great importance for the plant operator.

Increased flow resistance because of dimensioning errors (e.g., pipe diameter too small) or because of misguided saving on investment costs will result in a corresponding loss of pressure and thus push up the energy costs for the compressed air supply.

The following example shows the higher costs for the extra energy required to compensate for the loss of pressure.

Operating pressure	6 bar
Pipe network length	200 m
Flow rate	12 m^3/min

DN_R	Pressure drop Δp (bar)	Energy costs €
90	**0.04**	**153,-/a**
70	0.2	614,-/a
50	0.86	3 344,-/a

It is therefore easy to calculate how long it would take to recoup the slightly higher expenditure for the larger dia. piping set against the increased energy costs of the small dia. piping.

Savings achieved during the initial acquisition are soon swallowed up by the high follow-up costs.

Leakage loss

It is important to know how much of the compressed air is being lost during its passage from the compressor to the point of use and where it escapes.

Leaks should be located using the BEKO leak detector.

The leakage volume is usually determined by emptying the receiver or measuring the compressor's running time. (s. page 4, Air quantity)

Emptying of the receiver:
The receiver (V_B) is filled to a given pressure p_A. Subsequently, it is measured how much time t it takes before the receiver pressure comes down to pressure p_E.

Example

V_B	=	1000 l
p_A	=	8 bar
p_E	=	6 bar
t	=	5 min
V_L	=	l/min

V_L = Leakage volume

$$\mathbf{V_L = \frac{V_B \times (p_A - p_E)}{t}}$$

$$V_L = \frac{1\,000\ \text{l} \times (8 - 6)}{5\ \text{min}} = \mathbf{400\ l/min}$$

Make sure that the shut-off devices at the end of the connecting pipes are closed so that the measurement is restricted to leakages in the pipe network.

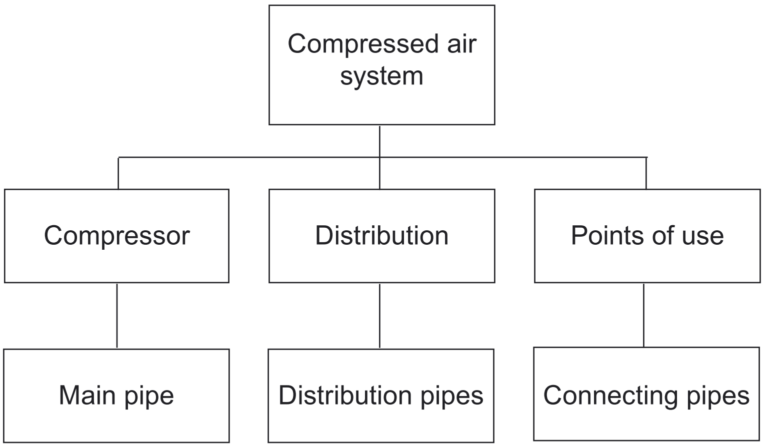
Configuration of a compressed air system

Compressed air systems consist of three main elements:

- **generation**
- **distribution, and**
- **consumption (points of use).**

The distribution system is divided into:

- **the main pipe,**
- **distribution pipes, and**
- **connecting pipes.**



Compressor

A number of manufacturers today offer modern compressor stations as comprehensive solutions tailored to the customer's specific requirements. This includes ensuring the necessary air quality as well as regulating the amount of compressed air, the time when it is supplied, and the desired operating pressure.

Compressed air generation is divided into:

- **air compression,**
- **treatment, and**
- **storage.**

During the first stage, the air is compressed by compressors belonging either to the group of positive displacement compressors or dynamic compressors. Positive displacement compressors comprise rotary compressors and piston compressors. Dynamic compressors convert motion, i.e., kinetic energy into pressure energy (aircraft engine).

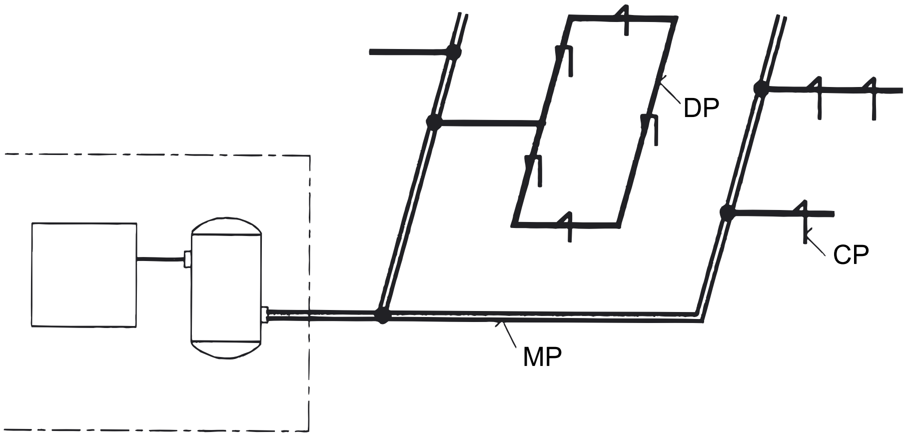
Distribution

The compressed air distribution network is divided into:

- **the main pipe (MP)**
- **distribution pipes (DP), and**
- **connecting pipes (CP)**

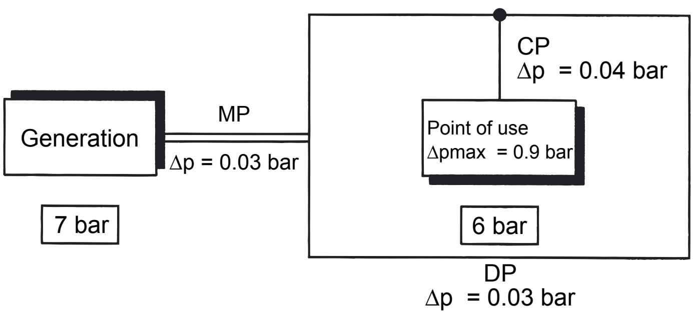
It is advisable to organize the pipe network according to function and use.

The pipe joints should be continuity bonded in order to prevent leaks in the distribution system. Flange joints and screwed connections should preferably be avoided. Clamped connections for plastic pipes should be pressure- and vacuum-tight and designed to function without elastomer seals.



$\Delta p_{network} \leq$ 0.1 bar

The pressure loss from the receiver to the point of use should not exceed 0.1 bar.



$\Delta p_{total} \leq$ 0,1 bar

With an optimum layout of the pipe network, the pressure loss is assumed to be:

0.03 bar for the main pipe (MP)
0.03 bar for the distribution pipes (DP)
0.04 bar for the connecting pipes (CP)

The total pressure loss of the system – including filters, separators, dryer, maintenance units and connecting hoses – should not exceed

1.0 bar.

To realize an operating pressure of 6 bar at the point of use, it will therefore be necessary to produce a pressure of 7 bar at the compressor station

Main pipe (MP)
The main pipe joins the compressor station to the distribution network. It should be dimensioned with adequate capacity for future expansion.

The pressure loss in the main pipe should not exceed

$\Delta p_{MP} \leq 0.03$ bar.

Distribution pipes (DP)
The distribution pipes distribute the compressed air within a point-of-use section. They can be arranged in the form of feeder branches, a ring line or a ring line with integrated feeder branches.

In production halls where the compressed air does not have to meet any special requirements, it is usual to install a ring line system. The installation of small ring lines to supply specific machines or plant groups is generally an advantage. Where this is not possible, i.e., where a large ring line has to be installed, it is advisable to combine this line with feeder branches. The provision of shutoff valves at strategic points makes it possible to close down individual pipework sections in order to carry out maintenance work or fit an extension.

Individual feeder branches may be installed for conveying compressed air of a specified standard to machine groups or other production equipment. This applies particularly to production processes and plant (assembly lines) where the production layout is frequently changed resulting in changes in the infrastructure.

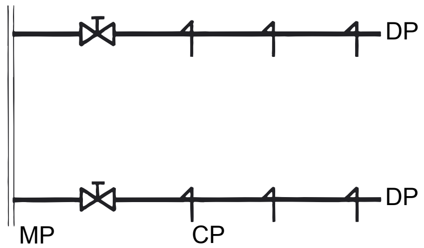
The pressure loss in the distribution pipes should not exceed

$\Delta \leq 0.03$ bar.

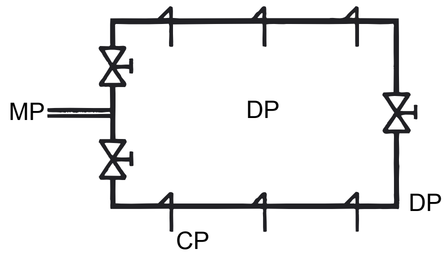
Nominal diameter (DN) of main pipe (MP) or distribution pipes (DP) with a length up to 100 m and an operating pressure of 6 bar.

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
53/3.2	50	63
30/1.8	40	50
15/0.9	32	40
10/0.6	25	32

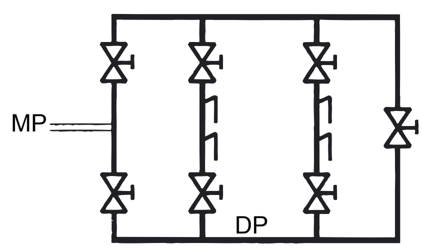
Feeder branch



Ring line



Ring line with feeder branches



Connecting pipes (CP)
The connecting pipe runs from the distribution pipe to the machine or compressed-air supply point. The way in which the connecting pipe is joined to the distribution pipe will depend on the actual air quality. If the air is not dried, the connecting pipe should be led to the top of the distribution line in order to keep out condensate.

If the air is dried, the connecting pipe can lead directly downwards.

Connecting pipes should always be fitted with a shutoff valve at the end. With an individual connecting pipe, the shutoff valve can be integrated into the downstream outlet connector. In the case of group connections via a manifold, it is recommended to install a separate shutoff valve at this point.

