Professional planning, calculation and equipment

Compact professional expertise for pressure maintenance, degassing, water make-up and water treatment systems
Reflex has set itself the goal of supporting you with well thought-out solutions. Whatever job you need doing in water supply engineering, why not put your trust in our comprehensive range of products and accompanying tailored services? We will ensure that your decision to opt for Reflex is the right one in every respect – from advice and design to installation and ongoing operation.

Reflex’s mission is embodied in the company’s slogan: “Thinking solutions”. Reflex’s strength is to think in terms of solutions. Reflex develops ideas that help you to move forward based on decades of experience, in-depth technical understanding and our intimate knowledge of the industry.
We make sure that everything fits

Heating, cooling and hot water supply systems – the demands on supply equipment are varied and complex. The range of services from Reflex offers a wide selection of products to meet any demand, which according to requirements can be used individually or combined to form carefully designed solutions. All our products reflect the fundamental understanding that Reflex has gathered through its intensive engagement with water supply engineering systems in all areas of water supply engineering.

In this brochure, we have compiled the essential notes and information regarding the planning, calculation and equipment of Reflex systems for the most common applications. Here we include the most important calculation parameters and physical principles, as well as insights into current legal framework conditions and additional technical recommendations. Should you have any further questions, your Reflex sales contact will be happy to help.
Calculation procedures

The aim of this guide is to provide you with the most important information required to plan, calculate and equip Reflex pressure-maintaining, degassing and heat exchanger systems. Calculation forms are provided for individual systems. Overviews detail the most important auxiliary variables and properties for calculation as well as relevant requirements for safety equipment.

Please contact us if you require any additional information. We will be happy to help you.

**Standards, guidelines**

The following standards and guidelines contain basic information on planning, calculation, equipment and operation:

- DIN EN 12828  Heating systems in buildings – Planning of hot water heating systems
- DIN 4747 T1  District heating systems, safety equipment
- DIN 4753 T1  Water heaters and water heating systems
- DIN EN 12976/77  Thermal solar systems
- VDI 6002 (Draft)  Solar heating for potable water
- VDI 2035 Part 1  Prevention of damage through scale formation in domestic hot water and water heating systems
- VDI 2035 Part 2  Prevention of damage through water-side corrosion in water heating systems
- EN 13831  Closed expansion vessels with built in diaphragm for installation in water systems
- DIN 4807  Expansion vessels
- DIN 4807 T1  Terms...
- DIN 4807 T2  Calculation in conjunction with DIN EN 12828
- DIN 4807 T5  Expansion vessels for potable water installations
- DIN 1988  Technical rules for potable water installations, pressure increase and reduction
- DIN EN 1717  Protection against pollution of potable water
- DGRl  Pressure Equipment Directive 97/23/EC
- BetrSichV  German Ordinance on Industrial Safety and Health (as of 01/01/2003)
- EnEV  Energy Saving Ordinance

**Planning documentation**

The product-specific information required for calculations can be found in the relevant product documents and, of course, at www.reflex.de.

**Systems**

Not all systems are covered by the standards, nor is this possible. Based on new findings, we therefore also provide you with information for the calculation of special systems, such as solar energy systems, cooling water circuits and district heating systems.

With the automation of system operation becoming ever more important, the pressure monitoring and water make-up systems are thus also discussed, in addition to central deaeration and degassing systems.

**Calculation program**

Computer-based calculations of pressure-maintaining systems and heat exchangers can be performed via our Reflex Pro calculation program which is available for download at www.reflex.de. Alternatively you could use our Reflex Pro app!

Both tools represent a quick and simple means of finding your ideal solution.

**Special systems**

In the case of special systems, such as pressure-maintaining stations in district heating systems with an output of more than 14 MW or flow temperature over 105 °C, please contact our technical sales department directly.
Role of pressure-maintaining systems

Pressure-maintaining systems play a central role in heating and cooling circuits and perform three main tasks:
1. They keep the pressure within permissible limits at all points of the system, thus ensuring that the max. excess operating pressure is maintained while safeguarding a minimum pressure to prevent vacuums, cavitation and evaporation.
2. They compensate for volume fluctuations of the heating or cooling water as a result of temperature variations.
Careful calculation, start-up and maintenance are essential to the correct functioning of the overall system.

Calculation parameters

Definitions according to DIN EN 12828 and following DIN 4807 T1/T2 based on the example of a heating system with a diaphragm expansion vessel (MAG)

Pressures are given as overpressures and relate to the expansion vessel connection or the pressure gauge on pressure-maintaining stations. The configuration corresponds to the diagram above.

- **pSV**: Safety valve activation pressure
- **pf**: Final pressure
- **pfil**: Filling pressure
- **pi**: Initial pressure
- **p0**: Minimum operating temperature
- **p0**: Pressure for avoiding - Vacuum formation - Evaporation - Cavitation
- **pS**: Pressure of liquid column based on static height (H)

The max. excess operating pressure must not be exceeded at any point within the system.

Most common configuration:
- Circulating pump in advance
- Expansion vessel in return
  = suction pressure maintenance

Normal pressure range = pressure maintenance setpoint value between p_i and p_f

Water seal V_WS to cover system-related water losses

PL_{max} according to DIN EN 12828; to ensure p_0 in hot water systems, an automatic water make-up system is recommended, along with an optional minimum pressure limiter.
### Properties of water and water mixtures

**Pure water without antifreeze additive**

<table>
<thead>
<tr>
<th>t / °C</th>
<th>0</th>
<th>10</th>
<th>20</th>
<th>30</th>
<th>40</th>
<th>50</th>
<th>60</th>
<th>70</th>
<th>80</th>
<th>90</th>
<th>100</th>
<th>105</th>
<th>110</th>
<th>120</th>
<th>130</th>
<th>140</th>
<th>150</th>
<th>160</th>
</tr>
</thead>
<tbody>
<tr>
<td>n / %</td>
<td>0</td>
<td>0.13</td>
<td>0.37</td>
<td>0.72</td>
<td>1.15</td>
<td>1.66</td>
<td>2.24</td>
<td>2.88</td>
<td>3.58</td>
<td>4.34</td>
<td>4.74</td>
<td>5.15</td>
<td>6.03</td>
<td>6.96</td>
<td>7.96</td>
<td>9.03</td>
<td>10.20</td>
<td></td>
</tr>
<tr>
<td>p_e / bar</td>
<td>-0.99</td>
<td>-0.98</td>
<td>-0.96</td>
<td>-0.93</td>
<td>-0.88</td>
<td>-0.80</td>
<td>-0.69</td>
<td>-0.53</td>
<td>-0.30</td>
<td>-0.21</td>
<td>0.01</td>
<td>0.43</td>
<td>0.98</td>
<td>1.70</td>
<td>2.61</td>
<td>3.76</td>
<td>5.18</td>
<td></td>
</tr>
<tr>
<td>Δn (°C)</td>
<td>0</td>
<td>0.64</td>
<td>1.34</td>
<td>2.10</td>
<td>2.50</td>
<td>2.91</td>
<td>3.79</td>
<td>4.34</td>
<td>4.74</td>
<td>5.15</td>
<td>6.03</td>
<td>6.96</td>
<td>7.96</td>
<td>9.03</td>
<td>10.20</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ρ / kg/m³</td>
<td>1000</td>
<td>1000</td>
<td>998</td>
<td>996</td>
<td>994</td>
<td>992</td>
<td>990</td>
<td>988</td>
<td>986</td>
<td>984</td>
<td>982</td>
<td>980</td>
<td>978</td>
<td>976</td>
<td>974</td>
<td>972</td>
<td>970</td>
<td></td>
</tr>
</tbody>
</table>

**Water with addition of antifreeze* 20 % (vol.), lowest permissible system temperature –10 °C**

| t / °C | 0 | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100 | 105 | 110 | 120 | 130 | 140 | 150 | 160 |
|-------|---|----|----|----|----|----|----|----|----|----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| n* / % | 0.07 | 0.26 | 0.54 | 0.90 | 1.33 | 1.83 | 2.37 | 2.95 | 3.57 | 4.23 | 4.92 | 5.64 | 6.40 | 7.19 | 8.02 | 8.89 | 9.79 |
| p_e* / bar | -0.9 | -0.8 | -0.7 | -0.6 | -0.4 | -0.1 | 0.23 | 0.70 | 1.33 | 2.13 | 3.15 | 4.38 | 6.96 | 7.96 | 9.03 | 10.20 |
| ρ / kg/m³ | 1000 | 1000 | 998 | 996 | 992 | 988 | 983 | 978 | 972 | 965 | 958 | 951 | 943 | 935 | 926 | 917 | 907 |

n - Percentage expansion for water based on a minimum system temperature of +10 °C (generally filling water)

n* - Percentage expansion for water with antifreeze additive* based on a minimum system temperature of –10 °C to –20 °C

Δn - Percentage expansion for water for calculation of temperature layer containers between 70 °C and max. return temperature

p_e - Evaporation pressure for water relative to atmosphere

p_e* - Evaporation pressure for water with antifreeze additive

ρ - Density

* - Antifreeze Antifrogen N; when using other antifreeze additives, the relevant properties must be obtained from the manufacturer

** Approximate calculation of water content V_s of heating systems**

- For systems with natural circulation boilers:
  \[ V_s = Q \cdot \text{vs} + \text{pipelines + other} \]
- For systems with heat exchangers:
  \[ V_s = Q \cdot (\text{vs} - 1.4 \text{l}) + \text{pipelines + other} \]
- For systems without heat generators:
  \[ V_s = Q \cdot (\text{vs} - 2.0 \text{l}) + \text{pipelines + other} \]

Where:
- \( Q \) - Installed heating output
- \( \text{vs} \) - Specific water content in litres/kW of heating systems (heat generators, distribution, heating surfaces)

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Where:
- \( Q \) - Installed heating output
- \( \text{vs} \) - Specific water content in litres/kW of heating systems (heat generators, distribution, heating surfaces)

**Important:** approximate values; significant deviations possible in individual cases

**nFH = percentage expansion based on the max. flow temperature of the floor heating**

**Approx. water content of heating pipes**

| DN (mm) | 10 | 15 | 20 | 25 | 32 | 40 | 50 | 60 | 65 | 80 | 100 | 125 | 150 | 200 | 250 | 300 |
|--------|----|----|----|----|----|----|----|----|----|----|-----|-----|-----|-----|-----|-----|-----|
| Litres/m | 0.13 | 0.21 | 0.38 | 0.58 | 1.01 | 1.34 | 2.1 | 3.2 | 3.9 | 5.3 | 7.9 | 12.3 | 17.1 | 34.2 | 54.3 | 77.9 |

**Important:** approximate values; significant deviations possible in individual cases
The hydraulic integration of pressure maintenance in the overall system greatly influences the pressure profile. This is made up of the normal pressure level of the pressure maintenance and the differential pressure generated when the circulating pump is running. Three main types of pressure maintenance are distinguished, although additional variants exist in practice.

**Input pressure maintenance** (suction pressure maintenance)
The pressure maintenance is integrated before the circulating pump, i.e. on the suction side. This method is used almost exclusively since it is the easiest to manage.

**Advantages:**
- Low normal pressure level
- Operating pressure > normal pressure, thus no risk of vacuum formation

**Disadvantages:**
- High operating pressure in the case of high circulating pump pressure (large-scale systems) \( p_{\text{max}} \) must be observed

**Follow-up pressure maintenance**
The pressure maintenance is integrated after the circulation pump, i.e. on the pressure side. When calculating the normal pressure, a system-specific differential pressure share of the circulating pump (50 to 100 %) must be included. This method is restricted to a limited number of applications → solar energy systems.

**Advantages:**
- Low normal pressure level, provided the full pump pressure is not required

**Disadvantages:**
- High normal pressure level
- Increased need to observe the required supply pressure \( p_{\text{sup}} \) for the circulating pump acc. to manufacturer specifications

**Medium pressure maintenance**
The measuring point of the normal pressure level is “moved” into the system by means of an analogy measurement section. The normal and operating pressure levels can be perfectly coordinated in a variable manner (symmetrical, asymmetrical medium pressure maintenance). Due to the technically demanding nature of this method, its use is restricted to systems with complicated pressure ratios, mainly in the field of district heating.

**Advantages:**
- Optimised, variable coordination of operating and normal pressure

**Disadvantages:**
- Highly demanding with regard to system technology

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**Reflex recommendation**
Use suction pressure maintenance! A different method should only be used in justified exceptional cases. Contact us for more information!
Reflex manufactures two different types of pressure-maintaining systems:

**Input pressure maintenance** (suction pressure maintenance)

- **Reflex diaphragm expansion vessels with gas cushions** can function without auxiliary energy and are thus also classed as static pressure-maintaining systems. The pressure is created by a gas cushion in the vessel. To enable automatic operation, the system is ideally combined with Reflex Fillcontrol Plus as well as Reflex Servitec make-up and degassing stations.

- **Reflex pressure-maintaining systems with external pressure generation** require auxiliary energy and are thus classed as dynamic pressure-maintaining systems. A differentiation is made between pump- and compressor-controlled systems. While Reflex Variomat and Reflex Gigamat control the pressure in the system directly on the water side using pumps and overflow valves, the pressure in Reflex Minimat and Reflexomat systems is controlled on the air side by means of a compressor and solenoid valve.

Both systems have their own advantages. Water-controlled systems, for example, are very quiet and react very quickly to changes in pressure. Thanks to the unpressurised storage of the expansion water, such systems can also be used as central deaeration and degassing units (Variomat). Compressor-controlled systems, such as Reflexomat, offer extremely flexible operation within the tightest pressure limits, specifically within ± 0.1 bar (pump-controlled approx. ± 0.2 bar) of the setpoint value. A degassing function can also be implemented in this case in combination with Reflex Servitec.

Our Reflex Pro calculation program will help you identify the ideal solution.

**Preferred applications** are detailed in the following table. Based on experience, we recommend that the pressure maintenance be automated – i.e. pressure monitoring with timely water make-up – and that systems be automatically and centrally vented. This eliminates the need for conventional air separators and laborious post-venting, while ensuring safer operation and lower costs.

### Special pressure-maintaining systems - overview

<table>
<thead>
<tr>
<th></th>
<th>Flow temp. up to 120 °C</th>
<th>Pressure maintenance</th>
<th>Autom. operation with make-up</th>
<th>Central deaeration and degassing</th>
<th>Preferred output range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reflex</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Without additional equipment</td>
<td>X</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>up to 1000 kW</td>
</tr>
<tr>
<td>- With Control make-up</td>
<td>X</td>
<td>X</td>
<td>---</td>
<td>---</td>
<td></td>
</tr>
<tr>
<td>- With Servitec</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Variomat</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 Single-pump system</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td>150 – 2000 kW</td>
</tr>
<tr>
<td>2-1 Single-pump system</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td>150 – 4000 kW</td>
</tr>
<tr>
<td>2-2 Dual-pump system</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td>500 – 8000 kW</td>
</tr>
<tr>
<td>Variomat Giga</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Without additional equipment</td>
<td>X</td>
<td>X</td>
<td>X*</td>
<td></td>
<td>5000 – 60,000 kW</td>
</tr>
<tr>
<td>- With Servitec</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
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<tr>
<td>- Special systems</td>
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<td></td>
<td>As required</td>
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<tr>
<td>Reflexomat Compact</td>
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<tr>
<td>- Without additional equipment</td>
<td>X</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>100 – 2000 kW</td>
</tr>
<tr>
<td>- With Control make-up</td>
<td>X</td>
<td>X</td>
<td>---</td>
<td>---</td>
<td></td>
</tr>
<tr>
<td>- With Servitec</td>
<td>X</td>
<td>X</td>
<td>X</td>
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<tr>
<td>Reflexomat</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Without additional equipment</td>
<td>X</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>150 – 24,000 kW</td>
</tr>
<tr>
<td>- With Control make-up</td>
<td>X</td>
<td>X</td>
<td>---</td>
<td>---</td>
<td></td>
</tr>
<tr>
<td>- With Servitec</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* In the case of return temperatures < 70 °C, the Variomat Giga can also be used for degassing purposes without additional equipment.
Nominal volume $V_n$

The pressure in the expansion vessel is generated by a gas cushion. The water level and pressure in the gas space are linked ($p \times V = \text{constant}$). Therefore, it is not possible to use the entire nominal volume for water intake purposes. The nominal volume is greater than the water intake volume $V_e + V_{WS}$ by a factor of $\frac{p_f + 1}{p_f - p_0}$.

This is one reason why dynamic pressure-maintaining systems are preferable in the case of larger systems and small pressure ratios ($p_f - p_0$). When using Reflex Servitec degassing systems, the volume of the degassing pipe (5 litres) must be taken into account during sizing.

Input pressure monitoring, input pressure $p_0$, minimum operating pressure

The gas input pressure must be manually checked before start-up and during annual maintenance work; it must be set to the minimum operating pressure of the system and entered on the name plate. The planner must specify the gas input pressure in the design documentation. To avoid cavitation on the circulating pumps, we recommend that the minimum operating pressure not be set to less than 1 bar, even in the case of roof-mounted systems and heating systems in low-rise buildings.

The expansion vessel is usually integrated on the suction side of the circulating pump (input pressure maintenance). In the case of pressure-side integration (follow-up pressure maintenance) the differential pressure of the circulating pumps $\Delta p_P$ must be taken into account to avoid vacuum formation at high points.

When calculating $p_0$ we recommend the addition of a 0.2 bar safety margin. This margin should only be dispensed with in the case of very small pressure ratios.

Initial pressure $p_i$, make-up

This is one of the most important pressures! It limits the lower setpoint value range of the pressure maintenance and safeguards the water seal $V_{WS}$, that is the minimum water level in the expansion vessel.

Accurate checking and monitoring of the input pressure is only ensured if the Reflex formula for the input pressure is followed. Our calculation program takes this into account. With these higher input pressures compared to traditional configurations (larger water seal), stable operation is assured. Known problems with expansion vessels caused by an insufficient or even missing water seal are thus avoided. Particularly in the case of small differences between the final pressure and input pressure, the new calculation method can result in somewhat larger vessels. However, in terms of enhanced operational safety, the difference is insignificant.

Reflex make-up stations automatically monitor and secure the initial or filling pressure. → Reflex make-up stations

Filling pressure $p_{fil}$

The filling pressure $p_{fil}$ is the pressure that must be applied, relative to the temperature of the filling water, to fill a system such that the water seal $V_{WS}$ is maintained at the lowest system temperature. In the case of heating systems, the filling pressure and initial pressure are generally the same (minimum system temperature = filling temperature = 10 °C). In cooling circuits with temperatures below 10 °C, for instance, the filling pressure is higher than the initial pressure.

Final pressure $p_f$

The final pressure restricts the upper setpoint value range of the pressure maintenance. It must be set such that the pressure on the system safety valve is lower by at least the closing pressure difference $ASV$ according to TRD 721. The closing pressure difference depends on the type of the safety valve.

Degassing, deaeration

Targeted venting is very important, particularly in the case of closed systems; otherwise, accumulations of nitrogen in particular can lead to troublesome malfunctions and customer dissatisfaction. Reflex Servitec degasses and makes up water automatically. → p. 53
Caution with roof-mounted systems and low-rise buildings

Reflex recommendation: $p_0 \geq 1$ bar

Use Refix in the case of corrosion risk

### Heating systems

**Calculation**
According to DIN 4807 T2 and DIN EN 12828.

**Configuration**
Usually in the form of suction pressure maintenance as per adjacent diagram with circulating pump in advance and expansion vessel in return – i.e. on the suction side of the circulating pump.

**Properties $n$, $p_e$**
Generally properties for pure water without antifreeze additive. $\rightarrow$ page 6

**Expansion volume $V$, highest temperature $t_h$**
Calculation of percentage expansion, usually between lowest temperature = filling temperature = 10 °C and highest setpoint value adjustment of temperature regulator $t_h$.

**Minimum operating pressure $p_0$**
Particularly in the case of low-rise buildings and roof-mounted systems, the low static pressure $p_{st}$ requires that the minimum supply pressure for the circulating pump be verified on the basis of manufacturer specifications. Even with lower static heights, we therefore recommend that the minimum operating pressure $p_0$ not be set to less than 1 bar.

**Filling pressure $p_{fil}$, initial pressure $p_i$**
Since a filling temperature of 10 °C generally equates to the lowest system temperature, the filling pressure and input pressure of an expansion vessel are identical. In the case of pressure-maintaining stations, it should be noted that filling and make-up systems may have to operate at a level approaching the final pressure. This only applies to Reflexomat.

**Pressure maintenance**
In the form of static pressure maintenance with Reflex N, F, S, G also in combination with make-up and degassing stations, or from approx. 150 kW as a Variomat pressure-maintaining station for pressure maintenance, degassing and water make-up, or in the form of a compressor-controlled Reflexomat pressure-maintaining station. $\rightarrow$ page 18

In systems with oxygen-rich water (e.g. floor heating with non-diffusion-resistant pipes), Reflex D, Reflex DE or Reflex C are used up to 70 °C (all water-carrying parts corrosion-resistant).

**Degassing, deaeration, water make-up**
To ensure ongoing safe and automatic operation of the heating system, the pressure-maintaining units should be equipped with make-up systems and supplemented with Servitec degassing systems. $\rightarrow$ page 28

**Intermediate vessels**
If a temperature of 70 °C is permanently exceeded by the pressure maintenance, an intermediate vessel must be installed to protect the diaphragms in the expansion vessel. $\rightarrow$ page 43

**Individual protection**
According to DIN EN 12828, all heat generators must be connected to at least one expansion vessel. Only protected shut-offs are permitted. If a heat generator is shut off hydraulically (e.g. in-line boiler circuits), the connection with the expansion vessel must remain intact. Therefore, in the case of multi-boiler systems, each boiler is usually secured with a separate expansion vessel. This is only included in the calculation for the relevant boiler water content.

