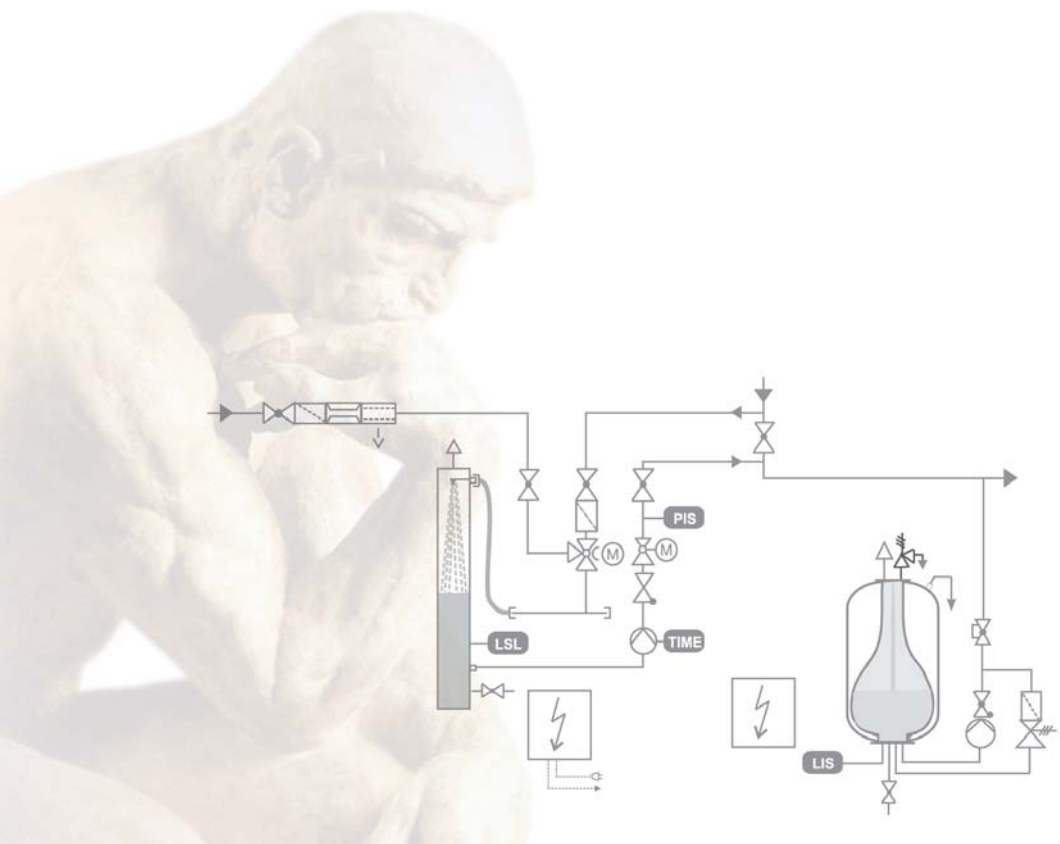
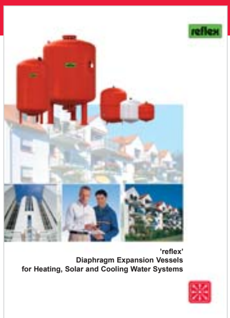
reflex