When a machine or production tool is connected directly to the distribution pipe, it is recommended to install an electrically operated shutoff valve. This will shut off the air supply when the machine is switched off. In this manner, the loss of compressed air through leaks in the machine can be avoided.

The pressure loss in the connecting pipes (CP) should not exceed

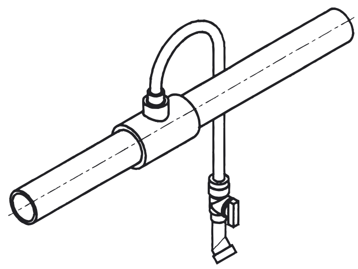
$$\Delta p \leq 0.04 \text{ bar}.$$

Q l/s, m³/min	DN mm	PB d
0.42/0.25	**12**	**16**
9.2/0.55	**15**	**20**
L = 10 m/p = 6 bar		

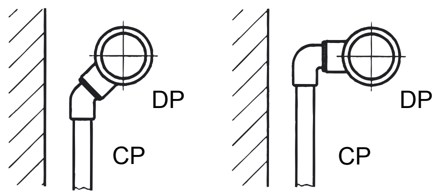
Nominal diameter (DN) of connecting pipes (CP) with a length of 10 m and an operating pressure of 6 bar.

Q l/s, m³/min	DN mm	PB d
16.6/1	**20**	**25**
33.3/2	**25**	**32**
L = 10 m/p = 6 bar		

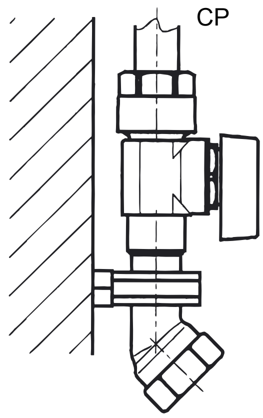
Arrangement of connecting pipe when the air is not dried



Arrangement of CP when the air is dry



Individual connecting pipe with integrated shutoff valve



Manifold for group connection

Selection of material and pipe system

Compressed air lines need to be **tight, maintenance-free** and **adequately dimensioned**.

The materials for compressed air pipes can be divided into the two major groups:

- **metals and**
- **plastics**.

The group of metals includes:

- steel
- copper
- stainless steel
- aluminium

and the group of plastics comprises, for example:

- **polybutene (PB)**
- polyethylene (PE)
- polypropylene (PP)
- acrylonitrile-butadiene styrene (ABS)

Nowadays plastic piping is becoming much more widely established, partly because of the growing compressed-air quality requirements with respect to cleanliness, and partly because these pipe systems are easier to install and maintain.

There is no material that is ideal under all circumstances for all compressed air lines. The right material is always determined by the requirements of the specific application.

Important selection criteria are:

- **Place of application**
- **Pressure/temperature limits**
- **Service life**
- **Safety**
- **Pipe jointing system**
- **Pipe-laying system**
- **Dimensioning**
- **Product range**

Generally, the compressed air facility should have the same pipe system throughout.

Selection criteria

Place of application
The majority of compressed air networks, more than 80 %, are found in workshops and production halls or inside other buildings. One can therefore assume an ambient temperature of 15 to 25 °C. However, it should be borne in mind that workshops with glass shed roofs exposed to the sun may have temperatures of 50 °C or more.

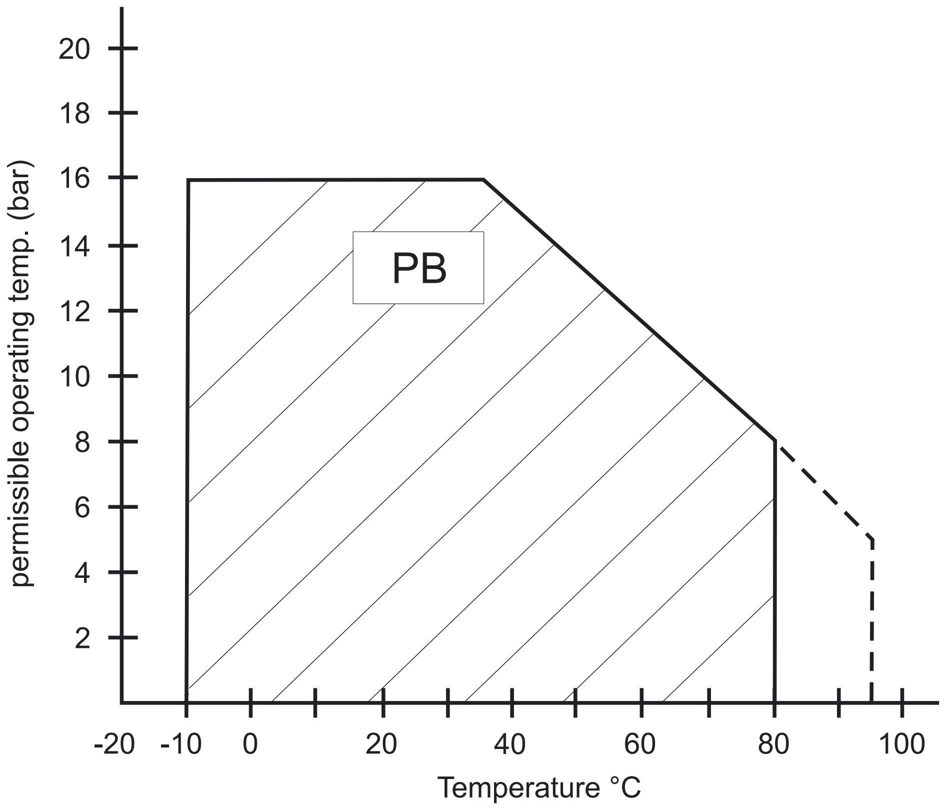
In view of its excellent suitability, the specialists at BEKO TECHNOLOGIES recommend polybutene (PB) as a material for compressed air pipes.

BEKOFLOW® - the flexible pipe system for compressed air distribution.

Pressure/temperature limits and service life of polybutene pipes

The following diagram shows the application limits of the material recommended by us.

The **service life** of the PB systems was calculated to be **25 years**, including a **safety factor** of **1.6**.



The application limits were determined on the basis of the corresponding endurance diagrams for the different pipe materials.

Polybutene (PB) was assessed according to **pipe series S5** conforming to **DIN 16968/16969**. This results in the following pipe dimensions:

d 16 x 2.2	d 50 x 4.6
d 20 x 2.8	d 63 x 5.8
d 25 x 2.3	d 75 x 6.8
d 32 x 2.9	d 90 x 8.2
d 40 x 3.7	d 110 x 10.0

For further calculations of the effective safety factor in relation to the actual operating pressure see page 14.

Calculation of effective safety factor and permissible operating pressure

For calculating the **safety factor (SF)** and the **operating pressure (p)**, it is first necessary to know the endurance strength of the material.

The endurance diagram for polybutene is set out on page 15.

This diagram shows the relevant endurance strength value (comparative stress) as a function of the desired service life and the maximum operating temperature. The calculation must also take the pipe dimensions into account.

The required safety factor SF for pipes made of polybutene is

SF = 1.5

The effective safety factor should be calculated using the following formula:

$$SF_e = \frac{\delta_B \times 20 \times s}{p \times (d-s)}$$

Example:

Service life	50 years
Temperature	70 °C
Operating pressure	6 bar
Material	PB
Pipe d x s	32 x 3.0
δ_B from the endurance diagram	7.5 N/mm^2

$$SF_e = \frac{7.5 \times 20 \times 3}{6 \times (32-3)} = 2.6$$

This example results in a safety factor of 2.6.

The maximum permissible operating pressure is calculated analogously by adapting the safety factor formula.

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

Example:

Service life	50 years
Temperature	70 °C
Operating pressure	10 bar
Material	PB
Pipe d x s	32 x 3.0
δ_B from the endurance diagram	7.5 N/mm^2

$$p = \frac{20 \times 3 \times 7.5}{(32-3) \times 1.5} = 10 \text{ bar}$$

SF = required safety factor
δ_B = comparative stress
p = operating pressure in bar
d = outside pipe diameter
s = pipe wall thickness

Determination of pipe wall thickness and pressure class

s = pipe wall thickness
p = operating pressure at 20 °C
δ_B = comparative stress
SF = safety factor

The dimensioning of polybutene pipes under internal pressure is carried out strictly on the basis of the strength requirements using the compressed-air receiver formula:

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

The above formula is used for all the pipe dimensions laid down in the standards.

In order to be able to select pipes, fittings and valves according to uniform criteria, they are divided into standardized pressure classes. A common method applied worldwide is the classification on the basis of **nominal pressure (PN)**.

Here, the nominal pressure (PN) indicates the permissible operating pressure at 20 °C.

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

Therefore, the nominal pressure class is not the decisive criterion. What really counts are the demands on the material at an operating pressure of 10 bar and a temperature of 70 °C, assuming a 50-year service life and including a safety factor of 1.5.

Keydata of BEKOFLOW® PB pipes

BEKOFLOW® PB pipes are manufactured to DIN 16968 und 16969.

