Self-acting Control Valves – Guarantor of Safety in Plant and Machinery Operation

Industrial valves are vital components of plants and machines in that they perform necessary regulating and control tasks. When plants are planned and designed, their various elements are not considered in complete isolation from one another, but are instead selected to complement each other in their intended purpose. Therefore, the optimal valve selection is particularly important.

Self-acting control valves have special advantages with regards to the smooth interaction of all plant components. Industrial valves without external energy supply are predominantly a guarantor of safety. A power failure, for example, has no impact on their function. The centuries-proven functional principle of control valves without an external energy supply also stands for the quick response behaviour of this valve type. In addition, low assembly and maintenance costs as well as the long operational lifespan of the valves, if properly selected, offer greater cost advantages in plant operation.

The following pages will give you an overview of the different fields of application as well as the differences in architecture and functionality of self-acting regulating valves. Our engineers, technicians and sales staff are ready to assist you in finding the optimal solution for your application. Please contact us!

Aspect No. 1 - Safety
- Proper functioning, even in the event of a power failure
- Proven functionality based on more than one hundred years of experience
- No risk regarding to maloperation
- Quick response behaviour of self-acting control valves
- Insusceptibility to computer viruses

Aspect No. 2 - Cost Benefits
- Low assembly and maintenance costs
- No external energy supply required
- Long operational lifespan with the proper selection of the valve

Aspect No. 3 – Assembly and Operation
- Easy installation of the valves
- Low net weight and compact design
- Valves can be operated even with poor infrastructure
- No cabling/networking or updates required
- Particularly sturdy and maintenance-friendly

Aspect No. 4 – Sustainability
- Resource-saving thanks to independence from external energy
- Long operational lifespan with the proper selection of the valve
- Recyclability of the used materials
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"Please give me every opportunity to think and work for you!"
Gustav Mankenberg, (1858-1945)
Comparing spring-operated Pressure Control Valves and their Tasks

**Pressure Reducing Valves**
Outlet pressure control valve – reduce a higher, often fluctuating pressure to a constant and adjustable pressure downstream of the valve.

**Back Pressure Regulator Valves**
Inlet pressure control valve – limit/build up an adjustable constant pressure upstream of the valve.

**Vacuum Breakers**
Vacuum limitation within pipelines, vessels, machines as well as vacuum systems.

**Pressure Surge Relief Valves**
Reduction of dynamic pressure surges within the pipeline system.
Flow Controllers
Limiting the flow independently from the inlet or outlet pressure without additional measuring and analysis equipment.

Differential Pressure Regulators
Regulate a pressure depending on a second varying pressure without external measurement sensors.

Vacuum Control Valves
Regulate a negative pressure in pipelines, vessels and similar plants.

Pilot-operated Control Valves
Their task depends on the selection of the pilot valve. All the tasks already described in the previous and/or following product sub-groups (pressure reducing valves, back pressure regulators, flow controllers ...) can be performed. Thus it is also possible to build a regulating valve with several functions/pilot valves.

Safety Valves
Emergency valves: if the max. permissible system pressure is exceeded, the excess medium is discharged.
Pressure Reducing Valves

Task
Outlet pressure control valves – reduce a higher, often varying inlet pressure to a constant adjustable pressure downstream of the valve.

Function
A spring (optionally a gas spring or weight) keeps the valve open, the outlet pressure acts through the control element (diaphragm, piston or bellows) onto the cone and, in the event of rising outlet pressure, proportionally closes the valve. The pressure to be controlled can be adjusted by a pre-tensioned/relieved spring through an adjusting screw.

Significant Applications – Special Features
Inert gas tank blanketing – precise millibar regulation also at high flow rates | steam management – very high pressures at high temperatures | hygiene applications – annealed surfaces and in conformity with the corresponding rules and regulations | component of machines – independently operating for any pressure level and medium, compact and universally applicable | process determining plant component – pressure management of media with special requirements

Field of Application
Protects all the devices, valves and installations situated downstream from excessive pressure build-up | simultaneously the consumption is reduced and the flow velocity and noise are minimised

Important Note
For toxic or hazardous media a closed spring cap with leakage line connection and adjusting screw seal must be provided | in the event of widely varying inlet pressures select a control valve with balanced seat

DN  15 - 400   PN  1 - 315   G   ½ - 2
\[p_2\]  0.002 - 160 bar   T  130 - 500 °C   \[K_{Ny}\]  0.2 - 1,200 m³/h

Installation Diagram

Application Diagram

Medium
Liquids | Gases | Steam

Advantage
Adjustable – customisable to meet new operating conditions | suitable control surface – precise regulation | independent from external energy – always functions | very quick reaction - makes your plant safer

Design Data required for Specification
1. Medium | 2. Temperature (°C) | 3. Flow rate (m³/h, Nm³/h, kg/h) | 4. Inlet pressure (bar) | 5. Outlet pressure (bar) to be controlled
Pressure Reducing Valve DM 652

1. inlet pressure up to 250 bar
2. CrNiMo steel (316L), deep-drawn, corrosion-resistant, lightweight and compact
3. Various connection alternatives: DIN-, ANSI-, JIS or aseptic flanges, welded ends and many more...
4. Mankenberg clamp system easy-to-maintain
5. Standard surface of the body Ra ≤ 1.6 μm easy-to-clean
6. Leakage line connection and adjusting screw seal (option) can be used for combustible and hazardous media in compliance with the UVV regulations
7. Adjusting screw as a function of display (option) non-varying installation height, function externally visible

- Inlet Pressure
- Outlet Pressure
- Control Pressure

Long operational lifespan, manageable installation, minimum space required, low delta-ferrite content possible

No adapters or fitting pieces required

Easy-to-clean
The diagrams show examples and must be verified in each individual case!

**Back Pressure Regulator Valves**

**Task**

Inlet pressure control valves – limit/build up a constant adjustable pressure upstream of the valve.

**Function**

A spring (optionally a gas spring or weight) keeps the valve closed, the inlet pressure exerts a force on the cone through the control element (diaphragm, piston or bellows) and, in the event of rising inlet pressure, proportionally opens the valve. The pressure to be controlled can be set by a pre-tensioned/relieved spring through an adjusting screw.

**Significant Applications – Special Features**

Inert gas tank blanketing – precise millibar regulation even with high flow rates | component of machines – independently operating for any pressure level and medium, compact and universally applicable | pressure management of media with special requirements

**Field of Application**

Protects upstream-located devices and installations from excessive or low pressure

**Important Note**

Provide a closed spring cap with leakage line connection and adjusting screw seal for toxic/hazardous media

<table>
<thead>
<tr>
<th>DN</th>
<th>15 - 400</th>
<th>PN</th>
<th>1 - 250</th>
<th>G</th>
<th>½ - 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>p₁</td>
<td>0.002 - 200 bar</td>
<td>T</td>
<td>130 - 400 °C</td>
<td>Kₜₕ</td>
<td>0.2 - 1,200 m³/h</td>
</tr>
</tbody>
</table>

**Installation Diagram**

1. Strainer (FI 6.01) | 5. Pressure gauge
2. Shut-off valves | 6. Leakage line
3. Back pressure regulator (UV 3.8) | 7. Pump
4. Safety valve (SV 29V) |

**Application Diagram**

<table>
<thead>
<tr>
<th>Medium</th>
<th>Place of Installation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Liquids</td>
<td>Main line, bypass or directly onto the machine</td>
</tr>
<tr>
<td>Gases</td>
<td></td>
</tr>
<tr>
<td>Steam</td>
<td></td>
</tr>
</tbody>
</table>

**Advantage**

Adjustable – customisable to meet new operating conditions | suitable control surface – precise regulation | independent from external energy – always functions | very quick reaction - makes your plant safer | less vulnerable to wear and tear than safety valves

**Design Data required for Specification**

1. Medium | 2. Temperature (°C) | 3. Flow rate (m³/h, Nm³/h, kg/h) | 4. Inlet pressure (bar) to be controlled | 5. Outlet pressure (bar)
CrNiMo steel (316L), deep-drawn, corrosion-resistant, lightweight and compact

long operational lifespan, manageable installation, minimum space required, low delta-ferrite content possible

leakage line connection and adjusting screw seal (option)
can be used for combustible and hazardous media in compliance with the German BGV rules

Mankenberg clamp system

easy-to-maintain

internal surface quality up to Ra ≤ 0.25 μm

easy-to-clean

as angle valve virtually pocket-free
also suitable for highly viscous media

Inlet Pressure
Oute Pressure

minimum weight
minimal heat losses for CIP / SIP applications

adjusting screw as a function of display (option)
non-varying installation height, function externally visible

various connection alternatives: DIN-, ANSI-, or aseptic flanges, welded ends ...
no adapters or fitting pieces required

Back Pressure Regulator UV 3.8
Pilot-operated Control Valves

Task
Pilot-operated control valves – their task depends on the selection of the pilot valve. All the tasks outlined in the previous and following product groups (pressure reducing valves, back pressure regulators, flow controllers ...) can be realised. Thus, it is also possible to build a control valve with several functions/pilot valves.

Function
The valve consists of a pilot valve and a main valve. The main valve cone is actuated through the pilot valve and caused to close or open. The pressure to be controlled can be adjusted by pre-tensioning/relieving the spring through an adjusting screw. Opening and closing velocities can be adjusted through the throttle unit.