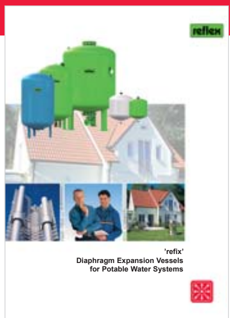



# Pressurization, degassing, make-up and heat exchanger systems

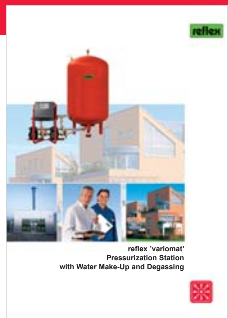
**Planning, calculation, equipment**

# Technical planning documentation



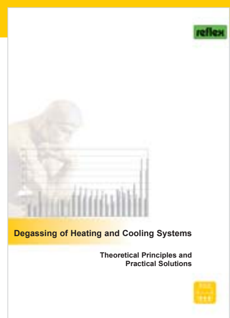


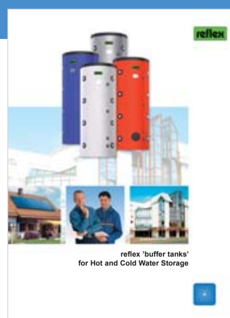




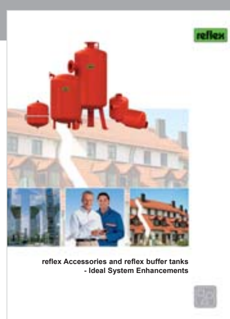













Calculate your individual applications on the move -
with our new **’reflex pro app’**!

# Contents





reflex

## Calculation procedures

The aim of this guide is to provide you with the most important information required to plan, calculate and equip Reflex pressurization, 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.

▶ Calculation forms
Auxiliary variables
▶

Please contact us if you require any additional information.
Your specialist adviser will be happy to help.

▶ Your specialist adviser
✆ → p. 55

**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 domestic water |
| VDI 2035 Part 1 | Prevention of damage through scale formation in domestic hot water and water heating installations |
| VDI 2035 Part 2 | Prevention of damage through water-side corrosion in water heating installations |
| EN 13831 | Closed expansion vessels with built in diaphragm for installation in water |
| DIN 4807 | Expansion vessels |
| DIN 4807 T1 | Terms... |
| DIN 4807 T2 | Calculation in conjunction with DIN EN 12828 |
| DIN 4807 T5 | Expansion vessels for drinking water installations |
| DIN 1988 | Technical rules for drinking water installations, pressure increase and reduction |
| DIN EN 1717 | Protection against pollution of potable water |
| DGRL | Pressure Equipment Directive 97/23/EC |
| BetrSichV | 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, 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 pressurization systems and heat exchangers can be performed via our **Reflex calculation program**, which is available for use or download at www.reflex.de. Another option is to use our new **'reflex pro app'**!
Both tools represent a quick and simple means of finding your ideal solution.

▶ Special pressure maintenance
✆ +49 2382 7069-536

**Special systems** In the case of special systems, such as pressurization stations in district heating systems with an output of more than 14 MW or flow temperature over 105°C, please contact our specialist department directly.

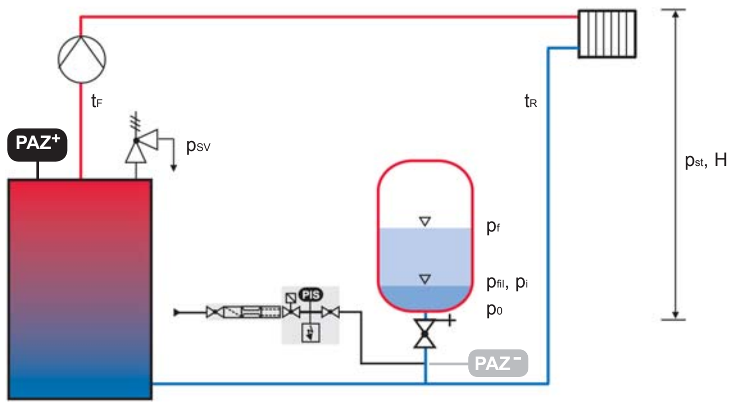
### Role of pressurization systems

Pressurization 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 authorized 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.
3. Provision for system-based water losses by means of a water seal.

Careful calculation, commissioning and maintenance are essential to the correct functioning of the overall system.