Due to the excellent degassing performance of Variomat, we recommend that the switch frequency be minimised by also fitting a diaphragm expansion vessel (e.g. Reflex N) to the heat generator in this case.
Reflex N, F, G in heating systems

Configuration: Input pressure maintenance, expansion vessel in return, circulating pump in advance, observe information on page 9 for follow-up pressure maintenance.

Object:

Initial data

<table>
<thead>
<tr>
<th>Heat generator</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heat output</td>
<td>Q₀ = .......... kW</td>
<td>.......... kW</td>
<td>.......... kW</td>
<td>.......... kW</td>
</tr>
<tr>
<td>Water content</td>
<td>Vₑ = .......... litres</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>System flow temperature</td>
<td>b = .......... °C</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>System return temperature</td>
<td>bₐ = .......... °C</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water content known</td>
<td>Vₚ = .......... litres</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Highest setpoint value adjustment</td>
<td>tₛ = .......... °C</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Temperature regulator</td>
<td>tₓ = .......... °C</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Antifreeze additive</td>
<td>n = .......... %</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Safety temperature limiter</td>
<td>tₐₙ = .......... °C</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Vₚ = .......... litres

Initial pressure at 10 °C filling temperature

Filling pressure

Pressure calculation

Input pressure

\[ p₀ = \text{stat. pressure } pₚ + \text{evaporation pressure } pₑ + (0.2 \text{ bar}) \]

Reflex recommendation

\[ pₚ = \quad \text{bar} \]

Safety valve actuation pressure

\[ pₑ \rightarrow \text{Reflex recommendation} \]

Final pressure

\[ pₛ \geq \text{safety valve } pₑ - 0.5 \text{ bar for } pₑ \leq 5 \text{ bar} \]

\[ pₛ \geq \text{input pressure } p₀ + 0.1 \times pₑ \text{ for } pₑ > 5 \text{ bar} \]

\[ pₛ \geq \quad \text{bar} \]

Vessel

Expansion volume

\[ Vₑ = \frac{n}{100} \times Vₑ = \quad \text{litres} \]

Water seal

\[ Vₛ = 0.005 \times Vₑ \quad \text{for } Vₑ > 15 \text{ litres with } Vₛ \geq 3 \text{ litres} \]

\[ Vₛ \geq 0.2 \times Vₑ \quad \text{for } Vₑ \leq 15 \text{ litres} \]

\[ Vₛ = \quad \text{litres} \]

Nominal volume

Without Servitec

\[ Vₚ = (Vₑ + Vₛ) \times \frac{pₚ + 1}{pₚ - p₀} \]

\[ Vₚ = \quad \text{litres} \]

With Servitec

\[ Vₚ = (Vₑ + Vₛ + 5 \text{ litres}) \times \frac{pₚ + 1}{pₚ - p₀} \]

\[ Vₚ = \quad \text{litres} \]

Initial pressure check

Without Servitec

\[ pᵢ = \frac{Vₑ \times (pₚ + 1)(n + nₐ)}{Vₑ \times (pₚ + 1) 2n} - 1 \text{ bar} \]

\[ pᵢ = \quad \text{bar} \]

With Servitec

\[ pᵢ = \frac{Vₑ \times (pₚ + 1)(n + nₐ)}{Vₑ \times (pₚ + 1) 2n} - 1 \text{ bar} \]

\[ pᵢ = \quad \text{bar} \]

\[ 1+ \]

Condition: \[ pᵢ \geq p₀ + 0.25 \ldots 0.3 \text{ bar, otherwise calculation for greater nominal volume} \]

Result summary

Reflex \( \ldots / \) \ldots \text{ bar} \ldots \text{ litres} \]

Reflex only for oxygen-rich water \( \text{e.g. floor heating} \)

\[ \text{Input pressure: } p₀ = \quad \text{bar} \rightarrow \text{check before start-up} \]

\[ \text{Initial pressure: } pᵢ = \quad \text{bar} \rightarrow \text{check make-up configuration} \]

\[ \text{Final pressure: } pₛ = \quad \text{bar} \]
In accordance with DIN EN 12828:

**every heat generator must be connected to one or more expansion vessels by at least one expansion line.**

You should select the appropriate circuit as follows:
- **Diaphragm expansion vessel in boiler return** – circulating pump in boiler flow line
  - Direct connection between diaphragm expansion vessel and heat generator
  - Low temperature load on diaphragm
  - Diaphragm expansion vessel on the suction side of the circulation pump to minimise the risk of a vacuum forming

**Please consult your specialist adviser in the event of any deviations!**

### Reflex installation examples (notes for the installer – hydraulic integration)

#### Reflex in a boiler system with 4-way mixer

**Notes for the installer**
- The boiler and system each have an expansion vessel. This ensures that no vacuum can form in the system circuit, even with fully sealing mixers.
- Reflex Fillset is a pre-packaged valve assembly providing a direct connection to potable water systems for making up and filling the system.

#### Reflex with automatic filling pressure monitoring

**Notes for the installer**
- A Reflex Fillcontrol Plus make-up station provides optimum functional support for your Reflex. It ensures your expansion vessel always contains water, which minimises vacuum formation and the ensuing air problems at high points.
- Reflex Fillset with system separator and water meter is easy to connect upstream to provide a direct connection to the potable water system.

→ Brochure Reflex
- Water treatment
- Make-up volume

The circuits must be adjusted to suit local conditions.
In accordance with DIN EN 12828:

every heat generator must be connected to one or more expansion vessels by at least one expansion line.

Which circuit should you choose?

You can have individual protection for each boiler through an expansion vessel, or opt for a common boiler and system protection option. When using shut-offs via boiler sequential circuits, you must ensure that the boiler in question is connected to at least one expansion vessel. It is always best to consult the boiler manufacturer.

**Notes for the installer**

Connecting numerous Reflex N 6 or 10 bar vessels to a battery circuit is usually a more cost-effective alternative to using larger Reflex G vessels.

The burner is used to shut off the corresponding boiler circulating pump and close the motorised valve M. This enables the boiler to remain connected to the Reflex. It is the most frequently used circuit for boilers with a minimum return flow temperature. When the burner is switched off, boiler circulation is prevented.

When the burner is switched off, the corresponding actuator M is closed via the temperature control while preventing unwanted circulation in the shut-off boiler. In addition, the boiler expansion line above the centre of the boiler prevents gravity circulation. This is ideally suited to systems without a minimum boiler return flow temperature (e.g. condensing systems).

Our Reflex Servitec vacuum spray-tube degassing unit guarantees effective system service:

- Displays and monitors pressure
- Provides automatic water make up and filling
- Centrally degasses and bleeds the contained, filling and make-up water

→ Brochure Reflex degassing systems and separation technology

The circuits must be adjusted to suit local conditions.
Solar thermal systems

Calculation
On the basis of VDI 6002 and DIN 4807 T2.

In the case of solar heating plants, the highest temperature cannot be defined via the regulator on the heat generator, but instead is determined by the stagnation temperature on the collector. This gives rise to two possible calculation methods.

Nominal volume
Calculation without evaporation in the collector
The percentage expansion $n^*$ and evaporation pressure $p_e^*$ are based on the stagnation temperature. Since some collectors can reach temperatures of over 200 °C, this calculation method cannot be applied here. In the case of indirectly heated tube collectors (heat pipe system), it is possible for systems to restrict the stagnation temperature. If a minimum operating pressure of $p_0 \leq 4$ bar is sufficient to prevent evaporation, the calculation can usually be performed without taking evaporation into account.

With this option, it should be noted that an increased temperature load will impact the anti-freeze effect of the heat transfer medium in the long term.

Nominal volume
Calculation with evaporation in the collector
For collectors with stagnation temperatures in excess of 200 °C, evaporation in the collector cannot be excluded. In this case, the evaporation pressure is only included in the calculation up to the desired evaporation point (110 - 120 °C). When calculating the nominal volume of the expansion vessel, the entire collector volume $V_c$ is included in addition to the expansion volume $V_e$ and the water seal $V_{WS}$.

This is the preferred option, as the lower temperature has a lesser impact on the heat transfer medium and the antifreeze effect is maintained for a longer period.

Nominal volume without evaporation

$$V_n = (V_e + V_{WS}) \frac{p + 1}{p_e - p_0}$$

Nominal volume with evaporation

$$V_n = (V_e + V_{WS} + V_c) \frac{p + 1}{p_e - p_0}$$
Reflex S in solar thermal systems

Configuration
Since the expansion vessel with safety valve in the return must be installed such that it cannot be shut off from the collector, this inevitably leads to follow-up pressure maintenance, i.e. integration of the expansion vessel on the pressure side of the circulating pump.

Properties $n^*$, $p_{e^*}$
When determining the percentage expansion $n^*$ and the evaporation pressure $p_{e^*}$ antifreeze additives of up to 40% must be taken into account according to manufacturer specifications. \(\rightarrow\) p. 6, properties for water mixtures with Antifrogen N

If calculating with evaporation, the evaporation pressure $p_{e^*}$ is included up to the boiling temperature 110 °C or 120 °C. The percentage expansion $n^*$ is then determined between the lowest ambient temperature (e.g. -20 °C) and the boiling temperature.

If calculating without evaporation, the evaporation pressure $p_{e^*}$ and the percentage expansion $n^*$ must be based on the stagnation temperature of the collector.

Input pressure $p_0$, minimum operating pressure
Depending on the calculation method employed, the minimum operating pressure (= input pressure) is adapted to the stagnation temperature in the collector (= without evaporation) or the boiling temperature (= with evaporation). In both cases, the normal configuration of the circulating pump pressure $Dp_P$ must be taken into account since the expansion vessel is integrated on the pressure side of the circulating pump (follow-up pressure maintenance).

Filling pressure $p_{f_{il}}$, input pressure $p_i$
As a rule, the filling temperature (10 °C) is much higher than the lowest system temperature, such that the filling pressure is greater than the initial pressure.

Pressure maintenance
Generally in the form of static pressure maintenance with Reflex S, also in combination with make-up stations.

Intermediate vessels
If a stable return temperature ≤ 70 °C cannot be guaranteed on the consumer side, an intermediate vessel must be fitted to the expansion vessel. \(\rightarrow\) p. 68
**Reflex S in solar energy systems with evaporation**

**Calculation method:** The minimum operating pressure \( p_0 \) is calculated such that no evaporation occurs up to flow temperatures of 110 °C or 120 °C – i.e. evaporation is permitted in the collector at stagnation temperature.

**Configuration:** Follow-up pressure maintenance, diaphragm expansion vessel in return to collector.

**Object:**

---

**Initial data**

<table>
<thead>
<tr>
<th>Number of collectors</th>
<th>( z )</th>
<th>units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Collector area ( A_c )</td>
<td>( z \times A_c )</td>
<td>m²</td>
</tr>
<tr>
<td>Collector surface area ( A_{CM} )</td>
<td>( A_{CM} = A_c )</td>
<td>m²</td>
</tr>
<tr>
<td>Water content per collector ( V_{CW} )</td>
<td>( z \times A_c )</td>
<td>litres</td>
</tr>
<tr>
<td>Water content ( V_{CW} )</td>
<td>( V_{CW} = A_{CM} )</td>
<td>litres</td>
</tr>
<tr>
<td>Highest advance temperature ( t_h )</td>
<td>110 °C or 120 °C</td>
<td>→ p. 6</td>
</tr>
<tr>
<td>Lowest ambient temperature ( t_a )</td>
<td>– 20 °C</td>
<td></td>
</tr>
<tr>
<td>Antifreeze additive</td>
<td>( \ldots %)</td>
<td></td>
</tr>
<tr>
<td>Static pressure ( p_a )</td>
<td>( \ldots ) bar</td>
<td></td>
</tr>
<tr>
<td>Pressure difference at circulating pump ( \Delta p )</td>
<td>( \ldots ) bar</td>
<td></td>
</tr>
<tr>
<td>Pressure calculation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Input pressure ( p_0 )</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Safety valve actuation pressure ( p_{SV} )</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Final pressure ( p_f )</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vessel</td>
<td></td>
<td></td>
</tr>
<tr>
<td>System volume ( V_s )</td>
<td>( V_s = V_{CM} + V_{in} + V_{out} + V_{WS} )</td>
<td>litres</td>
</tr>
<tr>
<td>Expansion volume ( V_e )</td>
<td>( V_e = \frac{\sigma^*}{100} \times V_s )</td>
<td>litres</td>
</tr>
<tr>
<td>Water seal ( V_{WS} )</td>
<td>( V_{WS} = \begin{cases} \frac{0.005}{V_s} \times V_s &amp; \text{for } V_s &gt; 15 \text{ litres} \ \frac{0.2}{V_s} \times V_s &amp; \text{for } V_s \leq 15 \text{ litres} \end{cases} )</td>
<td>litres</td>
</tr>
<tr>
<td>Nominal volume ( V_n )</td>
<td>( V_n = V_s + V_{in} + V_{out} )</td>
<td>litres</td>
</tr>
<tr>
<td>Check of initial pressure ( p_i )</td>
<td>( \frac{1}{V_n} \left[ V_n + V_{in} + V_{out} \right] )</td>
<td>bar</td>
</tr>
<tr>
<td>Check of initial pressure ( p_i )</td>
<td>( p_i = \frac{1}{V_n} \left[ V_n + V_{in} + V_{out} \right] )</td>
<td>bar</td>
</tr>
<tr>
<td>Percentage expansion ( n^* )</td>
<td></td>
<td>%</td>
</tr>
<tr>
<td>Filling pressure ( p_{fil} )</td>
<td>( p_{fil} = V_n \times \frac{1}{V_s} \times \frac{n^* - V_{WS}}{100} )</td>
<td>bar</td>
</tr>
<tr>
<td>Result summary</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

**Pressure calculation**

**Input pressure**

\[
p_0 = \text{stat. pressure } p_a + \text{pump pressure } \Delta p + \text{evaporation pressure } p^*_\text{e}
\]

\[
p_0 = p_a + \Delta p + p^*_\text{e}
\]

**Safety valve actuation pressure**

\[
p_{SV} \rightarrow \text{Reflex recommendation}
\]

**Final pressure**

\[
p_f \geq p_0 + 1.5 \text{ bar for } p_{SV} \leq 5 \text{ bar}
\]

\[
p_f \geq p_0 + 2.0 \text{ bar for } p_{SV} > 5 \text{ bar}
\]

**Vessel**

**System volume**

\[
V_s = V_{CM} + V_{in} + V_{out} + V_{WS}
\]

**Expansion volume**

\[
V_e = \frac{\sigma^*}{100} \times V_s
\]

**Water seal**

\[
V_{WS} = \begin{cases} \frac{0.005}{V_s} \times V_s & \text{for } V_s > 15 \text{ litres} \\ \frac{0.2}{V_s} \times V_s & \text{for } V_s \leq 15 \text{ litres} \end{cases}
\]

**Nominal volume**

\[
V_n = V_s + V_{in} + V_{out}
\]

**Check of initial pressure**

\[
p_i = \frac{1}{V_n} \left[ V_n + V_{in} + V_{out} \right]
\]

**Condition:**

\[
p_{SV} \geq p_i + 0.25 \cdot 0.3 \text{ bar, otherwise calculation for greater nominal volume}
\]

**Percentage expansion**

\[
n^* = \frac{\text{between lowest temperature } (-20 \degree C) \text{ and filling temperature (usually } 10 \degree C)}{\text{bar}} \times 100%
\]

**Filling pressure**

\[
p_{fil} = V_n \times \frac{1}{V_s} \times \frac{n^* - V_{WS}}{100} - 1 \text{ bar}
\]

**Result summary**

Reflex S/10 bar \( \ldots \) litres

---

**Check compliance with minimum supply pressure** \( p_{SW} \) for circulating pumps acc. to manufacturer specifications

\[
p_{SW} = p_0 - \Delta p
\]

---

**Check compliance with max. operating pressure**

---

**Diagram:**

- Check compliance with minimum supply pressure
- Check compliance with max. operating pressure
Reflex S in solar energy systems without evaporation

**Calculation method:** The minimum operating pressure $p_0$ is set such that no evaporation occurs in the collector – generally possible at stagnation temperatures $\leq 150$ °C.

**Configuration:** Follow-up pressure maintenance, diaphragm expansion vessel in return to collector.

**Object:**

<table>
<thead>
<tr>
<th>Initial data</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of collectors</td>
<td>$z$ units</td>
</tr>
<tr>
<td>Collector surface area</td>
<td>$A_c$ m²</td>
</tr>
<tr>
<td>Water content per collector</td>
<td>$V_c$ litres</td>
</tr>
<tr>
<td>Highest advance temperature</td>
<td>$b$ °C</td>
</tr>
<tr>
<td>Lowest ambient temperature</td>
<td>$t_A$ °C</td>
</tr>
<tr>
<td>Static pressure</td>
<td>$p_s$ bar</td>
</tr>
<tr>
<td>Difference at circulating pump</td>
<td>$\Delta p_r$ bar</td>
</tr>
<tr>
<td>Pressure calculation</td>
<td></td>
</tr>
<tr>
<td>Input pressure</td>
<td>$p_i = p_s + \Delta p_r + p_{evaporation}$</td>
</tr>
<tr>
<td>Safety valve actuation pressure</td>
<td>$p_{SV} = p_i + 1.5$ bar for $p_{SV} \leq 5$ bar, $p_{SV} + 2.0$ bar for $p_{SV} &gt; 5$ bar</td>
</tr>
<tr>
<td>Final pressure</td>
<td>$p_f = p_{SV} - 0.5$ bar for $p_{SV} \leq 5$ bar, $p_{SV} - 0.1 p_{SV}$ for $p_{SV} &gt; 5$ bar</td>
</tr>
<tr>
<td>Vessel</td>
<td></td>
</tr>
<tr>
<td>System volume</td>
<td>$V_s = V_c + V_{pip} + V_{buffer} + other$</td>
</tr>
<tr>
<td>Expansion volume</td>
<td>$V_r = \frac{n^*_F}{100} V_s$</td>
</tr>
<tr>
<td>Water seal</td>
<td>$V_{WS} = 0.005 V_r$ for $V_r &gt; 15$ litres, $V_{WS} = 0.2 V_r$ for $V_r \leq 15$ litres</td>
</tr>
<tr>
<td>Nominal volume</td>
<td>$V_n = \frac{p_i + 1}{p_f - p_0} V_r$</td>
</tr>
<tr>
<td>Check of initial pressure</td>
<td>$p_i = \frac{p_i + 1}{V_r / (p_f + 1)} - 1$ bar</td>
</tr>
<tr>
<td>Percentage expansion</td>
<td>$n^* = \frac{n^*_F}{100}$</td>
</tr>
<tr>
<td>Filling pressure</td>
<td>$p_f = V_n x \frac{p_i + 1}{V_r - V_n n^* + V_{WS}} - 1$ bar</td>
</tr>
<tr>
<td>Result summary</td>
<td></td>
</tr>
</tbody>
</table>

**Reflex S/10 bar:** $\ldots$ litres

**Input pressure** $p_i = \ldots$ bar → check before start-up

**Initial pressure** $p_i = \ldots$ bar → check make-up configuration

**Filling pressure** $p_f = \ldots$ bar → refilling of system

**Final pressure** $p_f = \ldots$ bar
Because of the low temperature load, the circulating pump and Reflex S are located in the collector return. This means that the expansion vessel must be installed on the pressure side of the circulating pump. The circulating pump pressure must therefore be considered when calculating the input pressure $p_0$.

There is no need to install the Reflex V intermediate vessel where the maximum possible temperature load for the expansion vessel is 70 °C.

If the floor heating circuit does not use oxygen-tight plastic tubing, there is a risk of corrosion. Even so, the safest option is to implement system separation between the boiler and floor circuit, e.g. with a Reflex Longtherm plate heat exchanger. We recommend using the Refix DE with special corrosion protection to prevent corrosion of the expansion vessel.

→ Refix brochure

The circuits must be adjusted to suit local conditions.
The circuits must be adjusted to suit local conditions.

Notes for the installer

- TRD 402, 18.6: The actual operating temperature can be used as the calculation temperature for expansion vessels and collection vessels.
- TRD 604 Part 2, 1.3.: There is no need to install a water level limiter with an expansion vessel if a minimum pressure limiter is activated for the expansion vessel when the water level drops below minimum. We recommend:
  - Reflex V intermediate vessel > 120 °C
  - with Reflex self-monitoring expansion-vessel valve section each with a max/min pressure limiter PAZ / PAZ and monitor PAS / PAS plus a safety temperature limiter TAZ for on-site installation.
Cooling water systems

Calculation
On the basis of DIN EN 12828 and DIN 4807 T2.

Configuration
In the form of input pressure maintenance as per adjacent diagram with expansion vessel on the suction side of the circulating pump, or in the form of follow-up pressure maintenance.

Properties n*
When determining the percentage expansion n*, antifreeze additives appropriate for the lowest system temperature must be included according to manufacturer specifications.
For Antifrogen N → p. 6

Expansion volume V
Calculation of the percentage expansion n* usually between the lowest system temperature (e.g. winter downtime: -20 °C) and the highest system temperature (e.g. summer downtime +40 °C).

Minimum operating pressure p
Since no temperatures > 100 °C are used, no special margins are required.

Filling pressure pfil, initial pressure pi
In many cases, the lowest system temperature is less than the filling temperature, meaning that the filling pressure is higher than the initial pressure.

Pressure maintenance
Generally in the form of static pressure maintenance with Reflex, also in combination with Control and Servitec make-up and degassing stations.

Degassing, deaeration, water make-up
To ensure ongoing safe and automatic operation in cooling water systems, the pressure-maintaining units should be equipped with make-up systems and supplemented with Servitec degassing systems. This is particularly important with cooling water systems, since no thermal deaeration effects apply. → p. 53.

