EFFICIENCY OF **COMPRESSED AIR SYSTEMS.**

- **Identifying savings potential**
- **Planning optimised, efficient installations**
- **Selective maintenance to preserve efficiency**

White Paper
Compressed Air
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03

viega

Energy-efficient and economical compressed air systems

EXPLOITING SAVINGS POTENTIAL THROUGH OPTIMISED COMPRESSED AIR DISTRIBUTION INSTALLATIONS

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Compressed air is indispensable in industrial settings, especially as a control medium for powering machines and systems. This is mainly due to its performance characteristics such as power, speed and precision combined with safe operation. However, this performance is accompanied by considerable power consumption – depending on the industry, this is estimated to be between 5 and 25 percent of the respective company's total power consumption.[1] This makes it all the more important to design compressed air systems to meet the demands of the specific application and to operate them economically.

The compressed air distribution architecture, the dimensioning of the pipelines and the choice of materials and connection technology are often underestimated, especially with regard to (preventive) maintenance and subsequent extensions. Empirical surveys during inspections of compressed air systems show that around 80 percent of the installations in industrial buildings have leaks – resulting in a loss of compressed air of up to 30 percent. The savings potential from continuous maintenance is correspondingly high. That said, leaks can be prevented or minimised as early as the planning stage for new installations or extensions. This increases the overall energy efficiency of the system.

This white paper outlines the expenditure involved in generating compressed air and the impact of the piping network on operating costs. It then presents concepts for planning and operating these compressed air distribution installations, which ensure greater levels of safety and lower costs.

80%

of compressed air installations have leaks that could easily be prevented

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INTRODUCTION

Although compressed air is used as a cross-sectional technology in almost all industrial sectors, including in mining and manufacturing, there are next to no reliable surveys on the power consumption required for this – an indication of how little attention has been paid thus far to the potential for energy savings in compressed air systems. The following observations show that a rethink is required in this regard.

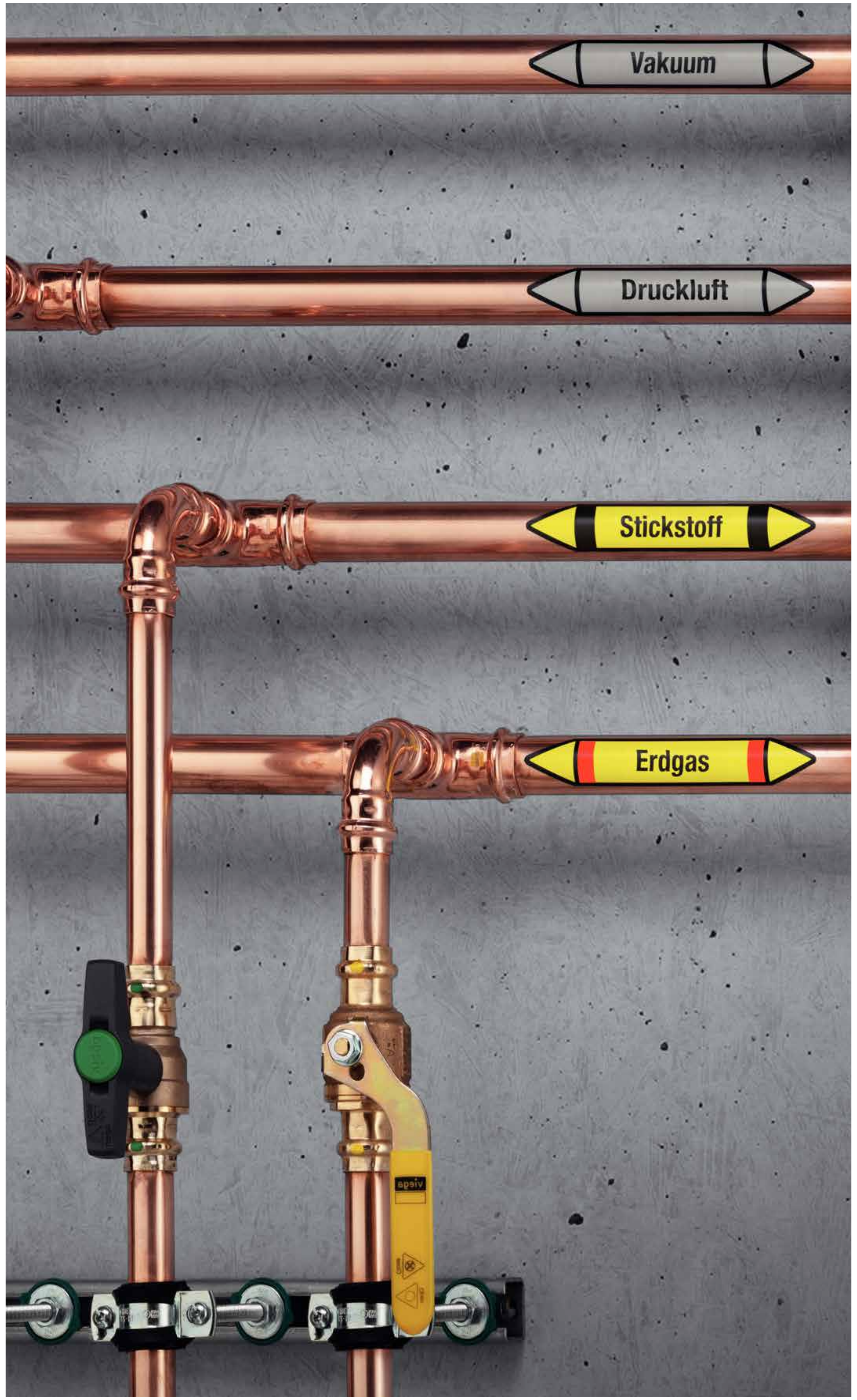
14.75 TWh

Power requirements of electric drives for compressed air generation

10.00 TWh

Power output of all German nuclear power plants connected to the grid in 2019

In the annual "Energy Balance for Germany", the Arbeitsgemeinschaft Energiebilanzen e.V. (German Working Group on Energy Balances – AGEB) breaks down consumption by sector, energy carrier and application. For 2019 – the last year without the distorting influences of the Covid-19 pandemic – the estimate for use of compressed air is as follows: Of the total electricity demand in the industrial sector, electric drives for compressed air generation account for 2 percent. "Only" 2 percent, you might say – but in absolute terms this equates to 14.75 TWh.[2] By way of comparison, the power output generated by Germany's nuclear power plants connected to the grid was around 10 TWh in 2019! Further estimates suggest that around 80 percent of applications are process or blast air applications and around 20 percent are control air applications, such as pneumatics.[3] Overall, compressed air systems cost German industry a total of around €544 million in electricity in the benchmark year 2019. Based on the 2022 electricity price, however, these costs have risen to almost €1.2 billion.[4]



Process air

Compressed air is defined as process air if it is physically or chemically involved as a medium in a machining or processing operation or if it is used to convey products. It always comes into direct contact with the product as part of a machining or processing operation. Typical examples are ventilation and drying processes.

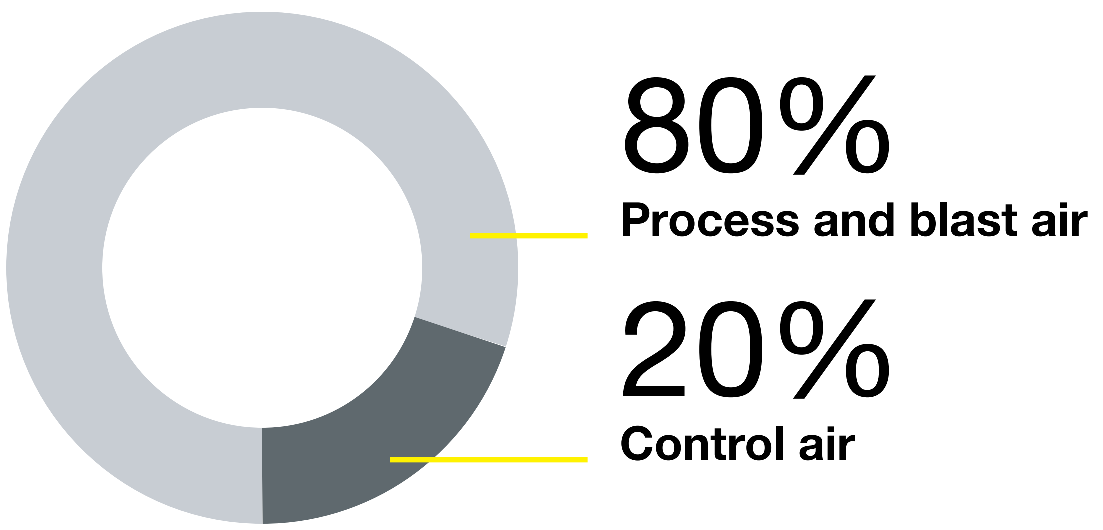
Blast air

Blast air is compressed air that is used to clean machines and workpieces ("blasting off"). Like process air, blast air comes into direct contact with the product in a machining or processing operation.

Control air

Control air is compressed air that is used to operate controls, linear and rotary compressed air motors and instrumentation. It is also known as instrument air, energy air or working air and does not come into contact with the product during the process. Typical examples are pneumatic appliances such as air hammers.