Significant Applications – Special Features
System pressure management in pipeline systems – a compact valve in relation to the high flow rate (inline version) | large treatment plants for any kind of fluids (from potable water through to alkaline solutions or acids, from petrol through to naphta or oil) – thanks to a variety of materials (for example high-quality stainless steel), it can be used also for corrosive and hazardous media

Field of Application
Similar to pressure reducing valves and/or back pressure regulators, but for large flow rates, high reduction ratios and in case very small control deviations are required

Important Note
Provide a closed spring cap, leakage line connection and adjusting screw seal for toxic/hazardous media | hydraulic dampers must be provided for gas applications to prevent the valves from vibrating | if several functions must be fulfilled, their sequence will have to be determined

<table>
<thead>
<tr>
<th>DN</th>
<th>50 - 800</th>
<th>PN</th>
<th>16 - 160</th>
<th>G</th>
<th>½ - 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>p₁ or p₂</td>
<td>2 - 40 bar</td>
<td>T</td>
<td>130 °C</td>
<td>Kᵥ₅</td>
<td>8 - 2,100 m³/h</td>
</tr>
</tbody>
</table>

Installation Diagram

Application Diagram

Medium
Liquids | Gases

Advantage
High precision control – enhances plant efficiency | adjustable opening and closing velocities – optimal control performance for your plant | different control tasks can be combined with one valve – saves space and investment costs

Design Data required for Specification
1. Medium | 2. Temperature (°C) | 3. Flow rate (m³/h, Nm³/h, kg/h) | 4. Inlet pressure (bar) | 5. Outlet pressure (bar) | 6. Control function

The diagrams show examples and must be verified in each individual case!
Pilot-operated Pressure Reducing Valve RP 814

1. can be used for high pressures possible up to PN160

2. replaceable pilot control flexibility of possible applications

3. pilot-operated high control precision, different control tasks for one valve

4. compact control unit minimum spare required

5. flow-optimised design allows high volume flows, reduced cavitation

6. various connection alternatives: DIN-, ANSI-, or JIS flanges ... no adapters or fitting pieces required
Flow Controllers

Task
Flow controllers – limit the flow independently from inlet pressure or outlet pressure without additional measuring and analysis equipment.

Function
The control valve keeps the differential pressure stable through an orifice. Constant differential pressure means constant volume flow, also in the event of pressure variations within the system. The pressure downstream of the orifice (smaller pressure) has an opening effect in combination with the spring. The pressure upstream of the orifice opposes the spring force. The pressure loss and the related volume flow is set via the spring. Consequently, a larger Delta P (tighten the spring) yields a higher volume flow.

Significant Applications – Special Features
Mobile fuel supply networks – purely mechanical system, operational without the need of auxiliary energy | limitation of heating steam quantity

Field of Application
Controls the quantity distribution in pipelines or systems with different consumers | thanks to the remote adjusting device, a use with variable flow quantities is also possible – consequently, the benefits of the medium-operated control valve are fully maintained

Important Note
Precisely specify the operating conditions | changes of temperature, density and medium must always be taken into consideration when the valve is selected.

<table>
<thead>
<tr>
<th>DN</th>
<th>15 - 150</th>
<th>PN</th>
<th>6 - 100</th>
<th>G</th>
<th>½ - 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>T</td>
<td>130 °C</td>
<td>K_v</td>
<td>0.2 - 160 m³/h</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Installation Diagram

Application Diagram

1. Strainer (FI 1.01)
2. Shut-off valves
3. Flow controller (MR 951)
4. Safety valve (SV 4)
5. Pressure gauge

Medium
Liquids, Gases, Steam

Place of Installation
Main line

Advantage
Independent from external auxiliary energy - use in remote areas, is operative as far as medium flows through the line | optionally with remote adjusting device – control is done from the control console

Design Data required for Specification
1. Medium | 2. Temperature (°C) | 3. Flow rate (m³/h) to be controlled | 4. Operating pressure (bar) | 5. Max. admissible differential pressure (bar)
Flow Controller

MR 951SO

precise quantity control without external energy
quantity control independent from pressure
various elastomers possible

internally piped
no external control line required
various pressure ranges
0.2 - 50 bar
Differential Pressure Regulating Valves

**Task**
Differential pressure regulating valve – regulates the pressure depending on a second, non-constant pressure without external measurement transducer.

**Function**
- **Based on a pressure reducing valve:** If the pipeline is depressurised, the valve is open and closes when the pre-set differential pressure is exceeded.
- **Based on a back pressure regulator:** If the pipeline is depressurised, the valve is closed and opens when the pre-set differential pressure is exceeded.

The desired differential pressure can be set by pre-tensioning/relieving the spring through an adjusting screw.

**Significant Applications – Special Features**
On machines for gas or lub oil blanketing for shaft sealing – independently operating, compact system
- for gas treatment or inertisation plants - suitable for all media, there are solutions for any pressure range

**Field of Application**
- Supply = basis: pressure reducing valve
- Protection = basis: back pressure regulator
- Supply lines with counter-pressure fluctuations

**Important Note**
A precise design taking into account the exact volume flows and pressures is essential
- function should be clarified with the Mankenberg expert

<table>
<thead>
<tr>
<th>DN</th>
<th>PN</th>
<th>G</th>
<th>KVs</th>
</tr>
</thead>
<tbody>
<tr>
<td>15 - 150</td>
<td>1 - 160</td>
<td>½ - 2</td>
<td>0.2 - 160 m³/h</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Δp</th>
<th>T</th>
<th>KVs</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.01 - 25 bar</td>
<td>130 °C</td>
<td>0.2 - 160 m³/h</td>
</tr>
</tbody>
</table>

**Medium**
- Liquids
- Gases
- Steam

**Place of Installation**
Main line, bypass

**Advantage**
- Adjustable - adaptable to new operating conditions
- Matching control surface – precise regulation
- Independent from external energy – is always operative
- Very fast reaction – makes your plant safer

**Design Data required for Specification**
1. Medium
2. Temperature (°C)
3. Flow rate (m³/h, Nm³/h, kg/h)
4. Differential pressure (bar) to be controlled
5. Inlet pressure (bar)
6. Outlet pressure (bar)
7. Control pressure (bar)
8. Rising differential pressure opens/closes (bar)
In principle, any balanced pressure regulating valve may serve as differential pressure, vacuum or flow control valve. The special advantages of these valves are obvious: to a large extent, they can be adapted to any procedural requirement and process. Flow control and differential pressure valves are suitable for all media, all pressures and any required volume flow. In addition, the valves are self-acting. They operate independently from external energy sources and are thus particularly safe in function.

- Can be specifically adapted to all special needs
- Can be used for all media
- Suitable for any kind of pressure (normal compressor pressure, millibar and high pressure ranges)
- Any requested flow rate can be designed

**Differential Pressure Regulating Valve**

Inlet Pressure $p_1$
Outlet Pressure $p_2$
Control Pressure $p_{st+}$
Control Pressure $p_{st-}$
**Vacuum Control Valves**

**Task**
Vacuum control valve – controls the negative pressure in pipelines, vessels and similar plants.

**Function**

Based on a **pressure reducing valve**: The outlet pressure to be controlled (negative pressure) acts on the control diaphragm through the control line connection in the spring cap and is in balance with the spring force. In pressureless condition, the valve is open and closes once the pre-set outlet pressure (negative pressure) has been reached. If the differential pressure in relation to the atmospheric pressure is reduced, the valve opens.

Based on a **back pressure regulating valve**: The outlet pressure (negative pressure) to be controlled acts on the control diaphragm through the control line connection in the spring cap and is in balance with the spring force. In pressureless condition, the valve is closed and opens once the pre-set outlet pressure (negative pressure) has been reached. If the differential pressure in relation to the atmospheric pressure is reduced, the valve closes.

**Significant Applications – Special Features**
Vacuum system control in the chemical and foodstuff industries

**Field of Application**

Based on a back pressure regulating valve (UV): serves for limitation of a vacuum (protection) | based on a pressure reducing valve (DM): serves for maintaining a vacuum (supply)

<table>
<thead>
<tr>
<th>DN</th>
<th>15 - 150</th>
<th>PN</th>
<th>1 - 16</th>
<th>G</th>
<th>½ - 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>$p_2$</td>
<td>0.002 - 1 bar abs.</td>
<td>T</td>
<td>130 °C</td>
<td>$K_{y5}$</td>
<td>0.2 - 160 m³/h</td>
</tr>
</tbody>
</table>

**Important Note**
A precise design taking into account the exact volume flows (caution with gases) and pressures is imperative | function should be clarified with the Mankenberg expert

**Design Data required for Specification**
1. Medium | 2. Temperature (°C) | 3. Flow rate (Nm³/h) | 4. Inlet pressure (bar) | 5. Outlet pressure (bar) | 8. Reduced outlet pressure causes opening / closure

**Medium**
Liquids | Gases | Steam

**Place of Installation**
Main line, bypass

**Advantage**
Adjustable - adaptable to new operating conditions | matching control surface – precise regulation | independent from external energy – low cradle-to-grave costs | very fast reaction – makes your plant safer | energy-efficient control of vacuum systems – reduces your operating costs
Vacuum Control Valve VV 5.1

CrNiMo steel (316L), deep-drawn, corrosion-resistant, lightweight and compact

- long operational lifespan, manageable installation, minimum space required, low delta-ferrite content possible
- various connection alternatives: DIN-, ANSI-, or aseptic flanges, welded ends ...
- no adapters or fitting pieces required

- many control modules available
- very precise regulation, also for millibar ranges
- adjusting screw as a function of display (option)
- non-varying installation height, function externally visible

- standard body surface quality
  \[ Ra \leq 1.6 \mu m \]
  easy-to-clean

- Mankenberg clamp system
  easy-to-maintain
**Vacuum Breakers**

**Task**
Vacuum breaker – limits the negative pressure in pipelines, vessels, machines as well as vacuum.

**Function**
The valve is kept closed through the pre-tensioned spring and the internal pressure acting on the cone. If the internal pressure falls below the response pressure, the atmospheric pressure causes the valve to open and air flows in.