Intermediate vessels
Although Reflex diaphragms are suitable for temperatures down to -20 °C and vessels to -10 °C, the possibility of the diaphragms freezing to the container cannot be excluded. We therefore recommend the integration of an intermediate vessel in the return to the refrigerating machine at temperatures ≤ 0 °C. → page 68

Individual protection
As in the case of heating systems, we recommend the use of individual protection for multiple refrigerating machines.
→ Heating systems, p. 10
## Reflex N, F, S, G in Cooling Water Systems

**Configuration:** Input pressure maintenance, diaphragm expansion vessel on the suction side, circulating pump, observe information on page 7 for follow-up pressure maintenance.

**Object:**

### Initial Data

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Return temperature to refrigerating machine ( t_R )</td>
<td>°C</td>
</tr>
<tr>
<td>Advance temperature to refrigerating machine ( t_F )</td>
<td>°C</td>
</tr>
<tr>
<td>Lowest system temperature ( t_{\text{min}} )</td>
<td>litres</td>
</tr>
<tr>
<td>Highest system temperature ( t_{\text{max}} )</td>
<td>litres</td>
</tr>
</tbody>
</table>

**Antifreeze additive \( \rho_{\text{st}} \): %**

**Percentage expansion \( n^* \):**

\[
n^* = \frac{n^*_{\text{at highest temp.}} - n^*_{\text{at lowest temp.}}}{t_{\text{max}} - t_{\text{min}}} = \text{°C}
\]

\[
n^* = \ldots \%
\]

**Percentage expansion between lowest temperature and filling temperature**

\[
n^*_F = \ldots \%
\]

**Static pressure \( p_{\text{sv}} \): bar**

**Pressure Calculation**

**Input pressure**

\[
p_0 = \rho_{\text{st}} + 0.2 \text{ bar}
\]

\[
p_0 = \ldots \text{ bar}
\]

**Safety valve actuation pressure**

\[
p_{\text{sv}} \geq \rho_{\text{st}} + 1.5 \text{ bar for } p_{\text{sv}} \leq 5 \text{ bar}
\]

\[
p_{\text{sv}} \geq \rho_{\text{st}} + 2.0 \text{ bar for } p_{\text{sv}} > 5 \text{ bar}
\]

**Final Pressure**

\[
p_f \leq p_{\text{sv}}
\]

\[
p_f = \ldots \text{ bar}
\]

**Vessel**

**System Volume**

\[
V_s = \ldots \text{ litres}
\]

\[
V_s = \ldots \text{ litres}
\]

\[
V_s = \ldots \text{ litres}
\]

\[
V_s = \ldots \text{ litres}
\]

**Expansion Volume**

\[
V_e = \frac{n^*}{100} \times V_s = \ldots \text{ litres}
\]

\[
V_e = \ldots \text{ litres}
\]

**Water Seal**

\[
V_{\text{WS}} = 0.005 \times V_s \quad \text{for } V_s > 15 \text{ litres with } V_{\text{WS}} \leq 3 \text{ litres}
\]

\[
V_{\text{WS}} = \ldots \text{ litres}
\]

**Nominal Volume**

Without Servitec

\[
V_n = (V_s + V_{\text{WS}}) \times \frac{p+1}{p-\rho_{\text{st}}}
\]

\[
V_n = \ldots \text{ litres}
\]

With Servitec

\[
V_n = (V_s + V_{\text{WS}} + 5 \text{ litres}) \times \frac{p+1}{p-\rho_{\text{st}}}
\]

\[
V_n = \ldots \text{ litres}
\]

**Selected \( V_n \): Reflex = \ldots \text{ litres}

**Initial Pressure Check**

Without Servitec

\[
p_i = \frac{p_1 + 1}{V_s + (p_1 + 1)}
\]

\[
p_i = \ldots \text{ bar}
\]

Condition:

\[
p_i \geq p_1 + 0.25 \ldots 3 \text{ bar, otherwise calculation for greater nominal volume}
\]

Filling Pressure

\[
p_{\text{fil}} = \frac{V_s \times (p_1 + 1)}{V_s + V_{\text{WS}} + n^* - V_{\text{WS}}}
\]

\[
p_{\text{fil}} = \ldots \text{ bar}
\]

Result Summary

<table>
<thead>
<tr>
<th>Reflex ( \ldots \text{ bar} ) \ldots \text{ litres}</th>
<th>Input pressure ( p_i = \ldots \text{ bar} \rightarrow ) check before start-up</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial pressure ( p_i = \ldots \text{ bar} \rightarrow ) check make-up configuration</td>
<td></td>
</tr>
<tr>
<td>Filling pressure ( p_{\text{fil}} = \ldots \text{ bar} \rightarrow ) refilling of system</td>
<td></td>
</tr>
<tr>
<td>Final pressure ( p_f = \ldots \text{ bar} \rightarrow ) refilling of system</td>
<td></td>
</tr>
</tbody>
</table>
Nominal volume $V_n$

The main feature of pressure-maintaining systems with external pressure generation is that the pressure is regulated by a control unit independently of the water level in the expansion vessel. As a result, virtually the entire nominal volume $V_n$ can be used for water intake purposes ($V_e + V_{WS}$). This represents a significant advantage of this method over pressure maintenance with expansion vessels.

Pressure monitoring, minimum operating pressure $p_0$

When calculating the minimum operating pressure, we recommend the addition of a 0.2 bar safety margin to ensure sufficient pressure at high points. This margin should only be dispensed with in exceptional cases, since this will otherwise increase the risk of outgassing at high points.

Initial pressure $p_i$

This restricts the lower setpoint value range of the pressure maintenance. If the pressure falls below the initial pressure, the pressure pump or compressor is activated before it is deactivated with a hysteresis of 0.2 ... 0.1 bar. The Reflex formula for the initial pressure guarantees the required minimum of 0.5 bar above saturation pressure at the high point of a system.

Final pressure $p_f$

The final pressure restricts the upper setpoint value range of the pressure maintenance. It must be set such that the pressure on the system safety valve is lower by at least the closing pressure difference $A_{sv}$, e.g. according to TRD 721. The overflow or discharge mechanism must open, at the very latest, when the final pressure is exceeded.

Working range $A_w$ of pressure maintenance

This depends on the type of pressure maintenance and is limited by the initial and final pressure. The adjacent values must be followed as a minimum.

Degassing, deaeration, water make-up

Targeted venting is very important, particularly in the case of closed systems; otherwise, accumulations of nitrogen in particular can lead to troublesome malfunctions and customer dissatisfaction. Reflex Variomat are already equipped with integrated make-up and degassing. Reflex Variomat Giga and Reflexomat pressure-maintaining systems are complemented by Reflex Servitec make-up and degassing stations as appropriate.

Partial flow degassing is only useful when integrated in the representative main flow of the system.

$V_n = 1.1 \left( V_e + V_{WS} \right)$

<table>
<thead>
<tr>
<th>Suction pressure maintenance</th>
<th>$p_s \geq p_x + p_r + 0.2 \text{ bar}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Final pressure maintenance</td>
<td>$p_f \geq p_x + p_r + \Delta p_f$</td>
</tr>
<tr>
<td>$p \geq p_x + 0.3 \text{ bar}$</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Closing pressure difference according to TRD 721 $A_{sv}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\text{SV-H} \quad 0.5 \text{ bar}$</td>
</tr>
<tr>
<td>$\text{SV-D/G/H} \quad 0.1 \text{ bar}$</td>
</tr>
<tr>
<td>$0.3 \text{ bar for } p_{sv} &lt; 3 \text{ bar}$</td>
</tr>
</tbody>
</table>

$A_r = p_s - p_f$

<table>
<thead>
<tr>
<th>Variomat</th>
<th>$\geq 0.4 \text{ bar}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variomat Giga</td>
<td>$\geq 0.4 \text{ bar}$</td>
</tr>
<tr>
<td>Reflexomat</td>
<td>$\geq 0.2 \text{ bar}$</td>
</tr>
</tbody>
</table>
Compensating volume flow $V$

In the case of heating systems that are equipped with pressure-maintaining systems controlled by an external energy source, the required compensating volume flow must be determined on the basis of the installed nominal heat output of the heat generators.

For example, with a homogeneous boiler temperature of 140 °C, the specific volume flow required is 0.85 l/kW. Deviations from this value are possible upon verification.

Cooling circuits are generally operated in a temperature range < 30 °C. The compensating volume flow is approximately half that of heating systems. Therefore, when making selections using the heating system diagram, only half of the nominal heat output $Q$ must be taken into account.

To facilitate your selection, we have prepared diagrams allowing you to determine the achievable minimum operating pressure $p_0$ directly on the basis of the nominal heat output $Q$.

**Redundancy due to partial load behaviour**

To improve partial load behaviour for pump-controlled systems in particular, we recommend the use of dual-pump systems, at least as of a heating output of 2 MW. In areas with particularly high operational safety requirements, the operator frequently demands system redundancy. In this context, it is practical to halve the output of each pump unit. Full redundancy is not generally required when you consider that less than 10 % of the pump and overflow output is required during normal operation.

Not only are Variomat 2-2 and Gigamat systems equipped with two pumps, but they also feature two type-tested overflow valves. Switching is performed on a load basis and in the case of malfunctions.
Reflex Variomat in heating and cooling systems

**Configuration**: Input pressure maintenance, Variomat in return, circulating pump in advance, observe information on page 7 for follow-up pressure maintenance.

**Object**:

<table>
<thead>
<tr>
<th>Initial data</th>
<th>Heat generator ( Q_i ) = .......... kW</th>
<th>Heat output ( Q_h = ) .......... kW .......... kW .......... kW .......... kW</th>
<th>( Q_{tot} = ) .......... kW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water content ( V_w = ) .......... litres</td>
<td>System flow temperature ( t_s = ) .......... °C → p. 6</td>
<td>Approximate water content ( V_i = ) .......... litres</td>
<td></td>
</tr>
<tr>
<td>System return temperature ( t_r = ) .......... °C</td>
<td>Water content known ( V_i = ) .......... litres</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Highest setpoint value adjustment</td>
<td>Temperature regulator ( t_{tr} = ) .......... °C → p. 6</td>
<td>Percentage expansion ( n = ) .......... %</td>
<td></td>
</tr>
<tr>
<td>Antifreeze additive</td>
<td>Safety temperature limiter ( t_{s} = ) .......... °C → p. 6</td>
<td>Evaporation pressure ( p_v &gt; 100 °C ) (with antifreeze additive ( p_v^* )) ( p_v = ) .......... bar</td>
<td></td>
</tr>
<tr>
<td>Static pressure ( p_s = ) .......... bar</td>
<td>Pressure calculation</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Pressure calculation**

| Minimum operating pressure \( p_0 = \) stat. pressure \( p_s + \) evaporation pressure \( p_v + (0.2 \text{ bar})^1 \) Condition \( p_0 \geq 1.3 \text{ bar} \) | \( p_0 = \) .......... bar |
| Final pressure \( p_f \geq \) minimum operating pressure \( p_0 + 0.3 \text{ bar} + \) working range Reflexomat A, \( p_f = \) .......... bar |
| Safety valve actuation pressure \( p_{sv} \geq \) final pressure \( + \) closing pressure difference \( A_{sv} \) \( p_{sv} = \) .......... bar |

**Control unit selection**

Diagram valid for heating systems/for cooling systems \( t_{max} \leq 30 °C \), only 50 % of \( Q_{tot} \) is to be considered.

<table>
<thead>
<tr>
<th>( p_0 \geq 1.3 \text{ bar} )</th>
<th>( q / \text{MW} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variomat 2</td>
<td>Variomat 2-1</td>
</tr>
<tr>
<td>8.0</td>
<td>8.0</td>
</tr>
<tr>
<td>7.0</td>
<td>7.0</td>
</tr>
<tr>
<td>6.0</td>
<td>6.0</td>
</tr>
<tr>
<td>5.0</td>
<td>5.0</td>
</tr>
<tr>
<td>4.0</td>
<td>4.0</td>
</tr>
<tr>
<td>3.0</td>
<td>3.0</td>
</tr>
<tr>
<td>2.0</td>
<td>2.0</td>
</tr>
<tr>
<td>1.0</td>
<td>1.0</td>
</tr>
</tbody>
</table>

Vessel

| Nominal volume \( V = \) taking water seal into account \( V_i = 11 \times V \times \frac{n + 0.5}{100} = \) .......... litres |

**Result summary**

<table>
<thead>
<tr>
<th>Variomat</th>
<th>VG basic vessel</th>
<th>VF secondary vessel</th>
<th>VW thermal insulation</th>
</tr>
</thead>
<tbody>
<tr>
<td>litres</td>
<td>litres</td>
<td>litres</td>
<td>litres</td>
</tr>
</tbody>
</table>

\( n + 0.5 \frac{100}{100} \) Minimum operating pressure \( p_0 = \) .......... bar

Final pressure \( p_f = \) .......... bar

**Note**: Due to the excellent degassing performance of Variomat, we generally recommend individual protection of the heat generator using Reflex diaphragm expansion vessels.

---

*The higher the value of \( p_0 \) over \( p_s \), the better the degassing function; 0.2 bar is required as a minimum.*

---

*Check compliance with max. operating pressure.*

---

*Expansion lines (ADL) see the entries in the adjacent curves. Please observe the pressure-dependent dimensions for dual-pump systems. We recommend choosing one dimension larger for the nominal connection in the case of an expansion line length > 10 m.*

---

*Automatic, load-specific activation and fault changeover of pumps and overflow units for Variomat 2-2.*

---

*The nominal volume can be distributed across multiple vessels.*
Reflex Variomat Giga in heating and cooling systems

**Configuration:** Input pressure maintenance, Variomat Giga in return, circulating pump in advance, observe information on page 7 for follow-up pressure maintenance.

**Object:**

<table>
<thead>
<tr>
<th>Heat generator</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>Q_{tot} = .......... kW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heat output Q_h</td>
<td>.......... kW</td>
<td>.......... kW</td>
<td>.......... kW</td>
<td>.......... kW</td>
<td></td>
</tr>
<tr>
<td>Water content V_w</td>
<td>.......... litres</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>System water content V_s</td>
<td>.......... °C</td>
<td>→ p. 6</td>
<td>Approximate water content V_i = f (V_s, t_F, Q_{tot})</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Heat output Q_h</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>Q_{tot} = .......... kW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heat output Q_h</td>
<td>.......... kW</td>
<td>.......... kW</td>
<td>.......... kW</td>
<td>.......... kW</td>
<td></td>
</tr>
<tr>
<td>Water content V_w</td>
<td>.......... litres</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>System water content V_s</td>
<td>.......... °C</td>
<td>→ p. 6</td>
<td>Approximate water content V_i = f (V_s, t_F, Q_{tot})</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Highest setpoint value adjustment</th>
<th>t_{max}</th>
<th>→ p. 6</th>
<th>Percentage expansion n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature regulator t_{TR} = .......... °C</td>
<td>n = .......... %</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Antifreeze additive n*</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Safety temperature limiter</th>
<th>t_{max} = .......... °C</th>
<th>→ p. 6</th>
<th>Evaporation pressure p_e at &gt; 100 °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safety temperature limiter</td>
<td>t_{max} = .......... °C</td>
<td>→ p. 6</td>
<td>Evaporation pressure p_e at &gt; 100 °C</td>
</tr>
<tr>
<td>Static pressure p_s = .......... bar</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Antifreeze additive n*</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Specific characteristic values</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum operating pressure p_{0} = stat. pressure + evaporation pressure + (0.2 bar)</td>
<td>p_{0} = .......... bar</td>
</tr>
<tr>
<td>Final pressure p = minimum operating pressure + 0.3 bar + working range Reflexomat</td>
<td></td>
</tr>
<tr>
<td>Safety valve p_{SV} ≥ final pressure + closing pressure difference + (0.2 bar)</td>
<td>p_{SV} = .......... bar</td>
</tr>
<tr>
<td>Response pressure p_{SV} ≥ p_{SV} + 0.5 bar for p_{SV} ≤ 5 bar</td>
<td></td>
</tr>
<tr>
<td>p_{SV} ≥ p_{SV} + 0.1 x p_{SV} for p_{SV} &gt; 5 bar</td>
<td></td>
</tr>
</tbody>
</table>

**Control unit selection**

Diagram valid for heating systems STL ≤ 120 °C

for cooling systems t_{max} ≤ 30 °C, only 50 % of Q_{tot} is to be considered

<table>
<thead>
<tr>
<th>Minimum operating pressure p_{0} = stat. pressure + evaporation pressure + (0.2 bar)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Final pressure p = minimum operating pressure + 0.3 bar + working range Reflexomat</td>
</tr>
<tr>
<td>Safety valve p_{SV} ≥ final pressure + closing pressure difference + (0.2 bar)</td>
</tr>
<tr>
<td>Response pressure p_{SV} ≥ p_{SV} + 0.5 bar for p_{SV} ≤ 5 bar</td>
</tr>
<tr>
<td>p_{SV} ≥ p_{SV} + 0.1 x p_{SV} for p_{SV} &gt; 5 bar</td>
</tr>
</tbody>
</table>

**Vessel**

Nominal volume V = taking water seal into account

V_s = 11 x V_i x n + 0.5 = 11 x .......... x .......... = .......... bar

Result summary

<table>
<thead>
<tr>
<th>GH hydraulic unit</th>
<th>.......... litres</th>
</tr>
</thead>
<tbody>
<tr>
<td>GG basic vessel</td>
<td>.......... litres</td>
</tr>
<tr>
<td>GF secondary vessel</td>
<td>.......... litres</td>
</tr>
</tbody>
</table>

The nominal volume can be distributed across multiple vessels.

For systems outside the displayed output ranges, please contact us.

Please contact our technical sales team.
**Reflexomat and Reflexomat Compact in heating and cooling systems**

**Configuration:** Input pressure maintenance, Reflexomat, Reflexomat Compact in return, circulating pump in advance, observe information on page 9 for follow-up pressure maintenance.

**Object:**

<table>
<thead>
<tr>
<th>Initial data</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Heat generator</td>
<td>Q&lt;sub&gt;t&lt;/sub&gt; = .......... kW</td>
</tr>
<tr>
<td>Heat output</td>
<td>1</td>
</tr>
<tr>
<td>Water content</td>
<td>V&lt;sub&gt;N&lt;/sub&gt; = .......... litres</td>
</tr>
<tr>
<td>System flow temperature</td>
<td>b&lt;sub&gt;1&lt;/sub&gt; = .......... °C</td>
</tr>
<tr>
<td>System return temperature</td>
<td>b&lt;sub&gt;2&lt;/sub&gt; = .......... °C</td>
</tr>
<tr>
<td>Water content known</td>
<td>V&lt;sub&gt;1&lt;/sub&gt; = .......... litres</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Pressure calculation</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum operating pressure</td>
<td>p&lt;sub&gt;0&lt;/sub&gt; = stat. pressure + evaporation pressure + (0.2 bar)</td>
</tr>
<tr>
<td>Recommendation</td>
<td>p&lt;sub&gt;0&lt;/sub&gt; ≥ 1.0 bar</td>
</tr>
<tr>
<td>Final pressure</td>
<td>p&lt;sub&gt;f&lt;/sub&gt; = minimum operating pressure + 0.3 bar + working range Reflexomat A&lt;sub&gt;N&lt;/sub&gt;</td>
</tr>
<tr>
<td>Safety valve actuation pressure</td>
<td>p&lt;sub&gt;SV&lt;/sub&gt; ≥ final pressure + closing pressure difference A&lt;sub&gt;SV&lt;/sub&gt;</td>
</tr>
<tr>
<td>Control unit selection</td>
<td>Diagram valid for heating systems t&lt;sub&gt;max&lt;/sub&gt; ≤ 30 °C, only 50 % of Q&lt;sub&gt;tot&lt;/sub&gt; is to be considered</td>
</tr>
</tbody>
</table>

**Result summary:**

- Reflexomat with control unit VS .......... / .......... litres Minimum operating pressure p<sub>0</sub> .......... bar
- RG basic vessel .......... litres Final pressure p<sub>f</sub> .......... bar
- or Reflexomat Compact .......... litres

**Vessel**

Nominal volume V<sub>N</sub> taking water seal into account

V<sub>N</sub> = 1.1 x .......... x .......... x .......... = .......... litres

The nominal volume can be distributed across multiple vessels.
District heating systems, large-scale and special systems

Calculation
The usual approach for heating systems, e.g. using DIN EN 12828, is often not applicable to district heating systems. In this case, we recommend that you coordinate with the network operator and the relevant authorities for systems subject to inspection. Contact us for more information!

Configuration
In many cases, the configurations for district heating systems differ from those used for heating installations. As a result, systems with follow-up and medium pressure maintenance are used in addition to classic input pressure maintenance. This has a direct impact on the calculation procedure.

Properties $n$, $p_e$
As a rule, properties for pure water without antifreeze additive are used.

Expansion volume $V_e$
Due to the frequently very large system volumes and minimal daily and weekly temperature fluctuations, when compared to heating systems, the calculations methods employed deviate from DIN EN 12828 and often produce smaller expansion volumes. When determining the expansion coefficient, for example, both the temperatures in the network advance and the network return are taken into account. In extreme cases, calculations are only based on the temperature fluctuations between the supply and return.

Minimum operating pressure $p_0$
The minimum operating pressure must be adapted to the safety temperature of the heat generator and determined such that the permitted normal and operating pressures are maintained throughout the network and cavitation on the pumps and control fittings is avoided.

Initial pressure $p_i$
In the case of pressure-maintaining stations, the pressure pump is activated if the pressure falls below the initial value. Particularly in the case of networks with large circulating pumps, dynamic start-up and shutdown procedures must be taken into account. The difference between $p_i$ and $p_e (= P_{L_{min}})$ should then be at least 0.5 - 1 bar.