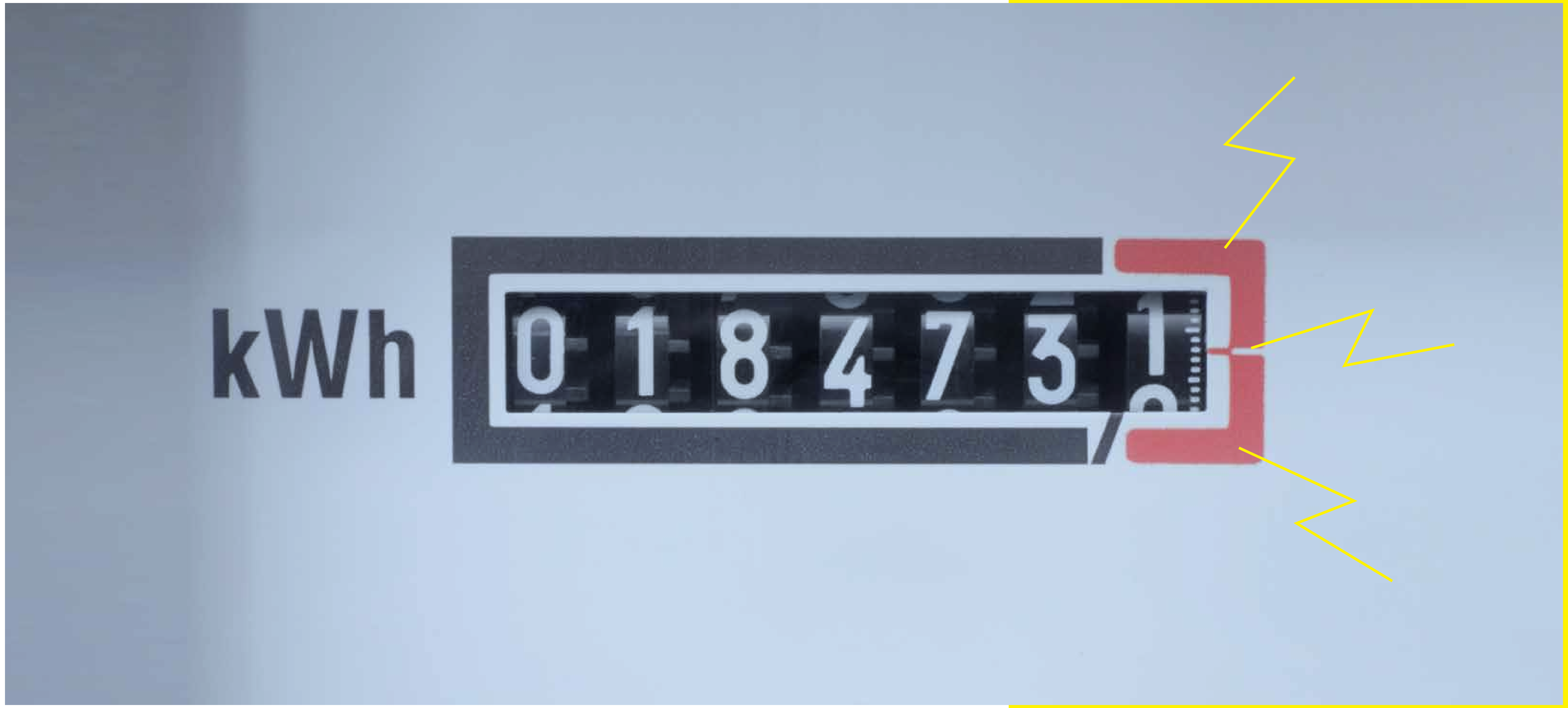
Compressed air applications in 2019



Source: German Engineering Federation (VDMA) standard sheet 15390-1

A recent study on the potential for energy and cost savings in fluid technology commissioned by the German Federal Environment Agency (UBA) came to the conclusion that compressed air systems are virtually impossible to substitute in order to save any appreciable amount of energy.[3] The focus must therefore be on increasing efficiency – both in order to maintain the competitiveness of each company in the face of sharply rising energy prices and to reduce the burden on the environment. This is also addressed in the final report entitled "Ecodesign Directive Lot 31" and in the concluding report entitled "Updating the data of the Energy Efficiency BAT data sheet".[1] After all, energy consumption will always result in CO_2 emissions as long as fossil fuels are the dominant source of energy.

In the following section, opportunities for saving energy are outlined and specified in practical terms with regard to the planning and operation of compressed air distribution systems.



Stop the meter: Optimising compressed air systems can also contribute to reduced energy consumption and averted emissions

Minimising the power requirement

IDENTIFYING AND EVALUATING SAVINGS POTENTIAL

Various analyses of the lifecycle costs of compressed air systems come to the conclusion that only 10 percent of the costs are attributable to the investment itself, but 70 to 80 percent are later attributable to energy as an operating cost item. Consequently, a cost-effective compressed air supply is primarily founded on minimising the power requirement. This is essentially determined by four aspects of a compressed air system:

- Compressed air generation
- Compressed air processing
- Compressed air distribution installation
- Compressed air consumers

It is now crucial for the overall efficiency of the system to bring these four points together in a requirements analysis when planning new buildings and in a consumption analysis when modernising existing ones.

When taking a holistic approach, the first question to ask is what operating pressures the consumers demand. Machines that require a compressed air connection of 6 bar, for example, will be significantly less expensive in terms of operating costs than those that require 8 bar. That is because a pressure reduction of 1 bar reduces the power consumption of the compressor by around 8 percent. This means that it is sometimes more energy-efficient to have a compressed air supply of 6 bar and to install a booster in the distribution system for individual consumers that require higher pressure levels. As an alternative, it may be worthwhile to have two separate compressed air distribution systems – one for medium operating pressures and a second for high operating pressures. Looking at the big picture, therefore, a trade-off has to be made between the (higher) investment costs and the (permanently lower) operating costs.

70–80%

of the lifecycle costs of a compressed air system are the energy costs of operation

1 bar

less operating pressure leads to

8%

less energy consumed by the compressor

Savings potential of compressed air generation

Optimise the compressor station

The compressed air generation system must be planned or adapted in line with the required operating pressure (bar) and air demand (m^3/h). Primarily, this concerns the design of the compressor station. For industrial applications with a high but fluctuating air demand, and at operating pressures of up to 15 bar, screw compressors are most prevalent. They account for about 80 percent of sales in the compressor market. Screw compressors can be sized from about 2 to 300 kW in terms of electrical power consumption. Piston compressors are preferred for smaller power ranges up to 20 kW. For very high air requirements at low operating pressure, turbo compressors with outputs up to the megawatt range are suitable.

Piston compressor
up to 20 kW

Screw compressor
2 – 300 kW

Turbo compressor
+1,000 kW

Advantageous compressor cascade

To ensure the efficiency of compressed air generation, it is crucial that the compressor (regardless of its construction type) is operated predominantly at the maximum degree of efficiency. This means that the compressor reaches its highest efficiency when delivering the air volume and pressure that is predominantly required, i.e. it is running at the energetically optimal operating point as often as possible. Given the fact that demand usually fluctuates temporarily, it often makes sense to install a compressor cascade. The cascade connection can be achieved by means of a higher-level control for one or more compressors with a fixed speed and additional speed-controlled compressors. In this way, idling losses in the units can be reduced. Additional compressed air tanks compensate for short-term load peaks and also help to increase the efficiency of the compressors.

Additional heat recovery

Heat recovery from the compressors can bring about further energy savings in compressed air generation – both through air cooling to assist in heating the fresh air and through water cooling to support water-borne heating systems or the potable water heating system. However, the following must be taken into account in the energy balance: the use of waste heat from the compressor station does improve the company’s energy balance, but the savings effect cannot be attributed to the compressed air generation itself.

> **Compressors in a cascade with a higher-level control system are ideal for efficient compressed air generation. They are most effective at aligning the optimum operating point with the appropriate air demand.**

Reduces losses effectively:
A compressor cascade with higher-level control combines appliances with a fixed speed and appliances with speed control

Powerful, precise and safe: Compressed air is an ideal medium. If the compressed air distribution installations are optimised, it becomes more energy-efficient.