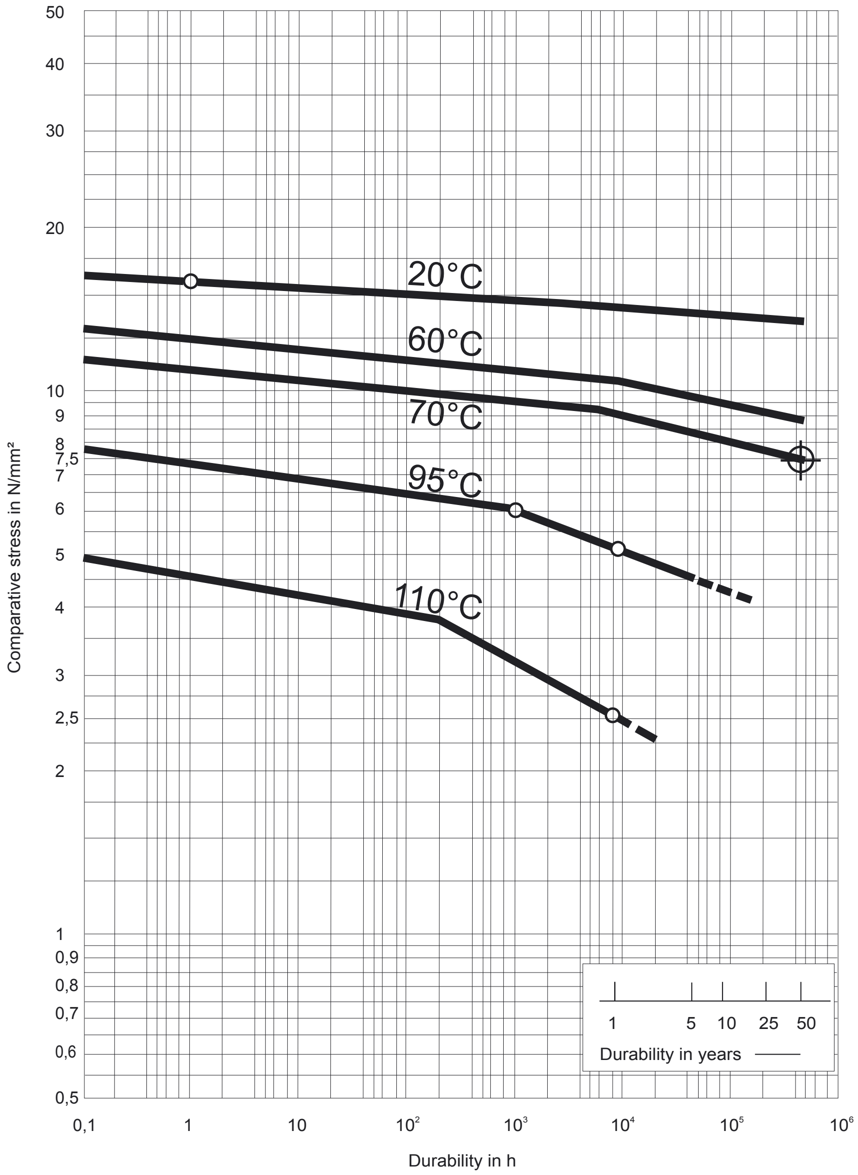
Inch	Nominal dia. DN	Outside pipe dia. d	Pipe wall thickness s	Inside pipe dia. d_i	Weight per m pipe kg	Water volume per m pipe l
⅜	12	16	2.2	11.6	0.088	0.10
½	15	20	2.8	14.4	0.141	0.16
¾	20	25	2.3	20.4	0.152	0.33
1	25	32	2.9	26.2	0.254	0.53
1¼	32	40	3.7	32.6	0.392	0.83
1½	40	50	4.6	40.8	0.610	1.31
2	50	63	5.8	51.4	0.969	2.07
2½	65	75	6.8	61.4	1.354	2.96
3	80	90	8.2	73.6	1.960	4.25
4	100	110	10.0	90.0	2.920	6.36

Measurements in mm

Pipe roughness factor k = 0.007

For PB according to DIN 1988

Endurance diagram of PB 4137 (see also DIN 16968/16969)



The comparative stress indicates fracture stress δ_B.

In other words, it shows the maximum load for the material in dependence on the temperature and service life.

Curves without safety factor.

The endurance diagram shows the interaction of

- temperature — t = ^{0}C
- service life (durability)
- comparative stress — δ = N/mm² or MPa (megapascal)

Example:

Temperature	= 70 ^{0}C
Service life (durability)	= 50 years
Comparative stress δ_B	= 7.5 N/mm²

Safety

The term “safety” covers a number of different aspects, such as:

- **fracture behaviour**
- **resistance** against UV radiation and compressor oils
- **corrosion**
- **behaviour in fire**

Since compressed air, contrary to water, is compressible (“squeezed” into a smaller space), mechanical damage to one of the pipes may result in an explosion-like expansion. It is therefore of vital importance that any mechanically damaged pipes cannot become a danger to the surroundings. For today’s compressed air applications, one should only use plastic pipes with **ductile fracture behaviour**, even below freezing point.

Ductile fracture behaviour means that **splinter formation will not occur** in the event of forceful damage to the pipe causing an explosion-type expansion.

For polybutene (PB), the limit temperature of the ductile behaviour is ≤ -5 ^{0}C.

Any compressed air network will inevitably contain traces of compressor oil and condensate. In order to ensure a long service life and maintain reliable operation of the compressed air system, the pipe material must be highly resistant against these substances.

Oil resistance of polybutene (PB)
Mineral oils, ester-containing oils and oils with aromatic amines can have a negative impact on the service life of pipe systems.

BEKOFLOW® is resistant against all the usual compressor oils. We will be happy to advise if you have any questions in this respect.

Corrosion behaviour
The material polybutene (PB) has the advantage that it is resistant against corrosion both from the inside and the outside. In the case of steel piping, moist and corrosive atmospheres always result in corrosion from the outside, while residual humidity in the compressed air produces corrosion from the inside.

Plastic pipe systems made of **PB** are **non-corrodible**; the quality of the compressed air flowing through the pipes is not affected.

Behaviour in fire
PB is a plastic material of fire class B2 conforming to DIN 41012 (normally flammable).

In an open fire PB burns with a bright flame. The fire gases smell of wax and paraffin. Toxic or corrosive combustion products – as occur with PVC or PVC-C – are not possible with polyolefins like PB because this material does not contain halogens (chlorine).

Where fire protection measures are required for pipes passing through a wall or ceiling, only use fireproofing arrangements with corresponding approval.

Safety

Equipotential bonding
According to German standard VDE 0190, equipotential bonding is required between all types of protective conductor (PE) and existing “conductive” pipes.

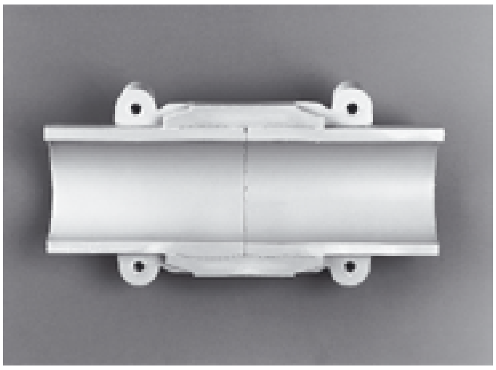
However, BEKOFLOW pipes are not electroconductive and can therefore not be used for equipotential bonding as stated in DIN VDE 0100.

Jointing system

Compressed air networks have to be tight to avoid loss of compressed air and unnecessarily high operating costs.

Leaks in the pipe network will mainly be found at the various joints.

Pipes and fittings (couplings, etc.) should be continuity bonded. By continuity bonding one understands direct homogeneous bonding between the pipe and the connection element without the use of any additional substances such as adhesives. A continuity-bonded connection can only be undone by complete destruction.



Resistance welding for PB joints

Vibrations
Vibrations are the root cause of most irregularities in compressed air networks. Therefore, it makes sense to use a pipe system that prevents the propagation of vibrations. Contrary to metal pipes, BEKOFLOW® pipes are flexible and can be used to provide a vibrationless pipe system.

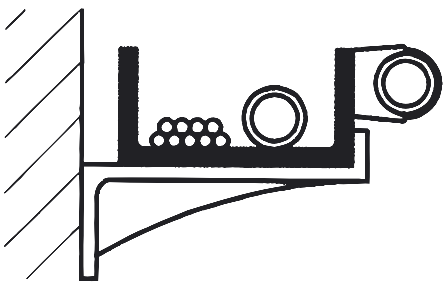
Pipe laying system

Pipe laying is dealt with here under the aspect of “material selection”.

The BEKOFLOW® pipes recommended by us are **more than 80 % lighter** than steel pipes manufactured to DIN 2440. In view of the flexibility of these pipes and their low weight, the scope for pipe installation is greatly increased.

Efficient preparation as well as simple and fast installation are decisive for **keeping the installation costs** as **low** as possible.

Because of their low weight, BEKOFLOW® pipes and fittings can be laid in or fixed along existing **cable ducts**.



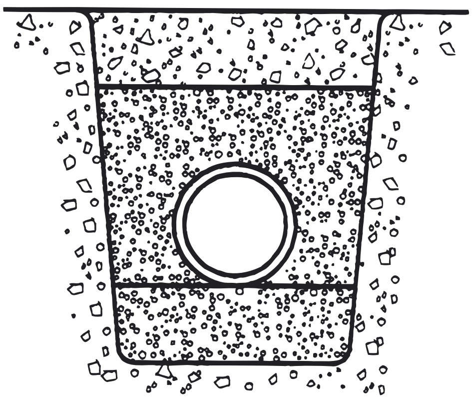
Depending on the pipe dimensions, the compressed air lines can be mounted using either **pipe clips** or **cable binders**.

Since plastics are not electroconductive, pipe installation in the cable duct is a particularly convenient option.

k = pipe roughness factor

In the case of installation in a hazardous area with a potentially explosive atmosphere it should be taken into account that a static discharge can occur with plastic pipes in certain conditions of humidity. For this type of installation, it is mandatory to observe the relevant regulations.

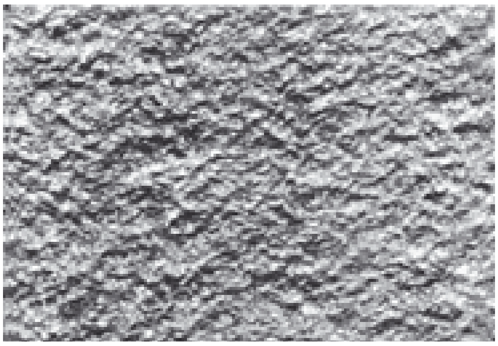
Plastic pipes are well suited to underground installation, particularly because they do not require special corrosion protection. Follow the corresponding guidelines (sand bed, etc.) for underground pipe installation.