**Significant Applications – Special Features**
System protection from vacuum | support of processes controlled by pumps

**Field of Application**
Protection of vessels, pipelines or systems from vacuum

**Important Note**
This is not a control valve but a vacuum relief valve

**Design Data required for Specification**
1. Medium | 2. Temperature (°C) | 3. Flow rate (Nm³/h) | 4. Response pressure (bar / differential pressure in relation to atmosphere)

**Medium**
- Liquids
- Gases
- Steam

**Place of Installation**
Dome on pipelines or vessels

**Advantage**
Simple (and consequently safe) possibility to protect the process (the system) from a vacuum. Thus investment costs are reduced (no vacuum-tight design required) | also serves as vacuum relief valve

---

**Installation Diagram**

**Application Diagram**

1 Vessel
2 Shut-off valves
3 Vacuum breaker (VV 34)
Vacuum Breaker with Setting Scale and Protective Cage

1. Differential pressure in relation to atmosphere can be manually set
2. Suitable for high pressures
3. Available in special materials also suitable for extreme requirements
4. NACE-compatible supply possible
5. Various connection alternatives: DIN-, ANSI-, or aseptic flanges, welded ends ...
   no adapters or fitting pieces required

Option

- Protective cage avoids unintended intrusion of foreign particles or sea birds

Atmosphere
Pressure Surge Relief Valves

**Task**
Pressure surge relief valves – decay of dynamic pressure peaks in the pipeline system.

**Function**
When the set pressure is reached, the valve opens extremely fast in order to discharge the medium out of the system. Then it closes slowly in a controlled way in order to prevent the generation of a new pressure surge.

**Significant Applications – Special Features**
Self-acting for extreme flow rates | straightway valve with optimised design with very low flow losses | direct acting or pilot-operated | short response times | suitable for all liquids | valve made of welded steel, CrNiMo steel or special stainless steel | can be designed for any application, any problem with regards to pressure relief can be solved | different designs for vertical or horizontal installation

**Field of Application**
Protection of pipelines and systems from pressure surges

**Important Note**
Requires a thorough analysis of the pressure surges in the system to be protected and a close co-operation with Mankenberg

<table>
<thead>
<tr>
<th>DN</th>
<th>80 - 400</th>
<th>PN</th>
<th>16 - 160</th>
</tr>
</thead>
<tbody>
<tr>
<td>$p_1$</td>
<td>max 160 bar</td>
<td>$T$</td>
<td>130 °C</td>
</tr>
<tr>
<td>$K_{ys}$</td>
<td>120 - 2,400 m³/h</td>
<td></td>
<td></td>
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</tbody>
</table>

**Medium**
Liquids

**Advantage**
Is always operative everywhere | prevents costly damage to the plant or to the environment

**Design Data required for Specification**
1. Medium | 2. Temperature (°C) | 3. Flow rate (m³/h) | 4. Nominal width of the pipeline (DN) | 5. Operating pressure (bar)

**Place of Installation**
Bypass

The diagrams show examples and must be verified in each individual case!
Pressure Surge Relief Valve SR 6.2

1. Straightway valve with CFD-optimised design
   - Very low flow losses

2. Valve in welded construction
   - Low weight, adapted overall length, special materials and individual flange standards possible

3. MOD (Manual Opening Device)
   - Function control, bleeding, flushing, filling of the valve

4. Pilot system, pipework, operating elements made of CrNiMo steel
   - Corrosion resistant

5. Pilot control, set pressure may be adjusted
   - Optimal response behaviour, closing time and response pressure can be adjusted

Inlet Pressure | Outlet Pressure

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Safety Valves

Task
Safety valve – emergency valves which drain the excess medium when the max. admissible pressure within the system is exceeded.

Function
A spring keeps the valve closed. The valve opens once the pre-set pressure has been reached.

Significant Applications – Special Features
There is nothing in process engineering which may not require the use of a safety valve | every problem has its solution

Field of Application
Protection against internal excess pressure | the laws and standards in effect normally determine the use of the safety valves

Important Note
Nonadjustable, small control surface | after a single response, the valve is no longer completely tight – repair required | as a general rule, regular inspections are set out by regulations and laws

<table>
<thead>
<tr>
<th>DN</th>
<th>15 - 150</th>
<th>PN</th>
<th>16 - 400</th>
<th>G</th>
<th>½ - 1 ½</th>
</tr>
</thead>
<tbody>
<tr>
<td>p₁</td>
<td>0.1 - 330 bar (g)</td>
<td>T</td>
<td>200 °C</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Medium
Liquids | Gases | Steam

Advantage
Required by law in plants, exclusively serves the purpose of providing protection against inadmissible excessive pressures

Design Data required for Specification
1. Medium | 2. Temperature (°C) | 3. Flow rate (m³/h, Nm³/h, kg/h) | 4. Operating pressure (bar) | 5. Response pressure (bar)

Place of Installation
Bypass

The diagrams show examples and must be verified in each individual case!
Safety Valve SV 4

- Different certificates and standards possible can be used worldwide
- Different materials and elastomers available

Drain hole (optional) complete draining of the valve is possible
Gas Spring Control

Options for Generating the Set Pressure at Pressure Control Valves

A mechanical spring or a pressurised gas spring and/or a pressurised gas cushion inside the so-called spring cap serve as setpoint adjuster for pressure control valves (for example pressure reducing valves, back pressure regulators or vacuum control valves).

In principle, setpoint adjusters feature two different modes of operation.

The purely mechanical adjustment

The set pressure is generated by the manual pre-tension of the spiral spring that is supported by the spring cap. The spring of a pressure reducing valve keeps the valve open, consequently, it closes with the rising back pressure. The pressure spring of a back pressure regulator, however, keeps the valve closed; it opens with the rising upstream pressure. A regulating valve with simple spring cap is especially suitable for plants where the set pressure need not be constantly changed.

The pneumatic remote control

In the gas spring cap, the set pressure is generated by the pressurised air acting on a diaphragm. An I/P converter regulates the control air pressure and, in return, receives its 4 - 20 mA signal directly from the process control system (PLS). The regulating device then controls a pressure which is equivalent to the control air pressure. For this purpose, the version with only one diaphragm is required.

To control pressures higher than the supplied control air pressure, a transformation ratio can be used. The transformation ratio results from the use of two diaphragms with differently sized so-called control surfaces. The advantages of the pneumatic control are the small control deviation, remote controllability and the possibility of using the superposition of the mechanical spring force and the pressurised gas spring.

Examples for Pressure Control Valves with Gas Spring Control:

- DM 152
- DM 462 /V
- DM 505
- DM 652
- DM 662
- UV 3.5
- UV 5.1
- UV 3.8

Simple gas spring cap with one diaphragm without transformation ratio

Gas spring cap with two diaphragms using the transformation ratio
Use of I/P Converters

All sorts of I/P converters transform the electrical input signal into a pneumatic output signal. In most cases the converter receives a direct current signal from 4 through 20 mA and, depending on the level of the pressurised gas (control air pressure), it sends a pneumatic signal in order to display different control ranges.

Benefits are:
» High accuracy
» Linear, continuous characteristics
» Direct acting, good dynamics, fast
» Well adapted for rapidly changing operating pressure conditions

Some I/P converters are provided with an internal logic in order that simple processes can also be displayed directly. An I/P converted control may also be superposed by the permanently set mechanical set point. This is commonly used in cyclical batch processes, where the pressure reducing valve can be remotely opened or closed, for example to allow flushing or cleaning with suitable media (steam or cleaning agents) without the need for manual adjustment.
Comparing Float-operated Control Valves and their Tasks

**Continuous Bleeding and Venting Valves**
Air supply and release to and from systems and vessels at full operating pressure

**Start-up Bleeding and Venting Valves**
Release of large air/gas quantities from systems or vessels at a small pressure difference

**Steam Trap**
Automatic discharge of arising condensate from steam or gases without heat loss

**Combined Bleeding and Venting Valve with Vacuum Valve**
A combination of an operating venting valve and a vacuum valve, release of small air/gas quantities in continuous operation; supply of large air quantities in the event of a vacuum

**Liquid Separator**
Automatic separation of liquids and condensate from gas and/or steam flows at operating pressure
Combined Bleeding and Venting Valve
A combination of a start-up and an operating venting valve suitable for start-up and continuous operation

Float Valves
Regulate the liquid level in a reservoir

Gas Separator
Automatic separation of gases from liquid flows at operating pressure
Start-up Bleeding and Venting Valves

Task
Bleeding and venting valve for start-up – Release of large air/gas quantities from systems or vessels at a small pressure difference

Function
The drain valve of the bleeding valve is operated by a float. When the plant is depressurised or empty, the valve is open. During the filling of the system, as the float rises with the liquid level, the drain valve is moved towards a closed position. The bleeding valve is for start-up operation, i.e. it does not reopen until the pressure within the bleeding valve falls below 0.1 bar.