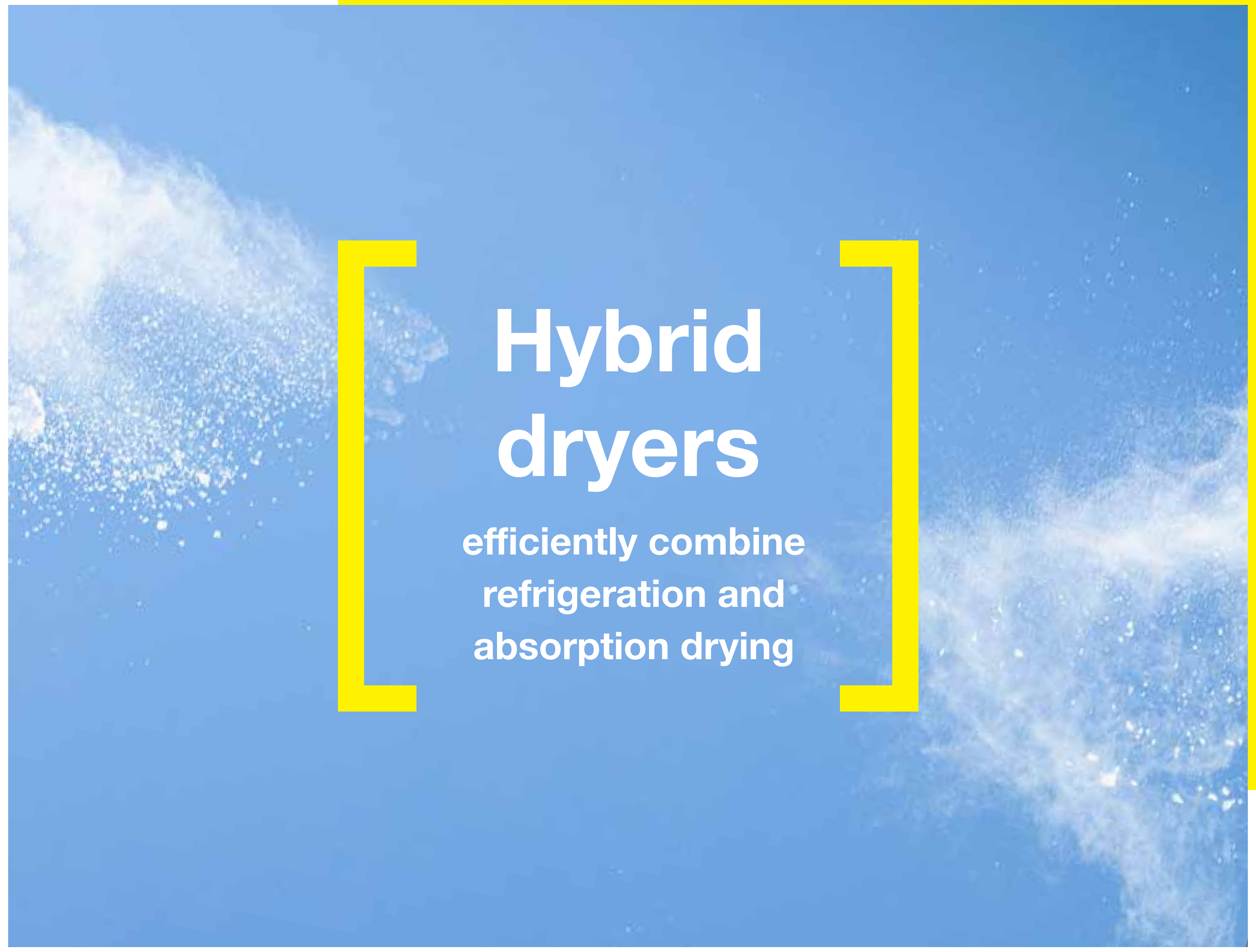
Savings potential of compressed air processing

Select the right quality

Compressed air processing usually accounts for only 2 percent of the power requirement of the overall system. However, the quality of the compressed air has an indirect effect on energy efficiency. After all, depending on the application, water, oil and particles are not only a risk to the health of employees and manufacturing quality. They also damage the compressed air system and cause leaks to occur more quickly and more frequently. This inevitably leads to maintenance-related malfunctions. ISO 8573-1 defines the classes of compressed air quality. In addition, machine manufacturers can also specify stricter guide values. If the manufacturer does not have any specific specifications for compressed air purity, the standard sheets of the German Engineering Federation (VDMA) 15390-1, 15390-2 and 15390-3 will provide guidance. The values are broken down by sector and are based on empirical values.

Drying as an efficiency factor

Drying, which must also be taken into account in the overall energy balance, is decisive for the purity of the compressed air. The required degree of drying, as a function of the pressure range and the air volume, determines which technology is the most appropriate in this context. Electricity-operated refrigeration dryers have the highest energy efficiency. They reduce the compressed air temperature by means of heat exchangers according to the refrigerator principle and discharge condensate together with solid particles and oil. Absorption dryers that work with drying agents are required to produce extremely dry air. These systems are very energy-intensive. Considerable energy savings can be made by using hybrid systems that first dehumidify the compressed air in the refrigeration dryer and then dry it further by way of absorption. Refrigerated compressed air drying and absorption drying are not in competition with each other, but should be used according to requirements.



Hybrid dryers

efficiently combine refrigeration and absorption drying

PURITY CLASSES FOR COMPRESSED AIR PURSUANT TO ISO 8573-1

Class	Maximum number of particles per m^3 / mass concentration C_p [mg/m^3]			Pressure dew point [°C] / residual moisture content C_w [g/m^3]	Oil content [mg/m^3]
	0.1–0.5 µm	0.5–1 µm	1–5 µm		
0	Specified by the appliance user or supplier, more stringent than Class 1				
1	≤ 20,000	≤ 400	≤ 10	≤ -70°C	≤ 0.01 mg/m^3
2	≤ 400,000	≤ 6,000	≤ 100	≤ -40°C	≤ 0.1 mg/m^3
3	Not specified	≤ 90,000	≤ 1,000	≤ -20°C	≤ 1 mg/m^3
4		Not specified	≤ 10,000	≤ 3°C	≤ 5 mg/m^3
5			≤ 100,000	≤ 7°C	
6	≤ 5 mg/m^3			≤ 10°C	
7	5–10 mg/m^3			≤ 0.5 g/m^3	
8				0.5–5 g/m^3	
9				5–10 g/m^3	
x	> 10 mg/m^3			> 10 g/m^3	> 5 mg/m^3

* If particles larger than 5 µm have been measured, the classes 0–5 cannot be applied

The higher the purity class, the higher the energy input. Therefore, the purity of the compressed air should match the manufacturer's information on machines and tools exactly. Overfulfilment costs unnecessary energy.

Savings potential of compressed air distribution

Design the piping system correctly

When considering the overall investment costs, compressed air distribution accounts for only a comparatively small part. But in the lifecycle, the piping system can result in considerable, and above all unnecessary, extra costs. What's more, the compressed air installation makes a decisive contribution to the security of supply.

Therefore, the following objectives must be taken into account during planning and installation:

- Dimension the piping adequately (= in line with demand)
- Keep pressure losses to a minimum
- Select pipe materials with high resistance to corrosion and mechanical stresses
- Use pipe connections that make repairs and extensions straightforward in day-to-day operations, and that are also as tight as possible

These aspects are explained in more detail on pages 12 to 21.

Savings potential of compressed air consumers

Uncover potential for efficiency

The efficiency of compressed air consumers depends very much on the make selected: The savings achieved with machines and tools that are supposedly cheap to buy are sometimes offset by a high air requirement. Therefore, the compressed air requirement specified in the manufacturer's information should always be included in the economic efficiency calculation. However, in order to quantify this financially, it is necessary to know the actual compressed air costs.

Therefore, a technical and economic analysis of the compressed air system should be a matter of course before any investment decision is made, and should be updated throughout the lifecycle. To identify potential energy savings, it may be useful to carry out monitoring pursuant to DIN EN ISO 50001 (or 50005 for small and medium-sized enterprises) as well as the compressed air auditing standards/specs ISO 11011 (for detailed analyses) and VDMA 4390 (for initial consultation).

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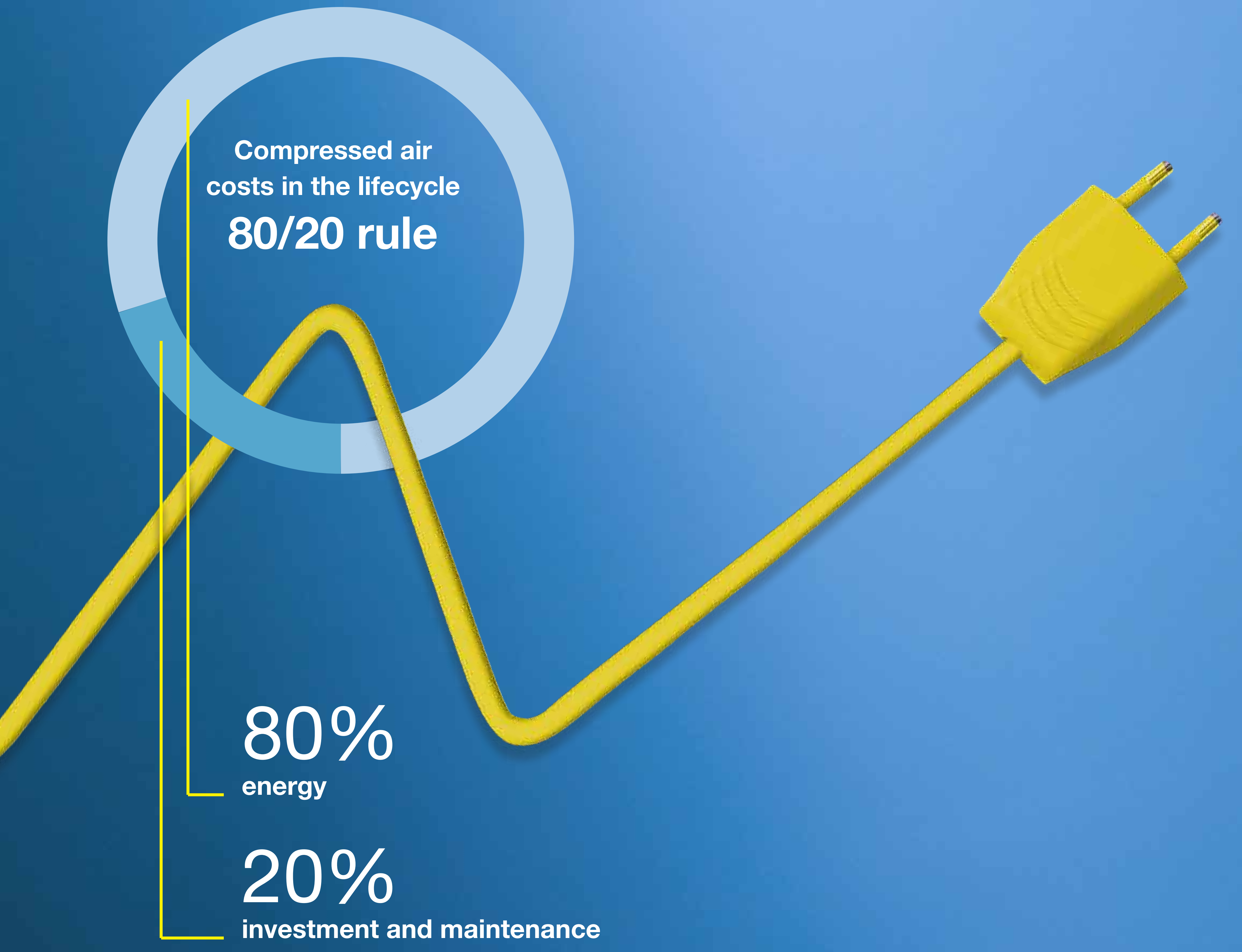
BAFA subsidy
Implementation of the energy management system DIN EN ISO 50001 is subsidised by the German Federal Office of Economics and Export Control (BAFA) in the form of an investment grant. Measures derived from this that help to make the compressed air supply more efficient also receive BAFA funding in some cases. Details are published in the support programme "Federal Funding for Energy and Resource Efficiency in Business".