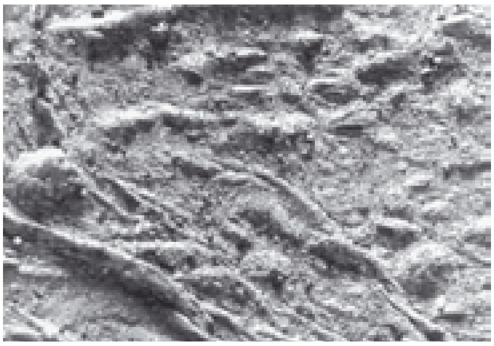
Dimensioning

A compressed air line is an energy line and should therefore be carefully dimensioned.

Plastic pipes made of polybutene (PB) are able to transport compressed air more economically than steel pipes. The smooth surface of PB pipes – k = 0.007 as against steel pipes with k = 0.15 – enables a higher air throughput for the same inside pipe diameter and the same pressure.



Surface of a plastic pipe



Surface of a steel pipe

Product range

The **BEKOFLOW® polybutene (PB) pipe system** is distinguished by a broad range of pipes from d 16 to d 110, coiled or in straight lengths, including fittings and outlet connectors.

Installation of the BEKOFLOW® system is greatly facilitated by the **resistance weld fittings** (couplings, elbows, tees, etc.) with their product-coded **plug-in connections** and the uncomplicated welding tool.

Resistance welding method
During resistance welding, the pipe and overlapping fitting are welded together without the use of any additional substances. The heat required for welding is generated through resistance wires embedded in the fitting.

A controlled supply of electrical energy is provided by the **HWSG-3** welding tool. The welding pressure required for the welding process is achieved through appropriate dimensioning of the BEKOFLOW® resistance weld fittings in relation to the BEKOFLOW® pipes.

General requirements
BEKOFLOW® resistance weld fittings made of polybutene (PB) are suitable for operating pressures up to 16 bar at 20 °C (PN 16) and 10 bar at 70 °C.

The installation of the BEKOFLOW® system offers a number of advantages:

- no preparation of pipe ends
- no moving out of alignment of pipes during installation
- no holding devices required
- simple, functionally and operationally safe cable binding
- well visible marking and welding indicator.

For fixing the screws during pipe assembly, the following torques have to be observed:

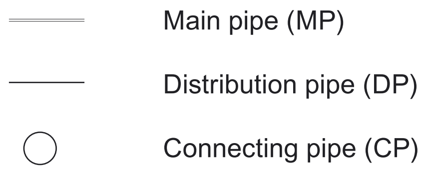
d16 and d20	1 Nm
d25 to d40	1.5 Nm
d50 and d63	1.5 to 2 Nm
d75 to d110	2.5 to 3 Nm

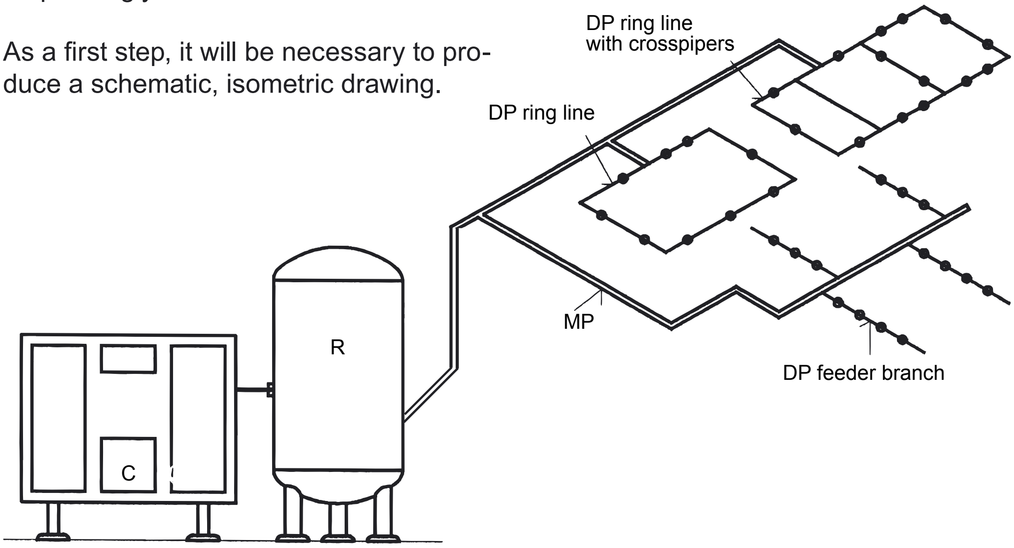
These values relate to a temperature of approx. 23 °C.

Pipework design and installation

For preparing a good design, it is important to be well informed about the actual conditions at the relevant plant. Combining different energy lines in or on the same carrier elements saves both installation time and costs. Since plastic piping is approximately 80 % lighter than metal piping, the installation expenditure is correspondingly reduced.

As a first step, it will be necessary to produce a schematic, isometric drawing.





The pipework layout must also examine if the pipe routes are located close to other operational areas – such as vehicle passages or the movement range of suspended loads – and ensure proper protection against mechanical damage, sudden shocks or impact loads.

Furthermore, it should be taken into account that plastic pipes react to temperature changes by expanding or shrinking. In the case of compressed air lines, such temperature changes are normally due to the ambient temperature.

Polybutene (PB) pipes can generally be laid according to two different installation methods.

I Bending or expansion section in stallation
This makes allowance for thermally induced changes in length.

II Rigid installation
Here, thermally induced changes in length must be taken up by the pipes.

The design should treat the main pipe, the distribution pipes, and the connecting pipes separately.

Main pipe

For the main pipe (MP) we recommend rigid installation up to d 63. As from size d 75, bending or expansion sections are appropriate.

Fixing points should be preferably be located at the outgoing T-piece to the distribution pipe.

There should always be a shutoff valve installed at the MP outlet and at the branching points. This allows shutting off individual network sections without affecting the entire compressed air supply.

Calculation of the bending section:

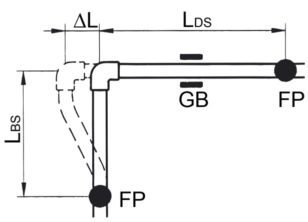
$$L_{BS} = C \times \sqrt{\Delta L \times d}$$

C for PB = 10

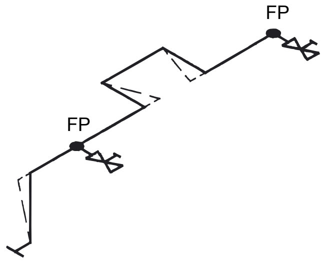
$$\Delta L = L_{DS} \times \alpha \times \Delta \upsilon$$

α for PB = 0.130 mm/mK

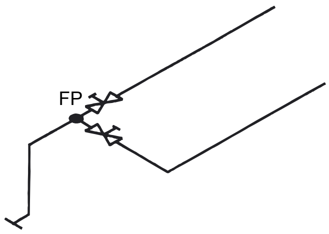
Change of direction



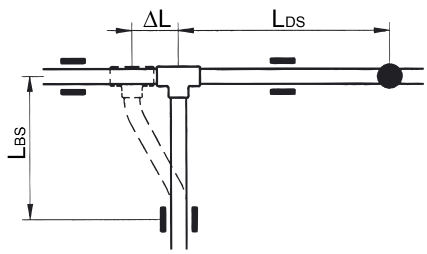
MP outlets to distribution pipe



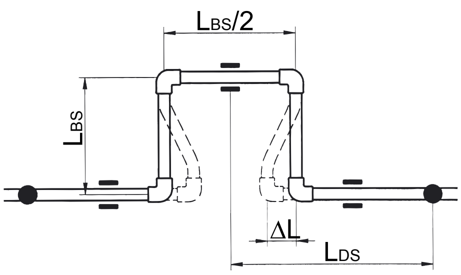
MP branching point



Branch pipe



Expansion bend



FP
•
Fixing point

GB
=
Sliding support

ΔL
Change in length

L_{DS}
Expansion section length

L_{BS}
Bending section length

α
Thermal expansion coefficient

d
Outside pipe diameter

C
Material factor

$\Delta \upsilon$
Temperature difference

Example of a bending section calculation:

LDS = 20 m
$\Delta\upsilon$ = 20 k
Pipe = DN 32

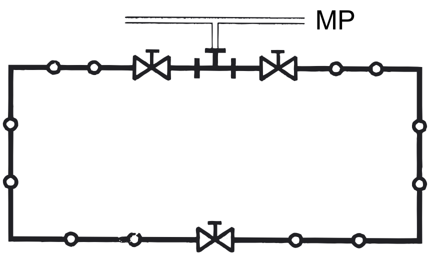
$$L_{BS} = C \times \sqrt{L_{DS} \times \alpha \times \Delta\upsilon \times d}$$

L_{BS} for PB = 32 cm

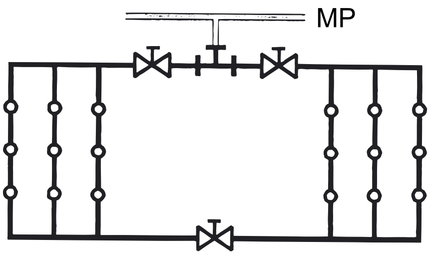
Distribution pipes

For the installation of distribution pipes there is a choice of three basic layouts.

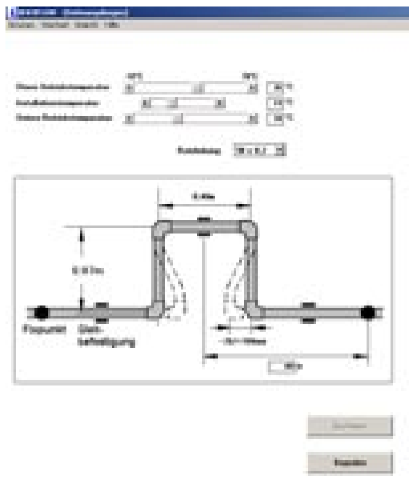
Ring line system



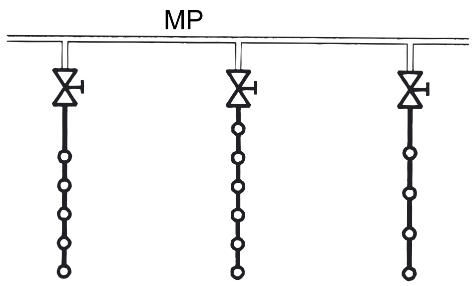
Ring line with cross pipes



Easy calculation using the BEKO dimensioning program.