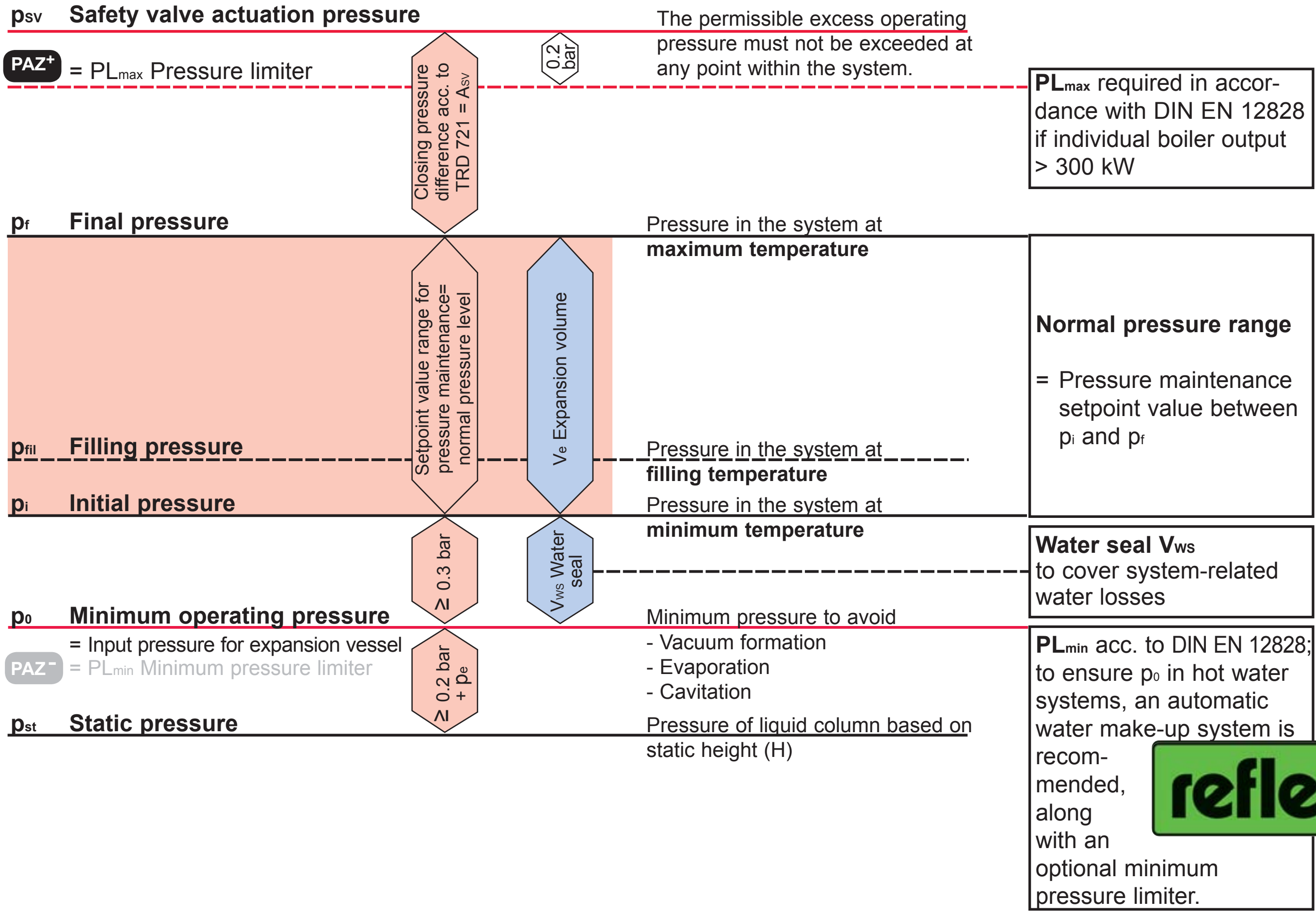
### Calculation parameters




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

**Definitions in accordance with DIN EN 12828 and following DIN 4807 T1/T2 based on the example of a heating system with a diaphragm expansion vessel.**