For maximum efficiency

Overview of sensible measures

As a reminder, by far the majority of the lifecycle costs of a compressed air system are the energy costs for its operation; investment and maintenance only account for one fifth.



That is why efficiency measures are the most important lever for cutting costs and helping to reduce emissions. There are opportunities in all four areas of the compressed air system.

	Power consumption	Investment	Maintenance
Compressed air generation	Precisely determine compressed air requirement Lowest possible operating pressure Heat recovery	Compressors in cascade with higher-level control Pressure support via pressure vessel	Regularly change the intake air filters
Compressed air processing	Determine the required compressed air purity pursuant to ISO 8573-1 and do not exceed it	It is preferable to use refrigeration dryers Level-controlled condensate drains	Regular maintenance
Compressed air distribution installation	Demand-based dimensioning Piping system with low pressure loss, especially at the connector and the fittings	Piping materials that are able to withstand mechanical and chemical stresses	Pipe connection technology with good leak tightness and straightforward machining characteristics
Compressed air consumers	Lowest possible requirements for compressed air purity	Tools and machines with low compressed air consumption	Connection lines that are as short and smooth as possible

Reducing structural losses

OPTIMISED PLANNING OF ENEGY-EFFICIENT COMPRESSED AIR DISTRIBUTION INSTALLATIONS

In several respects, distribution is crucial for cost-effective provision of compressed air. There are many interacting factors here; the three areas of dimensioning, architecture and the piping system itself are particularly worth looking at.

Dimensioning
The dimensioning of the piping has an impact on the pressure losses in the installation, for example, due to the resulting flow velocities. High flow velocities also increase the risk of leaks and increase the volume of air lost as a result. These leaks are caused, among other things, by corroded lines, leaky screw fittings, defective condensate drains or leaky couplings, to name just a few examples.

The flow velocity of compressed air in piping is usually 2 to 3 m/s. To achieve faster strokes with pneumatic cylinders, a higher flow velocity can prove useful. However, as a rule, it should not exceed 20 m/s, otherwise flow noise and turbulent flow will occur. Furthermore, the pipe dimensions determine the limits within which the compressed air distribution can be extended when machines or other compressed air consumers are added to the production system.

To operate a compressed air network economically, determining the needs-based compressed air quantities that are currently required is just as necessary as having a “technical development strategy”: when, how and at what cost should the dimensioning of the compressed air distribution installation be adapted to changing needs?

The architecture
The architecture of the compressed air distribution installation is also of relevance to pressure losses and opportunities for expansion in this context. Moreover, due to the expected pressure fluctuations, the structure of the installation determines the supply reliability of all consumers/machines in case of different levels of air extraction at various points; the keyword here being realistic concurrency. There is more information on dimensioning on pages 14 and 15.

20 m/s

should be the maximum flow velocity

The piping system
Finally, the extent of the pressure losses in the operation phase also depends on the piping system itself, in particular on connectors and fittings, bottlenecks or changes in direction, which generate corresponding flow resistances. The mechanical and chemical robustness of the pipe material as well as the leak tightness of the connection points are, in turn, decisive in terms of leaks, i.e. compressed air losses and, as a result, maintenance costs. More information can be found on pages 20 and 21.

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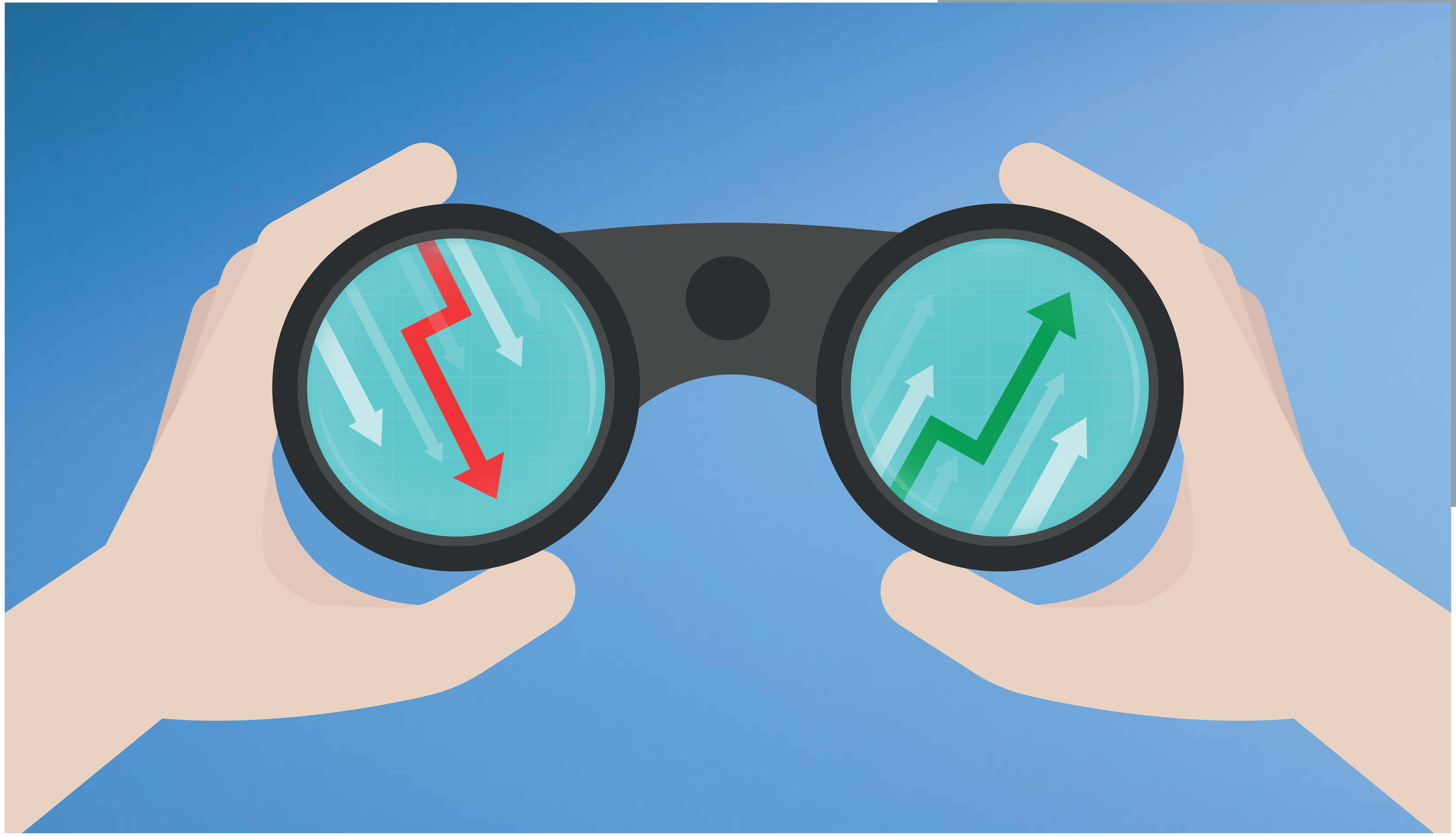
Equalisation through greater capacity?
Deficiencies in the planning and execution of compressed air installations are often compensated for by increasing the capacity of the compressor station so that the required volumetric flow and operating pressure are sufficiently available to the individual consumers despite distribution deficiencies. However, this increases the compressed air costs considerably and puts additional strain on the compressed air installation. Instead, it makes more sense to redesign the compressed air system and, if necessary, to reinstall parts of it. This outlay pays for itself comparatively quickly and ensures an increase in operational safety, as the following detailed considerations clearly show.