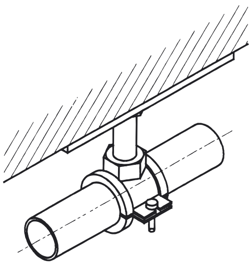
Feeder branches



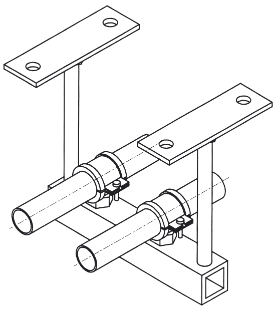
“Strategic” positioning of the shutoff valves makes it possible to close down individual zones of the distribution line without interrupting the compressed air supply elsewhere.

The distribution lines should preferably share a carrier system together with other energy lines. Laying the distribution lines in or on the ducts of electric cables is the easiest and most convenient method. There will be no interference with the cables because plastics are not conductive.

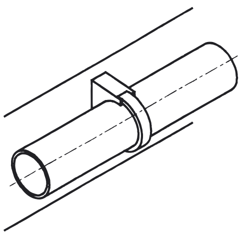
Normal mounting on ceilings, walls or other carriers using pipe clamps



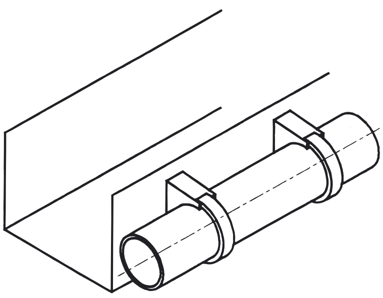
Mounting on/along pipework routes using pipe clamps



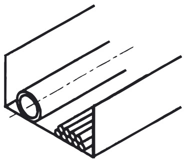
Mounting system using pipe clips



Mounting on a cable duct using pipe clips



Installation in a cable duct



Inside the cable duct, the pipe can be fixed with cable binders.

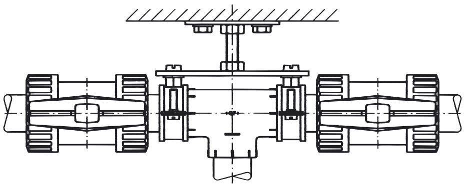
Rigid or flexible pipe installation

Depending on the type of installation – rigid or flexible – the correct arrangement of fixing points is very important.

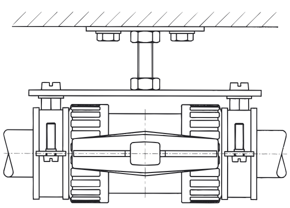
For **feeder branches**, fixing points (FP) should be arranged according to the local conditions.

In the case of **ring lines**, the fixing points (FP) should be located at the ring inlet, in the area of shutoff valves and, where appropriate, at the junctions of the cross pipes.

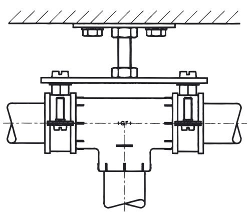
FP at the ring inlet



FP at shutoff valve



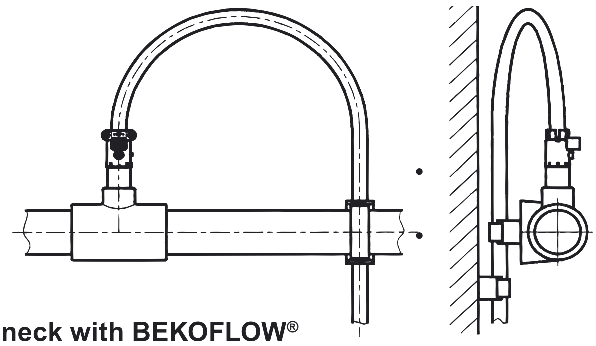
FP at T-piece



Caution:
Any heavy valves or other devices incorporated into the line must be fixed separately.

Connecting pipes

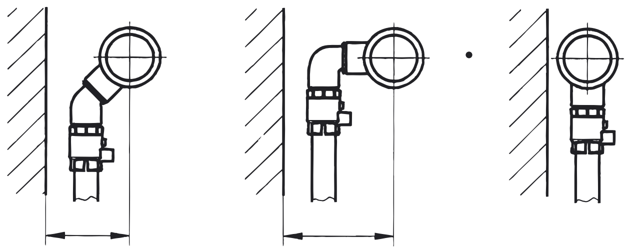
In the case of moist compressed air, the connecting pipes (CP) should be joined to the top of the distribution line (DP).



T-piece with HWS outlet
PB pipe 16x2.2 or 20x2.8 can be bent to swan-neck shape
Bending radius min 8xd

Swan neck with BEKOFLOW® pipes
Dimensions d 16, d 20 and d 25

In the case of dry compressed air, the connecting pipes (CP) can be joined to the distribution line (DP) in any order.

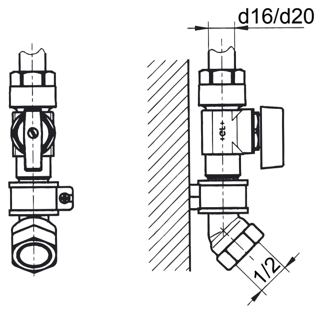


For joining the connecting pipe to the distribution pipe, it is recommended to fit an appropriate resistance weld fitting at the transition point. This will speed up and simplify the installation.

Joining of CP with d 16 or larger

The connection to the machine or device at the end of the connecting pipe can be in the form of a single or multiple system.

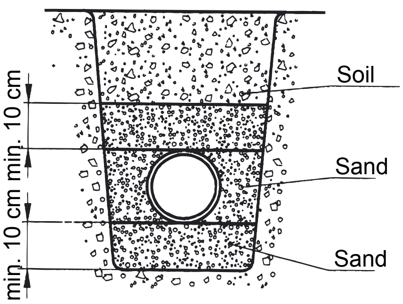
End connections should always be provided with a shutoff valve. Multiple system see p. 10 (manifold).



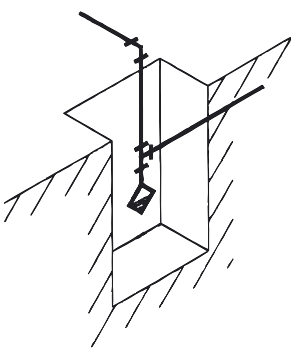
Single end connection

Underground laying
BEKOFLOW® is resistant to corrosion and can therefore also be laid underground.

The trench should be about 1 m deep and as narrow as possible. Stones and other sharp objects have to be removed. The bottom of the trench should be covered with approx. 10 cm of sand or other fine-grained material. The fill material coming into contact with the piping should be of the same kind as at the bottom of the trench and should extend to at least 10 cm above the top of the pipe.

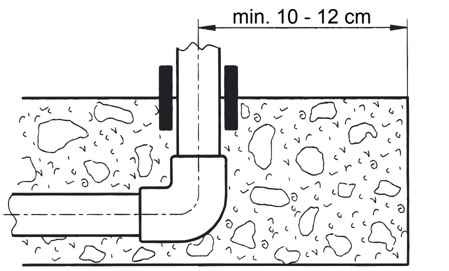


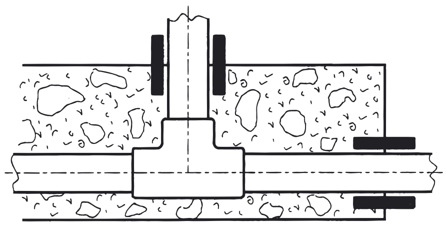
Due to the risk of condensate formation associated with underground piping there should be a water separator installed at a low point of the line.



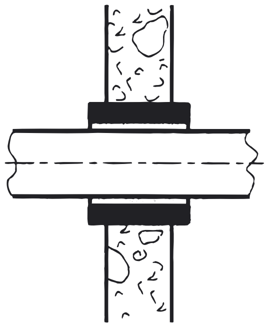
Duct laying
When the pipes are laid in ducts that are then filled with concrete, it must be ensured that the pipes are fully enclosed.

At the entry and exit points of the pipes, provision should be made to protect the pipes against damage.





If the pipe passes through a wall or ceiling, it must be surrounded by a sleeve or by insulation material to separate it from the construction element. The sleeve should protrude slightly at both ends of the construction element.



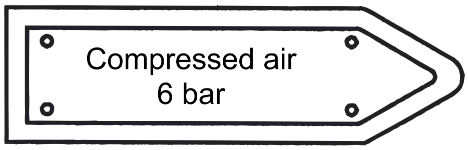
Marking

In accordance with VEG 1 § 49 and DIN 2403, pipes have to be marked for the purpose of identification. Marking to indicate the throughput medium (fluid) is essential in the interest of safety and effective fire fighting.

Appropriate marking must be

- at the beginning and end of the pipe
- at branching and passage points, and
- on the valves.

Fluid	Group	Colour	– RAL –
Water	1	green	6018
Compr. air	**3**	**grey**	**7001**
Gas	4/5	yellow	1012
Acid	6	orange	2000
Lyes	7	purple	4001
Oxygen	0	blue	5015
Steam	2	red	3003



Pipe clamp arrangement BEKOFLOW®

Spacing of pipe mounting elements		
Dimension in mm d x s	Compressed air line up to 20 °C	
	without support shells L1 (cm)	with support shells L2 (m)
16 x 2.2 20 x 2.8 25 x 2.3	60 cm 70 cm 90 cm	ca. 1.5 - 2.0 m
32 x 3.0 40 x 3.7 50 x 4.6 63 x 5.8	100 cm 120 cm 150 cm 170 cm	ca. 2.0 - 2.5 m
78 x 6.8 90 x 8.2 110 x 10.0	180 cm 200 cm 220 cm	ca. 2.5 - 3.0 m

Pipe clamps have to be arranged in such a way that they can accommodate any typical changes in pipe length. Likewise, where pipes pass through a wall or ceiling they must be allowed sufficient play.