Pressure maintenance
In the case of larger networks, almost exclusively in the form of pressure maintenance with external pressure generation, e.g. Variomat, Variomat Gigamat, Reflexomat Compact or Reflexomat. With operating temperatures over 105 °C or safety temperatures STL > 110°C, the special requirements of DIN EN 12952, DIN EN 12953 or TRD 604 BI 2 can be applied.

Degassing
We recommend that heat generation systems that do not have a thermal degassing system be equipped with a Servitec vacuum spray-tube degassing unit.
Hydraulic integration
You should select the appropriate circuit as follows:
Reflexomat in boiler return – circulating pump in boiler flow line
Direct connection between the Reflexomat and heat generator
Low temperature load on diaphragm
If the continuous load of the diaphragm is at risk > 70 °C,
Reflex V intermediate vessels are to be installed in the expansion lines
Install Reflexomat on the suction side of the circulation pump to mini-
mise the risk of a vacuum forming

For multi-boiler systems (→ page 16–17) it is standard practice to
protect each boiler individually with an additional expansion vessel and
also to protect the boiler and system together as a whole. When using
shut-offs via boiler sequential circuits, you must ensure that the boiler
in question is connected to at least one expansion vessel. It is always
best to consult the boiler manufacturer.

Please consult your specialist adviser in the event of any
deviations!

Reflexomat with RS.../1 in a single-boiler system, make-up with Reflex Fillcontrol Auto Compact

Notes for the installer

- The Reflexomat is integrated into the re-
turn between the boiler shut-off and the
boiler and with the Reflex V intermediate
vessel for return temperatures > 70 °C.

- Reflex Fillcontrol Auto Compact
Make-up with pump is adjusted during
use in Reflexomat systems to “level-
dependent controller”. Make-up is then
performed based on the filling level in the
RG basic vessel. The 230 V signal of the
Reflexomat is to be switched to floating
via an attached coupling relay on site.

- Reflex Fillcontrol Auto Compact has an
open system separation tank and can be
connected directly to the potable water
system. The delivery rate is between 120
and 180 l/h for a delivery pressure of up
to max. 8.5 bar.

The circuits must be adjusted to suit local conditions.
Individual boiler protection
The burner is used to shut off the corresponding boiler circulating pump and close the motorised valve. During this, the boiler remains connected to the Reflexomat; the most frequently used circuit for boilers with a minimum return flow temperature. When the burner is switched off, boiler circulation is prevented.

Water make-up systems without pump
If the make-up volume is at least 1.3 bar above the final pressure of the Reflexomat, the Reflex solenoid valve with ball valve can be used for making up directly without an additional pump. For make-up from the potable water system, Reflex Fillset is to be prefixed.

The circuits must be adjusted to suit local conditions.
**Reflex Reflexomat (notes for the installer)**

**Reflexomat with RS.../2 in a multi-boiler system, make-up and degassing with Reflex Servitec**

- **Joint boiler and system protection**
  When the burner is switched off, the corresponding actuator is closed via the temperature control while preventing unwanted circulation in the shut-off boiler. In addition, the boiler expansion line above the centre of the boiler prevents gravity circulations. This is ideally suited to systems without a minimum boiler return flow temperature (e.g. condensing systems).

- **Reflexomat and Reflex Servitec - the ideal combination!**
  Combine the Reflexomat with the Servitec spray-tube degassing. The unit does not only perform make-up and rid the make-up water of dissolved gases; it also provides practically gas-free water content in the system. This reliably prevents air problems caused by free gas bubbles at high points in the system, circulating pumps or control valves andeffectively averts corrosion problems.

The circuits must be adjusted to suit local conditions.

The same applies to the combination of Reflexomat and Reflex Servitec: The pressure in the highly degassed, bubble-free water content is “gently absorbed” by the Reflexomat.
Reflex Variomat assembly

Excerpts from the assembly, operating, and maintenance instructions

- Vertical installation in a frost-free, well-ventilated room with drainage facility.
- Control unit and the vessels should be preferably installed on the same level, control unit should under no circumstances be installed above vessels! Install vessels in a vertical position.
- The pressure cell for the level gauge is to be mounted on the base provided for the VG basic vessel. In order not to affect the level gauge, the VG basic vessel and the first VF secondary vessel must always be connected to the connection sets provided in a flexible manner.
- The VG basic vessel must not be rigidly attached to the floor.
- In the case of heating systems, the VW thermal insulation is recommended for the VG basic vessel.
- Flush connection lines before start-up!

Close-up:

Variomat connection

Operation of the Servitec degassing unit is ensured only if the Servitec unit is integrated in a representative main current of the system. The following minimum flow rates $V$ must be maintained during operation.

In the case of an inclination of $\Delta t = 20 \, \text{K}$ this corresponds to a minimum power range of the consumer facility for $Q$.

<table>
<thead>
<tr>
<th>Variomat 1</th>
<th>Variomat 2-1</th>
<th>Variomat 2-2/35</th>
<th>Variomat 2-2/60 - 95</th>
</tr>
</thead>
<tbody>
<tr>
<td>$V$</td>
<td>2 m³/h</td>
<td>4 m³/h</td>
<td>2 m³/h</td>
</tr>
<tr>
<td>$Q$</td>
<td>47 kW</td>
<td>94 kW</td>
<td>47 kW</td>
</tr>
</tbody>
</table>

In order to prevent coarse dirt from entering the Variomat directly, the connection lines must be integrated from above or, as illustrated, integrated as an immersion tube in the main line.

The dimension of the expansion line is selected according to page 12.

Attention, dirt!

- Integration of the pump and overflow lines in the system to prevent coarse dirt from entering (see detail).
- Dimensions for the expansion lines.

- If the Reflex Fillset is not fitted, a dirt trap must be installed (mesh size 0.25 mm) in the make-up line NS.
Reflex Variomat installation examples (general notes)

**Individual protection:** Due to the excellent degassing performance of Variomat, we recommend that the switch frequency be minimised by also fitting a diaphragm expansion vessel (e.g. Reflex N) to the heat generator.

**Integration in the system:** In order to prevent coarse dirt from entering the Variomat and clogging up the dirt trap, integration must be performed according to the diagram on page 24. The pipelines for the heating system and potable water make-up unit must be flushed before start-up.

**Connection line for make-up:** When directly connecting the make-up line to a potable water system, Reflex Fillset must be prefixed (shut-off, system separator, water meter, dirt trap). If Reflex Fillset is not installed, a dirt trap with a mesh size of ≤ 0.25 mm must be fitted, at least to protect the make-up solenoid valve. The line between the dirt trap and the solenoid valve must be kept as short as possible and flushed.

**Reflex Variomat 1 in a single-boiler system ≤ 350 kW, < 100 °C, make-up with potable water**

Notes for the installer

- It is not necessary to mount additional cap valves in the expansion line.

- Reflex Fillset with integrated system separator must be prefixed when connecting it to the potable water system.

- For expansion lines over 10 m in length, we recommend choosing one dimension larger for the nominal values, e.g. DN 32 instead of DN 20. See also p. 67.

The circuits must be adjusted to suit local conditions.
Reflex Variomat installation examples (notes for the installer)

Reflex Variomat 1 in a district heating substation, make-up via FW return flow

- District heating water is generally best suited as make-up water. Water treatment can be omitted.
- Coordination with the heating supplier is necessary! Observe connection conditions!
- Lay expansion lines over 10 m in length in DN 32. → p. 31/67

Variomat 2:
For special requirements, e.g. in district heating, an optional board is available with 6 digital input and 6 floating output contacts and pressure and level outputs via an isolation amplifier.
Please contact us for more information!

Reflex Variomat 2-1 in a system with central return flow addition, make-up via softening system

- Variomat must always be integrated in the main volumetric flow so that a representative part flow can be degassed. In the case of central return flow addition, this is on the system side. This provides individual protection for the boiler.
- If the capacity of the Reflex Fillset is exceeded ($k_{VS} = 1 \text{ m}^3/\text{h}$), then an alternative corresponding connection group is provided by the customer in the make-up supply. A filter mesh size of max. 0.25 mm is permissible.

→ p. 31/67

EXTRAS: 2 pumps with soft start, electrical main switch, load-specific activation and fault switchover
**Reflex Variomat installation examples (notes for the installer)**

**Reflex Variomat 2-2 in a multi-boiler system, advance > 100 °C, make-up via softening system**

- For water treatment systems, Reflex Fillset is installed with system separator and water meter in front of the softening system.
- Provide individual protection for multi-boiler systems with Reflex.
- Several F secondary vessels can be connected.

The circuits must be adjusted to suit local conditions.

**EXTRAS:**
- 2 pumps with soft start
- Electrical main switch
- Load-specific activation and fault switchover
Reflex Variomat Giga installation examples (notes for the installer)

**Reflex Variomat Giga** up to TR ≤ 105 °C with GH hydraulics and controller GS 1.1 in a multi-boiler system, return flow temperature ≤ 70 °C

- In order to minimise the temperature load of the vessel diaphragm, installation of the Variomat Giga is recommended before the integration point of the return flow temperature-raising facility (seen in flow fitting).

- * When using Servitec systems, this connection must be closed, since the medium is directly fed into the network via the Servitec.

**Reflex Variomat Giga** up to TR ≤ 105 °C with GH hydraulics and GS 3 controller in a multi-boiler system, return flow temperature > 70 °C

- For multi-boiler systems with hydraulic points, the integration of the expansion line on the consumer side and individual protection for the boiler is recommended due to the low temperature load of the Gigamat.

- For Variomat Giga, the minimum pressure protection is ensured by using an additional solenoid valve, which is connected from the minimum pressure limiter at the station.

- Variomat Giga systems are generally used in large output ranges. Here (RL > 70 °C) we recommend the use of Reflex Servitec spray-tube degassing units for active corrosion protection, as a central “system bleeding point” and for central make-up.
Up to outputs of 30 MW, a standardised programme is also available for use in systems above 105 °C with self-monitoring operation according to TRD 604 Part 2, DIN EN 12952 and 12953. The Variomat Giga and the corresponding accessory technology can be selected using the Reflex Product Manager.

Apart from the pressure maintenance PIS and pressure protection PAZ, temperature protection TAZ is also integrated, which is triggered by the safety circuit when a set temperature has been exceeded (generally > 70 °C).

The circuits must be adjusted to suit local conditions.
Reflex Variomat Giga non-standard programme explained using an example with medium pressure maintenance

The Reflex Variomat Giga non-standard programme is tailored to your individual needs and requirements.

With complicated network pressure conditions in particular, it may be necessary to use medium pressure maintenance instead of the standard suction or final pressure maintenance. → p. 27

Minimum pressure monitoring
If the minimum operating pressure is not reached on the component-tested minimum pressure limiter PAZ, then the electrical actuator in the overflow line is closed and the heat generation switched off. The minimum pressure limiter must be mounted on the expansion line, and in the case of medium pressure maintenance, in the medium pressure maintenance.

Operation acc. to TRD 604 ASV Part 2
For systems > 105 °C with self-monitoring operation, the water level in the expansion vessels is monitored with additional component-tested water level sensors.

Temperature monitoring
For systems > 105 °C, a safety temperature limiter is installed after the intermediate vessel, which is integrated into the safety chain.
Reflex Variomat Giga – the individual non-standard programme (with TÜV inspection)

Reflex Variomat Giga non-standard control unit with electrical overflow valves, electrical actuator and SPS
Hot water systems

Potable water is essential to life! For this reason, the expansion vessels in drinking water installations must meet the special requirements of DIN 4807 T5. Only water-carrying vessels are permitted.

Calculation
According to DIN 4807 T5. → form on p. 25

Configuration
As per adjacent diagram.
As a rule, the safety valve should be installed directly at the cold water inlet of the water heater. In the case of Refix DD and DT, the safety valve can also be fitted directly before the flow fitting (in water flow direction), provided that the following conditions are met:

Refix DD with T-piece:
- Rp ¾ max. 200 l Water heater
- Rp 1 max. 1000 l Water heater
- Rp 1¼ max. 5000 l Water heater

Refix DT flow fitting: Rp 1¼ max. 5000 l Water heater

Properties n, p
Generally calculation between cold water temperature of 10 °C and max. hot water temperature of 60 °C.

Input pressure \( p_0 \), minimum operating pressure
The minimum operating pressure or input pressure \( p_0 \) in the expansion vessel must be at least 0.2 bar below the minimum flow pressure. Depending on the distance between the pressure reducing valve and the Refix unit, the input pressure must be adjusted to between 0.2 and 1.0 bar below the set pressure of the pressure reducing valve.

Initial pressure \( p_i \)
The initial pressure is identical to the set pressure of the pressure reducing valve. Pressure reducing valves are required according to DIN 4807 T5 to ensure a stable initial pressure and thus achieve the full capacity of the Refix unit.

Expansion vessel
In potable water systems according to DIN 1988, only water-carrying Refix vessels meeting the specifications of DIN 4807 T5 may be used. In the case of non-potable water systems, Refix units with a single connection are sufficient.
### Pressure-maintaining systems

**Object:**

- **Initial data**
  - Tank volume
  - Heating output
  - Water temperature in tank
  - Set pressure of pressure reducing valve
  - Safety valve setting
  - Peak flow

- **Selection according to nominal volume \( V_n \)**

- **Selection according to peak volume flow \( V_p \)**

- **Result summary**

### Refix in hot water systems

#### Initial data

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tank volume</td>
<td>( V_{hi} ) litres</td>
</tr>
<tr>
<td>Heating output</td>
<td>( q ) kW</td>
</tr>
<tr>
<td>Water temperature in tank</td>
<td>( t_{w} ) °C</td>
</tr>
<tr>
<td>Set pressure of pressure reducing valve</td>
<td>( p_i ) bar</td>
</tr>
<tr>
<td>Safety valve setting</td>
<td>( p_{SV} ) bar</td>
</tr>
<tr>
<td>Peak flow</td>
<td>( V_{P} ) m³/h</td>
</tr>
</tbody>
</table>

#### Selection according to nominal volume \( V_n \)

- **Input pressure**
  
  \[
  p_0 = \frac{n \times (p_{SV} + 0.5)(p_{0} + 1.2)}{100 \times (p_{SV} + 1)(p_{SV} - p_{0} - 0.7)} \text{ bar}
  
- **Nominal volume**
  
  \[
  V_n = V_{hi}
  \]

#### Selection according to peak volume flow \( V_p \)

- **Recomm. max. peak flow \( V_p^* \)**
  - Refix DD 8 – 33 litres
  - Refix DD 60 – 500 litres
  - Refix DT 80 – 3000 litres
  - Refix DE/DC

- **Actual pressure loss with volume flow \( V \)**
  - \( \Delta p = \frac{\dot{V} [m^3/h]^2}{2.5 m^3/h} \) negligible
  - \( \Delta p = \frac{\dot{V} [m^3/h]^2}{2.7 m^3/h} \) negligible
  - \( \Delta p = \frac{\dot{V} [m^3/h]^2}{7.2 m^3/h} \)

- **Result summary**

| Refix DT | \( V_n \) litres | Nominal volume | \( V_n \) litres |
| Refix DD | \( V_p \) litres, \( G = \ldots \) (standard Rp 1/4 included) |
| Refix DT | \( V_p \) litres | Input pressure | \( p_0 \) bar |

---

*calculated for a speed of 2 m/s*
Quoted from DIN 4807 T5:
"In order to perform maintenance and inspection of the gas input pressure, ... a ... protected shut-off fitting with an emptying facility must be installed."
"For safe continuous operation ... maintenance with inspection of the set input pressure must be performed at least once annually."
Set input pressure $p_0$ of Refix to between 0.2 and 1 bar below the set value of the pressure reducing valve.

**Refix DD, DT 60 - 500' with Flowjet flow fitting**

The complete solution with Flowjet flow fitting

Advantages: With Flowjet, mounting is simple and according to DIN. A shut-off facility, an emptying facility and flow are guaranteed for Refix.

1. Refix DD or Refix DT 60 - 500'
2. Flowjet flow fitting as optional accessory for Refix DD:
   - Standard with T-piece Rp $\frac{3}{4}$, $V \leq 2.5 \text{ m}^3/\text{h}$
   - for T-piece Rp 1, $V \leq 4.2 \text{ m}^3/\text{h}$
   - for Refix DT 60 - 500' with Flowjet: Standard with Rp 1¼, $V \leq 7.2 \text{ m}^3/\text{h}$
3. Reflex wall bracket for 8–25 litres
   - (33 l with brackets, DT with feet)
4. A safety valve may be installed in the flow direction before Refix DD or DT5 with Flowjet, provided that the nominal diameter of the required SV is ≤ the subsequent tank feed.

**Refix DD without Flowjet flow fitting**

During maintenance, if a Flowjet flow fitting is not provided, the feed to the water heater must be shut off and the Refix DD emptied using a fitting provided by the customer.

1. Refix DD
2. T-piece Rp $\frac{3}{4}$
   - for T-piece Rp 1
   - $V \leq 2.5 \text{ m}^3/\text{h}$
   - $V \leq 4.2 \text{ m}^3/\text{h}$
3. Reflex wall bracket for 8–25 litres
   - (33 l with brackets)

**Refix DT with duo connection**

- Additional fittings are necessary for shutting off and emptying the Refix DT with duo connection.
- The safety valve should be installed at the cold water inlet of the storage tank such that it cannot be shut off.
Pressure booster systems (PBS)

Calculation
According to DIN 1988 T5: Technical rules for potable water installations, pressure increase and reduction.
→ see form on p. 43

Configuration
On the input pressure side of a PBS, Refix expansion vessels relieve the connection line and the supply network. The use of these must be agreed with the relevant water utility company.

On the follow-up pressure side of a PBS, Refix vessels are installed to reduce the switch frequency, particularly in the case of cascade control systems.

Installation on both sides of the PBS may also be necessary.

Input pressure $p_{in}$, input pressure $p_i$
The minimum operating pressure or input pressure $p_i$ in the Refix vessel must be set approx. 0.5 to 1 bar below the minimum supply pressure on the suction side and 0.5 to 1 bar below the switch-on pressure on the pressure side of a PBS.
Since the initial pressure $p_i$ is at least 0.5 bar higher than the input pressure, a sufficient water seal is always ensured; this is an important prerequisite for low-wear operation.
In potable water systems according to DIN 1988, only water-carrying Refix vessels meeting the specifications of DIN 4807 T5 must be used. In the case of non-potable water systems, Refix units with a single connection are sufficient.
Refix in pressure booster systems (PBS)

Object:

**Configuration: Refix on input pressure side of PBS**

**Installation:** As agreed with the relevant water utility company (WUC)

**Necessity:** Applies if the following criteria are not met
- In the event of the failure of a PBS pump, the flow rate in the PBS connection line must not change by more than 0.15 m/s
- If all pumps should fail, it must not change by more than 0.5 m/s
- During pump operation, the supply pressure must not drop by more than 50% of the minimum value \(p_{\text{minS}}\) and must be at least 1 bar

**Initial data:**
- min. supply pressure \(p_{\text{pit}} = \ldots \text{bar}\)
- Max. delivery rate \(V_{\text{maxP}} = \ldots \text{m}^3/\text{h}\)

**Selection according to DIN 1988 T5**

- \(p_{\text{pit}} = \text{min. supply pressure} - 0.5 \text{ bar}\)

<table>
<thead>
<tr>
<th>(V_{\text{maxP}} / \text{m}^3/\text{h})</th>
<th>Refix DT with duo connection (V_{\text{litres}})</th>
<th>Refix DT (V_{\text{litres}})</th>
</tr>
</thead>
<tbody>
<tr>
<td>(\leq 7)</td>
<td>300</td>
<td>300</td>
</tr>
<tr>
<td>(&gt; 7 \leq 15)</td>
<td>500</td>
<td>600</td>
</tr>
<tr>
<td>(&gt; 15)</td>
<td></td>
<td>800</td>
</tr>
</tbody>
</table>

**Configuration: Refix on follow-up pressure side of PBS**

- To restrict the switch frequency of pressure-controlled systems

**Max. delivery head of PBS** \(H_{\text{max}} = \ldots \text{mWs}\)
**Max. supply pressure** \(p_{\text{pit}} = \ldots \text{bar}\)
**Switch-on pressure** \(p_{\text{on}} = \ldots \text{bar}\)
**Cut-out pressure** \(p_{\text{out}} = \ldots \text{bar}\)
**Max. delivery rate** \(V_{\text{maxP}} = \ldots \text{m}^3/\text{h}\)
**Switch frequency** \(s = \ldots \text{i/h}\)
**Number of pumps** \(n = \ldots \)
**Electrical power of most powerful pump** \(P_{\text{el}} = \ldots \text{kW}\)

- \(s - \text{switch frequency i/h} 20 15 10\)

**Pump output kW**

<table>
<thead>
<tr>
<th>(\leq 4.0)</th>
<th>(\leq 75)</th>
<th>(\leq 75)</th>
</tr>
</thead>
</table>

**Nominal volume** \(V_{\text{n}} = 0.33 \times V_{\text{maxP}} + 1/(p_{\text{pit}} - p_{\text{on}}) \times s \times n\)

| \(V_{\text{n}} = \ldots \text{litres}\) |
|----------------|----------------|----------------|

- - To store the minimum supply volume \(V_{\text{i}}\) between activation and deactivation of the PBS

**Switch-on pressure** \(p_{\text{pit}} = \ldots \text{bar}\)
**Cut-out pressure** \(p_{\text{out}} = \ldots \text{bar}\)
**Input pressure Reflex** \(p_{\text{io}} = \ldots \text{bar} \rightarrow \text{Reflex recommendation: } p_{\text{in}} = p_{\text{pit}} - 0.5 \text{ bar}\)
**Storage capacity** \(V_{\text{s}} = \ldots \text{l}\)

| \(V_{\text{n}} = V_{\text{i}} \times (p_{\text{on}} + 1)/(p_{\text{on}} + 1) (p_{\text{out}} - p_{\text{on}})\) |
|----------------|----------------|----------------|

| \(V_{\text{n}} = \ldots \text{litres}\) |
|----------------|----------------|----------------|

**Check of max. excess operating pressure**

| \(p_{\text{max}} \leq 11 \times p_{\text{pit}} H_{\text{max}} / \text{mWs} \times 10\) |
|----------------|----------------|----------------|

| \(p_{\text{max}} = p_{\text{pit}} + \ldots \text{bar}\) |
|----------------|----------------|----------------|

**Result summary**

| Refix DT \(10\text{ bar}\) | Nominal volume \(V_{\text{n}} \ldots \text{litres}\) |
|----------------|----------------|----------------|

| With duo connection DN 50 \(10\text{ bar}\) | Usable volume \(V_{\text{u}} \ldots \text{litres}\) |
|----------------|----------------|----------------|

| Refix DT \(16\text{ bar}\) | Input pressure \(p_{\text{p}} \ldots \text{litres}\) |
|----------------|----------------|----------------|
Make-up and degassing systems can automate system operation and make a significant contribution to operational reliability. While Variomat pressure-maintaining stations are supplied with integrated make-up and degassing functions, additional units are required in the case of Reflex diaphragm expansion vessels as well as Reflexomat and Variomat Giga pressure-maintaining stations.