Forward planning prevents pressure losses and leaks.



Planning as an efficiency factor: If a piping network is planned wisely and also modified in the event of a change of use or extension, the potential for savings is great

Dimensioning of pipelines

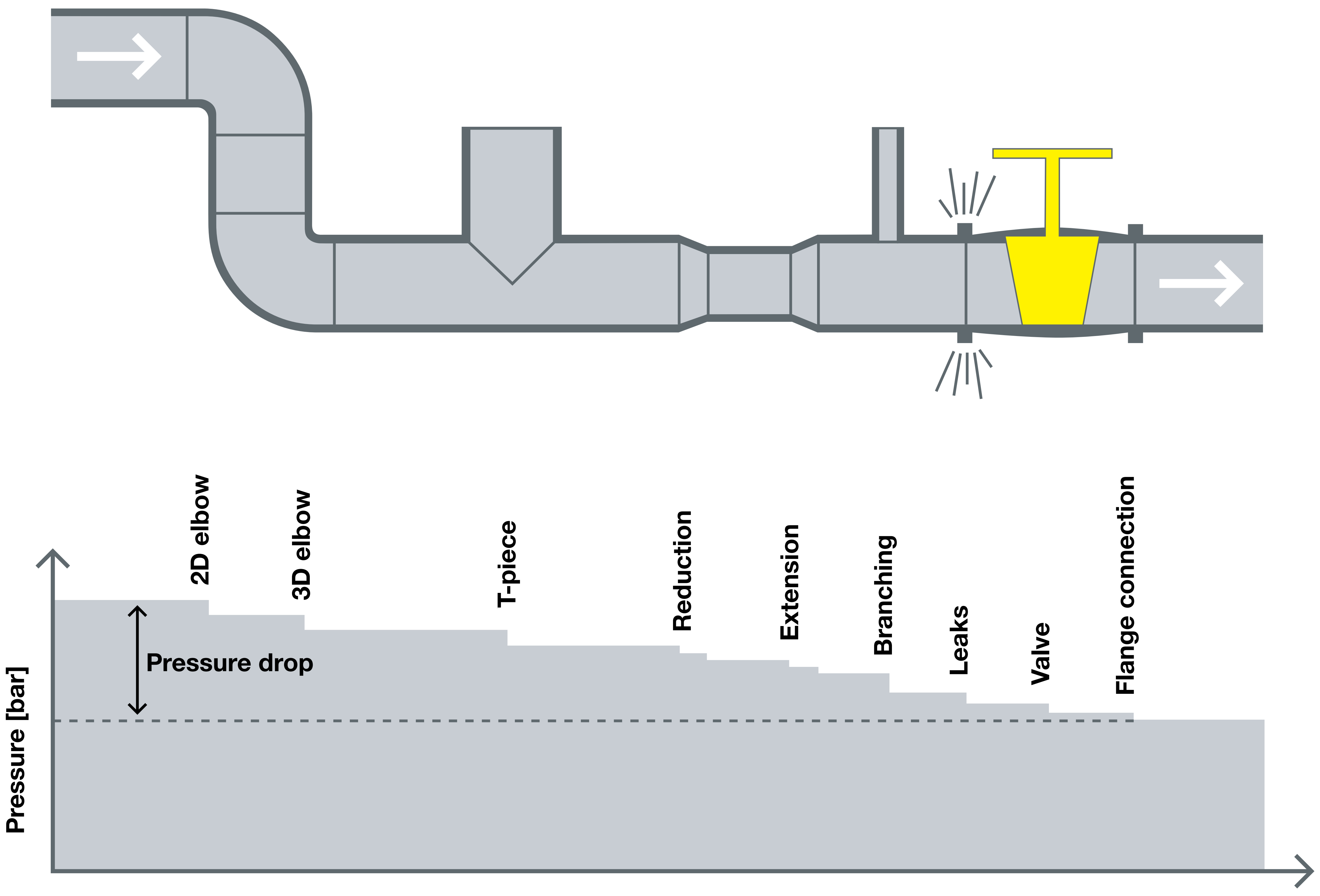
Limit losses effectively

The piping network should be divided into three logical sections. For each of these piping sections, the pressure loss caused by the flow resistance must be calculated and limited:

- **The supply line**
  This connects the compressor station to the manifold. The pressure loss should not exceed 30 hPa (0.03 bar) in this case.[5]
- **The manifold**
  This conveys the compressed air to the points of use. Likewise, the pressure loss in this section should not exceed 30 hPa (0.03 bar).
- **The connection line**
  This branches off from the manifold to the consumers. Here, the pressure loss must be limited to 40 hPa (0.04 bar). If a compressed-air service unit is also required for setting the consumer operating pressure, the pressure loss in the connection line, including any connection hose, should not exceed 500 hPa (0.5 bar). Tip: Connection hoses that are as short as possible and are smooth instead of spiral-shaped reduce the pressure loss significantly.

The pipeline dimensions can be determined based on the required volumetric flow within the limits of the aforementioned pressure losses, either graphically using the nomogram from Technical Regulation VDMA 15391-1 or mathematically. In both cases, the permissible pressure loss and the fluidic pipe length provide the basis. This represents the flow resistance caused by pipe friction in piping, fittings and moulded pieces.

MAGNITUDES OF FLOW RESISTANCES AND PRESSURE LOSSES



Source: Adapted from the BOGE Compressed Air Compendium 2018

The flow resistance should be determined for each of the three piping sections described. If the pipeline routing and thus the number of connectors and fittings are not yet known with complete certainty, the fluidic pipe length can be roughly calculated using a factor of 1.6 of the total pipe length. In addition, when dimensioning the piping, especially the distribution supply line, reserves should only be factored in if there are already firm plans to extend the compressed air system. The rationale behind this is that these “safety margins” will lead to an avoidable increase in operating costs, which in some cases can be as high as 20 percent, if it transpires that they are not needed at all or only to a limited extent at a later date.

Up to 20%

of this can be caused by unnecessary “dimensioning reserves”

Limiting losses effectively

System architecture

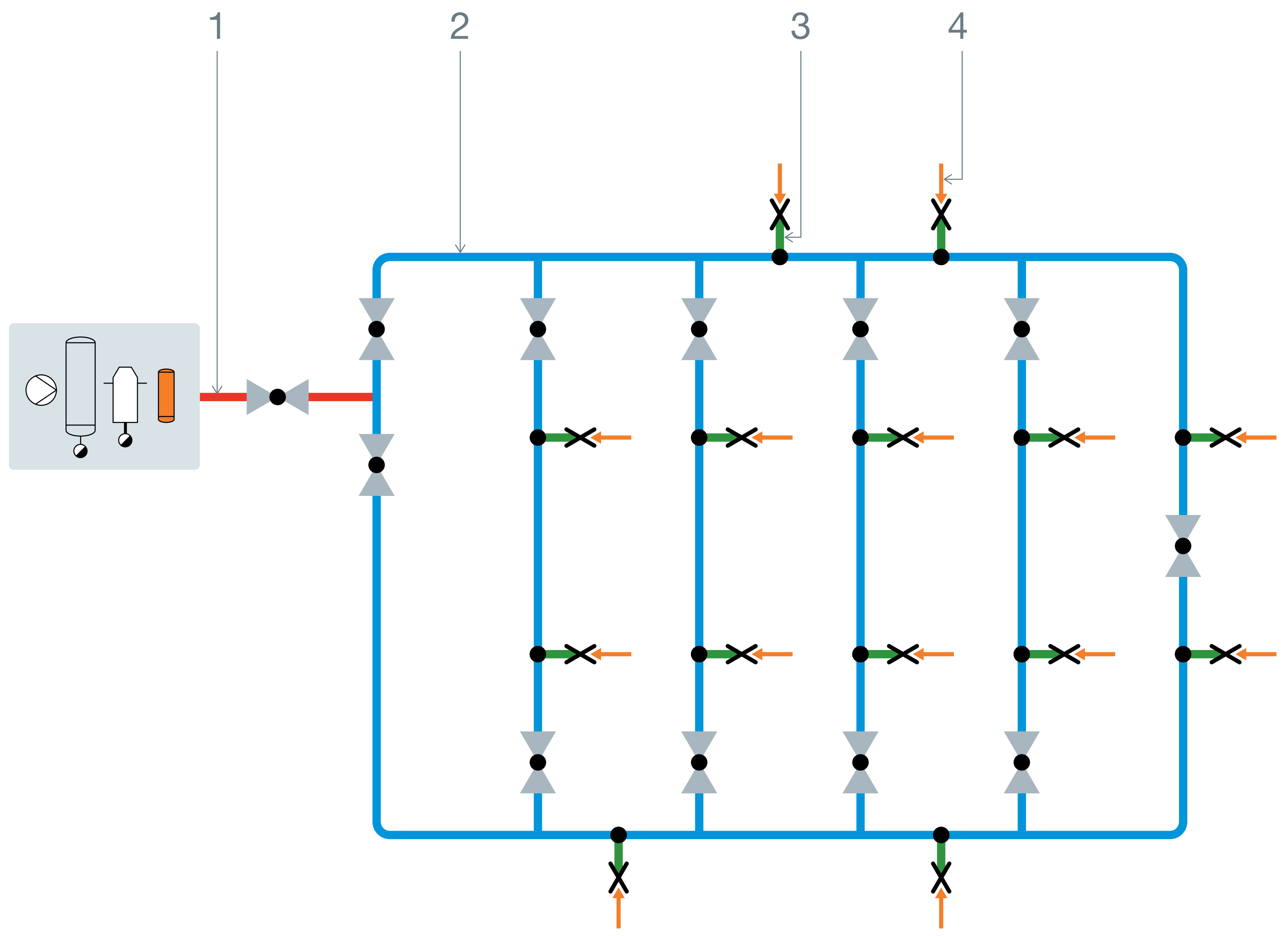
When planning the compressed air distribution installation, the following fundamental points should be discussed:

- Given the size of the compressed air distribution installation, would it be more streamlined to have several separate feed-in points for the compressed air? If the answer is yes, is it structurally possible to have two compressor stations? Tip: If a central compressed air processing unit is connected downstream of each compressor station, this generally results in lower pressure losses than having pressure reducers with condensate traps at each consumer.
- Should decentralised compressed air tanks be incorporated into the system? This could allow the installation as a whole to be operated more energy-efficiently at a lower pressure if only a few individual consumers require a high operating pressure.
- Is it possible to use a ring system for distribution or is it necessary to use long single supply lines to connect the consumers or machines?