In the case of longer lines, the changes in length can be subdivided by using suitable fixing points to allow better distribution of these changes.

Dimensioning

Compressed-air pipe systems, as energy carriers, have to be carefully calculated and dimensioned.

If the compressed air pipes are calculated according to the same principles as water pipes, the result will be an energy loss of > 50 %.

For correct dimensioning, it is necessary to know three major factors:

I Network concept

II Pipe material

III Total compressed air demand

Network concept

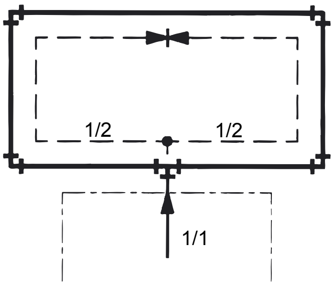
The pipe network consists of:

– The **main pipe** with a maximum pressure loss of **Δp ≤ 0.03 bar.** This main pipe is the connecting element between the receiver and the distribution pipes.

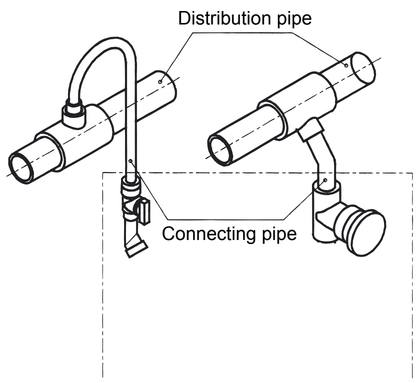
– The **distribution pipes** with a maximum pressure loss of **Δp ≤ 0.03 bar**. They can be in the form of a ring line or feeder branches.

Compared with feeder branches, ring lines have the advantage that they can offer twice the capacity. They are recommended particularly for facilities where the points of use are fairly equally spaced out.

The ring line is calculated analogous to a feeder branch, i.e., the ring is divided in the middle and calculated with half the nominal length and half the necessary air demand.



– The **connecting pipes** with a maximum pressure loss of **Δp ≤ 0.04 bar**. These pipes represent the link between the distribution pipe and the point of use.



Point of use
Δp ≤ 0.9 bar

Compressed air demand

The compressed air demand is determined on the basis of the specifications for the machine or device connected to the compressed air network. However, in order to ensure that the pipe network is not overdimensioned, it is important to determine the **degree of utilization η** and take this into account.

For calculating the necessary compressed air demand it is recommended to include an extra allowance and adequate spare capacity.

Allowances for:

- **Leaks at the points od use 10%**
- **Estimation errors 10%**
- **Spare capacity 20%**

Examples of the determination of the compressed air demand:

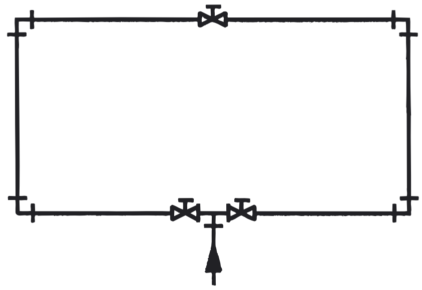
Machine No.	1	2
Compr. air demand **$\dot{V}$ = l/min**	300	500
Number of machines **n**	2	1
Degree of utilization **η = %**	50	25
Compr. air demand **V = l/min**	300	125
Total compr. air demand	**425 l/min**	

$$V = \dot{V} \times n \times \eta$$

Compressed air demand incl. allowances

V = 600 l/min

Pipe system dimensioning



The network layout determines the length of the main pipe, distribution pipes and connecting pipes. Pipe fittings (elbows, T-pieces, etc.) and valves must be added to the length of the line according to their equivalent pipe length value.

The initial dimensioning of the pipe system can be carried out on the basis of Table 1. For the maximum flow rates of the different pipe diameters at different operating pressures it is assumed that the pressure loss will be 0.03 bar over a pipe length of 100 m.

Table 1

Operating pressure (bar)	4	6	8	10	12	16
Pipe diameter	Max. flow rate (m³/min)					
d 16	–	–	–	–	1.10	0.15
d 20	–	–	–	0.18	0.20	0.25
d 25	0.20	0.28	0.30	0.34	0.38	0.45
d 32	0.48	0.55	0.62	0.70	0.75	0.85
d 40	0.78	0.90	1.00	1.30	1.50	1.70
d 50	1.40	1.75	2.00	2.20	2.60	3.00
d 63	2.50	3.25	3.80	4.20	4.60	5.20
d 75	4.10	5.00	6.00	7.00	7.50	8.20
d 90	7.00	8.10	9.95	11.00	12.50	14.00
d 110	11.50	14.00	16.00	18.00	20.00	20.00

Pipe length L = 100 m
Pressure loss Δp = 0.03 bar

1 m³/min = 1 000 l/min = 16.7 l/s

Example:

DP	=	110 m
Δp	=	0.03 bar
p	=	6.0 bar
V	=	4 500 l/min

Distribution pipe	**d 75**	L = 110 m
1 T-piece		2.5 m
4 Elbows 90⁰		6.0 m
3 Ball valves		approx. 1.6 m
Total lenght		**120.1 m**

For an operating pressure of 6 bar and a compressed air demand of 4,500 l/min (4.5 m³/min) Table 1 indicates a pipe diameter of

d 75.

The initial pipe dimensioning can also be calculated with the following approximation:

$$\mathbf{DN} = \sqrt[5]{\frac{1.6 \times 10^3 \times \dot{V}^{1.85} \times L}{\Delta p \times p}}$$

The allowances for fittings and valves are set out in Table 2 (see p. 31).

DN	=	nominal pipe diameter	(m)
L	=	pipe length	(m)
$\dot{V}$	=	vol. flow rate	(m³/s)
Δp	=	pressure loss	(Pa)
p	=	network pressure	(Pa)

1 bar = 10^5 Pa

Nomogram

The **nomogram** offers an easy and fast way for determining the correct pipe dimensions.

Procedure:
1. Determine pipe length (m) **A** and flow rate (m³/min) **B** and join by line **1**.

2. Join pressure loss (bar) **E** and operating pressure (bar) **D** by line **2**.

3. Join the two intersections of **1/C** and **2/F** by line **3**.

4. The intersection of line **3** and **G** shows the appropriate pipe dimension.

Example:

Δp	=	0.03 bar
p	=	6 bar
V	=	4.5 m³/min
L	=	120 m

Pipe d = 75

Nomogram for determining the diameter of BEKOFLOW® pipes

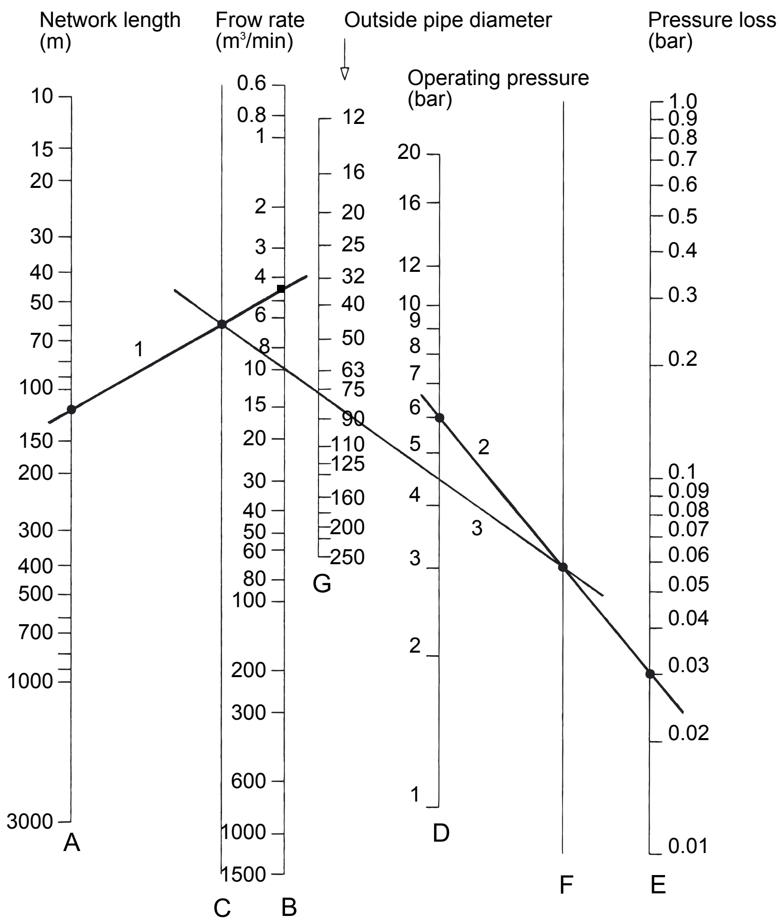
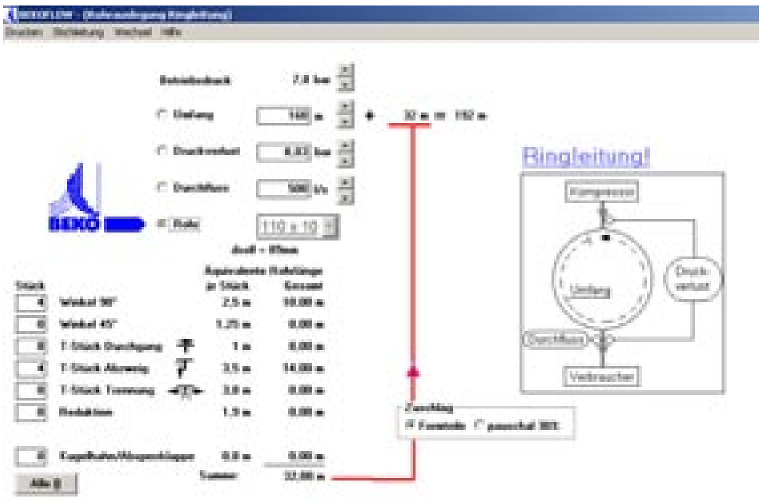