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



## Properties and auxiliary variables

### Properties of water and water mixtures

Pure water without antifreeze additive

| t / °C | 0 | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100 | 105 | 110 | 120 | 130 | 140 | 150 | 160 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| n / % (+ 10°C of t) | | 0 | 0.13 | 0.37 | 0.72 | 1.15 | 1.66 | 2.24 | 2.88 | 3.58 | 4.34 | 4.74 | 5.15 | 6.03 | 6.96 | 7.96 | 9.03 | 10.20 |
| $p_e$ / bar | | -0.99 | -0.98 | -0.96 | -0.93 | -0.88 | -0.80 | -0.69 | -0.53 | -0.30 | 0.01 | 0.21 | 0.43 | 0.98 | 1.70 | 2.61 | 3.76 | 5.18 |
| Δn ($t_R$) | | | | | | | | 0 | 0.64 | 1.34 | 2.10 | 2.50 | 2.91 | 3.79 | | | | |
| ρ / kg/m³ | 1000 | 1000 | 998 | 996 | 992 | 988 | 983 | 978 | 972 | 965 | 958 | 955 | 951 | 943 | 935 | 926 | 917 | 907 |

Water with antifreeze additive* 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* / % (- 10°C of t) | 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 | --- | 0.33 | 0.85 | 1.52 | 2.38 | 3.47 | 4.38 |
| ρ / kg/m³ | 1039 | 1037 | 1035 | 1031 | 1026 | 1022 | 1016 | 1010 | 1004 | 998 | 991 | --- | 985 | 978 | 970 | 963 | 955 | 947 |

Water with antifreeze additive* 34% (vol.)
Lowest permissible system temperature - 20°C

| t / °C | 0 | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100 | 105 | 110 | 120 | 130 | 140 | 150 | 160 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| n* / % (- 20 °C of t) | 0.35 | 0.66 | 1.04 | 1.49 | 1.99 | 2.53 | 3.11 | 3.71 | 4.35 | 5.01 | 5.68 | --- | 6.39 | 7.11 | 7.85 | 8.62 | 9.41 | 10.2 |
| $p_e$* / bar | | | | | | -0.9 | -0.8 | -0.7 | -0.6 | -0.4 | -0.1 | --- | 0.23 | 0.70 | 1.33 | 2.13 | 3.15 | 4.41 |
| ρ / kg/m³ | 1066 | 1063 | 1059 | 1054 | 1049 | 1043 | 1037 | 1031 | 1025 | 1019 | 1012 | --- | 1005 | 999 | 992 | 985 | 978 | 970 |

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 or -20°C
Δv - 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

- $V_s = \dot{Q}_{tot} \times v_s$ + pipelines + other → for systems with natural circulation boilers
- $V_s = \dot{Q}_{tot} (v_s - 1.4\ l)$ + pipelines + other → for systems with heat exchangers
- $V_s = \dot{Q}_{tot} (v_s - 2.0\ l)$ + pipelines + other → for systems without heat exchangers

($\dot{Q}_{tot}$: Installed heating output)

$V_s$ = ..................... + ..................... + ..................... = ..................... liters

- Specific water content $v_s$ in liters/kW of heating systems (heat exchangers, distribution, heating surfaces)

| $t_F/t_R$ °C | Radiators | | Plates | Convectors | Ven-tilation | Floor heating |
|---|---|---|---|---|---|---|
| | Cast iron radiators | Tube and steel radiators | | | | |
| 60/40 | 27.4 | 36.2 | 14.6 | 9.1 | 9.0 | $V_s$ = 20 l/kW<br>$V_s^{**} = 20\ l/kW \cdot \frac{n_{FH}}{n}$ |
| 70/50 | 20.1 | 26.1 | 11.4 | 7.4 | 8.5 | |
| 70/55 | 19.6 | 25.2 | 11.6 | 7.9 | 10.1 | |
| 80/60 | 16.0 | 20.5 | 9.6 | 6.5 | 8.2 | |
| 90/70 | 13.5 | 17.0 | 8.5 | 6.0 | 8.0 | |
| 105/70 | 11.2 | 14.2 | 6.9 | 4.7 | 5.7 | |
| 110/70 | 10.6 | 13.5 | 6.6 | 4.5 | 5.4 | |
| 100/60 | 12.4 | 15.9 | 7.4 | 4.9 | 5.5 | |

- Caution: approximate values; significant deviations possible in individual cases.