Significant Applications – Special Features
Quick filling of large-volume systems or reservoirs with liquids – also suitable for media with a lower density than water has highly corrosive media or atmosphere (for example marine environment) – various materials (through to Titanium) and coatings can be used as a corrosion protection measure

Field of Application
Pipelines, vessels or systems with high volume flows, that are frequently filled or drained (for example marine loading pipelines)

Important Note
Does not open under pressure (remains closed during operation also when liquid is no longer present)

DN 25 - 300  PN 16  T 130 °C  Q -18,550 Nm³/h

Installation Diagram

Application Diagram

1. Pipeline  2. Start-up bleeding valve (EB 3.52)  3. Pump

Place of Installation
On pipelines or vessels at high points of the system

Advantage
A large seat diameter allows for extreme flow rates within a short period of time at a low differential pressure, consequently, faster and safer start-up of plants (plant sections), prevention of vacuum shocks

Design Data required for Specification
1. Medium  2. Temperature (°C)  3. Flow rate (Nm³/h)  4. Operating pressure (bar)  5. Ambient conditions
CrNiMo steel (316L), deep-drawn, corrosion-resistant, lightweight and compact

long operational lifespan, manageable installation

large seat diameter

high flow rate also at small ΔP

soft seal

sealed valve closure

Mankenberg clamp system
easy-to-maintain

standard surface of the body
Ra ≤ 1,6 μm
easy-to-clean

overhead float guide
resistant to contamination

low-density media, for example NAFTA, is also possible
allows the use in the petrochemical industry

optional elastomers
ozone-resistant version, in conformity with FDA regulations, adaptable to various operating conditions

various connection alternatives: DIN-, ANSI-, or aseptic flanges, welded ends ...
no adapters or fitting pieces required

Start-up Bleeding and Venting Valves EB 3.52
Bleeding and Venting Valves for Continuous Operation

Task
Bleeding and venting valve for continuous operation – serve for air supply and release in systems and vessels at full operating pressure.

Function
The rising fluid level raises the float and closes the valve. The liquid level falls when air enters the system or the plant is switched off, causing the valve to open and let air flow in or out. The lever function allows opening and closing at very low or also at very high pressures.

Significant Applications – Special Features
Bleed air discharge from plants that are operated with deionized water – very high resistance to fully demineralized water | water treatment in swimming pools – corrosion resistant to chlorine and salt water, ozone resistant | fuel systems – fail-safe also with media having a low specific density

Field of Application
Plants in which air/gas should continuously be introduced or air entry cannot be avoided | installations containing liquids from which gas emanates during operation (pressure reduction, temperature change)

Important Note
Fill or drain the system slowly | reduced throughput at small pressure | possibly insufficient protection from a vacuum

<table>
<thead>
<tr>
<th>Medium</th>
<th>Place of Installation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Liquids</td>
<td>On pipelines or vessels at high points of the system, bridges</td>
</tr>
<tr>
<td>Gases</td>
<td></td>
</tr>
</tbody>
</table>

Advantage
Discharges air/gas, that accumulates during operation, from the system without fluid loss | ensures efficiency of the system also when operated for long periods | prevents pressure surges

Design Data required for Specification
1. Medium | 2. Temperature (°C) | 3. Flow rate (Nm³/h) | 4. Operating pressure (bar)
CrNiMo steel (316L), deep-drawn, corrosion-resistant, lightweight and compact

long operational lifespan, manageable installation, minimum space required

standard surface Ra ≤ 1.6 μm easy-to-clean

1 sturdy valve mechanism  low maintenance

5

Mankenberg clamp system easy-to-maintain

inner parts and float resistant to pressure and corrosion, made of CrNiMo stainless steel (316L) long operational lifespan

3

2

optional elastomers ozone-resistant version, in conformity with FDA regulations

6

Mankenberg clamp system easy-to-maintain

3

inner parts and float resistant to pressure and corrosion, made of CrNiMo stainless steel (316L) long operational lifespan

4

2

Mankenberg clamp system easy-to-maintain

3

inner parts and float resistant to pressure and corrosion, made of CrNiMo stainless steel (316L) long operational lifespan

4

2

Bleeding and Venting Valves for Continuous Operation EB 1.12
**Combined Bleeding and Venting Valves**

**Task**
Combined bleeding and venting valve – a combination of start-up and operating venting valve; suitable for both start-up and continuous operations.

**Function**
Combined bleeding and venting valves have two cones. During start-up, a large quantity of air is conducted away via the large cone at low pressure. When the system is filled, the venting valve remains closed. If some further small quantities of air accumulate during operation, the small cone also opens under pressure and discharges the air. The large cone does not open until the pressure within the bleeding valve falls below 0.1 bar.

**Significant Applications – Special Features**
Large pipeline networks for water with high gas content – quick filling of the system to ensure a safe discharge of the gas in normal everyday operation.

**Field of Application**
In systems that are frequently started and shut down, in which air/gas accumulates during operation (for example in surface mining).

**Important Note**
The bleeding and venting performances for start-up and continuous operation are distinctly different from each other – functions must be checked separately.

**Medium**
Liquids | Gases

**Place of Installation**
Main pipeline

**Advantage**
Combines the advantages of start-up and continuous bleeding and prevents vacuums and pressure surges with one single device – saves space and investment costs.

**Design Data required for Specification**
1. Medium | 2. Temperature (°C) | 3. Flow rate (Nm³/h) | 4. Operating pressure (bar)

---

[Diagram of installation and application]
**Combined Bleeding and Venting Valve**

CrNiMo steel (316L), deep-drawn, corrosion-resistant, lightweight and compact

- **1.** Long operational lifespan, manageable installation, minimum space required, low delta-ferrite content possible
- **2.** Sturdy valve mechanism, low maintenance
- **3.** Various connection alternatives: DIN- or ANSI- flanges or threaded connection on the outlet side, no adapters or fitting pieces required
- **4.** Standard surface Ra ≤ 1.6 μm, easy-to-clean
- **5.** Rinsing / draining trap
- **6.** Mankenberg clamp system, easy-to-maintain
- **7.** Optional elastomers, ozone-resistant version, in conformity with FDA regulations
- **8.** Float rod guide (PTFE bushing) on the top, no hindrance by the flap, better function, long operational lifespan
- **9.** Reinforced and enlarged float, adhesion can be tolerated
- **10.** Inner parts and float resistant to pressure and corrosion, made of CrNiMo stainless steel (316L), long operational lifespan, frost-resistant
- **11.** Extended casing, valve mechanism is kept free from contaminants

**EB 1.84**
Task
Combined bleeding and venting valve – a combination of an operating venting valve and a vacuum valve, release of small air / gas quantities in continuous operation; supply of large air quantities in the event of a vacuum.

Function
A rising liquid level causes the float to rise and the valve closes. When the liquid level falls because of incoming air or a plant shut-down, the valve also opens under pressure and lets the air flow in or out. In the event of a vacuum, for example owing to a pump failure, the vacuum valve opens immediately and prevents damages.

Significant Applications – Special Features
Vacuum-vulnerable plants and vessels (for example plastic pipelines), which require a higher ventilation capacity

Field of Application
Vacuum-vulnerable plants and vessels (for example plastic pipelines), which require a higher ventilation capacity

Important Note
Vacuum breakers are non-adjustable and cannot be set – clarify in advance whether the set differential pressure to the atmosphere is acceptable for the system

<table>
<thead>
<tr>
<th>Medium</th>
<th>Place of Installation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Liquids</td>
<td>On pipelines or vessels at high points of the system</td>
</tr>
<tr>
<td>Gases</td>
<td></td>
</tr>
</tbody>
</table>

Advantage
Very large ventilation capacities – enhanced protection from a vacuum  |  the “small” performance of the bleeding valve prevents pressure surges when the system is re-started

Design Data required for Specification
1. Medium  |  2. Temperature (°C)  |  3. Flow rate (Nm³/h)  |  4. Operating pressure (bar)
**Combined Bleeding and Venting Valve with vacuum valve**

1. CrNiMo steel (316L), deep-drawn, corrosion-resistant, lightweight and compact
   - long operational lifespan, manageable installation, minimum space required
2. Integrated vacuum breaker with protection cap
   - very high ventilation performance, protection from foreign particles
3. Mankenberg clamp system
   - easy-to-maintain
   - various connection alternatives: DIN-, ANSI-, or aseptic flanges, welded ends ...
   - no adapters or fitting pieces required
4. Sturdy valve mechanism
   - low maintenance
5. Standard surface
   - Ra ≤ 1,6 μm
   - easy-to-clean
6. Atmosphere

**EB 1.57**
Steam Traps

Task
Steam trap – automatic discharge of arising condensate from steam or gases.

Function
The rising level of the accumulated condensate causes the float to rise and the valve to open. Now the condensate can flow off. The level then drops, the valve closes again and prevents the loss of steam or gas.