Fillcontrol make-up stations ensure that there is always sufficient water in the expansion vessel – an elementary prerequisite for system function. They also meet the requirements of DIN EN 1717 and DIN 1988 for safe make-up from potable water systems.

Reflex Servitec degassing stations can not only make up water; they can also be used for central venting and degassing of systems. Our joint research with the Technical University of Dresden has underlined the essential nature of these functions, particularly in the case of closed systems. Measurements of supply water, for example, produced nitrogen concentrations between 25 and 45 mg/litre, which is 2.5 times higher than the natural concentration of potable water. → p. 54

### Overview of Reflex water make-up systems

<table>
<thead>
<tr>
<th>Water make-up fittings</th>
<th>Automatic water make-up systems</th>
<th>Automatic water make-up systems with pump</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fillset Compact</td>
<td>Fillset</td>
<td>Fillset Impuls</td>
</tr>
<tr>
<td>DVGW-approved system separation</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>kVS</td>
<td>1.5 m³/h</td>
<td>1.5 m³/h</td>
</tr>
<tr>
<td>Pump</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Integrated shut-off</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Wall mount</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

**Automatic water make-up**
- Based on time, cycle or total amount
- Level-control on pressure-maintaining systems
- Pressure-dependent Magcontrol

**Alarm message**
- X
- X
- X
- X

**Water meter**
- X
  - Contact water meter

**Evaluation**
- Water softening
  - With contact water meter
  - With contact water meter
  - With contact water meter

---

Make-up and degassing systems
The system pressure is indicated on the display and monitored by the controller. If the pressure falls below the initial value \( p < p_0 + 0.3 \text{ bar} \), controlled water make-up takes place. Faults are displayed and can be transferred via a signal contact. In the case of potable water make-up, a Reflex system must be preceded by a Reflex Fillset unit. A finished combination of both systems, with an integrated pressure reducing valve, is available in the form of Reflex Fillcontrol for smaller make-up volumes.

The pressure immediately before the water make-up must be at least 1.3 bar higher than the input pressure of the expansion vessel. The make-up volume \( V \) can be determined from the \( k_{VS} \) value.

**Fillcontrol Plus diagram**

\[
V = \sqrt{p^* - (p_0 + 0.3)} \times k_{VS}
\]

**Make-up volume**

<table>
<thead>
<tr>
<th>System</th>
<th>Delivery Rate</th>
<th>k_{VS}</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fillcontrol</td>
<td>0.6 m³/h</td>
<td></td>
</tr>
<tr>
<td>Fillcontrol Plus</td>
<td>1.4 m³/h</td>
<td></td>
</tr>
<tr>
<td>Fillcontrol Plus + Fillset</td>
<td>0.7 m³/h</td>
<td></td>
</tr>
</tbody>
</table>

* \( p^* \) = excess pressure immediately before make-up station in bar

**Fillcontrol Auto**

Fillcontrol Auto is a make-up station with a pump and open reservoir (system separation vessel) as a means of isolation from the potable water system according to DIN 1988 or DIN EN 1717.

Fillcontrol Auto is generally used when the fresh water supply pressure \( p \) is too low for direct make-up without a pump or when an intermediate vessel is required for separation from the potable water system.

The delivery rate is between 120 and 180 l/h at a max. delivery head of 8.5 bar.
Reflex Fillcontrol Auto Compact is set to "level-dependent control" in systems with pressure expansion vessels, e.g. Reflex. Make-up then takes place at filling pressure or if the initial pressure in the expansion vessel is too low. The make-up line must be integrated in the proximity of the expansion vessel.

- DN 15 up to 10 m connection line
- DN 20 over 10 m connection line

The circuits must be adjusted to suit local conditions.

Reflex Fillcontrol Auto Compact is set to "level-dependent control" in systems with pump or compressor-controlled pressure-maintaining stations, e.g. Reflex Gigamat, Reflex Reflexomat. Make-up is then performed based on the filling level LS in the expansion vessel of the pressure-maintaining station. A 230 V input on the Fillcontrol Auto is available for this.

- DN 15 up to 10 m connection line
- DN 20 over 10 m connection line

The circuits must be adjusted to suit local conditions.
Reflex Fillsoft perfectly complements Reflex make-up systems so that filling and make-up water is checked and prepared before being fed into the system. The VDI 2035 Part 1 requirements, “Prevention of damage in water heating installations” are fulfilled using a highly efficient Na-ion exchanger. The pH value is not influenced by this procedure.

**Technical data**

- **Max. excess operating pressure**: 8 bar
- **Max. operating temperature**: 40°C
- **Capacity**
  - Fillsoft I: 6000 l x °dGH
  - Fillsoft II: 12,000 l x °dGH
- **Connection**
  - Inlet: Rp ½
  - Outlet: Rp ½
- **Weight**
  - Fillsoft I: 4.1 kg
  - Fillsoft II: 7.6 kg

Reflex Fillmeter with run time monitoring makes a system log book unnecessary.

Reflex Softmix for achieving the desired degree of water hardness.

Reflex GH hardness testing kit for determining regional degree of water hardness.

The circuits must be adjusted to suit local conditions.
Water softening systems

Water hardness

The need to protect heat generation systems (boilers and heat exchangers) from calcification is dictated, among other things, by the total water hardness of the filling and make-up water.

In this context, measurements are primarily based on VDI 2035, page 1, as well as the specifications of the relevant manufacturers.

**Necessity: VDI 2035, page 1: Requirements of filling and make-up water**

Due to the compact design of modern heat generators, the need to prevent calcification is ever growing. The current trend is for large heating outputs with small water volumes. VDI 2035, page 1, was revised in December 2005 to address this matter in a more focused manner and provide recommendations for damage prevention.

**Calcification: Ca²⁺ + 2HCO₃⁻ → CaCO₃ + CO₂ + H₂O**

The ideal location to implement necessary measures is in the filling and make-up line of the heating system. Appropriate systems for automatic water make-up are simply to be added in line with requirements.

### Initial data

- **Output-specific system volume for heat output**
- **Output-specific heat generator content**

### Circulating water heaters or devices with electric heating elements

- vC < 0.3 l/kW

### Reflex GH hardness testing kit for independent measurement of local water hardness

<table>
<thead>
<tr>
<th>Group</th>
<th>Total heating output</th>
<th>Total hardness [dGH]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Based on spec. system volume vₜ (system volume/lowest individual heating output)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&lt; 20 l/kW</td>
</tr>
<tr>
<td>1</td>
<td>&lt; 50 kW</td>
<td>≤ 16.8 *dGH for circulation heaters</td>
</tr>
<tr>
<td>2</td>
<td>50 - 200 kW</td>
<td>≤ 11.2 *dGH</td>
</tr>
<tr>
<td>3</td>
<td>200 - 600 kW</td>
<td>≤ 8.4 *dGH</td>
</tr>
<tr>
<td>4</td>
<td>&gt; 600 kW</td>
<td>&lt; 0.11 *dGH</td>
</tr>
</tbody>
</table>

**Total heating output**

This is the total of all individual heat generator outputs.

**Lowest individual heating output**

This represents the smallest individual heating output of a single heat generator forming part of a heat generator network.

**Output-specific system volume**

This represents the entire water content of the system incl. heat generators relative to the smallest individual heating output.

**Output-specific boiler volume**

This is the characteristic value of the heat generator content relative to its heating output. The lower the value, the thicker the limescale deposits that can be expected in the case of calcification in the heat generator.

**Regional total water hardness**

In many cases, the most practical solution is to feed potable water from the public supply network into the systems as filling or make-up water. The local lime content or regional water hardness can vary greatly, sometimes even fluctuating within the same region. The regional water hardness can be checked with the relevant water provider or established on-site by means of a test (Reflex GH hardness testing kit). The relevant measures can then be derived on this basis. Water hardness is generally measured in dGH (degrees of general hardness). 1 dGH equates to 0.176 mol/m³, while 1 mol/m³ converts to 5.6 dGH.
Softening processes

There are a number of methods for eliminating or disabling hard water minerals:

**Cation exchangers**
With cation exchange, the calcium and magnesium ions in the filling water are replaced with sodium ions, while the calcium and magnesium is retained in the cation exchanger. This prevents the hard water minerals from entering the heating system. This procedure has no influence on the pH value of the filling water, and the permeability also remains unchanged.

In the cation exchanger, the filling and make-up water is simply passed over sodium ion-enriched plastic, after which the chemical ion exchange process is performed automatically.

**Decarbonisation**
With decarbonisation, the hydrogen carbonate ions are removed or carbon dioxide is produced in conjunction with a hydrogen ion. The hardening cations in the magnesium and calcium are bound to the cation exchanger mass and thus removed. Due to the generated carbon dioxide, the pH value of the water is changed and the salt content reduced. A base exchanger is then added to compensate for this.

Decarbonisation works on the basis of the ion exchange principle and is used wherever a definite need exists to reduce the salt content of the water (e.g. steam generators).

**Desalination**
As the name suggests, desalination involves the removal of parts of the salt-forming anions and cations. In the case of full desalination, all these ions are effectively removed (demineralised water). There are two main methods used for desalination. On the one hand, the ion exchange process is again employed, in this case in a mixed bed exchanger. The other method is reverse osmosis, in which the salts are removed from the water by means of a diaphragm. This procedure is both technically demanding and highly energy-intensive and more suited to large water volumes. When using demineralised water, a pH adjustment function must be implemented in the system.

**Hardness stabilisation**
Hardness stabilisation is a water treatment that influences the calcium precipitation to the point that no scale formation occurs. Two specific procedures are employed. The first involves the addition of polyphosphate, thus suppressing the calcification though not fully eliminating it. Slurry formation can occur (calcium precipitation in the water), as the carbonate ion concentration is not reduced. This procedure requires chemical understanding, monitoring and regularity. The other procedure to be included under the general heading of physical water treatment involves the formation of stabilising crystal seeds, e.g. using magnetic fields, thus avoiding the need for chemicals or chemical processes. The effectiveness of the latter solution remains a matter of great dispute.
Water softening systems

Practical water softening

For heating systems in the low to medium output range, cation exchangers are the ideal means of preventing calcification in heat generators. This cost-effective solution is simple to implement and best suits the specific requirements.

Water softening with cation exchangers in the filling and make-up line

Using the appropriate Reflex Fillsoft cation exchanger, fully or partially demineralised water can be produced to exact requirements.

Filling and make-up water

This term from VDI 2035, page 1, represents the water and specific volume that is required to completely refill a system or must be added during operation.

Soft water

This is water that has been completely freed of the hard water minerals calcium and magnesium thus eliminating the possibility of calcification. A specific characteristic value for the amount of soft water that a softening system can produce is the soft water capacity \( K_W [l^{\ast}dGH] \). The filling and make-up water is not always to be fully demineralised, nor does it always have to be. Water that has not been completely freed of hardening minerals is also referred to as partially demineralised water.

<table>
<thead>
<tr>
<th>Type</th>
<th>Soft water capacity ( K_W ) ([l^{\ast}dGH])</th>
<th>( k_m ) ([m^3/h])</th>
<th>( V_{max} ) ([l/h])</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fillsoft I</td>
<td>6000</td>
<td>0.4</td>
<td>300</td>
</tr>
<tr>
<td>Fillsoft II</td>
<td>12,000</td>
<td>0.4</td>
<td>300</td>
</tr>
</tbody>
</table>

Diagram for Fillsoft I + Fillset Compact

Diagram for
Fillcontrol Plus + Fillsoft II + Fillmeter + Fillset Compact

Diagram for
Reflex Softmix produces partially demineralised water.

Diagram for
Reflex Fillmeter monitors the capacity of the Fillsoft.
Water softening systems

### Reflex Fillsoft

**Object:**

**Initial data**

<table>
<thead>
<tr>
<th>Heat generator</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heat output (Q_\text{K})</td>
<td>(\ldots) kW</td>
<td>(\ldots) kW</td>
<td>(\ldots) kW</td>
<td>(\ldots) kW</td>
<td>(\ldots) kW</td>
</tr>
<tr>
<td>Water content (V_\text{K})</td>
<td>(\ldots) litres</td>
<td>(\ldots) l</td>
<td>(\ldots) l</td>
<td>(\ldots) l</td>
<td>(\ldots) l</td>
</tr>
<tr>
<td>Water content known (V_2)</td>
<td>(\ldots) litres</td>
<td>(\ldots) litres</td>
<td>(\ldots) litres</td>
<td>(\ldots) litres</td>
<td>(\ldots) litres</td>
</tr>
</tbody>
</table>

\(Q_\text{min} = \ldots\) kW

Checks whether the unit is a circulating water heater (< 0.3 l/kW)

### Specific characteristic values

**Output-specific boiler water content**

\[V_\text{V} = \frac{V_2}{Q_\text{min}} = \ldots\] l/kW

**Output-specific system content**

\[V_\text{V} = \frac{V_2}{Q_\text{tot}} = \ldots\] l/kW

### Water hardness

**Regional total water hardness**

\(GH_{\text{tot}} = \ldots\) °dGH

**Target total water hardness**

\(GH_{\text{t}} = \ldots\) °dGH

\(Q_{\text{tot}} = \ldots\) kW

\(Q_{\text{min}} = \ldots\) kW

\(V_{\text{V}} = \ldots\) litres

Data from water provider or self-measurement → p. 30

Water softening is required when \(GH_{\text{act}} > GH_{\text{t}}\)

**Soft water capacity of:**

- Fillsoft I \(K_\text{W} = 6,000\) l°dGH
- Fillsoft II \(K_\text{W} = 12,000\) l°dGH
- Fillsoft FP \(K_\text{W} = 6,000\) l°dGH/unit

### Possible filling and make-up water volumes

**Possible filling water volume (mixed)**

\[V_\text{F} = \frac{K_\text{W}}{GH_{\text{act}} - GH_{\text{t}}} = \ldots\] litres

**Possible make-up water volume**

\[V_\text{M} = \frac{K_\text{W}}{(GH_{\text{act}} - 0.11\text{°dGH})} = \ldots\] litres

\(V_\text{M} = \ldots\) litres

\(n = \frac{V_\text{F} (GH_{\text{act}} - GH_{\text{t}})}{K_\text{W}} = \ldots\) litres

\(n = \ldots\) litres

\(V_\text{M} = \frac{n \times 6,000\text{°dGH} - (V_\text{F} \times (GH_{\text{act}} - GH_{\text{t}}))}{(GH_{\text{act}} - 0.11\text{°dGH})} = \ldots\) litres

\(V_\text{M} = \ldots\) litres

### Result summary

<table>
<thead>
<tr>
<th>Fillsoft</th>
<th>Type</th>
<th>System content (V_\text{V})</th>
<th>\ldots) litres</th>
</tr>
</thead>
<tbody>
<tr>
<td>FP replacement cartridge</td>
<td>Number</td>
<td>Possible filling water volume (partially/fully demineralised)</td>
<td>\ldots) litres</td>
</tr>
<tr>
<td>Softmix</td>
<td>Yes</td>
<td>Possible residual make-up volume (fully demineralised)</td>
<td>\ldots) litres</td>
</tr>
<tr>
<td>Fillmeter</td>
<td>Yes</td>
<td>Possible residual make-up volume (partially demineralised)</td>
<td>\ldots) litres</td>
</tr>
<tr>
<td>Hardness testing kit</td>
<td>Number</td>
<td>\ldots) litres</td>
<td></td>
</tr>
</tbody>
</table>
For small single-boiler systems that are fitted, in some cases, with a wall mount device, softening may be necessary for as little as < 50 kW.

The simplest way to integrate Fillsoft: manual water make-up with the fill meter as capacity monitoring. Don’t forget the Fillset for make-up from the potable water system.

For multi-boiler systems, the output-specific water content is multiplied by 2 or more and is likely to increase the requirements according to VDI 2035 page 1.

Essential requirements for the make-up function have already been provided in conjunction with the Reflex system technology. For make-up from the potable water system, also combine Fillsoft with Fillset.

In relatively small networks, installations with buffer tanks usually lead to a requirement for full softening according to VDI 2035 Part 1. The Fillsoft is pre-equipped for this.

Don’t forget the Fillsoft FE external pressure sensor in combination with a Fillcontrol make-up station.
Degassing stations

In most cases, a single sample in a glass vessel is sufficient to identify excess gas accumulation in closed systems. Upon relaxation, the sample takes on a milky appearance due to the formation of micro-bubbles.

Servitec in Fillcontrol Plus mode for Reflex and other expansion vessels
The pressure is indicated on the display and monitored by the controller (min./max. fault message). If the pressure falls below the initial value \( p < p_0 + 0.3 \text{ bar} \) the necessary checks are performed and degassed water made up by means of leakage volume monitoring. This also enables refilling of systems during manual operation. This helps to minimise the amount of oxygen injected into the system.

The additional cyclical degassing of the circulating water removes accumulating excess gases from the system. This central "deaeration" makes circulation problems due to free gases a thing of the past.

The combination of Servitec and Reflex expansion vessels is technically equivalent to Variomat pressure-maintaining stations and represents a cost-effective alternative, particularly in the sub-500 kW output range.

→ Reflex calculation for diaphragm expansion vessels page 9

→ Servitec as per table below

Servitec in Levelcontrol Plus mode for Variomat and Variomat Giga
The functionality is similar to that of Servitec in Fillcontrol Plus mode, except that the water is made up on the basis of the water level in the expansion vessel of the pressure-maintaining station. For this purpose, a corresponding electrical signal (230 V) is required from this station. The pressure monitoring is either dispensed with or is performed by the pressure-maintaining station.

Make-up volume, system volume
The throughput volumes of the Servitec system depend on the pumps employed and the settings of the corresponding pressure reducing and overflow valves. In the case of standard systems with default factory configuration, the values in the table apply on a type-specific basis. The recommended max. system volumes are subject to the condition that partial flow degassing of the network volume takes place at least once every two weeks. In our experience, this is sufficient even for networks with extremely high loads.

Note that Servitec can only be used within the specified operating pressure range – i.e. the specified operating pressures must be maintained at the Servitec integration point. In the case of deviating conditions, we recommend the use of special systems.

Degassing of water-/glycol mixtures is a more elaborate process, a fact that is underlined by the special technical equipment used for the glycol variants.

<table>
<thead>
<tr>
<th>Type</th>
<th>System volume Vₗₚ</th>
<th>Water make-up rate</th>
<th>Working pressure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Servitec 25</td>
<td>up to 2 m³</td>
<td>Up to 0.05 m³/h</td>
<td>0.5 to 2.5 bar</td>
</tr>
<tr>
<td>Servitec 35</td>
<td>up to 60 m³</td>
<td>Up to 0.35 m³/h</td>
<td>1.3 to 2.5 bar</td>
</tr>
<tr>
<td>Servitec 60</td>
<td>up to 100 m³</td>
<td>Up to 0.55 m³/h</td>
<td>1.3 to 4.5 bar</td>
</tr>
<tr>
<td>Servitec 75</td>
<td>up to 100 m³</td>
<td>Up to 0.55 m³/h</td>
<td>1.3 to 5.4 bar</td>
</tr>
<tr>
<td>Servitec 95</td>
<td>up to 100 m³</td>
<td>Up to 0.55 m³/h</td>
<td>1.3 to 7.2 bar</td>
</tr>
<tr>
<td>Servitec 120</td>
<td>up to 100 m³</td>
<td>Up to 0.55 m³/h</td>
<td>1.3 to 9.0 bar</td>
</tr>
</tbody>
</table>

For water-glycol mixtures up to 70 °C

<table>
<thead>
<tr>
<th>Type</th>
<th>System volume Vₗₚ</th>
<th>Water make-up rate</th>
<th>Working pressure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Servitec 25/gl</td>
<td>up to 2 m³</td>
<td>Up to 0.05 m³/h</td>
<td>0.5 to 2.5 bar</td>
</tr>
<tr>
<td>Servitec 60/gl</td>
<td>up to 20 m³</td>
<td>Up to 0.55 m³/h</td>
<td>1.3 to 4.9 bar</td>
</tr>
<tr>
<td>Servitec 75/gl</td>
<td>up to 20 m³</td>
<td>Up to 0.55 m³/h</td>
<td>1.3 to 6.7 bar</td>
</tr>
<tr>
<td>Servitec 95/gl</td>
<td>up to 20 m³</td>
<td>Up to 0.55 m³/h</td>
<td>1.3 to 9.0 bar</td>
</tr>
</tbody>
</table>

Servitec units for higher system volumes and temperatures up to 90 °C are available on request.
Many heating systems suffer from "air problems". Intensive research in conjunction with the Energy Technology Institute of the Technical University of Dresden has shown that nitrogen is one of the main causes of circulation problems. Measurements on existing systems produced nitrogen concentrations between 25 and 50 mg/l, much higher than the natural concentration of potable water (18 mg/l). Our Servitec system rapidly reduces the concentration to near 0 mg/l.