** If the floor heating is operated and protected as part of the overall system with lower flow temperatures, $v_s$** must be used to calculate the total water volume

$n_{FH}$ = percentage expansion based on the max. flow temperature of the floor heating

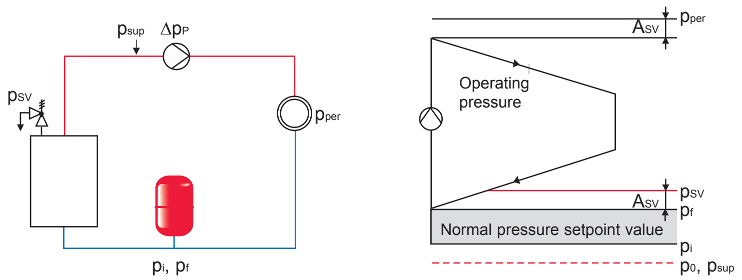
- Approx. water content of heating pipes

| DN | 10 | 15 | 20 | 25 | 32 | 40 | 50 | 60 | 65 | 80 | 100 | 125 | 150 | 200 | 250 | 300 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Liters/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 |

# Hydraulic integration

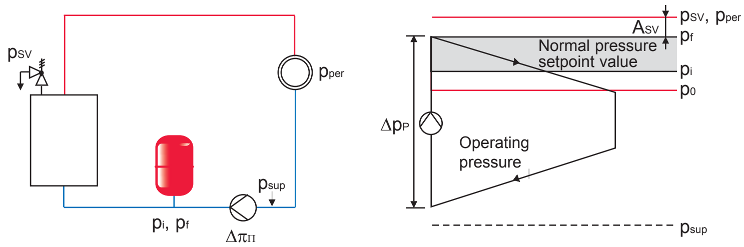
The hydraulic integration of pressure maintenance in the overall system greatly influences the pressure profile. This is made up of the normal pressure level of the pressure maintenance and the differential pressure generated when the circulating pump is running. Three main types of pressure maintenance 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); $p_{per}$ must be observed

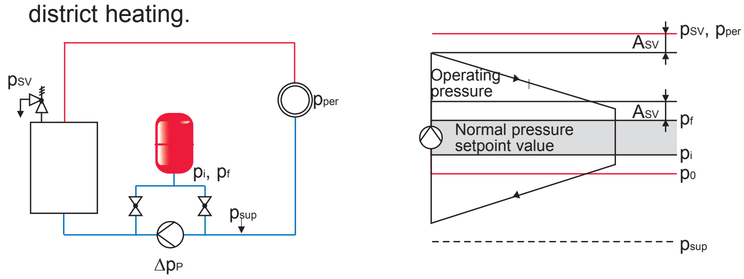
**Follow-up pressure maintenance** The pressure maintenance is integrated **after** the circulating pump, i.e. on the pressure side. When calculating the normal pressure, a system-specific differential pressure share of the circulating pump (50 ... 100%) must be included. This method is restricted to 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 $p_{sup}$ for the circulating pump according 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:
  - Optimized, variable coordination of operating and normal pressure
- Disadvantages:
  - Highly demanding with regard to system technology

**Reflex recommendation** Use suction pressure maintenance! A different method should only be used in justified exceptional cases. Contact us for more information!

## Special pressurization systems - overview

Reflex manufactures two different types of pressurization system:

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

- **Reflex pressurization systems with external pressure generation** require auxiliary energy and are thus classed as dynamic pressurization systems. A differentiation is made between pump- and compressor-controlled systems. While reflex 'variomat' and reflex 'gigamat' control the system pressure 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.

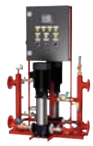
- **'Degassing of heating and cooling systems'**
This brochure explains when and why the use of degassing systems is required, particularly in closed systems.