From the point of view of energy efficiency and security of supply, a compressed air installation that uses a ring system is preferable. The piping section from the supply line to each consumer is shorter in this architecture and therefore associated with lower pressure loss. What's more, individual sections can be selectively closed off for maintenance and repair work. In the tree structure of single supply lines, the closer the shut-off is to the compressor station, the greater the number of consumers to be disconnected from the network.

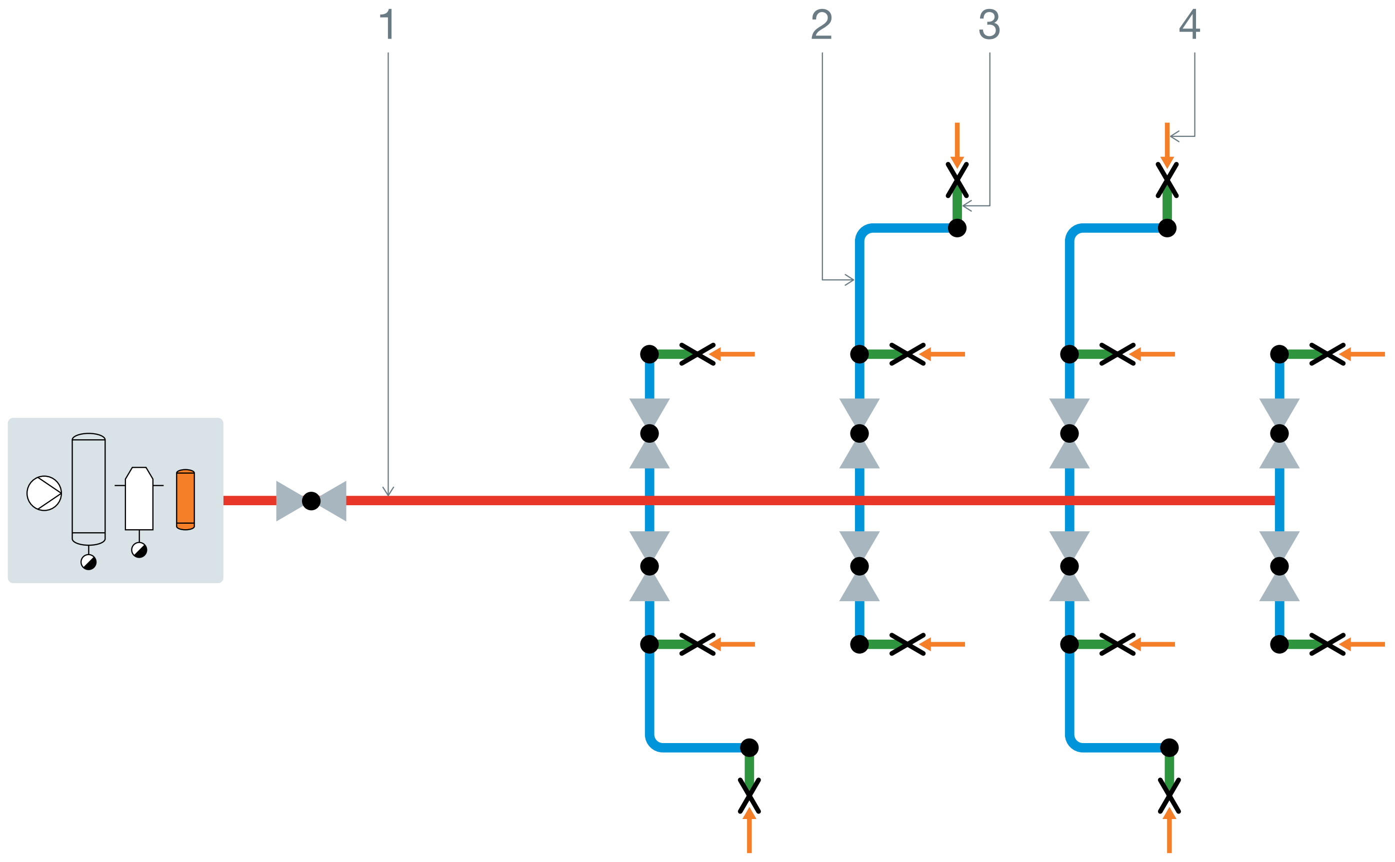
ARCHITECTURAL PRINCIPLE OF COMPRESSED AIR DISTRIBUTION INSTALLATIONS

Compressed air supply with ring system



1 Supply line
2 Ring system
3 Connection line
4 Connection point

Compressed air supply with single supply line



1 Supply line
2 Single supply line
3 Connection line
4 Connection point

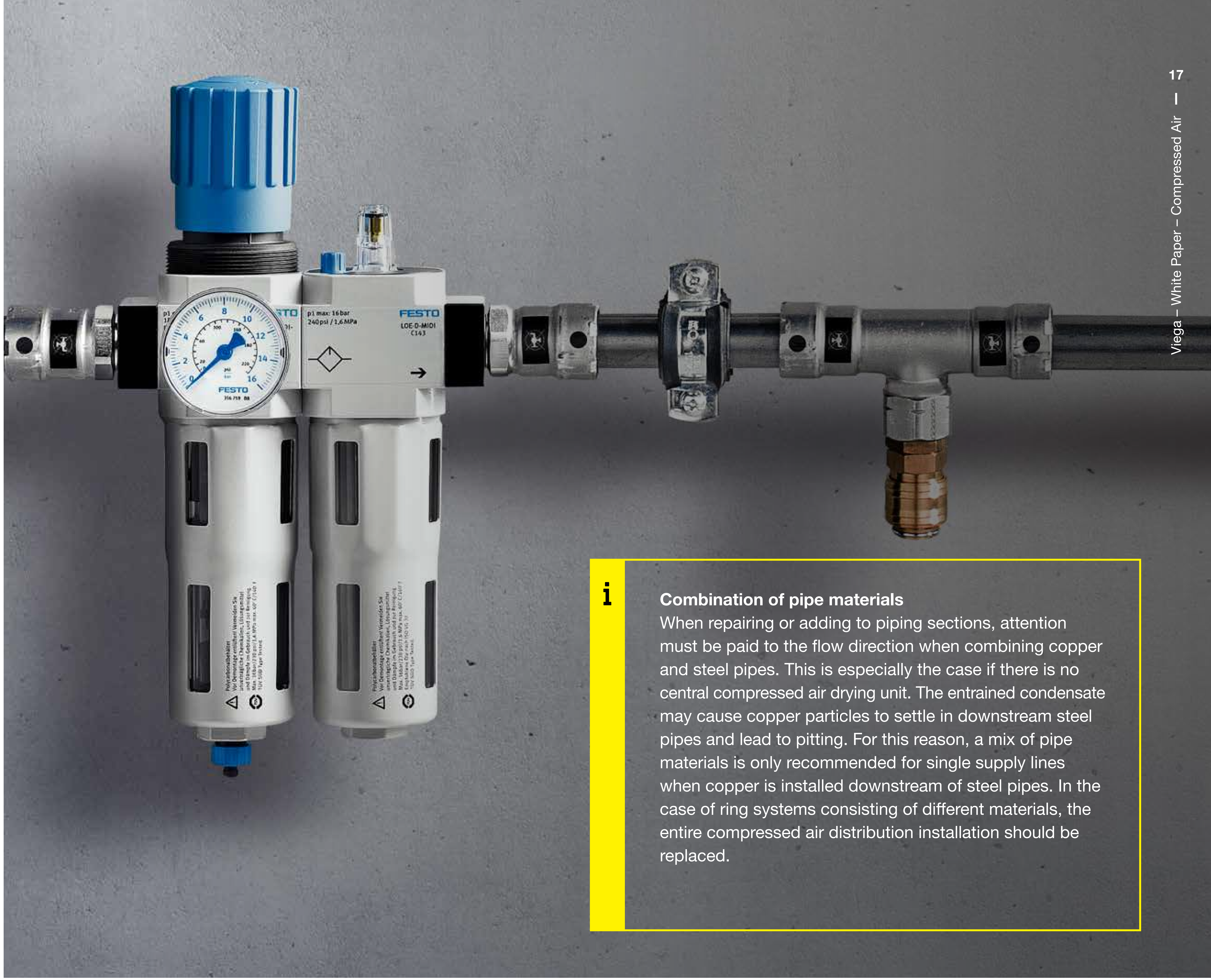
Limiting losses effectively

Condition of the piping system

The quality of the piping system can be assessed in the following respects:

- **Pipe material**
  Is the material resistant to mechanical and chemical stresses and to corrosion?
- **Connectors**
  Do they exhibit minimal flow resistance and a high level of leak tightness over a long lifecycle?
- **Connection technology**
  What is the constructional design like? Does it also make the piping system easy to handle – even in the case of repairs and extensions during operation?