Significant Applications – Special Features
Draining machines such as engines and compressors – very compact, easy-to-clean | drains cold condensate at hazardous gas mixtures – soft seal and lever closing mechanism protect against escape of gas

Field of Application
Removal of liquids from gas and steam systems | protection of downstream devices, valves and installations from cavitation and water hammers

Important Note
Additional bleeding of steam systems is recommended | additional compensation line (gas commuting line) should be provided for drainage of compressed air or gases

Design Data required for Specification
1. Medium | 2. Temperature (°C) | 3. Condensate volume (l/h) | 4. Operating pressure (bar)

Medium
Liquids | Gases | Steam

Advantage
Safe discharge of liquids from gas/steam systems | prevents damage from “water hammers” | prevents damage caused by the escape of gaseous media

Place of Installation
Lowest point in the system, condensate collection points, condensate collection tanks

DN 15 - 150  PN 16 - 40  G ½ - 1
p 0 - 40 bar  T 200 °C  Q 193 m³/h
Steam Trap for Cold Condensates

**KA 2K**

**CrNiMo steel (316L), deep-drawn, corrosion-resistant, lightweight and compact**

**long operational lifespan, manageable installation, minimum space required, low delta-ferrite content possible**

**standard surface Ra ≤ 1.6 μm**

**easy-to-clean**

**Mankenberg clamp system**

**easy-to-maintain**

**inner parts and float resistant to pressure and corrosion, made of CrNiMo stainless steel (316L)**

**long operational lifespan**

**gas commuting line connection**

**optimal pressure compensation**

**soft seal**

**valve is tight already when unpressurised**

**sturdy valve mechanism**

**low maintenance**

**Special Features**

**ATEX certified**

**suitable for the use in explosive areas**
**Task**
Float valves – regulate the liquid level in a vessel.

**Function**

- **Feed valve:** The rising fluid level raises the float and closes the valve through the float lever. Further fluid flow is inhibited. When the fluid level falls, the valve is open again thus allowing the inflow of the fluid.
- **Drain valve:** As the fluid level in the tank falls, the own weight of the float causes the valve to close, and further fluid withdrawal is inhibited. The rising fluid level raises the float and opens the valve through the float level allowing the withdrawal of the fluid again.

**Significant Applications – Special Features**
Level regulation in or towards the tank – adjustable construction size, also for media with a lower density than water

**Field of Application**
Installation in tanks, external installation on tanks

<table>
<thead>
<tr>
<th>DN</th>
<th>15 - 400</th>
<th>PN</th>
<th>16 - 40</th>
<th>G</th>
<th>1/4 - 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>p</td>
<td>0 - 16 bar</td>
<td>T</td>
<td>130 °C</td>
<td></td>
<td>Kᵥ₅ 0.2 - 1,800 m³/h</td>
</tr>
</tbody>
</table>

**Important Note**
- Possibly insufficient protection from a vacuum
- Various installation possibilities
- Pressure-retaining tanks only
- Calculation of the float size on basis of the fluid density and pressures within the pipeline and tanks
- Dimensions for installation/fitting to avoid problems during installation

**Installation Diagram**

1. Valves for installation in tanks (NV 94)
2. Valves for installation on tanks (NV 67e)
3. Pipeline valves (NV 16e)

**Medium**
Liquids

**Advantage**
Mechanical | also suitable for low-density media | various installation options

**Design Data required for Specification**
1. Medium | 2. Temperature (°C) | 3. Flow rate (m³/h) | 4. Supply pressure (bar) | 5. Counterpressure (bar) | 6. Tank pressure (bar)
Float Valve NV 66E

CrNiMo steel (316L), deep-drawn, corrosion-resistant, lightweight and compact

- long operational lifespan, manageable installation, minimum space required
- standard surface RA ≤ 1.6µm
- easy-to-clean
- inlet pressure balanced cone
- small float required
- soft seal
- sealed valve closure

Mankenberg clamp system
- easy-to-maintain

- various connection alternatives: DIN-, ANSI-, or aseptic flanges, welded ends...
- no adapters or fitting pieces required
- adaptable floats and elastomers can be used for any liquid media
**Task**

Liquid separator - automatic separation of liquids and condensate from gas and/or steam flows at operating pressure.

**Function**

Mankenberg liquid separators are swirl separators using the cyclone principle. The separated fluid is collected in the integrated liquid discharge trap and safely drained automatically through the float control and without requiring external energy.

**Significant Applications – Special Features**

- Air humidification systems – extremely compact thanks to the integrated liquid discharge trap
- Dehumidification in pressure boosting systems – also suitable for highly corrosive condensates
- All materials made of high-quality stainless steel with smooth surface which prevents adherence of particles

**Field of Application**

- Drying of steam or gas to protect devices, valves and installations from cavitation and water hammers
- Optimised thermal energy of saturated steam
- Generation of dry saturated steam for pure and sterile steam systems

**Important Note**

Sufficient flow velocity and knowledge of the density of the drained fluid is required

---

**Design Data required for Specification**

1. Medium  
2. Flow rate (Nm³/h, kg/h)  
3. Separating performance (l/h)  
4. Operating pressure (bar)  
5. Temperature (°C)

---

**Medium**

- Gases
- Steam

**Place of Installation**

Main pipe

**Advantage**

Compact design | reliably separates liquids from gas (steam) – prevents damage to downstream valves and devices

---

**Installation Diagram**

![Installation Diagram]

1. Separator with discharge trap (AS 2)  
2. Shut-off valve  
3. Steam pressure control valve (DM 652)
Pipeline Valve with integrated Liquid Discharge Trap

**Special Features**

1. CrNiMo steel (316L), deep-drawn, corrosion-resistant, lightweight and compact
2. Long operational lifespan, manageable installation, minimum space required, low delta-ferrite content possible
3. Mankenberg clamp system, easy-to-maintain
4. Various connection alternatives: DIN-, ANSI-, or aseptic flanges, welded ends...
   - No adapters or fitting pieces required
5. Standard surface Ra ≤ 1.6 μm, easy-to-clean
6. Integrated liquid discharge trap, automatic discharge, no fluid losses
### Task
Gas separator - automatic separation of gases from liquid flows at operating pressure.

### Function
When the fluid flushes a special packed bed, the gas remains stuck in the form of micro gas bubbles. These bubbles accumulate and rise then. The integrated bleeding valve discharges the accumulating gas automatically and without fluid losses.

### Significant Applications – Special Features
Are used when no dome can be installed: petrol stations, ship unloading facilities for low-density fluids

### Field of Application
Separators of gas bubbles from measuring devices, for example flow metres and volume metres

### Important Note
Maximum flow velocity of abt. 1m/s

### Design Data required for Specification
1. Media (liquid and gas)  
2. Flow rate (m³/h)  
3. Separating performance (Nm³/h)  
4. Operating pressure (bar)  
5. Temperature (°C)

### Medium
Liquids

### Place of Installation
Main pipe

### Advantage
Compact design  
reliably separates gas from liquids  
assumes the function of a pipe expansion  
separates the gases from the medium by a special packed bed and an integrated bleeding valve  
without fluid loss

### DN 15 - 100  PN 16  G ½'' - 2''

<p>| | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>p₁</td>
<td>0 - 16 bar</td>
<td>T</td>
<td>200 °C</td>
<td></td>
</tr>
<tr>
<td>p₂</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>p₃</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Qₕ</td>
<td>73 m³/h</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Qₕ₉₉₉₉</td>
<td>25 m³/h</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

The diagrams show examples and must be verified in each individual case!
Pipeline Valve with integrated Bleeding Valve

CrNiMo steel (316L), deep-drawn, corrosion-resistant, lightweight and compact, also available in special materials

1. Long operational lifespan, manageable installation, minimum space required
2. A special packed bed separates the gas from the liquid
3. Mankenberg clamp system easy-to-maintain
4. Various connection alternatives: DIN-, ANSI-, or aseptic flanges, welded ends ...
5. No adapters or fitting pieces required
6. Standard surface Ra ≤ 1.6 μm easy-to-clean

Spacial Features
- Integrated bleeding valve automatic discharge, no fluid losses
Corrosion-resistant Materials

The right selection of material makes a difference

Stainless steel is required for numerous applications and industries. This material is used for a huge variety of purposes in essential sectors such as raw material extraction, the pharmaceutical and chemical industries, plant construction, oil & gas, offshore applications etc. Mankenberg’s product range of flexible standard valves or project-related special valves is correspondingly broad. The operating conditions at the customer’s site sometimes require ultra-clean surfaces of the valves whilst other valves must be capable of sustaining the flow of dirty or highly corrosive media. Hence, the optimum solution is selected in close consultation with our engineers, technicians and sales staff. A particular challenge is to select the suitable material for applications in chemical-technical processes, in which caustic and/or corrosive fluids are used. The same applies to the maritime domain or saline liquids, which is generally referred to as sea water resistance. It requires special diligence and clarification of all the technical and chemical details in order to properly assess the loading conditions of the material and the interaction between the medium and the environmental conditions. Stainless steels, i.e. corrosion-resistant steels, become resistant to corrosion because a so-called passive layer forms on the surface. Such layers consists of chromium-rich metallic oxide or metallic oxide hydrate preventing the direct contact of the metal with the corroding medium. Even in the event of small lesions, a new layer builds up independently at the relevant area. If this is not the case, for example due to a lack of oxygen, either pitting corrosion or crevice corrosion may occur.