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 unpressurized 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 calculation program will help you identify the ideal solution.



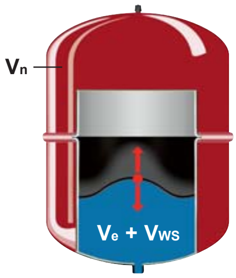
- **Preferred applications** are detailed in the following table. Based on experience, we recommend that the pressure maintenance be **automated** – i.e. pressure monitoring with timely water make-up – and that systems be automatically and **centrally vented**. This eliminates the need for conventional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

| | Standard pressure maintenance<br>Flow temp. up to 120°C | Pressure maint. | Autom. operation with make-up | Central deaera-tion and degassing | Preferred output range | |
|---|---|---|---|---|---|---|
| 'reflex' expan-sion vessel | - Without additional equipment<br>- With 'control' make-up<br>- With 'servitec' | X<br>X<br>X | ---<br>X<br>X | ---<br>---<br>X | Up to 1,000 kW |  |
| 'variomat' | 1 Single-pump system<br>2-1 Single-pump system<br>2-2 Dual-pump system | X<br>X<br>X | X<br>X<br>X | X<br>X<br>X | 150 - 2,000 kW<br>150 - 4,000 kW<br>500 - 8,000 kW |  |
| 'gigamat' | - Without additional equipment<br>- With 'servitec' | X<br>X | X<br>X | X*<br>X | 5,000 - 60,000 kW |  |
| | - Special systems | As required | | | | |
| 'minimat' | - Without additional equipment<br>- With 'control' make-up<br>- With 'servitec' | X<br>X<br>X | ---<br>X<br>X | ---<br>---<br>X | 100 - 2,000 kW |  |
| 'reflexomat' | - Without additional equipment<br>- With 'control' make-up<br>- With 'servitec' | X<br>X<br>X | ---<br>X<br>X | ---<br>---<br>X | 150 - 24,000 kW |  |

* In the case of return temperatures < 70°C, reflex 'gigamat' can also be used for degassing purposes without additional equipment

## Reflex diaphragm expansion vessels types: ’reflex N, F, S, G’

**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 x V = 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 pressurization 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 liters) must be taken into account during sizing.

Without degassing

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

With reflex ’servitec’

$$V_n = (V_e + V_{WS} + 5\,l) \frac{p_f + 1}{p_f - p_0}$$

**Pressure monitoring**
**Input pressure $p_0$**
Minimum operating pressure

The gas input pressure must be manually checked before commissioning 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 0.2 bar safety margin. This margin should only be dispensed with in the case of very small pressure ratios.

Input pressure maintenance

$p_0 \geq p_{st} + p_e + 0.2$ bar

$p_0 \geq 1$ bar   Reflex recommendation

Follow-up pressure maintenance

$p_0 \geq p_{st} + p_e + \Delta p_P$

**Initial pressure $p_a$**
**Water 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 ’control’ make-up stations automatically monitor and secure the initial or filling pressure. → reflex ’control’ make-up stations

Reflex formula for initial pressure

$p_i \geq p_0 + 0.3$ bar

**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 (lowest 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 $A_{SV}$ in accordance with TRD 721. The closing pressure difference depends on the type of the safety valve.

Reflex recommendation

$p_f \; = p_{SV} - A_{SV}$

$p_{SV} \geq p_0 + 1.5$ bar
for $p_{SV} \leq 5$ bar

$p_{SV} \geq p_0 + 2.0$ bar
for $p_{SV} > 5$ bar

Closing pressure difference acc. to TRD 721 $A_{SV}$

| | |
|---|---|
| SV-H | 0.5 bar |
| SV-D/G/H | 0.1 $p_{SV}$<br>0.3 bar for<br>$p_{SV}$ < 3 bar |

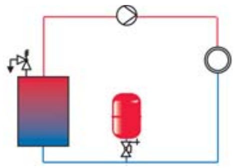
**Degassing**
**Deaeration**

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’ degases and makes up water automatically. → p. 28