The pipe material
The mechanical and chemical resistance of metallic compressed air piping is significantly greater than that of plastic piping. Parameters such as the maximum permissible operating pressure also remain largely unaffected by external and internal temperatures in metal pipes. Therefore, compressed air distribution systems made of galvanised steel pipe or, after compressed air drying, of thick-walled steel pipe are usually installed. Corrosion-resistant stainless steel pipes are the preferred choice for piping sections with higher condensate accumulation. That said, copper lines are also conceivable and feasible.



Combination of pipe materials
When repairing or adding to piping sections, attention must be paid to the flow direction when combining copper and steel pipes. This is especially the case if there is no central compressed air drying unit. The entrained condensate may cause copper particles to settle in downstream steel pipes and lead to pitting. For this reason, a mix of pipe materials is only recommended for single supply lines when copper is installed downstream of steel pipes. In the case of ring systems consisting of different materials, the entire compressed air distribution installation should be replaced.

The connectors

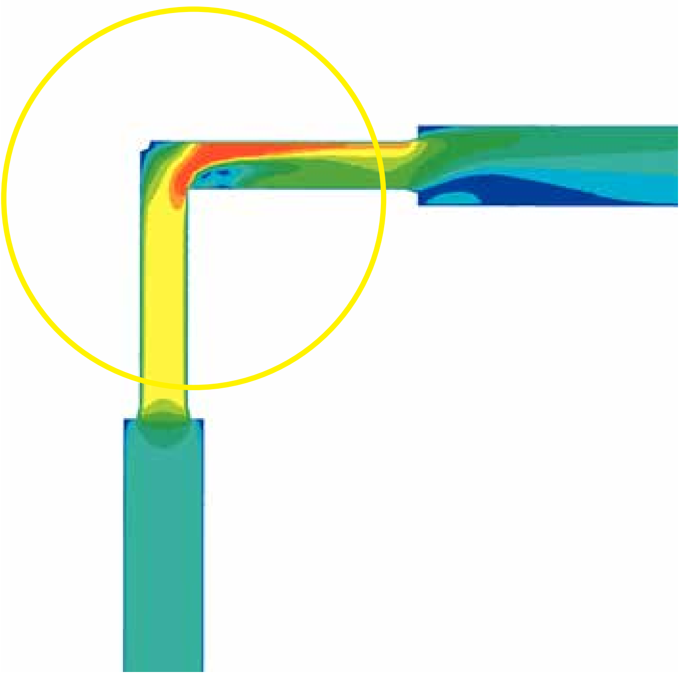
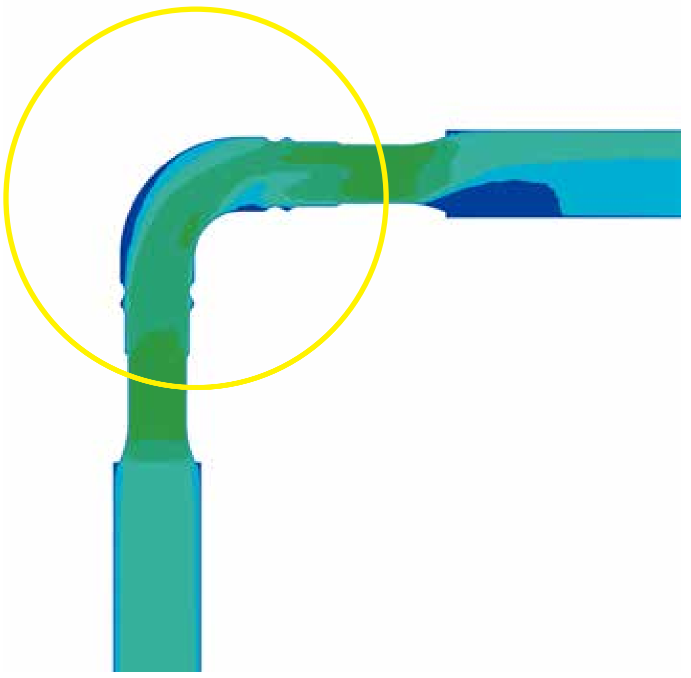
The flow characteristics of connectors differ greatly due to their respective design. For this reason, during the planning stage, flow-impaired moulded pieces such as T-pieces and angle pieces should be avoided as far as possible, opting for elbows with large radii instead. To increase the range of compressed air distribution installations while keeping compressed air losses within the aforementioned economic limits, unnecessary redirections – for example to bypass a ceiling lintel or a hall column – should also be eliminated during the pipeline routing process.

The connection technology

Regardless of the pipe material, the connection technology plays a central role in the susceptibility to leakage. Furthermore, the quality of mechanical handling often determines how tightly the connection has been made. For instance, skilled workers are required for all welded and soldered connections. Threaded and flange connections, on the other hand, must be sealed with particular care. All these procedures also have a significant time requirement in common. Therefore, in recent decades, press connection technology has also become increasingly popular for piping installation in industrial applications. This is available for all pipe materials up to a nominal width of DN 100.

> # Up to DN 100
> **possible with press connections**

CONSTRUCTIVE FLOW PROPERTIES OF CONNECTORS

Flow-impaired elbow	Flow-optimised 90° elbow
	

PROPERTIES OF CONNECTION TECHNOLOGY FOR COMPRESSED AIR SYSTEMS

	Pressure loss	Time requirement (work preparation, post-processing & creating the connection)
Threaded connectors	High ↗	High ↗
Flange connections	Low ↘	High ↗
Welded connections	Low ↘	Very high ↑
Soldered connections	Low ↘	High ↗
Press connections	Low ↘	Very low ↓

In terms of handling, press connection technology is generally superior to other types of connection, although differences between the systems must also be taken into account. Learning how to use the relevant press tools is quick and easy and does not require any additional qualification as is the case with welding. The benefits of press connection technology are particularly evident when installation work needs to be carried out during operation (system extension or repairs). Fire protection precautions right through to operation downtime, as are required for welding, are no longer necessary. It is also much easier to carry out work at height, overhead and in hard-to-reach places using press machines and, for example, press rings or press slings than it is to carry out mirror welding or soldering. Up to 80 percent less time is required for this technique, which is another reason why press connection technology has become so popular: the pressing process itself lasts only a few seconds.

Up to 80%

less time required due to press connections

This simple and reliable press connection technology is also ideal because compressed air distribution installations often need to be extended and adapted during operation.

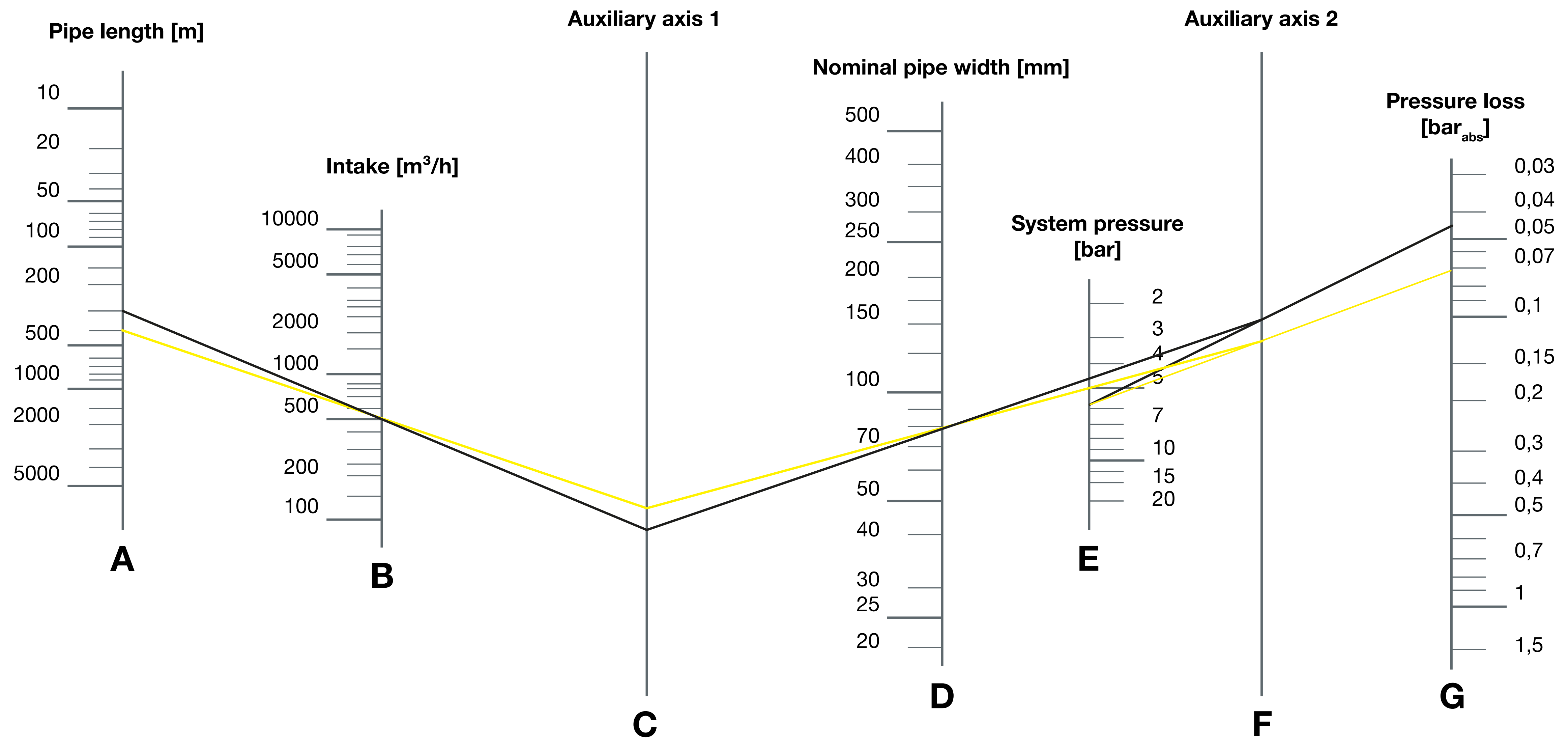
The preparatory work is limited to deburring the metal pipe with a special tool and marking the insertion depth.