Table2
Equivalent pipe lengths for fittings and valves

Pipe diameter A	16	20	25	32	40	50	63	75	90	110
Fittings Elbows 90^{0}	1.30	0.40	0.50	0.60	0.80	1.00	1.25	1.50	1.80	2.50
Elbows 45^{0}	0.15	0.20	0.25	0.30	0.40	0.50	0.60	0.75	0.90	1.25
T-piece, flow-through	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
Reduction	0.20	0.25	0.30	0.40	0.50	0.70	0.90	1.20	1.50	1.90
Swan-neck section	0.70	0.82	1.00	–	–	–	–	–	–	–
Valves Ball valve/ Shutoff valve	–	0.16	0.18	0.20	0.24	0.28	0.40	0.52	0.65	0.80
Diaphragm valve	–	0.90	1.20	1.60	2.10	2.60	3.30	4.10	5.00	6.20

You can do this calculation quite easily using our BEKOFLOW® calculation program. Just enter the existing values such as operating pressure, pipe length and flow rate. The program will then calculate the appropriate pipe dimensions.



Flange joints/screwed connections

Connection:
plastic-to-plastic

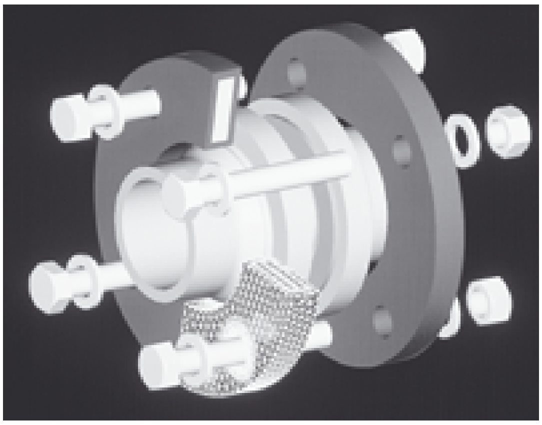
Flange joints or O-ring sealed screwed connections are generally used for the detachable connection of plastic pipes with each other and for the transition from plastic pipes to metal pipes or metal devices (valves, pumps).

- Screwed connections up to d 63
- Flange joints up to d 110

Flange joints with O-rings do not require any great tightening torque. It is recommended to use a torque wrench to avoided overtightening of the bolts.

Guide values for tightening the bolts of flange joints with O-rings:

Outside pipe diameter	mm	16	20	25	32	40	50	63	75	90	110
Torque	Nm	3	3	4	5	10	12	15	18	20	22



Bolts, nuts, washers, standard type

Always use washers

Connection:
Plastic-to-metal

- Flange joints are normally chosen for the transition from plastic to metal because the sealing surfaces of the metal flanges are usually grooved.
- The bolts of flange joints with flange seals must be tightened with a torque wrench in order to avoid damage to the flange or flange sleeve. The guide values for the necessary torques in relation to the different pipe diameters are set out in the following table.

Outside pipe diameter	mm	16	20	25	32	40	50	63	75	90	110
Nominal diameter DN	mm	10	15	20	25	32	40	50	65	80	100
Torque	Nm	6	7	9	10	20	25	30	35	40	45

Material

The technical data are non-binding. They do not represent an assurance of properties. Beko reserves the right to make changes. Applicable are our General Terms and Conditions of Sale

Resistance

Plastics have become established as suitable materials for modern pipe systems. Plastic pipes have proved their excellence not only for water applications but also for transporting highly corrosive fluids. Hybrid pipes consisting of metal/ plastic or glass have been replaced by cheaper and safer all-plastic pipes with long durability.

The Chemical Resistance List is a useful guide for general information about the compatibility of PB with liquid or gaseous media. The list is regularly revised and updated. However, the data are based on immersion tests with samples that are not under mechanical load. Consequently, the results are not fully applicable to pipes under stress or interior pressure.

The effect of chemical mixtures may be different, due to the interaction of their components, to the known effect of the individual components. With regard to special applications we would be ready to advise you at any time.

Changes in the composition of the fluid being transported or special operating conditions can result in a different material behaviour compared with the data listed in the table. Where in doubt, it is advisable to carry out tests (test installation) under the relevant operating conditions. The data contained in the list are for information only and cannot be used in the context of guarantee claims. These data correspond to the state of the art and may be amended in the light of new findings. Updates are made on a regular basis.

We would be pleased to send this list to you upon request.

Classification

The usual classification for plastics uses the following reference levels:

+	Resistant	Use of polybutene possible
O	Limited resistance	Restricted use of polybutene
-	Not resistant	Use of polybutene normally not possible

Resistant: +
Within the specified pressure and temperature limits the material is not, or only slightly, affected by the fluid transported.

Limited resistance: O
The fluid transported attacks the material or causes swelling of the material. With respect to pressure and/or temperature, it will be necessary to lay down appropriate limits taking account of the expected service life. A noticeable shortening of the service life cannot be excluded.

Not resistant: -
The material cannot be used for this particular fluid or can only be used under special conditions.

Pipe connections

Metal pipe connections
The following metals are used on PB pipe systems:

Alloy	**Brass**	**Brass, dezincification resistant**	**Alloyed steel**	**Brass, nickel-plated**
DIN Abbreviation	17660 CuZn 39 Pb 2 CuZn 39 Pb 3	 CuZn 35 Pb 5 (CR-brass)	17455 12CrNi 18 8	Coating thickness ≈ 6 µm

Resistance welding connections
Polybutene resistance welding connections are generally suitable for all polybutene-compatible fluids. Exception: readily diffusing, metal-attacking substances such as:

- Hydrogen bromide — HBr
- Hydrogen fluoride (hydrofluoric acid) — HF
- Fluorosilicic acid (sand acid) — H_2SiF_6
- Hydrogen chloride (hydrochloric acid) — HCl
- Hypochloric acid (hypochlorous acid) — HOCl-aqueous

Flanged and screwed connections
With flanged and screwed connections, the material of the sealing elements must be taken into account.

Sealing materials (elastomers)

Depending on the specific operating and load conditions, the lifetime of sealing materials can vary greatly from that of the pipe material.

In the case of compressed air application with mineral oil containing air, NBR or FPM seals have to be used instead of EPDM seals.

Sealing material	General chemical/physical resistance	Max. operating temperature
EPDM ethylene-propylene diene rubber	Resistant against aggressive, oxidizing fluids Not resistant against hydrocarbons, mineral oils and fats	90 °C (short-time 120 °C)
NBR nitrile rubber	Resistant against hydrocarbons, oils and fats Not resistant against oxidizing fluids	90 °C (short-time 120 °C)
FPM fluorinated rubber	Resistant against aggressive, oxidizing fluids such as hydrocarbons, solvents, oils and fats	150 °C (short-time 200 °C)

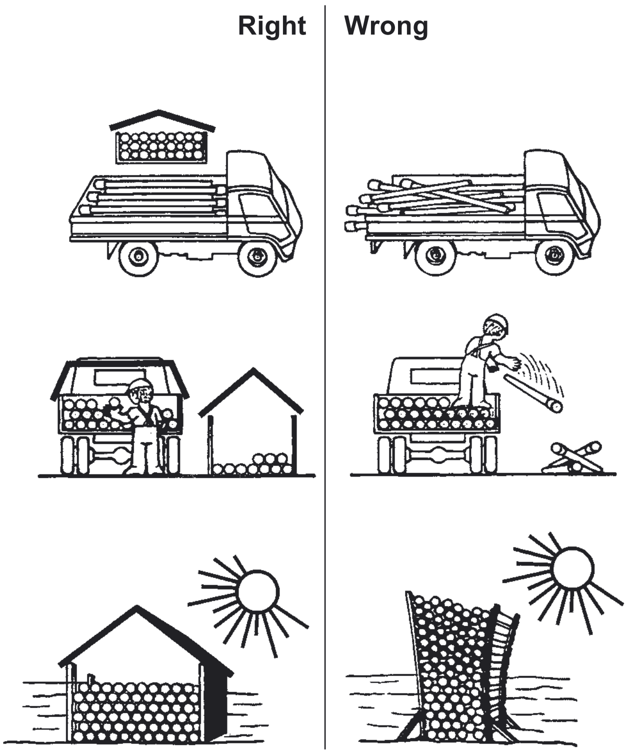
Characteristics of polybutene

Mechanical and physical characteristics

Characteristics	Value	Unit	Test standard
Density	0.93	g/cm^3	DIN 53479
Melting range	122-128	°C	DTA
Vicat softening temperature	113	°C	DIN 53735
Glass temperature	- 18	°C	ASTM D-746
Heat of fusion	~ 100	kJ/kg	DSC
Thermal conductivity	0.22	W/mK	DIN 52612
Thermal expansion coefficient	0.13	mm/mK	DIN 53752
Modulus of elasticity	350	MPa	DIN 53457
Shore hardness	53	D-Skala	ISO 8608
Notched impact strength	40	(0 °C) kJ/m^2	DIN 53453
Elongation at break	> 125	%	DIN 53457
Tensile strength	33	MPa	DIN 53455
Yield stress	17	MPa	DIN 53455
Heat capacity	1.8	kJ/kgK	

Transport and storage of plastic pipes and fittings

Storage - handling of plastic pipes and fittings



Plastic is a material that reacts sensitively to impact loads or squeezing during low temperatures. The actual temperature limit depends on the specific material:

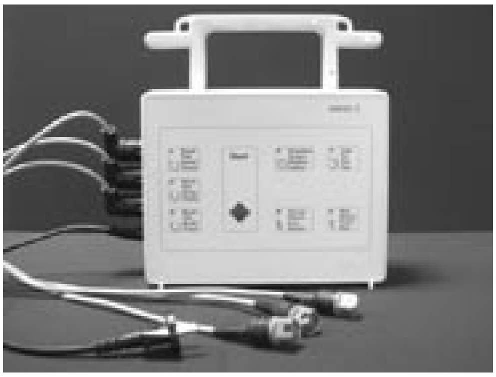
PP-R PVC-C	BEKOFLOW® (PB)
+ 5 ^{0}C	- 10 ^{0}C

Below these temperatures, the pipes and fittings need to be specially protected against mechanical loads from outside.