### 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



'reflex'
'variomat'
'gigamat'
'reflexomat'

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

**Expansion volume $V_e$**
**Highest temperature $t_{TR}$** Calculation of percentage expansion, usually between lowest temperature = filling temperature = 10°C and highest setpoint value adjustment of temperature regulator $t_{TR}$

**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.

▶ **Caution** with roof-mounted systems and low-rise buildings

Reflex recommendation:

$p_0 \geq 1$ bar

**Filling pressure $p_{fil}$**
**Initial pressure $p_a$** 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 pressurization systems, 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 the make-up and degassing stations 'control' and 'servitec', or from approx. 150 kW as a 'variomat' pressurization station for pressure maintenance, degassing and water make-up, or in the form of a compressor-controlled 'reflexomat' pressurization station. → page 18



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

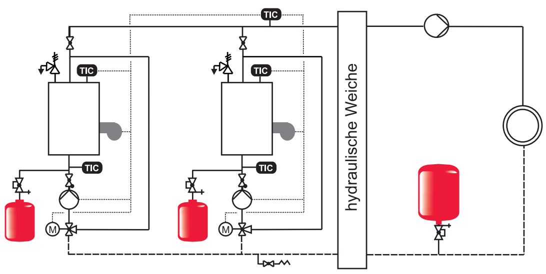
▶ In the case of corrosion risk, use 'refix'

**Degassing, deaeration, water make-up** To ensure ongoing safe and automatic operation of the heating system, the pressurization units should be equipped with make-up systems and supplemented with 'servitec' degassing systems. More information can be found on page 28.

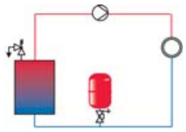
**In-line vessels** If a temperature of 70°C is permanently exceeded by the pressure maintenance, an in-line vessel must be installed to protect the diaphragms in the expansion vessel. → page 43

**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 minimized by also fitting a diaphragm expansion vessel (e.g. 'reflex N') to the heat generator in this case.

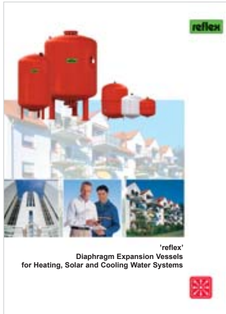


## 'reflex N, F, G' in heating systems



**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

| | | | | | | |
|---|---|---|---|---|---|---|
| Heat generator | | 1 | 2 | 3 | 4 | |
| Heat output | $Q_h$ | = .......... kW | .......... kW | .......... kW | .......... kW | **$Q_{tot}$ = .......... kW** |
| Water content | $V_W$ | = .......... liters | | | | |
| System flow temperature | $t_F$ | = .......... °C | → p. 6 | Approximate water content | | **$V_s$ = .......... liters** |
| System return temperature | $t_R$ | = .......... °C | | $v_s = f(t_F, t_R, Q)$ | | |
| Water content known | $V_s$ | = .......... liters | | | | |
| Highest setpoint value adjustment Temperature regulator | $t_{TR}$ | = .......... °C | → p. 6 | Percentage expansion n | | **n = .......... %** |
| Antifreeze additive | | = .......... % | | (with antifreeze additive n*) | | |
| Safety temperature limiter | $t_{STL}$ | = .......... °C | → p. 6 | Evaporation pressure $p_e$ at > 100°C with antifreeze additive $p_e$*) | | **$p_e$ = .......... bar** |
| Static pressure | $p_{st}$ | = .......... bar | | | | **$p_{st}$ = .......... bar** |

▶ If $_R$ > 70°C, 'V in-line vessel' required

### Pressure calculation

**Input pressure** $p_0$ = stat. pressure $p_{st}$ + evaporation pressure $p_e$ + (0.2 bar)[1]

$p_0$ = .......................+......................................+ (0.2 bar)[1] = ............ bar