![Servitec test system in a heat transfer station of the Halle energy utility](image)

**Figure 1:**
Servitec test system in a heat transfer station of the Halle energy utility
- Heat output: 14.8 MW
- Water content: approx. 100 m³
- Return temperature: ≤ 70 °C
- Return pressure: approx. 6 bar

![Nitrogen reduction using Servitec partial flow degassing in a test system of the Halle energy utility](chart)

**Figure 2:**
Nitrogen reduction using Servitec partial flow degassing in a test system of the Halle energy utility

* Natural concentration of potable water = 18 mg/l N.

In 40 hours, Servitec reduced the N₂ content to almost 10 % of the initial value, thereby eliminating 4 m³ of nitrogen. The air problems in the high-rise buildings were successfully eradicated.

![Nitrogen-rich, cloudy sample](image)

![Clear, translucent sample](image)

Both samples are virtually oxygen-free
Reflex Servitec – installation examples

Reflex Servitec in Magcontrol mode for systems with diaphragm pressure expansion vessels

- The pressure is shown on the display
- Excess and insufficient pressure levels are signalled
- Automatic, controlled make-up in the event that the system fails to reach the filling pressure of 0.2 bar
- Servitec degassing of the make-up and filling water

Reflex Servitec in Levelcontrol mode for systems with pump- or compressor-controlled pressure-maintaining stations

- Vacuum degassing of a part flow of the circuit water takes place according to an optimised schedule using a selectable degassing mode
  - Continuous degassing (after start-up)
  - Interval degassing (automatically activated after continuous degassing)
- Automatic, controlled make-up if the minimum water level is not reached in the expansion vessel of the pump- or compressor-controlled pressure-maintaining station
- Servitec degassing of make-up water
Preferably install the Servitec unit on the system side so that the temperature load remains ≤ 70 °C.

When using softening systems, they should be installed between the Fillset and Servitec units.

If the shut-off at the integration point of Servitec is closed when decommissioning the circulating pumps, the part flow degassing remains functional.

The combination of Servitec with compressor-controlled pressure-maintaining stations (for example Reflexomat) is especially recommended. The system uncompromisingly degassed by the Servitec is softly cushioned by the Reflexomat.

The water level in the expansion vessel is monitored by the control unit of the pressure-maintaining station. The 230 V make-up signal supplied by the pressure-maintaining station triggers the make-up process with degassing.

Optimum degassing is ensured by integrating Servitec in the main volumetric flow of the circuit water.

When combining pump-controlled pressure-maintaining stations with a Servitec unit, we always recommend individual boiler protection using a diaphragm pressure expansion vessel (for example Reflex).

The circuits must be adjusted to suit local conditions.
Heat balances
The role of a heat exchanger is to transfer a specific heat quantity from the hot to the cold side. The transfer capacity is not only device-specific but also dependent on the required temperatures. As a result, we do not speak of ... kW heat exchangers, but rather that a device can transfer ... kW with the specified heat spreads.

Applications
- As a system separator from media that must not be mixed, e.g.
  - Heating and potable water
  - Heating and solar system water
  - Water and oil circuits
- For separating circuits with different operating parameters, e.g.
  - Excess operating pressure of page 1 exceeds the max. excess operating pressure of page 2
  - Water content of page 1 is significantly higher than that of page 2
- To minimise interference between the two circuits

Counterflow
As a rule, heat exchangers should always be connected on the basis of the counterflow principle as only this will ensure that they can deliver their full capacity. In the case of parallel flow connections, significant performance losses can be expected.

Hot and cold side
The allocation of the two system circuits as the primary and secondary side varies by individual application. In the case of heating systems, the hot side is usually described as the primary side, whereas the cold side is the primary side in cooling and refrigerating systems. The differentiation between hot and cold sides is both clearer and non-application-specific.

Inlet/outlet
When configuring heat exchangers, problems are often encountered with the terms ‘advance’ and ‘return’ as the calculation software requires accurate designation of the inlet and outlet. A clear distinction must be made between the hot heating advance on the outlet side of the heat exchanger and the inlet into the plate heat exchanger delivered from the heating system in a cooled state. In the Reflex calculation software, ‘inlet’ always refers to the supply to the plate heat exchanger, while the ‘outlet’ is defined correspondingly.

Example applications:
- Indirect district heating connections
- Floor heating
- Potable water heating
- Solar energy systems
- Machine cooling
Thermal length
The performance or operating characteristic of a plate heat exchanger describes the ratio between the actual cooling on the hot side and the theoretical maximum cooling to inlet temperature on the cold side.

Operating characteristic = $\Phi = \frac{\vartheta_{\text{hot, in}} - \vartheta_{\text{hot, out}}}{\vartheta_{\text{hot, in}} - \vartheta_{\text{cold, in}}} < 1$

The term “thermal length” is often used as a qualitative description of the heat exchanger’s performance. This is a device-specific property that depends on the structure of the heat exchanger plates. Increased profiling and narrower channels raise the flow turbulence between the plates. The “thermal length” of the device is increased thus raising its performance and allowing it to better align the temperatures of both media.

Log mean temperature difference
A measure of the driving force of the heat transfer is the temperature difference between the hot and cold medium. Since this constitutes a non-linear transition, the driving force is linearised under the term “log mean temperature difference $\Delta \vartheta_{\text{ln}}$”.

$\Delta \vartheta_{\text{ln}} = \frac{\vartheta_{\text{hot, out}} - \vartheta_{\text{cold, in}}}{\ln \left( \frac{\vartheta_{\text{hot, out}} - \vartheta_{\text{cold, out}}}{\vartheta_{\text{hot, in}} - \vartheta_{\text{cold, in}}} \right)}$

The lower this driving temperature difference, the greater the surface area to be provided; this can result in very large systems for cold water networks in particular.

Terminal temperature difference
The terminal temperature difference is of central importance to the configuration of heat exchangers. It states to what extent the outlet temperature on side 2 is aligned with the inlet temperature on side 1. The smaller this temperature difference, the greater the transfer area that must be provided, and this in turn dictates the price of the system. For heating systems, an appropriate terminal temperature difference of $\geq 5$ K is assumed. In the case of cooling systems, terminal temperature differences of 2 K are sometimes required, which can only be implemented with very large systems. A critical assessment of the terminal temperature difference can thus have a significant impact on overall costs.

Terminal temperature difference = $\vartheta_{\text{hot, out}} - \vartheta_{\text{cold, in}}$

Pressure losses
An important criterion for the configuration of heat exchangers is the permissible pressure loss. Similarly to the terminal temperature difference, a very low pressure loss is generally only possible with very large heat exchangers. In such cases, increasing the temperature spread can help to reduce the volume flow to be circulated and thus also the pressure loss experienced by the heat exchanger. If a higher pressure loss is available in a system, e.g. in the case of district heating networks, it may be expedient to permit a slightly higher pressure loss in order to significantly reduce the size of the system.

Flow properties
The size of a heat exchanger is also greatly dictated by the flow properties of the media. The greater the turbulence with which the heat transfer media pass through the system, the higher not only the transferable output but also the pressure losses. This interrelation between output, system size and flow properties is described by the heat transfer coefficient.

Surface reserve
To determine the size of a heat exchanger, the first step is to establish the required transfer area on the basis of the boundary conditions. When applying a maximum pressure loss, for example, this can result in devices with a significant excess surface area. This surface reserve is a theoretical value. When operating the plate exchanger, the temperatures of the two heat transfer media are aligned to the point that the excess surface area no longer exists. In a heating circuit, the target temperature is generally specified via the regulator. A theoretical surface reserve is removed by reducing the heating mass flow via the regulator. The temperature on the outlet side of the hot medium is thus reduced correspondingly. When sizing the control fittings, the reduced mass flow must be taken into account to avoid overdesigning.
Heat exchanger systems

Physical principles

Heat balances
Heat emission and absorption of heat transfer media:

\[ Q = \dot{m} \times c \times (\vartheta_{\text{hot},\text{in}} - \vartheta_{\text{hot},\text{out}}) \]

Based on the specified temperature spread and the circulated mass, the above formula can be used to calculate the capacity to be transferred.

Heat transport via heat exchanger plates:

\[ \dot{Q} = k \times A \times \Delta \vartheta \]

The heat transfer coefficient \( k \) [W/m²K] is a medium- and device-specific variable comprising the flow properties, nature of the transfer surface and type of the heat transfer media. The more turbulent the flow, the higher the pressure loss and thus also the heat transfer coefficient. The log mean temperature difference \( \Delta \vartheta \) is a pure system variable resulting from the established set temperatures.

Using a complicated calculation algorithm, the heat transfer coefficient is first established on the basis of the boundary conditions, after which the necessary system size is determined on the basis of the required transfer surface area.

Initial data
The following values must be known to be able to configure a heat exchanger:
- Type of media (e.g. water, water/glycol mixture, oil)
- Properties of any media other than water (e.g. concentrations, density, heat conductivity and capacity, viscosity)
- Inlet temperatures and required outlet temperatures
- Capacity to be transferred
- Permitted pressure losses

If the systems are operated under very different (e.g. seasonal) conditions, as in the case of district heating networks for instance, the heat exchangers must also be configured to suit these conditions.

Calculation program
Computer-based calculations of pressure-maintaining systems and heat exchangers can be performed via our Reflex Pro calculation program which is available for use or download at www.reflex.de. Another option is to use our Reflex Pro app! Both tools represent a quick and simple means of finding your ideal solution.
System equipment

Safety technology
Applicable standards for the safety equipment of heat exchangers as indirect heat generators include:
• DIN 4747 for district heating substations
• DIN EN 12828 for water heating systems; see section “Safety technology” from p. 63
• DIN 1988 and DIN 4753 potable water heating systems

The following information on system equipment is to support you with your system configuration and help to avoid frequent problems with system operation and device failures during the planning phase.

Regulating valve
The configuration of the regulating valve is of utmost importance to the stable operation of a heat exchanger. It should not be oversized and must ensure stable regulation even under low loads.

One particular selection criterion is the valve authority. It describes the ratio between the pressure losses with a fully opened regulating valve and the maximum available pressure loss with the valve closed. If the valve authority is too low, the regulating effect of the valve is insufficient.

Valve authority = \( \frac{\Delta p_{RV \text{ (100 % stroke)}}}{\Delta p_{RV \text{ max}}} \) ≥ 30 to 40 %

Once the pressure loss via the regulating valve has been determined, the \( k_{VS} \) value can be established. It must be based on the actual mass flow of the circuit to be regulated.

\[ k_{VS} \geq k_{V} = \frac{V_{hn} \sqrt{1 \text{ bar}^{-1}}}{\Delta p_{RV}} \]

The \( k_{VS} \) value of the selected regulating valve should not be significantly higher than the calculated value (do not use safety margins!). Otherwise, there is a risk of system instability and frequent switching, particularly under weak or partial loads, and this is one of the most frequent failure causes of plate heat exchangers.

Temperature sensor, temperature regulator
The temperature sensors must be fast and virtually inertia-free and must always be fitted in the immediate vicinity of the plate heat exchanger outlet to ensure quickest possible actuation of the regulation to respond to changing conditions or variables. If slow sensors and regulators are used and situated far from the plate heat exchanger, there is a risk of periodic overshooting of the set point value temperatures and, consequently, frequent switching of the controls. Such unstable control behaviour can result in the failure of the plate heat exchanger. If additional control circuits are connected downstream of the heat exchanger control circuit, e.g. for secondary heating circuit regulation, they must communicate with one another.

Important!
Great care must be taken when selecting regulators and regulating valves. An incorrect configuration can result in unstable operation, which in turn leads to excessive dynamic stress on materials.
Preferably select potable water outlet temperature as ≤ 60 °C, in order to reduce the risk of calcification (heating medium temperature ≤ 70 °C).

In the case of constant flow on the potable water side, the risk of calcification is lower; where necessary, connect the circulation line on the cold water side behind the charge pump. Important: For the configuration of the heat exchanger, the total maximum potable water volume flow (V_{charge}) and the circulation volume flow (V_{circ}) must be recorded.

When used as a flow limiter without a downstream tank, a fast regulator must be used.

### Configuration data

For flat collectors, the heat exchanger should be designed for a transfer capacity of 500 W/m² collector surface area (opt. efficiency 65 % with global radiation of 800 W/m²).

**Pure potable water heating**

Collector temperature: 55/35 °C (antifreeze proportion acc. to the following values), TW temperature: 10/50 °C

**Heating the buffer tank**

Collector temperature: 55/35 °C (antifreeze proportion acc. to the following values), HW temperature: 30/50 °C

**Antifreeze** (propylene glycol) in connection with potable water or foods

- 25 % frost-proof to -10 °C
- 38 % frost-proof to -20 °C
- 47 % frost-proof to -30 °C

**Antifreeze** (ethylene glycol) in hot water heating systems or technical cooling systems

- 25 % frost-proof to -13 °C
- 34 % frost-proof to -20 °C
- 50 % frost-proof to -36 °C

Please observe the minimum dosage quantities from the manufacturer!

The circuits must be adjusted to suit local conditions.
When retrofitting Reflex Longtherm for system separation in "old" systems, the floor and boiler circuits must be flushed beforehand.

Boiler regulation enables low return temperatures for utilisation of condensing technology.

Use corrosion-protected expansion vessel Refix DE in the floor heating circuit.

The specific technical connection conditions of the heat source must be observed.

Due to the often high temperature and pressure requirements and the changing operating mode, it is imperative that the assembly, operating and maintenance instructions are adhered to precisely.

When connecting the contact heat consumers (e.g. potable water heating, industry requirements), the summer temperatures for the district heating system must be observed precisely.

The circuits must be adjusted to suit local conditions.
Within the meaning of the guidelines and regulations, equipment is defined as all pieces of equipment that are required for operation and safety, such as connection lines, fittings and control devices.

Safety equipment is defined in standards. The main pieces of equipment are described below. Pages 70-73 provide an overview of heat generation systems with operating temperatures up to 105 °C according to DIN EN 12828 and hot water systems according to DIN 4753.

### Safety valves (SV)

Safety valves protect heat and cold generators, expansion vessels and the entire system against impermissible excess pressures. When configuring safety valves, potential loading conditions (e.g. heat supply in the case of shut off heat generators, pressure increases caused by pumps) must be taken into account.

**Hot water generators**

**DIN EN 12828**: “Each heat generator in a heating system must be secured against exceeding the maximum operating pressure by at least one safety valve.”

To ensure that they can discharge safely and adequately, safety valves on directly heated heat generators must be configured for saturated steam in relation to the nominal heat output $Q$. In heat generators with an output of over 300 kW, an expansion trap should be connected for the phase separation of steam and water. In the case of indirectly heated heat generators (heat exchangers), sizing for water outflow is possible if the emission of steam is excluded by the temperature and pressure conditions. Based on experience, dimensioning can be performed on the basis of a fluid outflow of $1/l/(h·kW)$.

According to DIN EN 12828, when using more than one safety valve, the smaller one must be configured for at least 40 % of the total discharge volume flow.

The technical specifications below are based on the rules already applied. The European standards to be applied in the future, e.g. EN ISO 4126-1 for safety valves had not been accepted at the time of printing this brochure. For the time being, we will therefore focus solely on the use of currently available and commonplace valves and their calculation criteria. As safety-relevant components, all valves must bear a CE mark according to the Pressure Equipment Directive 97/23/EC (DRGL) and should be component tested. The descriptions of safety valves below relate to valves that are currently available on the market. In the medium term, valves will be rated and identified according to DIN ISO 412, and dimensioning will have to be carried out accordingly.

**SV code letter H**

These safety valves are known generally as “diaphragm safety valves” with response pressures of 2.5 and 3.0 bar. In accordance with TRD 721, in Germany H valves can be used up to a maximum response pressure of 3 bar. The performance is defined independently of the brand. For the purposes of simplification, the blow-off steam and water are equated, irrespective of the response pressure (2.5 or 3.0 bar).

**SV code letter D/G/H**

If the response pressures deviate from 2.5 and 3.0 bar or if an output of 900 kW is exceeded, D/G/H safety valves are used. The blow-off rates are specified for each specific brand according to the allocated outflow numbers.

**Hot water systems**

In hot water systems according to DIN 4753, only safety valves with the code letter W are permitted. In some cases, combined valves W/F (F - fluids) are offered. The performance values are defined in TRD 721.

**Solar energy systems**

Solar energy systems according to VDI 6002 are to be fitted with H or D/G/H safety valves, while intrinsically safe systems should also be fitted with F safety valves (outflow for fluids only). Solar energy systems that are calculated according the specifications in this documentation are deemed intrinsically safe.

**Cooling water systems**

For cooling water systems in which evaporation can be excluded, F safety valves can be used according to the manufacturer. The loading conditions must be calculated specifically.

**Expansion vessels**

If the max. excess operating pressure of expansion vessels is below the permissible operating pressure of the system, intrinsic safeguarding is required. The loading conditions must be calculated specifically. Suitable valves are H, D/G/H and safety valves according to the AD data sheet A2 (e.g. F).

Although Reflex expansion vessels for pump-controlled pressure-maintaining stations are depressurised in normal operation, pressurisation can be expected in the event of incorrect operation. They are therefore protected with F valves via the control unit. At blow-off pressure (5 bar) the maximum possible volume flow is to be discharged. This generally works out as $1/l/(h·kW)$ relative to the connected overall heat output.

* The Reflex product range does not include safety valves.
Safety valves on heat generators according to DIN EN 12828, TRD 721***

**Code letter H**, blow-off pressure $p_{SV}$: 2.5 and 3.0 bar

<table>
<thead>
<tr>
<th>Inlet connection [G] - outlet connection [G]</th>
<th>$\frac{1}{4}$ - $\frac{3}{4}$</th>
<th>$\frac{3}{4}$ - 1</th>
<th>1 - 1$\frac{1}{4}$</th>
<th>1$\frac{1}{4}$ - 1$\frac{1}{2}$</th>
<th>1$\frac{1}{2}$ - 2</th>
<th>2 - 2$\frac{1}{2}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blow-off rate for steam and water/kW</td>
<td>$\leq 50$</td>
<td>$\leq 100$</td>
<td>$\leq 200$</td>
<td>$\leq 350$</td>
<td>$\leq 600$</td>
<td>$\leq 900$</td>
</tr>
</tbody>
</table>

**Code letter D/G/H**, e.g. LESER, type 440*

The water outflow table can be applied for heat exchangers provided that the conditions opposite are met.

<table>
<thead>
<tr>
<th>$p_{SV}$/bar</th>
<th>2.5</th>
<th>3.0</th>
<th>3.5</th>
<th>4.0</th>
<th>4.5</th>
<th>5.0</th>
<th>5.5</th>
<th>6.0</th>
<th>7.0</th>
<th>8.0</th>
<th>9.0</th>
<th>10.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steam outflow</td>
<td>198</td>
<td>323</td>
<td>514</td>
<td>835</td>
<td>1291</td>
<td>2199</td>
<td>3342</td>
<td>5165</td>
<td>5861</td>
<td>9484</td>
<td>9200</td>
<td>15100</td>
</tr>
</tbody>
</table>

Max. primary flow temperature $t_F$ to prevent evaporation at $p_{SV}$

<table>
<thead>
<tr>
<th>$p_{SV}$/bar</th>
<th>2.5</th>
<th>3.0</th>
<th>3.5</th>
<th>4.0</th>
<th>4.5</th>
<th>5.0</th>
<th>5.5</th>
<th>6.0</th>
<th>7.0</th>
<th>8.0</th>
<th>9.0</th>
<th>10.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blow-off rate/m³/h</td>
<td>2.8</td>
<td>3.0</td>
<td>9.5</td>
<td>14.3</td>
<td>19.2</td>
<td>27.7</td>
<td>28.0</td>
<td>32.1</td>
<td>39.6</td>
<td>46.2</td>
<td>50.9</td>
<td></td>
</tr>
</tbody>
</table>

**Safety valves on water heaters** according to DIN 4753 and TRD 721

**Code letter W**, blow-off pressure $p_{SV}$: 6, 8, 10 bar, e.g. SYR type 2115*

When making a selection, the system-specific conditions should be compared with the manufacturer specifications for the valves (e.g. temperature load).