Importance of selecting the right press connectors – a calculation example

Irrespective of these basic performance characteristics of press connection technology, the manufacturer's information on the flow characteristics of the relevant connector should also be checked. This is because there can be major differences in this regard depending on the press connector system selected, which later translate into considerable pressure losses in the overall system – i.e. increased expenses for pressure generation. The following example shows how much of a difference this makes:

A compressed air installation with a pipe length of 300 metres is operated with a compressed air volume of 500 m^3/h and a nominal pipe width of 80 millimetres at 6 bar. Two different cases are considered. Case A: Connectors with low zeta values are used. Case B: Connectors with high zeta values are used. In case A, the equivalent pipe length is 400 metres due to the positive zeta values. Using the diagram below, this results in a pressure loss of 0.045 bar. In case B, the equivalent pipe length is 450 metres on account of the poor zeta values. This results in a pressure loss of 0.06 bar. Consequently, the pressure loss in this case is more than 30 percent higher than in the more favourable case A, all other conditions being equal. The pressure loss must be offset by a higher compressor output (see diagram).

EXAMPLE CALCULATION FOR PRESSURE LOSSES IN TWO DIFFERENT PIPING SYSTEMS



Source: Adapted from Nils Wolf 2019, www.technikdoku.com

Realising savings

SELECTIVE MAINTENANCE TO **PRESERVE EFFICIENCY**

Since up to 80 percent of the lifecycle costs of a compressed air installation are attributable to power consumption, the maintenance carried out on a compressed air system is of particular importance. Considerable savings can be achieved with the following measures:

- Systematic monitoring for early detection and elimination of leaks
- Adjustment of piping dimensions in established compressed air installations to achieve a sufficient volumetric flow at an appropriate flow velocity
- Operating pressure set as required and not excessively high across the board
- Optimised compressed air requirement for the connected machines and tools

EXAMPLES OF SAVINGS THROUGH MAINTENANCE AND OPTIMISATION OF COMPRESSED AIR DISTRIBUTION SYSTEMS

Operating conditions	Optimisation	Energy saving*	Cost saving**
6 bars of operating pressure	Leak eliminated, hole diameter 3	3.1 kWh	€4,964 p.a.
12 bars of operating pressure	Leak eliminated, hole diameter 3	12.5 kWh	€20,015 p.a.
50 mm pipe internal diameter	Redimensioned to 90 mm	52 kWh	€83,263 p.a.
	Operating pressure reduced by 1 bar	6 to 10%	
	Demand-based dimensioning of pneumatic drives^3	Approx. 40%	

* 4,000 operating hours per year
** 40.03 cents/kWh (last updated 07/2020)

Continuous optimisation of compressed air distribution systems should have the goal of keeping the system pressure as low as possible. The necessary operating pressure of each consumer must be taken into account. An undersupply leads to productivity losses, an oversupply increases compressed air costs. The rule of thumb is to set the feed of the compressor station at a maximum of 1.0 bar above the required flow pressure of the consumers in order to compensate for pressure losses in the distribution system (see the appendix for the definition of “flow pressure”). More significant pressure losses are economically intolerable and should be mitigated by re-dimensioning the piping network.

Compressed air losses due to leaks must be limited to a maximum of 10 percent. Installing pressure and flow meters in the piping network and monitoring them will provide initial indications. Furthermore, it is recommended that machines and tools are inspected regularly for leaks. This task can also be assigned to external service providers – a service that usually pays off in the short term through energy savings and does not tie up internal capacity or make it necessary to purchase the measuring devices required.

Checking the compressed air quality is also part of the regular maintenance intervals for the compressed air system. If the purity class required by the machine and tool manufacturers pursuant to ISO 8573-1 is not met, this will result in malfunctions at first and then possibly in operational failures. In addition, high pressure losses and, consequently, high compressed air costs are caused by a high degree of filter contamination. This applies both to intake filters on the compressor and to any compressed air filters. The inspection intervals of each filter are to be determined empirically in line with the respective operating conditions.

The following VDMA Technical Regulations contain further information on the development of a company-specific maintenance plan:

- VDMA 15391-1:2020-05; Safe and economical compressed air distribution – Part 1: Planning and new construction
- VDMA 15392:2017-09; Typical requirements for service work on a compressed air system
- VDMA 4370:2012-11; Energy-efficient compressed air systems – Guidelines for identifying and evaluating existing vulnerabilities and correctly identifying the potential for energy savings

No matter if it is process air, control air or (as in this case) blast air, optimised systems play a significant role in saving energy

CONCLUSION

30%

of compressed air lost due to avoidable leaks

8%

energy saving through precise dimensioning of pipelines

Up to 40%

saving from pneumatic systems designed to meet demand

High potential for energy savings: Compressed air is expensive. This makes it all the more important to optimise compressed air distribution systems and make savings in various ways.

Compressed air is costly, but indispensable for operational reasons. This is because in the manufacturing industry in particular, only a small proportion can be replaced by electric drives in a cost-effective manner. As a result, the supply of compressed air is usually seen as an unavoidable cost factor – but it does offer a lot of savings potential. It is estimated, for example, that 80 percent of compressed air systems have leaks, causing up to 30 percent of the compressed air to be lost. This needs to be avoided or rectified. Precise dimensioning of the pipeline systems, which should also be designed to optimise flow, offers a further opportunity to improve efficiency, in this case by an average of 8 percent. By designing pneumatic systems in a demand-based manner, further energy savings of up to 40 percent can be achieved.[3]

The huge opportunities for cost reduction associated with refurbishing and modernising compressed air distribution installations can be tapped with easy-to-install piping systems, even during day-to-day operations. Press connection technology offers many economic and technical benefits for compressed air systems.

APPENDIX

Term	Unit	Explanation
Operating pressure	bar or Pa	Manufacturer's information on the specific pressure required for the machine or tool to operate or reach the expected performance level.
Pressure drop	bar or Pa	Difference to the pressure generated by the compressor caused by leaks, flow resistance or compressed air consumption.
Compressed air requirement	m^3/h	Specific air volume required by a compressed air consumer per hour for correct operation.
Compressed air loss	bar or Pa	Pressure lost on the way from the compressor to the consumer due to leaks.
Pressure loss	bar or Pa	Pressure lost on the way from the compressor to the consumer due to unavoidable losses despite the pipelines being optimally dimensioned. This is caused, among other things, by flow resistance. The pressure loss in the entire compressed air distribution installation should be a maximum of 1 bar. To ensure that the flow pressure in the installation corresponds to the operating pressure of the consumers, the pressure loss must be offset by a correspondingly higher system pressure (6 bar operating pressure + 1 bar pressure loss = 7 bar system pressure downstream of the compressor).

Term	Unit	Explanation
Flow pressure	bar or Pa	Pressure actually applied to the compressed air consumer when it is operational. The flow pressure can be significantly lower than the static operating pressure set on the compressed-air service unit, because the flow resistances are only effective when the compressed air is flowing.
Air volume	m^3	Air volume that is compressed by the compressor, is distributed via the piping and in total corresponds to the compressed air requirement of all consumers.
Flow velocity	m/s	Speed at which the air volume flows through the piping. The smaller the nominal pipe diameter, the higher the flow velocity and consequently the pressure loss.
Flow resistance		Resistance that the compressed air has to overcome on its way to each consumer. This resistance generates pressure losses and is caused by friction on the inner pipe walls, small pipe dimensions, bottlenecks in connectors and fittings, redirections, etc. Therefore, from a fluidic point of view, ensuring short distances to the consumer by means of ring systems with as few connectors as possible is the most favourable solution.

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5 VDMA 15391-1:2020-05; Safe and economical compressed air distribution – Part 1: Planning and new construction.

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Documents

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Planungswissen-Industrietechnik | viega.de

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All references to persons apply to all genders.

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