Safety note

As a rule, plastic pipes and fittings have to be protected against exterior influences. Direct exposure to sunlight, impact or external pressure loading must be avoided. The pipes and fittings should be kept in their original packaging and should not be stored outdoors. Always ensure observance of the relevant guidelines for transport, storage, processing, mounting and installation.

Resistance welding



Special features

- Integrated coding enables recognition of the particular fitting and its dimensions.
- Fully automatic welding process after pressing the **start** button. Therefore, errors due to setting the wrong parameters cannot occur.
- Beginning and end of the welding process are signalled visually as well as acoustically.
- Faults during the welding process are indicated.
- Simultaneous welding of up to three connections of different sizes.

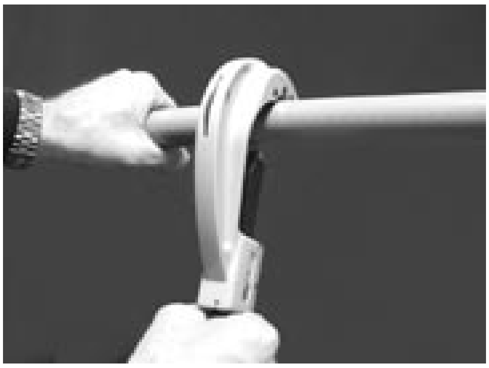
Welding parameters

Outside pipe diameter d	Welding time t (sec.)	Cooling time t (min)
16	37	2
20	47	2
25	55	2
32	70	4
40	120	4
50	145	4
63	180	6
75	185	6
90	200	6
110	210	6

The welded parts require a cooling period before use.

Welding preparation

The welding tool and the welding areas must be in a clean and dry condition.



Cut the pipes at a right angle and – where necessary – deburr inside and outside.

Do **not** chamfer the pipe ends!

Use suitable plastic pipe cutters.

Clean the joint surfaces of the parts to be welded (fitting and pipe) immediately before welding. Use absorbent, non-lint paper (only moistened) and an ethyl alcohol based cleansing agent and thoroughly clean the pipe and fitting.

Fixing the pipe ends inside the fitting

Mark the depth of the pipe insertion into the fitting. The insertion depth of the pipes into the coupling must be marked on both pipes.

Do not use any wax or grease pencils!

Insert the pipes up to the mark into the fitting. The pipe faces must meet in the middle of the coupling.

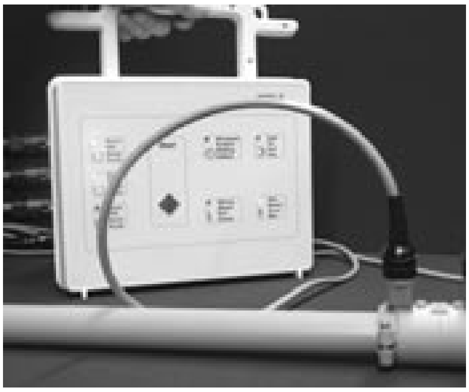
Fully tighten the screws of the integrated pipe fixing system using a hexagon socket wrench alternately. With pipe surface temperatures of > 40 °C and the resulting expansion, it is difficult to push the fitting onto the pipe end because of the necessary tight tolerances.

Functional description

1. Connect the welding tool to the power supply, all the pilot lights will light up for two seconds. After that, the **Power** light will be on continuously.

2. Connect the welding cables to the corresponding fitting.

Pilot light **Ready** will light up.

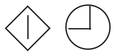


Each of the connected welding channels will independently recognize the connected fitting and its dimensions.

Up to three welding operations can be carried out simultaneously and for different dimensions.

Welding channels that are not connected are "blocked", i.e., without electrical power, during the welding process.

Start the welding process by pressing the **Start** button. The **Welding** light will blink; the welding start will also be indicated by an acoustic signal.



The **Ready** light of the connected welding channel will blink.

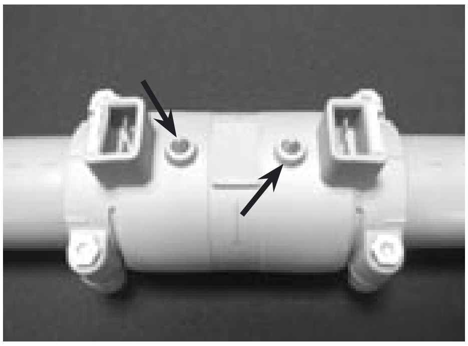
4. After termination of the longest welding time, the end of welding will be indicated by an acoustic signal and by lighting up of the **End** pilot light.

The **Ready** light of welding channels with shorter welding times will go out when the time is over.

5. Disconnect the welding cables from the fitting. Only the **Power** light will still be on; all three welding channels are now free again

6. **Checking the welding results**
The visual welding indicator confirms the termination of the welding process.

The indicator consists of a pin that appears on the coupling when the welding has been successfully completed.



During the welding process, the fittings and pipes being welded must only be subjected to the forces stemming from the original fixing of the pipe.

Technical Data

Voltage:	U_{Prim}	230 V
	U_{Sek}	185 V
Frequency:	50/60 Hz	
Current:	I_{Prim}	7.5 A
	I_{Sek}	3x2.5 A
Output:	P_{Prim}	25-1 400 W
Device No.		

Maintenance
Clean the welding device with a damp cloth. Only use alcohol or spirits for cleaning front panel and plates; **do not use** thinners or solvents.

Error signals

Cause	Remedy
1. Connect the welding tool to the power supply	
All the pilot lights are blinking	
– Voltage is not in the correct range (185/264 V)	⇨ Change to a different power source
– Ambient temperature is too high or too low (40 °C/-15 °C)	⇨ Protect the device against sources of cold or heat
Lights on display do not light up	
– No suooly voltage	⇨ Check the mains fuses
– Faulty device	⇨ Replace the device; examination by BEKO TECHNOLOGIES GmbH Neuss
2. Connect welding cable to the fitting	
Pilot light **Ready** does not light up	
– Defective welding cable	⇨ Replace the cable
– Defective fitting	⇨ Replace the fitting
3. Pilot light 'Error' is blinking	
– Cause not identifiable according to above points 1 and 2	⇨ Replace the device; examination by BEKO TECHNOLOGIES GmbH Neuss
4. Welding interruption	
Pilot light **Error** is blinking – Fitting disconnected from the welding cable – Deviation from permissible voltage – Deviation from permissible ambient temperature	⇨ Disconnect the welding cable from the fitting and the power supply cable from the power supply. **Repeat the welding operation after waiting at least 1 h**
Lights on display do not light up – Faulty device – Short-circuit in power supply – Device not connected to power supply – No supply voltage	⇨ Replace the defective device; examination by BEKO TECHNOLOGIES GmbH Neuss

In order to cancel the **Error** signal, the device has to be disconnected from the power supply.

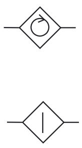
Compressors (DIN 28 004, DIN ISO 1219)

- General
- Piston compressor
- Screw compressor
- Turbo compressor
- Fan, blower

Pumps (DIN 28 004, DIN ISO 1219)

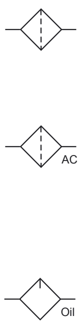
- General
- Diaphragm pump
- Gear pump

Water separators



- Cyclone separator
- Impaction / impingement separator

Filters (DIN ISO 1219)



General

Add filter specification next to the symbol

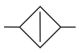
0.01	Filter fineness 0.01 µm (microfilter)
AC	Activated carbon
DF	Dust filter
MS	Medical sterile filter
HP 1	High pressure filter with 1 µm filter fineness
HT	High temperature dust filter
A	Suction filter
:	:
:	:

Modified representation: oiler

Measuring equipment / sensors (partly DIN ISO 1219)

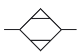
- General
- Pressure gauge
- Differential pressure gauge
- Pressure switch
- Temperature measurement
- Temperature display / indicator
- Dew point / pressure dew point
- Relative humidity
- Volumetric flow (flow rate)
- Velocity
- Measurement of pH value

Heat exchangers (DIN ISO 1219)



General

Compressed air dryers (DIN ISO 1219)

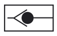
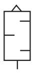
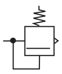
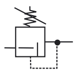
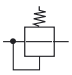
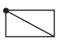
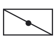
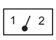


General

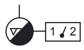
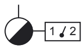
Identification of method (no DIN)

- Refrigeration dryer (with air-to-air heat exchanger)
- Adsorption dryer
- Membrane dryer

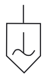
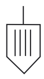
Equipment & accessories (DIN ISO 1219)

	Receiver
	Non-return valve with reset spring
	Non-return valve without reset spring
	Silencer
	Shutoff valve, general
	Solenoid valve
	Compressed air line (working line)
	Control cable
	Compressed air connection
	Safety valve
	Pressure regulator
	Pressure maintaining valve
	Swing check valve
	Start-up valve
	Throughput control valve
	Control, general

Condensate drains

	General
	Manual drain
	Float drain
	Time-controlled solenoid valve
	Electronically level-controlled drain with float
	Electronically level-controlled drain with sensor

Condensate treatment technology (no DIN - Symbols available)

	Static oil-water separator
	Chemical splitting plant
	Membrane filtration