<table>
<thead>
<tr>
<th>Inlet connection G</th>
<th>Tank volume litres</th>
<th>Max. heating capacity kW</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\frac{1}{4}$</td>
<td>$\leq 200$</td>
<td>75</td>
</tr>
<tr>
<td>$\frac{3}{4}$</td>
<td>$&gt; 200 \leq 1000$</td>
<td>150</td>
</tr>
<tr>
<td>1</td>
<td>$&gt; 1000 \leq 5000$</td>
<td>250</td>
</tr>
<tr>
<td>1$\frac{1}{4}$</td>
<td>$&gt; 5000$</td>
<td>30000</td>
</tr>
</tbody>
</table>

**Safety valves in solar energy systems** according to VDI 6002, DIN 12976/77, TRD 721

**Code letter H, D/G/H, F** (intrinsically safe systems)

<table>
<thead>
<tr>
<th>Inlet port DN</th>
<th>15</th>
<th>20</th>
<th>25</th>
<th>32</th>
<th>40</th>
</tr>
</thead>
<tbody>
<tr>
<td>Collector inlet surface m²</td>
<td>$\leq 50$</td>
<td>$\leq 100$</td>
<td>$\leq 200$</td>
<td>$\leq 350$</td>
<td>$\leq 600$</td>
</tr>
</tbody>
</table>

**Safety valves in cooling systems and on expansion vessels**

**Code letter F** (only with guaranteed fluid outflow), e.g. SYR, type 2115*

* Contact the manufacturer for up-to-date values

** Protection of Reflex expansion vessels in pressure-maintaining stations

Vessels up to 1000 litres, Ø 740 mm, G $\frac{1}{2}$ = 3100 kW = 3100 l/h

as of 1000 litres, Ø1000 mm, G 1 = 10,600 kW = 10,600 l/h

*** If safety valves according to DIN ISO 4126 are used, an appropriate calculation base must be applied.

---

The water outflow table can be applied for heat exchangers provided that the conditions opposite are met.
Exhaust lines from safety valves, expansion traps

Exhaust lines must meet the conditions of DIN EN 12828, TRD 721 and – in the case of solar energy systems – VDI 6002. In accordance with DIN EN 12828, safety valves are to be fitted in such a way that the pressure loss in the connection line to the heat generator does not exceed 3 % of the nominal pressure of the safety valve and the pressure loss in the blow-off line does not exceed 10 % of the nominal pressure of the safety valve. On the basis of the withdrawn standard DIN 4751 T2, these requirements have been compiled in a number of tables for simplification purposes. Mathematical verification may be required in individual cases.

Expansion traps, installation

Expansion traps are installed in the exhaust lines of safety valves as a means of phase separation of steam and water. A water discharge line must be connected at the lowest point of the expansion trap, which discharges heating water in a safe and observable manner. The steam exhaust line must be routed from the high point of the expansion trap to the outside.

Necessity

In accordance with DIN EN 12828 for heat generators with a nominal heat output of > 300 kW. In the case of indirectly heated heat generators (heat exchangers), expansion traps are not required if the safety valves can be dimensioned for water outflow, i.e. if there is no risk of steam formation on the secondary side.

→ Safety valves on heat generators, see page 64

Exhaust lines and Reflex expansion traps in systems according to DIN EN 12828

Safety valves with code letter H, blow-off pressure pSV ≤ 2.5 and 3.0 bar

<table>
<thead>
<tr>
<th>Safety valve d1 DN</th>
<th>Nominal output Heat generator Q kW</th>
<th>Exhaust line d2 DN Length m No. of bends</th>
<th>SV supply d20 DN Length m No. of bends</th>
<th>SV with or without T expansion trap d10 DN Length m No. of bends</th>
<th>SV with T expansion trap SV – T line d20 DN Length m No. of bends</th>
<th>Exhaust line SV supply d20 DN Length m No. of bends</th>
<th>Water discharge line d40 DN Length m No. of bends</th>
</tr>
</thead>
<tbody>
<tr>
<td>15 20</td>
<td>≤ 50</td>
<td>20 ≤ 4 ≤ 3 20 ≤ 4 ≤ 3</td>
<td>15 ≤ 1 ≤ 1</td>
<td>--- ≤ 1 ≤ 1</td>
<td>--- ≤ 1 ≤ 1</td>
<td>--- ≤ 1 ≤ 1</td>
<td>--- ≤ 1 ≤ 1</td>
</tr>
<tr>
<td>20 25</td>
<td>≤ 100</td>
<td>20 ≤ 4 ≤ 3 20 ≤ 4 ≤ 3</td>
<td>20 ≤ 1 ≤ 1</td>
<td>--- ≤ 1 ≤ 1</td>
<td>--- ≤ 1 ≤ 1</td>
<td>--- ≤ 1 ≤ 1</td>
<td>--- ≤ 1 ≤ 1</td>
</tr>
<tr>
<td>25 32</td>
<td>≤ 200</td>
<td>25 ≤ 4 ≤ 3 25 ≤ 4 ≤ 3</td>
<td>25 ≤ 1 ≤ 1</td>
<td>--- ≤ 1 ≤ 1</td>
<td>--- ≤ 1 ≤ 1</td>
<td>--- ≤ 1 ≤ 1</td>
<td>--- ≤ 1 ≤ 1</td>
</tr>
<tr>
<td>32 40</td>
<td>≤ 350</td>
<td>32 ≤ 4 ≤ 3 32 ≤ 4 ≤ 3</td>
<td>32 ≤ 1 ≤ 1</td>
<td>270 ≤ 5 ≤ 2</td>
<td>80 ≤ 5 ≤ 2</td>
<td>100 ≤ 5 ≤ 2</td>
<td>100 ≤ 5 ≤ 2</td>
</tr>
<tr>
<td>40 50</td>
<td>≤ 600</td>
<td>40 ≤ 4 ≤ 3 40 ≤ 4 ≤ 3</td>
<td>40 ≤ 1 ≤ 1</td>
<td>380 ≤ 6 ≤ 2</td>
<td>100 ≤ 5 ≤ 2</td>
<td>150 ≤ 5 ≤ 2</td>
<td>180 ≤ 6 ≤ 2</td>
</tr>
<tr>
<td>50 65</td>
<td>≤ 900</td>
<td>50 ≤ 4 ≤ 3 50 ≤ 4 ≤ 3</td>
<td>50 ≤ 1 ≤ 1</td>
<td>480 ≤ 7 ≤ 2</td>
<td>150 ≤ 5 ≤ 2</td>
<td>200 ≤ 5 ≤ 2</td>
<td>200 ≤ 5 ≤ 2</td>
</tr>
</tbody>
</table>

Safety valves with code letter D/G/H, blow-off pressure pSV ≤ 10 bar

<table>
<thead>
<tr>
<th>Safety valve d1 DN</th>
<th>Exhaust line d2 DN Length m No. of bends Blow. press. bar</th>
<th>SV supply d20 DN Length m No. of bends</th>
<th>Type T</th>
<th>Blow. press. bar</th>
<th>SV – T line d20 DN Length m No. of bends</th>
<th>SV with or without T expansion trap d10 DN Length m No. of bends</th>
<th>SV with T expansion trap SV – T line d20 DN Length m No. of bends</th>
<th>SV supply d20 DN Length m No. of bends</th>
<th>Water discharge line d40 DN Length m No. of bends</th>
</tr>
</thead>
<tbody>
<tr>
<td>25 40</td>
<td>≤ 5.0 ≤ 0.2 ≤ 1 ≤ 0.5 ≤ 1</td>
<td>25 ≤ 1 ≤ 1</td>
<td>170 ≥ 1 ≤ 0.5 ≤ 0.2 ≤ 1</td>
<td>50 ≥ 1 ≤ 0.5 ≤ 1</td>
<td>65 ≥ 1 ≤ 0.5 ≤ 1</td>
<td>100 ≥ 1 ≤ 0.5 ≤ 1</td>
<td>150 ≥ 1 ≤ 0.5 ≤ 1</td>
<td>200 ≥ 1 ≤ 0.5</td>
<td>250 ≥ 1 ≤ 0.5</td>
</tr>
<tr>
<td>30 50</td>
<td>≤ 5.0 ≤ 0.2 ≤ 1 ≤ 0.5 ≤ 1</td>
<td>30 ≤ 1 ≤ 1</td>
<td>170 ≥ 1 ≤ 0.5 ≤ 1</td>
<td>65 ≥ 1 ≤ 0.5 ≤ 1</td>
<td>100 ≥ 1 ≤ 0.5 ≤ 1</td>
<td>150 ≥ 1 ≤ 0.5 ≤ 1</td>
<td>200 ≥ 1 ≤ 0.5</td>
<td>250 ≥ 1 ≤ 0.5</td>
<td></td>
</tr>
<tr>
<td>35 65</td>
<td>≤ 5.0 ≤ 0.2 ≤ 1 ≤ 0.5 ≤ 1</td>
<td>35 ≤ 1 ≤ 1</td>
<td>170 ≥ 1 ≤ 0.5 ≤ 1</td>
<td>70 ≥ 1 ≤ 0.5 ≤ 1</td>
<td>100 ≥ 1 ≤ 0.5 ≤ 1</td>
<td>150 ≥ 1 ≤ 0.5 ≤ 1</td>
<td>200 ≥ 1 ≤ 0.5</td>
<td>250 ≥ 1 ≤ 0.5</td>
<td></td>
</tr>
<tr>
<td>40 80</td>
<td>≤ 5.0 ≤ 0.2 ≤ 1 ≤ 0.5 ≤ 1</td>
<td>40 ≤ 1 ≤ 1</td>
<td>170 ≥ 1 ≤ 0.5 ≤ 1</td>
<td>80 ≥ 1 ≤ 0.5 ≤ 1</td>
<td>100 ≥ 1 ≤ 0.5 ≤ 1</td>
<td>150 ≥ 1 ≤ 0.5 ≤ 1</td>
<td>200 ≥ 1 ≤ 0.5</td>
<td>250 ≥ 1 ≤ 0.5</td>
<td></td>
</tr>
<tr>
<td>50 100</td>
<td>≤ 5.0 ≤ 0.2 ≤ 1 ≤ 0.5 ≤ 1</td>
<td>50 ≤ 1 ≤ 1</td>
<td>170 ≥ 1 ≤ 0.5 ≤ 1</td>
<td>90 ≥ 1 ≤ 0.5 ≤ 1</td>
<td>100 ≥ 1 ≤ 0.5 ≤ 1</td>
<td>150 ≥ 1 ≤ 0.5 ≤ 1</td>
<td>200 ≥ 1 ≤ 0.5</td>
<td>250 ≥ 1 ≤ 0.5</td>
<td></td>
</tr>
<tr>
<td>60 125</td>
<td>≤ 5.0 ≤ 0.2 ≤ 1 ≤ 0.5 ≤ 1</td>
<td>60 ≤ 1 ≤ 1</td>
<td>170 ≥ 1 ≤ 0.5 ≤ 1</td>
<td>100 ≥ 1 ≤ 0.5 ≤ 1</td>
<td>100 ≥ 1 ≤ 0.5 ≤ 1</td>
<td>150 ≥ 1 ≤ 0.5 ≤ 1</td>
<td>200 ≥ 1 ≤ 0.5</td>
<td>250 ≥ 1 ≤ 0.5</td>
<td></td>
</tr>
</tbody>
</table>

* When combining several lines, the cross-section of the collecting main must be at least the same as the sum of the cross-sections of the individual lines.
Pressure limiters

Pressure limiters are electromechanical switchgears, and according to the Pressure Equipment Directive 97/23/EC (DGRL) are defined as pieces of equipment that perform a safety function. The limiters used must therefore carry a CE symbol and be component tested. In the event of exceeding or not reaching the correct pressure, the heating will be switched off immediately and locked.

**Maximum pressure limiter** $P_{\text{Lmax}}$

DIN EN 12828: “All heat generators with a nominal heat output of $P_{\text{Lmax}}$ more than 300 kW must be fitted with a safety pressure limiter.”

As a general rule, pressure limiters are set 0.2 bar below the safety valve actuation pressure.

Pressure limiters are not required for heat exchangers (indirect heating).

**Minimum pressure limiter** $P_{\text{Lmin}}$

DIN EN 12828, the standard for systems with operating temperatures $P_{\text{Lmin}} \leq 105 \, ^{\circ}\text{C}$ does not require a minimum pressure limiter in all cases. It is only required as a replacement measure for the water level limiter on directly heated heat generators.

A minimum pressure limiter can also be used to monitor function in systems with pressure-maintaining systems that are not supported by an automatic make-up system.
Expansion lines, shut-offs, draining

Expansion lines, heat generators up to 120 °C
DIN EN 12828: “Expansion lines must ... be dimensioned such that their flow resistance \( \Delta p \) ... can only bring about a pressure increase ... to which the pressure limiters (PLmax) and safety valves (pSV) do not respond.”

The base volume flow to be applied is 1 litre/(hkW) relative to the nominal heat output of the heat generator \( Q \).

In the case of suction pressure maintenance, the permissible pressure loss \( \Delta p \) results mainly from the difference between the safety valve actuation pressure \( p_{SV} \) or set pressure of the pressure limiter \( PL_{max} \) and the final pressure \( p_f \), minus a specific tolerance. The pressure loss is mathematically verified by the following relationship:

\[
\Delta p \left( \text{1 litre/(hkW)} \right) = \Sigma (R_l + Z).
\]

Verification is not necessary if the following table values are used. In the case of Reflex Variomat pressure-maintaining stations, the expansion lines are also dimensioned according to the degassing performance. → Reflex Variomat brochure

<table>
<thead>
<tr>
<th>Expansion line</th>
<th>DN 20 ( \frac{3}{4}&quot; )</th>
<th>DN 25 ( 1&quot; )</th>
<th>DN 32 ( 1\frac{1}{4}&quot; )</th>
<th>DN 40 ( 1\frac{1}{2}&quot; )</th>
<th>DN 50 ( 2&quot; )</th>
<th>DN 65</th>
<th>DN 80</th>
<th>DN 100</th>
</tr>
</thead>
<tbody>
<tr>
<td>( Q/kW )</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>length ≤ 10 m</td>
<td>350</td>
<td>2100</td>
<td>3600</td>
<td>4800</td>
<td>7500</td>
<td>14000</td>
<td>19000</td>
<td>29000</td>
</tr>
<tr>
<td>( Q/kW )</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>length &gt; 10 m ≤ 30 m</td>
<td>350</td>
<td>1400</td>
<td>2500</td>
<td>3200</td>
<td>5000</td>
<td>9500</td>
<td>13000</td>
<td>20000</td>
</tr>
</tbody>
</table>

Incidentally, it is both permissible and common for expansion lines on expansion vessel or pressure-maintaining station connections to be “contracted” to smaller dimensions.

Potable water installations

In hot water and pressure booster systems, the connection lines for water-carrying vessels are determined on the basis of the peak volume flow \( V_p \) as per the specifications of DIN 1988 T3. For Refix DT5 from 80 litres, the bypass lines for repair purposes (closed during operation) should generally be one dimension smaller than the main line. Refix DT units with flow fittings are pre-equipped with an integrated bypass (open during operation). Special calculations are required when using Refix units for pressure surge damping.

Shut-offs, draining

To be able to perform maintenance and inspection work in a correct and professional manner, the water spaces of expansion vessels must be configured such that they can be shut off from those of the heating/cooling system. The same applies for expansion vessels in potable water systems. This facilitates (and, in some cases, enables) the annual inspection of the pressure-maintaining system (e.g. gas input pressure check on expansion vessels).

In accordance with DIN EN 12828, cap ball valves with socket fittings as well as integrated drainage and quick couplings are provided; these components are subject to minimal pressure loss and are protected against inadvertent closing.

In the case of Refix DT 60–500 litres, a Flowjet flow fitting Rp 1¼ is supplied for on-site installation, which combines the shut-off function, draining and bypass in a single unit. For Refix DD 8–33 litres, our Flowjet flow fitting Rp ¾ with protected shut-off and draining is available as an optional accessory. The T-piece for the water flow is supplied with the Refix DD unit, in this case in Rp ¾ format. Larger T-pieces must be provided by the customer.

In the case of Refix DT 80–3000 litres, the required fittings must be procured by the customer. In this case we recommend that the supplied fittings be used for installation.
Intermediate vessels

Intermediate vessels protect the diaphragms of expansion vessels from impermissible temperature loads. According to DIN 4807 T3 and EN 13831, the continuous temperature on the diaphragms must not exceed 70 °C. In a cooling water systems, temperatures ≤ 0 °C should be avoided.

In heating systems
As a rule, heating systems are operated at return temperatures of ≤ 70 °C. The installation of intermediate vessels is not necessary. In the case of older systems and industrial plants, return temperatures > 70 °C are sometimes unavoidable.

No general formula exists for calculating the intermediate vessel. The decisive factor is the water quantity heated to over 70 °C. This will generally be around 50 % of the system volume. For systems with heat reservoirs, up to 100 % is possible.

\[
V_n = \frac{\Delta n}{100} V_s (0.5 \text{ to } 1.0)
\]

→ \(\Delta n\) see ‘Properties and auxiliary variables’ p. 6

\(\rightarrow V_s\) system volume

In cooling circuits
If the temperature drops to ≤ 0 °C, we recommend that the intermediate vessel be dimensioned as follows.

\[V_c = 0.005 V_r\]

In solar energy systems
Without evaporation

\[V_c = \frac{\Delta n}{100} V_r\]

With evaporation

\[V_c = \frac{\Delta n}{100} V_r + V_c\]
Reflex accessory installation examples (notes for the installer)

**Reflex accessory** in a heating system with return temperature > 70 °C and individual boiler output > 300 kW

DIN EN 12828:
- All expansion vessels must be arranged such that they can be shut off from the heating system.
  - Reflex expansion vessel connection assembly
  - Reflex SU quick coupling

"It must be possible to drain the water space ... in expansion vessels."
- Reflex expansion vessel connection assembly and Reflex SU quick coupling have integrated drainage

Heat generators with a nominal heat output of more than 300 kW must have an expansion trap in the immediate vicinity of each safety valve.
- Reflex T expansion trap

DIN 4807 Part 3:
- "In continuous operation, the temperature on the diaphragm must not exceed 70 °C."
  - Install Reflex V intermediate vessel upstream of the expansion vessel

- We recommend installation of a Reflex EB dirt collector, particularly for old systems.

- Use of an MBM II diaphragm rupture detector is possible for Reflexomat vessels and Refix DT potable water expansion vessels as an option.
## Safety equipment for hot water heating systems

in acc. with DIN EN 12828, operating temperatures up to 105 °C

### Direct heating
(heated with oil, gas, coal or electric energy)

<table>
<thead>
<tr>
<th>Temperature protection</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Temperature measuring device</strong></td>
</tr>
<tr>
<td><strong>Safety temperature limiter, or monitor,</strong> according to EN 60730-2-9</td>
</tr>
<tr>
<td><strong>Temperature regulator</strong>²)</td>
</tr>
</tbody>
</table>

### Indirect heating
(heat generators heated with liquids or steam)

<table>
<thead>
<tr>
<th>Temperature protection</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Temperature measuring device</strong></td>
</tr>
</tbody>
</table>

### Low-water protection

- **Low boiler level**
  - \( Q_n \leq 300 \text{ kW} \)
    - Not required if no permissible heating with low water level
  - \( Q_n > 300 \text{ kW} \)
    - WMS or SPL\(_{\text{max}}\) or flow restrictor

- **Boilers in roof-mounted systems**
  - WMS or SPL\(_{\text{max}}\) or flow restrictor or suitable device

- **Heat generator with heating that is unregulated or cannot be quickly deactivated (solid fuel)**
  - Emergency cooling (e.g., thermal discharge safety device, safety heat consumer) with safety temperature limiter to take effect if max. operating temperature exceeded by more than 10 K

### Pressure protection

<table>
<thead>
<tr>
<th>Pressure measuring system</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Safety valve</strong> in acc. with prEN 1268-1 or prEN ISO 4126-1, TRD 721</td>
</tr>
<tr>
<td><strong>Expansion trap</strong> per SV</td>
</tr>
<tr>
<td><strong>Pressure limiter</strong> max. TÜV-tested</td>
</tr>
</tbody>
</table>
| **Pressure maintenance** Expansion vessel | - Pressure regulation within boundaries of \( p_p \) as expansion vessel or expansion vessel with external pressure generation
  - Protected shut-off and draining of expansion vessels should be possible for maintenance purposes |
| **Filling systems** | - Assurance of operational min. water seal VWS, autom. make-up with water meter
  - Connections to potable water systems must comply with prEN 806-4, or DIN 1988 or DIN EN 1717 |

### Heating

|  
|-----------------|
| **Heating** | Primary shut-off valve, if \( t_{\text{st}} > t_{\text{sec}} \) (\( p_{\text{SV}} \))
  - Recommendation: Primary shut-off valve also for \( t_{\text{st}} > t_{\text{per sec}} \) |

³) STL recommended, as STM automatically releases heating when temperature drops below limit, thus “sanctioning” the failure of the regulator.

²) If the temperature regulator is not type-tested (e.g., DDC without structure shut-off for max. target temperature), an additional type-tested temperature monitor must be provided in the case of direct heating.