Stainless steels have a percentage by mass of the element chromium of not less than 12 % and of the element carbon that should not exceed 0.12 %. Hence, the percentage of the alloying element chromium is decisive for the corrosion resistance of stainless steel. In case the steel contains further alloying elements such as molybdenum or the like, the material becomes more resistant also to highly aggressive operating conditions.

The suitable valve from the right material for your application:

Our team competently provides comprehensive advice – Take us at our word!
Stainless Steel and its Resistance to Corrosion

<table>
<thead>
<tr>
<th>Corrosion Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>General Corrosion</strong></td>
<td>The passive layer is completely destroyed&lt;br&gt;This type of corrosion depends on the consistency of the fluid&lt;br&gt;Can be avoided by optimally selecting the material with respect to the medium</td>
</tr>
<tr>
<td><strong>Pitting Corrosion</strong></td>
<td>Can be avoided by selecting molybdenum-containing steel types</td>
</tr>
<tr>
<td><strong>Crevice Corrosion</strong></td>
<td>Occurs in a design-related enclosed hollow space of the equipment and in a chloride-containing environment&lt;br&gt;Can be prevented through avoiding enclosed hollow spaces already during the design phase</td>
</tr>
<tr>
<td><strong>Corrosion by Contamination</strong></td>
<td>Is caused by ferrous deposits and brings about a contamination</td>
</tr>
<tr>
<td><strong>Intergranular Corrosion</strong></td>
<td>Diffuses from the grain boundaries in heat-sensitized areas&lt;br&gt;The chromium degrades and impairs the passivating effects&lt;br&gt;Can be avoided by selecting low-carbon steel types</td>
</tr>
<tr>
<td><strong>Stress Corrosion Cracking</strong></td>
<td>Occurs in a chloride-containing environment, when the equipment is exposed to high stress, for example&lt;br&gt;Can be avoided by selecting a suitable stainless steel&lt;br&gt;Transcrystalline or intergranular crack path at sensitized microstructures</td>
</tr>
</tbody>
</table>
Corrosion-resistant Materials

The higher the pitting index, the more resistant to pitting and crevice corrosion. Alloys with a PREN > 33 are deemed to be seawater resistant. Hastelloy® C-4 and Titanium are deemed to be highly resistant to seawater. A higher pitting index is required in the event of an increasing salt content and/or rising temperature.

<table>
<thead>
<tr>
<th>Material Name</th>
<th>Material Number</th>
<th>Standard</th>
<th>Main Alloy Components in mass%</th>
<th>Pitting Index (PREN)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stainless Steel</td>
<td>1.4404</td>
<td>X2CrNiMo17-12-2</td>
<td>DIN EN 316L</td>
<td>Cr 16.5 - 18.5, Ni 10.0 - 13.0, Mo 2.0 - 2.5</td>
</tr>
<tr>
<td></td>
<td>1.4571</td>
<td>X6CrNiMoTi17-12-2</td>
<td>ASTM 316Ti</td>
<td>Cr 16.5 - 18.5, Ni 10.5 - 13.5, Ti 2.0 - 2.5</td>
</tr>
<tr>
<td>Duplex</td>
<td>1.4462</td>
<td>X2CrNiMo22-5-3</td>
<td>A182F51</td>
<td>Cr 21.0 - 23.0, Ni 4.5 - 6.5, Mo 2.5 - 3.5</td>
</tr>
<tr>
<td>Alloy 904L</td>
<td>1.4539</td>
<td>X2NiCrMoCu25-20-5</td>
<td>N08904</td>
<td>Cr 19.0 - 21.0, Ni 24.0 - 26.0, Mo 4.0 - 5.0</td>
</tr>
<tr>
<td>Super Duplex</td>
<td>1.4410</td>
<td>X2CrNiMo25-7-4</td>
<td>S32750</td>
<td>Cr 24.0 - 26.0, Ni 6.0 - 8.0, Mo 3.0 - 4.5</td>
</tr>
<tr>
<td>Super Duplex</td>
<td>1.4501</td>
<td>X2CrNiMoCuWN25-7-4</td>
<td>S32760</td>
<td>Cr 24.0 - 26.0, Ni 6.0 - 8.0, Mo 3.0 - 4.0</td>
</tr>
<tr>
<td>Cronifer 1925Mo</td>
<td>1.4529</td>
<td>X1NiCrMoCu25-20-7</td>
<td>N08926</td>
<td>Cr 19.0 - 21.0, Ni 24.0 - 26.0, Mo 6.0 - 7.0</td>
</tr>
<tr>
<td>254 SMO®</td>
<td>1.4547</td>
<td>X1CrNiMoCuN20-18-7</td>
<td>S31254</td>
<td>Cr 19.5 - 20.5, Ni 17.5 - 18.5, Mo 6.0 - 7.0</td>
</tr>
<tr>
<td>Hastelloy® C-4</td>
<td>2.4610</td>
<td>NiMo16Cr15Fe6W4</td>
<td>N06455</td>
<td>Cr 14.5 - 17.5, Ni 66.0, Mo 14.0 - 17.0</td>
</tr>
<tr>
<td>Titanium</td>
<td>3.703</td>
<td>R50400</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Behavior of corrosion-resistant stainless steel 1.4529 / 1.4547

Excellent corrosion resistance owing to an increased percentage of chromium and molybdenum.

1) Pitting Corrosion

Pitting is a particular type of corrosion in media containing chloride ions. In the event that the protective passive layer of the stainless steel is interrupted owing to small lesions, a local corrosion attack occurs. Pits or holes that are often as small as pinholes, form more readily. As long as the exposure persists, the pits or holes will enlarge.

2) Crevice Corrosion

Crevice corrosion can be found in already existing gaps or fissures which are often generated by the overall design. The passive layer of the stainless steel cannot form there at all and aggressive media such as salt water accelerate the corrosion process. If, in addition, the oxygen, which is necessary to form the passive layer, is not available, heavy crevice corrosion may occur.
Used corrosion-resistant Seal Materials

<table>
<thead>
<tr>
<th>Material Name</th>
<th>Working Temperature</th>
<th>Typical Application Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>MVQ, Silikon</td>
<td>Resistant in waters up to 100 °C</td>
<td>suitable for temporary steam sterilisation up to 130 °C</td>
</tr>
<tr>
<td>EPDM</td>
<td>Constant operation temperature from -40 °C through to 140 °C</td>
<td>suitable for steam sterilisation up to 130 °C (up to max. 180 °C)</td>
</tr>
<tr>
<td>FPM (as per DIN-ISO)</td>
<td>Constant operation temperature from -20 °C through to 140 °C</td>
<td>suitable for temporary steam sterilisation up to 140 °C (from min. -35 °C and max. 230 °C)</td>
</tr>
<tr>
<td>FKM (as per ASTM), Viton®</td>
<td>Constant operation temperature from -30 °C through to 130 °C</td>
<td>suitable for temporary steam sterilisation up to 130 °C (up to min. 60 °C)</td>
</tr>
<tr>
<td>NBR, Perbunan®</td>
<td>Constant operation temperature from -30 °C through to 80 °C</td>
<td>suitable for temporary steam sterilisation up to 130 °C (up to min. 60 °C)</td>
</tr>
<tr>
<td>PTFE, Teflon®</td>
<td>Physiologically harmless up to 200 °C</td>
<td>suitable for use from -200 °C through to 260 °C</td>
</tr>
<tr>
<td>CR, NR</td>
<td>-30 °C through to 90 °C</td>
<td>for special applications</td>
</tr>
<tr>
<td>FFKM / FFFPM, Karlrez®, ISO-LAST®</td>
<td>-20 °C through to 275 °C</td>
<td>with special compounds, temperatures from -30 °C through to 325 °C can be reached</td>
</tr>
<tr>
<td>FEPM</td>
<td>-10 °C through to 200 °C</td>
<td>High resistance especially to amine-containing additives and corrosion inhibitors</td>
</tr>
<tr>
<td>VA, Graphit</td>
<td>-200 °C through to 500 °C</td>
<td>Use at high temperatures</td>
</tr>
<tr>
<td>EU, Eladur®</td>
<td>-20 °C through to 80 °C</td>
<td>Mostly used with gases, for ex. CO₂, nitrogen, air</td>
</tr>
</tbody>
</table>
Quality has many different faces

Industrial valves perform key functions in plants and pipelines and therefore have a considerable influence on customers’ own processes: accuracy of control, reliability and safety are paramount. Quality control at Mankenberg is thus a central theme which runs through all aspects of the production process. At Mankenberg, quality control is a separate team whose members are directly answerable to the Managing Director. Everything that leaves our production halls has to be checked by the experienced hands of our quality control team. But if we are honest, even these high standards are not enough to satisfy us when it comes to quality.