³) Based on invalid DIN 4751 T2
Safety equipment for hot water heating systems

in acc. with DIN EN 12828, operating temperatures up to 105 °C

Example: direct heating

Key

1 Heat generator
2 Shut-off valves, advance/return
3 Temperature regulator
4 Safety temperature limiter, STL
5 Temperature measuring device
6 Safety valve
7 Expansion trap (T) > 300 kW
8 SPLmax, Q > 300 kW
9 SPLmin, as optional substitute for low-water protection
10 Pressure gauge
11 Low-water protection, up to 300 kW also as substitute for SPLmin or flow monitor or other permitted measures
12 Filling/draining system (filling/draining tap)
13 Automatic water make-up (Fillcontrol Plus + Fillset + Fillcontrol)
14 Expansion line
15 Protected shut-off valve (SU quick coupling, MK cap ball valve)
16 Deaeration/draining before expansion vessel
17 Expansion vessel (e.g. Reflex N)

Not required for indirect heating, if SV can be calculated for water outflow (→ p. 39)

Not required if additional STL and SPLmax fitted
## Equipment, accessories, safety technology, inspection

### Safety equipment of hot water systems according to DIN 4753 T1

#### Requirements of potable water systems

Potable water heater closed, indirect heating  
Grouping according to DIN 4753 T1:  
- **Gr. I**: $p \times V \leq 300 \text{ bar l} \leq 10 \text{ kW}$ or $V \leq 15 \text{ l}$ and $Q \leq 50 \text{ kW}$  
- **Gr. II**: if gr. I thresholds exceeded

#### Temperature protection

<table>
<thead>
<tr>
<th>Equipment</th>
<th>DIN 4753 T1, DIN 4747</th>
</tr>
</thead>
</table>
| Thermometer | May be part of regulator, not required for gr. 1  
| Temperature regulator | Type-tested  
| Safety temperature limiter | According to DIN 3440  
| | As of heating medium temperatures $> 100 ^\circ \text{C}$, setpoint value $\leq 60 ^\circ \text{C}$, maximum value $95 ^\circ \text{C}$ (not applicable for gr. 1)  
| | As of heating medium temperatures $> 110 ^\circ \text{C}$, setpoint value $\leq 95 ^\circ \text{C}$, maximum value $110 ^\circ \text{C}$ for $V < 5000 \text{ l}$ and $Q \leq 250 \text{ kW}$ no intrinsic safety required according to DIN 3440; for district heating systems, actuator valve with safety function according to DIN 32730

#### Pressure protection

<table>
<thead>
<tr>
<th>Equipment</th>
<th>DIN 4753 T1</th>
</tr>
</thead>
</table>
| Pressure gauge | Required for tanks $> 1000 \text{ l}$; general installation near safety valve, recommended for cold water systems  
| Safety valve | - Installation in cold water line  
| | - No shut-offs or impermissible narrowing between water heater and safety valve  
| Nominal content of water space | Max. heating output | Connection nominal diameter  
| $\leq 200 \text{ l}$ | $75 \text{ kW}$ | DN 15  
| $\leq 1000 \text{ l}$ | $150 \text{ kW}$ | DN 20  
| $\leq 5000 \text{ l}$ | $250 \text{ kW}$ | DN 25  
| $> 5000 \text{ l}$ | Selection according to max. heating capacity

#### Pressure reducing valve

<table>
<thead>
<tr>
<th>Equipment</th>
<th>DVGW-approved</th>
</tr>
</thead>
</table>
| Required: | - If the pressure for the cold water supply $> 80 \%$ of the safety valve actuation pressure  
| | - In case of installation of diaphragm expansion vessels (expansion vessel-W according to DIN 4807 T5) to ensure a constant normal pressure level before the vessel

#### Diaphragm expansion vessels

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Expansion vessel-W according to DIN 4807 T5</th>
</tr>
</thead>
</table>
| - Requirements of DIN 4807 T5: Water flow under defined conditions  
| | Green colour  
| | Diaphragms and non-metallic parts according to KTW-C as a minimum  
| | Installation of pressure reducing valve  
| | Protected shut-off of expansion vessel  
| - Input pressure set to 0.2 bar below pressure reducing valve

#### Potable water protection

<table>
<thead>
<tr>
<th>Equipment</th>
<th>DIN 1988 T2, T4 or DIN EN 1717</th>
</tr>
</thead>
</table>
| Backflow preventer | DVGW-approved  
| | Prescribed for potable water heaters $> 10 \text{ litres}$, shut-off on both sides, test system to be implemented after first shut-off

#### Design of potable water heaters

<table>
<thead>
<tr>
<th>Equipment</th>
<th>DIN 1988 T2 for heating water complying with category 3 of DIN EN 1717 (absence or minimal amount of toxic additives (e.g. ethylene glycol, copper sulphate solution); see DIN for other media and designs</th>
</tr>
</thead>
</table>
| Design type B, corrosion-resistant heating surfaces and linings | (copper, stainless steel, enamelled)  
| e.g. Reflex Longtherm plate heat exchanger  
| Permissible for max. operating pressure on heating side $\leq 3 \text{ bar}$ |  
| Design type C = B + no detachable connections; quality of non-detachable connections must be verified by means of a procedure inspection (e.g. AD data sheets, HP series), e.g. tube heat exchanger  
| Also permissible for max. operating pressure on heating side $> 3 \text{ bar}$

---

**reflex**
Safety equipment of hot water systems according to DIN 4753 T1

Example A: Hot water systems in storage system, boiler protection ≤ 100 °C

Example B: Hot water systems in storage charging system, heating medium > 110 °C protected

Key

1 Heat generator (boiler, heat exchanger)  9 Boiler regulation with actuation of hot water supply
2.1 HW tank with integrated heating surface  10 Heating regulation with actuation of storage charging system
2.2 HW tank without heating surface  11 Shut-off valve
3 Diaphragm expansion vessel for potable water (see also p. 24-25)  12 Non-return valve
4 Diaphragm SV, code letter W  13 Test system
5 Volume adjusting valve  14 Pressure reducing valve
6.1 Charge pump, heating side  Also possible as combined fitting with safety valve 4
6.2 Charge pump, potable water side
7 Circulating pump
8.1 Thermostat for activating charge pump 6.1
8.2 Type-tested temperature regulator
8.3 Type-tested temperature limiter
8.4 Control valve with safety function

▶ Code letters, symbols → page 79
Inspection and maintenance of systems and pressure vessels

What is tested and why

Diaphragm expansion, in-line and blow-off vessels as well as heat exchangers and boilers are all examples of pressure vessels. They all possess a risk potential resulting mainly from the pressure, volume, temperature and the medium itself.

Specific legal requirements apply for the manufacture, start-up and operation of pressure vessels and complete systems.

Manufacture according to DGRL

Since 01/06/2002, the production and initial inspection of pressure vessels by the manufacturer, as well as their placing on the market, has been governed throughout Europe by the Pressure Equipment Directive 97/23/EC (DGRL). Only pressure vessels complying with this Directive may be brought into circulation.

Reflex diaphragm expansion vessels meet the requirements of Directive 97/23/EC and are marked with the number 0045.

“0045” represents TÜV Nord as the named inspection authority.

A new feature is that the manufacturer certification previously issued on the basis of the steam boiler or pressure vessel ordinance is now being replaced with a declaration of conformity. → page 78

In the case of Reflex pressure vessels, the declaration of conformity is part of the supplied assembly, operating and maintenance instructions.

Operation according to BetrSichV

Within the meaning of the ordinances, the term ‘operation’ refers to the assembly, use, pre-commissioning inspection and recurring inspection of systems requiring monitoring. The steam boiler and pressure vessel ordinances previously applicable in Germany were replaced by the Ordinance on Industrial Safety and Health (BetrSichV) on 01/01/2003.

With the introduction of the Ordinance on Industrial Safety and Health and the Pressure Equipment Directive, the previously applicable steam boiler and pressure vessel ordinances were finally replaced with a standardised set of regulations on 01/01/2003.

The necessity of inspections prior to start-up and that of recurring checks, as well as the relevant inspecting authority are defined on the basis of the risk potential according to the specifications of the DGRL and BetrSichV. For this purpose, the categories medium (fluid), pressure, volume and temperature are applied according to the conformity assessment diagrams in Appendix II of the DGRL. A specific assessment for the Reflex product range can be found in tables 1 and 2 (→ p. 76). The applicability of the specified maximum intervals is subject to compliance with the measures in the relevant Reflex assembly, operating and maintenance instructions.

During the conformity assessment on the part of the manufacturer according to DGRL, the maximum permissible parameters for the vessel apply, while the operator’s assessment according to BetrSichV can be based on the maximum actual parameters for the system. Therefore, when assessing and categorising the pressure PS, the maximum possible pressure must be applied that can occur even in the case of extreme operating conditions, malfunction and operating errors on the basis of the pressure protection of the system or system component. The fluid group is selected according to the actual medium employed.
§ 14 Inspection prior to start-up
• Assembly, installation
• Installation conditions
• Safe function

§ 15 Recurring inspections
• Documentation and organisation check
• Technical inspection
  - External inspection
  - Internal inspection
  - Strength test

For recurring inspections, the operator must define the inspection intervals on the basis of a safety evaluation and the applicable maximum intervals.
(Tables 1 and 2, → p. 76)

If the system is to be commissioned by an authorised inspection body (AIB), the check lists created by the operator must be provided to and agreed with the relevant authority.
The safety evaluation must distinguish between the following:
- The overall system, which can also comprise multiple items of pressure equipment and be configured for specific safety thresholds for the system pressure and temperature – e.g. hot water boiler with expansion vessel, secured via the safety valve and the boiler’s STL
- The system components – e.g. the hot water boiler and expansion vessel – may belong to different categories and thus be evaluated differently from a safety perspective.

If the overall system is made up solely of components that must be inspected by a qualified person (QP), the overall system can also be inspected by a QP.

In the case of external and internal checks, inspections may be replaced with other equivalent procedures, while the static pressure tests for strength tests can be substituted with comparable, non-destructive procedures.

Transition regulations
For systems comprising pressure equipment commissioned before 01/01/2003, a transitional period applied up to 31/12/2007.

Since 01/01/2008 the provisions of the BetrSichV apply unconditionally to all systems requiring monitoring.

Maintenance
While the specifications of the DGRL and BetrSichV are geared primarily towards safety aspects and health protection in particular, the purpose of maintenance work is to ensure optimum and efficient system operation while minimising faults. System maintenance is performed by a specialist commissioned by the operator. This may be a plumber or a Reflex service representative (→ p. 80–81).

Maintenance of diaphragm expansion vessels must be performed according to manufacturer specifications, among other things, and thus take place on a yearly basis. This mainly comprises the inspection and adjustment of the vessel input pressure as well as the system filling or initial pressure. → p. 9

We recommend that our pressure-maintaining, make-up and degassing systems be maintained at the same frequency as our diaphragm expansion vessels, i.e. annually.

All Reflex products are supplied with assembly, operating and maintenance instructions (→ p. 78) containing all relevant information for the plumber and operator.
Table 1:
Inspection of Reflex pressure vessels according to BetrSichV, edition dated 27/09/2002, as amended on 23/12/2004, with operation according to Reflex assembly, operating and maintenance instructions
Applicable for all
• Reflex, Refix, Variomat, Variomat Giga, Reflexomat, Reflexomat Compact vessels and the Servitec spray-tube and
• Intermediate vessels, dirt collectors and Longtherm plate heat exchangers at max. operating temperatures > 110 °C
of the system (e.g. STL setting)
Classification in fluid group 2 according to DGRL - (e.g. water, air, nitrogen = non-explosive, non-toxic, not easily flammable).

<table>
<thead>
<tr>
<th>Assessment/category</th>
<th>Pre-start-up, § 14</th>
<th>Recurring inspections, § 15</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Inspecting party</td>
<td></td>
</tr>
<tr>
<td>V</td>
<td>1 litre and</td>
<td></td>
</tr>
<tr>
<td>PS x V</td>
<td>≤ 50 bar x litre</td>
<td></td>
</tr>
<tr>
<td>PS ≤ 1000 bar</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PS x V</td>
<td>&gt; 50 ≤ 200 bar x litres</td>
<td>QP</td>
</tr>
<tr>
<td>PS x V</td>
<td>&gt; 200 ≤ 1000 bar x litres</td>
<td>AIB**</td>
</tr>
<tr>
<td>PS x V</td>
<td>&gt; 1000 bar x litres</td>
<td>AIB**</td>
</tr>
</tbody>
</table>

* Recommendation:
Max. 10 years for Reflex and Refix with bladder diaphragms as well as Variomat and Variomat Gigamat vessels, but at the very least when opening for repair purposes (e.g. diaphragm replacement) according to Appendix 5 Section 2 and Section 7(1) of BetrSichV

** Important note:
As of 01/01/2005, the following applies for applications in heating and cooling systems:
In the case of indirectly heated heat generators (Longtherm) with a heating medium temperature no higher than 120 °C (e.g. STL setting) and expansion vessels (Reflex, Refix, Variomat, Variomat Giga, Reflexomat or Reflexomat Compact vessels) in heating and cooling/refrigerating systems with water temperatures no higher than 120 °C, the inspections may be performed by a qualified person (QP).

Table 2:
Inspection of Reflex pressure vessels according to BetrSichV, edition dated 27/09/2002, as amended on 23/12/2004, with operation according to Reflex assembly, operating and maintenance instructions
Applicable for all
• Intermediate vessels, dirt collectors and Longtherm plate heat exchangers at max. operating temperatures ≤ 110 °C of the system (e.g. STL setting)
Classification in fluid group 2 acc. to DGRL - (e.g. water = non-explosive, non-toxic, not easily flammable).

<table>
<thead>
<tr>
<th>Assessment/category</th>
<th>Pre-start-up, § 14</th>
<th>Recurring inspections, § 15</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Inspecting party</td>
<td></td>
</tr>
<tr>
<td>PS ≤ 10 bar or</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PS x V &lt; 10,000 bar x litres</td>
<td>AIB</td>
<td>QP</td>
</tr>
<tr>
<td>if PS ≤ 1000 bar</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10 &lt; PS ≤ 500 bar and</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PS x V &gt; 10,000 bar x litres</td>
<td>AIB</td>
<td>QP</td>
</tr>
</tbody>
</table>
Table 3: Inspection according to BetrSichV, edition dated 27/09/2002, as amended on 23/12/2004, for Reflex Longtherm brazed plate heat exchangers in systems with hazardous media and operation according to Reflex assembly, operating and maintenance instructions. 

Classification in fluid group 1 according to DGRL - (e.g. gasoline = explosive, highly flammable, toxic, oxidising). This fluid group is only permitted for Longtherm!

Applicable for permissible operating temperatures \( t > t_{\text{boiling}} \) at atmospheric pressure + 0.5 bar.

<table>
<thead>
<tr>
<th>Assessment/category</th>
<th>Pre-start-up, § 14</th>
<th>Recurring inspections</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Inspecting party</td>
<td>External(^a)</td>
</tr>
<tr>
<td>V ( \leq ) 1 litre and</td>
<td>No special requirements; to be arranged by the operator based on the current state of the art and according to the specifications in the operating instructions(^d)</td>
<td></td>
</tr>
<tr>
<td>PS ( \leq 200 ) bar</td>
<td>QP</td>
<td>QP</td>
</tr>
<tr>
<td>PS x V ( \leq 25 ) bar \times ( \leq 25 ) litres</td>
<td>AIB</td>
<td>QP</td>
</tr>
<tr>
<td>PS ( \leq 200 ) bar</td>
<td>AIB</td>
<td>AIB</td>
</tr>
<tr>
<td>PS x V ( &gt; 1000 ) bar \times ( &gt; 1000 ) litres</td>
<td>AIB</td>
<td>AIB</td>
</tr>
</tbody>
</table>

Note: Longtherm plate heat exchangers must be classified in the higher category of the two chambers.

Note: If the "Assessment/category" column contains multiple criteria without "and" specifications, exceeding one criterion must result in the application of the next highest category.

| PS | Maximum possible excess pressure in bar resulting from the system configuration and operation |
| n | Expansion coefficient for water |
| V | Nominal volume in litres |
| t | Operating temperature of fluid |
| \( t_{\text{boiling}} \) | Boiling temperature of fluid under atmospheric pressure |

| QP | Qualified person in accordance with § 2 (7) BetrSichV, who possesses the required expertise to inspect the pressure equipment on the basis of his or her training, professional experience or recent professional activity |
| AIB | Authorised inspection body according to § 21 BetrSichV, currently TÜV |

1) 2-yearly external inspections are not necessary with normal Reflex applications. Only necessary if the pressure equipment is heated by fire, waste gas or electricity.

2) In accordance with §15 (10), inspections and strength tests can be substituted with equivalent, non-destructive test procedures if their execution is not possible due to the construction of the pressure equipment or not expedient due to its mode of operation (e.g. fixed diaphragm).

3) With regard to the max. excess operating pressure of the equipment, this applies to the following products:
   - Reflex up to N 12 litres/3 bar, Servitec type ≤ 120
   - Longtherm rhc 15, rhc 40 ≤ 50 plates, rhc 60 ≤ 30 plates

4) To be defined by the operator on the basis of manufacturer information and experience with operational modes and feeds. The inspection can be performed by a qualified person (QP) according to § 2 (7) BetrSichV.

5) Irrespective of the max. operating temperature
Example:  
Reflex assembly, operating and maintenance instructions with declaration of conformity according to DGRL.
Terms

<table>
<thead>
<tr>
<th>Formula letter</th>
<th>Explanation</th>
<th>See page (among others)</th>
</tr>
</thead>
<tbody>
<tr>
<td>( A_p )</td>
<td>Working range of pressure maintenance</td>
<td>18</td>
</tr>
<tr>
<td>( A_{SV} )</td>
<td>Closing pressure difference for safety valves</td>
<td>5, 9</td>
</tr>
<tr>
<td>( \eta )</td>
<td>Expansion coefficient for water</td>
<td>6, 10, 24</td>
</tr>
<tr>
<td>( \eta^* )</td>
<td>Expansion coefficient for water mixtures</td>
<td>6, 13, 16</td>
</tr>
<tr>
<td>( \eta_{hi} )</td>
<td>Expansion coefficient relative to return temperature</td>
<td>11</td>
</tr>
<tr>
<td>( p_i )</td>
<td>Minimum operating pressure</td>
<td>5, 9, 18, 23, 24</td>
</tr>
<tr>
<td>( p_i )</td>
<td>Initial pressure</td>
<td>5, 9, 18, 23, 24</td>
</tr>
<tr>
<td>( p_v )</td>
<td>Evaporation pressure for water</td>
<td>6</td>
</tr>
<tr>
<td>( p_v^* )</td>
<td>Evaporation pressure for water mixtures</td>
<td>6</td>
</tr>
<tr>
<td>( p_f )</td>
<td>Final pressure</td>
<td>5, 9, 18</td>
</tr>
<tr>
<td>( p_f )</td>
<td>Filling pressure</td>
<td>5, 9</td>
</tr>
<tr>
<td>( p_s )</td>
<td>Static pressure</td>
<td>5, 9</td>
</tr>
<tr>
<td>( p_{SV} )</td>
<td>Safety valve actuation pressure</td>
<td>5, 9</td>
</tr>
<tr>
<td>( p_{max} )</td>
<td>Minimum supply pressure for pumps</td>
<td>7</td>
</tr>
<tr>
<td>( p_{max} )</td>
<td>Max. excess operating pressure</td>
<td>7</td>
</tr>
<tr>
<td>( V )</td>
<td>Compensating volume flow</td>
<td>19</td>
</tr>
<tr>
<td>( V_0 )</td>
<td>System volume</td>
<td>6</td>
</tr>
<tr>
<td>( v_s )</td>
<td>Specific water content</td>
<td>6</td>
</tr>
<tr>
<td>( V_s )</td>
<td>Expansion volume</td>
<td>5, 9, 23</td>
</tr>
<tr>
<td>( V_1 )</td>
<td>Collector content</td>
<td>12, 14, 39</td>
</tr>
<tr>
<td>( V_1 )</td>
<td>Nominal volume</td>
<td>9, 18</td>
</tr>
<tr>
<td>( V_{WS} )</td>
<td>Water seal</td>
<td>5, 9</td>
</tr>
<tr>
<td>( \Delta p_{P} )</td>
<td>Pump differential pressure</td>
<td>7</td>
</tr>
<tr>
<td>( \rho )</td>
<td>Density</td>
<td>6</td>
</tr>
</tbody>
</table>

Code letters

**T – Temperature**

- \( T \) Temperature test port
- \( TI \) Thermometer
- \( TIC \) Temperature regulator with display
- \( TAZ^* \) Temperature limiter, STL, STM

**P – Pressure**

- \( P \) Pressure test port
- \( PI \) Pressure gauge
- \( PC \) Pressure regulator
- \( PC \) Pressure switch
- \( PS \) Pressure switch
- \( PAZ^* \) Pressure limiter - min., \( SPL_{min} \)
- \( PAZ^+ \) Pressure limiter - max., \( SPL_{max} \)

**L – Water level**

- \( LS \) Water level switch
- \( LS^* \) Water level switch - max.
- \( LS^- \) Water level switch - min.
- \( LAZ^* \) Water level limiter - min.

Symbols

- Shut-off valve
- Fitting with protected shut-off and draining
- Spring-loaded safety valve
- Non-return valve
- Solenoid valve
- Motorised valve
- Overflow valve
- Dirt trap
- Water meter
- System separator
- Pump
- Heat consumer
- Heat exchangers

Code letters according to DIN 19227 T1, “Graphical symbols and code letters for process technology”
### Quick selection table for Reflex N and Reflex S

**Heating systems: 90/70°C**

<table>
<thead>
<tr>
<th>Input pressure $p_0$ bar</th>
<th>$V_n$ 2.5</th>
<th>$V_n$ 3.0</th>
<th>$V_n$ 4.0</th>
<th>$V_n$ 5.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.5</td>
<td>100</td>
<td>120</td>
<td>120</td>
<td>120</td>
</tr>
<tr>
<td>1.0</td>
<td>120</td>
<td>140</td>
<td>140</td>
<td>140</td>
</tr>
<tr>
<td>1.5</td>
<td>140</td>
<td>160</td>
<td>160</td>
<td>160</td>
</tr>
<tr>
<td>2.0</td>
<td>160</td>
<td>180</td>
<td>180</td>
<td>180</td>
</tr>
<tr>
<td>2.5</td>
<td>180</td>
<td>200</td>
<td>200</td>
<td>200</td>
</tr>
</tbody>
</table>

### Reflex recommendations:
- Select sufficiently high safety valve actuation pressure: $p_{SV} \geq p_0 + 1.5$ bar
- If possible, apply a 0.2 bar margin when calculating the gas input pressure: $p_i = \frac{H}{10} + 0.2$ bar
- Due to the required supply pressure for the circulating pumps, select an input pressure of at least 1 bar also for roof-mounted systems: $p_i \geq 1$ bar
- In a vented system in cold conditions, set the water-side filling or input pressure at least 0.3 bar higher than the input pressure: $p_{fil} \geq p_0 + 0.3$ bar

### Approximately water content:
- Radiators: $V_i = Q [kW] \times 13.5 L/kW$
- Panel-type radiators: $V_i = Q [kW] \times 8.5 L/kW$

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Reflex Pro, available online or to download at [www.reflex.de](http://www.reflex.de) and as an app in the iTunes Store.