All our suppliers are DIN EN 9001 certified and are subject to a strict evaluation system. It is included in the closed loop improvement process that we set up ourselves. When it comes to supplier relationships, feedback functions in both directions. This enables us to increase the degree of mutual transparency and confidence.
Acceptances and Certificates

Inspection Certificates and Material Certificates
- EN 10204 / 2.1
- EN 10204 / 2.2
- EN 10204 / 3.1
- EN 10204 / 3.2

Acceptance Tests
- German Technical Monitoring Association (TÜV)
- Germanischer Lloyd (GL)
- Lloyd’s Register of Shipping (LRS)
- Bureau Veritas (BV)
- Det Norske Veritas (DNV)
- Registro Italiano Navale (RINA)
- American Bureau of Shipping (ABS)

Approvals and Certificates
- ISO 9001 since 1994
- Pressure Equipment Directive 97/23/EG
- AD-2000 sheet HP 0
- Environmental Management System EN 14001
- Occupational Health and Safety Management BS OHSAS 18001
- VGB Certificate acc. to KTA 1401
- TR CU 032 and TR CU 010
- Penetrant Testing Level 2 (PT) as per DIN 473
- DIN EN ISO 3834-2

Qualified Welders
- AD2000-HP3
- DIN EN 287-1
- DIN EN 1418
- DIN EN 9606-1
- DIN EN 9606-5

Welding Procedure Test
- AD2000-HP2 / 1
- DIN EN ISO 15614-1
- DIN EN ISO 15614-5
- Others on request

On Request
- Norsok (Norsk Sokkels Konkurranseposisjon)
- NACE (National Association of Corrosion Engineers)
- ANSI (American National Standards Institute)
- ASME (American Society of Mechanical Engineers)
- API (American Petroleum Institute)
- JIS (Japan Industrial Standard)
The Way to the proper Valve

**K_v Value**

The K_v value is an important parameter for the performance of the valve and thus decisive for valve selection. The flow coefficient K_v (m³/h) indicates the specific volume flow rate of a valve at a determined lift (conditions: pressure loss across the valve 1 bar, medium water 5 – 40 °C).

**Calculation of the K_v Value**

The K_v value (application) is calculated from the given operating conditions of the application and allows the selection of the proper valve.

**Calculation Formular**

<table>
<thead>
<tr>
<th>Gas</th>
<th>( \Delta p &lt; \frac{p_1}{2} )</th>
<th>( \Delta p &gt; \frac{p_1}{2} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( k_v = \frac{Q_N}{514} \sqrt{\frac{\rho_N \times (t_1 + 273,15)}{\Delta p \times p_2}} )</td>
<td>( k_v = \frac{Q_N}{257 \times p_1} \sqrt{\frac{\rho_N \times (t_1 + 273,15)}{\Delta p \times p_2}} )</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Steam</th>
<th>( \Delta p &lt; \frac{p_1}{2} )</th>
<th>( \Delta p &gt; \frac{p_1}{2} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( k_v = \frac{G}{461} \sqrt{\frac{t_1 + 273,15}{\Delta p \times p_2}} )</td>
<td>( k_v = \frac{G}{230 \times p_1} \sqrt{t_1 + 273,15} )</td>
<td></td>
</tr>
</tbody>
</table>

| Liquid | \( k_v = Q \sqrt{\frac{\rho}{1000 \times \Delta p}} \) |

- \( Q \) m³/h: Flow rate at operating conditions
- \( Q_N \) m³/h: Volume flow at normal condition
- \( G \) kg/h: Mass flow
- \( p_1 \) bar: Inlet pressure (abs)
- \( p_2 \) bar: Outlet pressure (abs)
- \( \Delta p \) bar: Differential pressure \((p_1 - p_2)\)
- \( p \) kg/m³: Density
- \( \rho_N \) kg/m³: Density at normal condition
- \( t_1 \) °C: Inlet temperature
Comfortable to calculate the $K_v$ and $K_{VS}$ Value

The calculation and design software ValvePilot assumes the task of calculating the $K_v$ and $K_{VS}$ value for you. These values are essential for the optimal selection of valves. In addition, the programme determines the following values/parameters:

- Noise pressure level
- Nominal diameter
- Reduction ratio
- Inflow and outflow velocity
- Phase changeover

ValvePilot also provides warnings about potential hazards such as cavitation, flashing or excessive noise pressure levels. You will also receive an alert if a pipe expansion is required owing to your operational data. Three different calculation modes Basic / Expert / Expert+ allow for a calculation tailored to your special needs. During the subsequent selection of the suitable pressure reducing valve or back pressure regulator, ValvePilot determines the optimal self-acting control valve for your application.

Take advantage of the opportunity to download ValvePilot as freeware or use it online.

valvepilot.com
Adjustment Ratio
The adjustment ratio is the proportion of the max. and min. volume flow to be controlled for a control valve. As a general rule, the adjustment ratio is ratio is approx. 10:1, however, it may be significantly larger for small valves.

Back Pressure Regulator Valves | Short Form: UV
The back pressure regulator valve (inlet pressure regulating valve) limits the pressure upstream of the valve to an adjusted (but changeable) nominal value. The back pressure regulator always drains the corresponding quantity of the fluid needed to reach the set value.

Balanced Valve
On a balanced valve, the forces acting on the cone are compensated on an equally sized release surface through the inlet or outlet pressure. Thus the valve features considerably better regulating properties.

Bleeding
Bleeding describes the process by which gas is discharged from the plant (pipeline) in a controlled manner through a bleeding valve. It is intended to enhance the safety and efficiency of the plant.

Buoyancy Force
The buoyancy force of a float is equivalent to the mass of the fluid displaced by it. As a general rule, the buoyancy forces indicated by Mankenberg refer to water.

Combined Venting and Bleeding Valve | Short Form: EB
Combined venting and bleeding valves have two functions, a start-up bleeding valve and an operating bleeding valve. Depending on the manufacturer, they are single devices placed in one housing or optimised solutions.

Combined Venting and Bleeding Valve with Vacuum Valve | Short Form: EB with VV
Combined venting and bleeding valves with a vacuum valve are operating bleeding valves with an integrated pressure-controlled vacuum breaker. They are installed in vacuum-vulnerable pipelines. The small bleeding performance of the operational air release reduces the risk of pressure surges.

Commuting Line
The commuting line is a compensation line for the cold condensate in steam traps. It allows the escape of the gas enclosed in the steam trap and thus creates space for the condensate.

Control Deviation
The control deviation indicates the extent of the variations. In the range from 10 % to 70 % of the possible flow rate, the pressure variation and the set value (psoll) must not vary more than + 10 %.

Control Line
The control line takes the inlet and outlet pressure to be regulated from the pipeline (at a location with low turbulences) and transfers it to the control unit. Thus the use of external control lines can contribute to a more stable behaviour of the control valve. Not every pressure regulating valve needs a control line. The control line can also be used to adjust pressures at locations remote from the valve.

Control Unit
The control unit transfers the pressure to be regulated to the pressure regulating valve mechanism. The pressure acting on the control surface closes (pressure reducing valve) or opens (back pressure regulator) the valve against the spring force.

Three construction types can be distinguished:
» Diaphragm
» Piston with O-ring and other seals
» Bellow
Corrosion by Contamination
See Corrosion page 46/47

Crevice Corrosion
See Corrosion page 46/47

Designation Line
The designation line includes information regarding valve type, connection size, rated pressure level at the inlet side, version, KVs value, elastomer code, control range, cone seal and material.

Differential Pressure | Δp
The differential pressure defines the pressure difference between inlet and outlet pressure. If pressure ranges are indicated, the smallest pressure difference is applicable for the design of the valves (calculation of the Ks value).

Differential Pressure Control Valve | Short Form: DV
Depending on the task, the differential pressure control valves are either pressure reducing valves or back pressure regulators, whose reference pressure is not the atmosphere but the system pressure in another section of the plant.

Double Seat
The double seat is a variant to increase the Kv value of a valve by installing two parallel seats instead of one. At Mankenberg, regulation is made through two cones that are firmly attached to each other.

Drain Control Valve | Short Form: NV (Level Control Valve)
Drain control valves are level regulating valves which limit the flow of fluid out of a vessel. As the float sinks, the valve is closed.

Float Valve | Short Form: NV (Level Control Valve)
The float valve, also called level control valve, is a float-controlled valve.

Float Weight
The float weight is the mass weight of the float. It is required for the closing or opening of float-controlled valves. It can be increased for some floats through filling them with sand and adapting them to the operating conditions.

Flow Controllers | Short Form: MR
Flow controllers are self-actuated regulating valves that control the volume flow by maintaining constant the differential pressure through an orifice.

Flow Velocity | v
The flow velocity (v), or stream velocity, is the velocity of a flow, a directed movement of particles or media. Depending on the medium, certain velocities are permitted. Consequently, the flow velocity and the resulting pressure loss serve as a basis for the design of the pipelines.

Gas Spring Cap
The gas spring cap is an alternative setpoint adjuster for pressure regulating valves. Unlike spring-loaded or weight-loaded valves, such regulating valves with gas spring cap are suitable for connection to an existing process control system (PLS). Therefore, they are generally used in cases, where the set value must be frequently changed (for example batch processes in the foodstuffs industry).

General Corrosion
See Corrosion page 46/47

Hard Facing
It is recommended that the cone for pressure regulating valves for liquids and with a pressure drop of approx. > 25 bar is designed with a hard facing layer. This will prevent early wear and tear due to cavitation.
**Glossary**

_**High Point**_
The high point is a local or the absolutely highest point of a pipeline. These points are especially important in piping engineering because they may be ideal points for bleeding as well as points of origin of vacuum shocks.

_**I/P converter**_
The I/P converter transforms an electrical input signal into a pneumatic output signal and, depending on the level of the pressurised gas (control air pressure), it sends a pneumatic signal in order to display different control ranges.

_**Inflow Regulator | Short Form: NV (Level Control Valve)**_
Inflow regulators are level control valves that limit the intake of a liquid in a vessel. As the float rises, the valve closes.

_**Inlet Pressure | p_1**_
The inlet pressure indicates the pressure upstream of the valve.

_**Installation**_
As a basic principle, pressure regulating valves should be installed in horizontal pipelines, however, a vertical line is also possible for gases. If the valve is installed horizontally into a vertical line, this may result in regulating inaccuracies and increased wear and tear.

Gases
Installation is possible with the spring cap pointing upwards or downwards or in vertical lines

Liquids
Installation with the spring cap pointing downwards. Thus gas cushions are avoided that may cause the valve to oscillate.

Steam
Installation with the spring cap pointing downwards to protect the diaphragm from overheating by means of a condensate guard. A steam dryer (liquid separator) should be installed on the upstream side.

_**Intergranular Corrosion**_
See Corrosion page 46 / 47

_**Intermediate Piece**_
The intermediate piece is an extension of the valve body for steam applications. The intermediate piece creates the required space for a water trap, which protects the diaphragm from the high steam temperatures.

_**K_v Value (Application) | K_v**_
The K_v value (m³/h) is a measure of the achievable flow rate of liquids or gases through a valve and is used to select and dimension the valves. It is calculated on basis of the operating conditions of the application. See page 50

_**K_v Value (Valve) | K_v**_
The flow coefficient K_v (m³/h) is the specific volume flow of a valve at a determined lift. Conditions: Pressure loss across the valve 1 bar, medium water 5 - 40 °C.

_**K_vs Value | K_vs**_
The required K_vs value is calculated on basis of the given operating conditions of an application and is augmented by 30 % in order to ensure that the selected valve always operates within its optimal performance range. The resulting K_vs value should be smaller than the K_v value of the used valve.

_**Leakage Line**_
In case of toxic or hazardous media, the leakage line installed at the valve drains the medium safely.
Lever Transmission
The lever transmission is the proportion between the length of the float lever and the lever of the valve cone at/in a float-controlled valve.

Lifting Lever
The lifting lever is a mechanical device to manually open safety valves for a functional test.

NACE
National Association of Corrosion Engineers is an American association of engineers and other experts with the aim of finding solutions for problems caused by corrosion.

Nominal Pressure
The nominal pressure is the design pressure of the plant and/or component.

Nominal Value
The nominal value is the value set on the valve that must be controlled.

Norm Cubic Metre | Nm³/h
The norm cubic metre (Nm³/h) is a volumetric unit to describe a quantity of gas. It indicates the volume of a gas at normal conditions for 1 bar (abs.) at a temperature of 20 °C.

Operating Pressure Range
See Pressure Range

Operating Pressure
Operating Pressure is the pressure prevailing throughout the plant.

Outlet Pressure | p₂
Outlet pressure is the designation for the pressure prevailing downstream of the valve.

Ozone-resistant Design
The valve is designed for use in an ozone-laden atmosphere (use of special materials).

Pilot-actuated Control Valves | Short Form: RP
As a general rule, pilot-actuated control valves are larger-sized valves with high volume flow that are controlled by a smaller pilot valve. This pilot also determines the function and the reduction ratio of the valve unit.

Pipeline Extension
A valve is often sufficiently dimensioned for a certain application with regards to the Kᵥ value, but might be too small in respect of the nominal diameter and the resulting flow velocities. Too high flow velocities result in noise, pressure rise and wear and tear. In such a case, the flow velocity can be reduced to an admissible value thanks to the pipeline extension.

Pitting Corrosion
See Corrosion page 46/47

Pitting Index
See Corrosion page 46/47

PREN
The PREN index is a measure of the corrosion resistance of stainless steel alloys.
PREN = 1 x %Cr + 3,3 x %Mo + 16 x %N

Pressure Drop | Δp
See Differential Pressure
Glossary

_Pressure Maintaining Valve_
See Back Pressure Regulator Valve

_Pressure Range_
The pressure range indicates the range within which a valve can be used. Thus the valve function is ensured within this range.
Example:
The indication pressure range 0-6 bar means for a bleeding and venting valve: the valve can be used for this system pressure range and will function.

_Pressure Reducing Valve  |  Short Form: DM_
Pressure reducing valves reduce a high, fluctuating inlet pressure to a lower and stable outlet pressure. They are open in unpressurised condition and closed with rising outlet pressure.

_Pressure Regulating Valve_
Pressure regulating valve is the general term for any form of valves that regulate the pressure.

_Pressure Regulator_
See pressure regulating valve

_Pressure Relief Valve  |  Short Form: SR_
Pressure relief valves protect pipelines from dangerous dynamic pressure changes (pressure surges).

_Reduction Ratio_
The reduction ratio is the quotient of inlet and outlet pressure. Due to its design, every pressure reducing valve has a maximum reduction ratio.
Example:
Reduction ratio 20:1 (the data sheet of the control valve indicates 20)
Example:
The nominal value for the outlet pressure of 1.2 bar is the highest admissible \( pv = 20 \times 1.2 \text{ bar} = 24 \text{ bar} \)

_Sea Water-resistant Materials_
All steel types having a PREN index > 33 are classified as sea water resistant materials.

_Seat Leakage_
The permissible seat leakage indicates how much water may flow through a closed valve during the final test on the test bench. Since control valves are always regulated through a fine balance of forces, a minor leakage is permitted. The corresponding quantities and test methods are internationally standardised.

_Seat Tightness_
See Seat Leakage

_Safety Valve_
Safety valves protect plants or plant components from inadmissible excessive pressures by responding quickly at a pre-set inlet pressure and discharging the fluid from the system.

_Self-acting Valve_
The valve operates independently. No additional energy supply is required (no power supply lines, no compressed air lines etc.).

_Separator  |  Short Form: AS_
Separators separate media of different states of aggregation.
_Setting Range
The setting range indicates the range within which a valve can be set.
Example:
The indication setting range 4 - 6 bar means for a
pressure reducing valve: the outlet pressure can be set between 4 and 6 bar
back pressure regulating valve: the inlet pressure can be set between 4 and 6 bar

_Silicone-free Design
Valve design without the use of silicone-containing sealants and lubricants.

_Sour Gas Directive
The Sour Gas Directive is a guideline for the selection of materials for the use in atmospheres containing H₂S.

_Standard Cubic Metre   |   Sm³/h
See Norm Cubic Metre

_Start-up Venting and Bleeding Valve   |    Short Form: EB
The start-up bleeding valves bleed plants with low internal pressure during start-up or filling. The float acts
directly onto the cone. Such valves have a large seat diameter to ensure fast bleeding at a pressure below 0.1
bar. During operation they are kept closed by the internal pressure of the vessel. In case of a suddenly occurring
vacuum the valves open and compensate the pressure. Thus damages caused by a vacuum will be avoided.

_Steam Trap   |    Short Form: KA
The steam trap discharges liquids from steam or gas systems

_Stress Corrosion Cracking
See Corrosion page 46 / 47

_Temperature Limits
Temperature limits show the minimum and maximum operating temperature of a valve. As a general rule, they can
be determined based on the used elastomers and the fluid taken as a basis for the calculation.

_Tightness of the Valve
See Seat Leakage

_Vacuum Breaker   |    Short Form: VV
The vacuum breaker is used to protect processes from inadmissible high vacuums. Vacuum breakers are set to a
differential pressure to the atmosphere, they open when this value is reached and let air flow into the system.

_Vacuum Control Valve   |    Short Form: VV
The vacuum control valve controls the negative pressure within pipelines, vessels and similar plants upstream and
downstream of the valve.

_Valve Cone
The valve cone is a movable component in the valve, that rests on the valve seat. Owing to the cone stroke the
valve opens, is throttled or closed.

_Valve Seat
The valve seat is the apron for a defined cross-flow aperture in the valve, through which the medium to be
regulated has to flow.

_Venting
Venting describes the process by which air is induced into the plant (pipeline) in a controlled manner through a
bleeding valve. It is intended to prevent the creation of a vacuum in the plant.
_Venting and Bleeding Valve   |   Short Form: EB
The venting and bleeding valves are used for supplying / discharging air in pipelines, see Venting and Bleeding.

_Venting and Bleeding Valve for Continuous Operation   |   Short Form: EB
The continuous bleeding valves are used to evacuate the air accumulating during operation. They are provided with a lever transmission thus they also operate at very low or very high pressures. If air intake is to be avoided the outlet must be provided with a non-return valve. In such a case they will act as bleeding valves without venting function.

_Water Trap
The water trap protects the diaphragm in steam control valves from overheating. The water trap must be created by filling water into the device prior to commissioning. During operation the water trap is maintained by cooling the steam at the valve side itself.

_Working Cubic Metres   |    m³/h at x bar(g)
The working cubic metre (m³/h at x bar(g)) is a volumetric unit to describe a gas in the operating condition, i.e. at operating pressure and operating temperature. Attention: When this unit is applied, always indicate the used reference pressure and reference temperature.