Reflex recommendation $p_0 \geq 1.0$ bar

**$p_0$ = .......... bar**

**Safety valve actuation pressure** $p_{SV}$ → Reflex recommendation

$p_{SV} \geq$ input pressure $p_0$ + 1.5 bar for $p_{SV} \leq 5$ bar

$p_{SV} \geq$ input pressure $p_0$ + 2.0 bar for $p_{SV} > 5$ bar

$p_{SV} \geq$ .......................+.......................................................... = ............ bar

**$p_{SV}$ = .......... bar**

**Final pressure** $p_f \leq$ safety valve $p_{SV}$ - closing pressure difference acc. to TRD 721

$p_f \leq p_{SV}$ - 0.5 bar for $p_{SV} \leq 5$ bar

$p_f \leq p_{SV}$ - 0.1 x $p_{SV}$ for $p_{SV} > 5$ bar

$p_f \leq$ ................................ - ............................................... = ............ bar

**$p_f$ = .......... bar**

[1] Recommendation

▶ Check rec. supply pressure of circulation pump as per manufacturer specifications

▶ Check compliance with perm. operating pressure

### Vessel

**Expansion volume** $V_e = \frac{n}{100} \times V_s$ = ...................... x ............................ = .......... liters

**$V_e$ = ......... liters**

**Water seal** $V_{WS} = 0.005 \times V_s$ for $V_n$ > 15 liters with $V_{WS} \geq 3$ liters

$V_{WS} \geq 0.2 \times V_n$ for $V_n \leq 15$ liters

$V_{WS} \geq$ ..........x .... = ...................... x ............................ = .......... liters

**$V_{WS}$ = ......... liters**

**Nominal volume**

Without 'servitec' $V_n = (V_e + V_{WS}) \times \frac{p_f + 1}{p_f - p_0}$

With 'servitec' $V_n = (V_e + V_{WS} + 5 \text{ liters}) \times \frac{p_f + 1}{p_f - p_0}$

$V_n \geq$ ............................ x .......................................... = .......... liters

Selected $V_n$ 'reflex' = .......... liters

**$V_n$ = ......... liters**

**Initial pressure check**

Without 'servitec' $p_i = \frac{p_f + 1}{1 + \frac{V_e (p_f + 1)(n + n_R)}{V_n (p_0 + 1)\, 2n}} - 1 \text{ bar}$

With 'servitec' $p_i = \frac{p_f + 1}{1 + \frac{(V_e + 5 \text{ liters})(p_f + 1)(n + n_R)}{V_n (p_0 + 1)\, 2n}} - 1 \text{ bar}$

$p_i = \frac{\text{..............................}}{1 + \frac{\text{..........................}}{\text{..........................}}} - 1 \text{ bar}$ = ............ bar

Condition: $p_i \geq p_0 + 0.25...0.3$ bar, otherwise calculation for greater nominal volume

**$p_i$ = .......... bar**

▶ Filling pressure = Initial pressure at 10°C filling temperature

### Result summary

| | |
|---|---|
| 'reflex ...' / ... bar ........... liters | Input pressure $p_0$ = ......... bar → check before commissioning |
| 'refix ...' / ... bar ........... liters | Initial pressure $p_i$ = ......... bar → check make-up configuration |
| 'refix' only for oxygen-rich water (e.g. floor heating) | Final pressure $p_f$ = ......... bar |

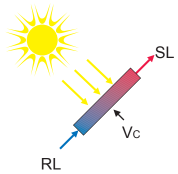
## Solar heating plants (solar energy systems)

**Calculation**

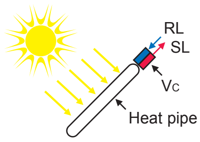
On the basis of VDI 6002 and DIN 4807 T2

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.

**Direct** heating in a flat collector or direct-flow tube collector




**Indirect** heating in a tube collector according to the heat pipe principle




▶ Note manufacturer specifications for stagnation temperatures!

**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 antifreeze effect of the heat transfer medium in the long term.

Nominal volume without evaporation

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

**Nominal volume**

**Calculation with evaporation in the collector**

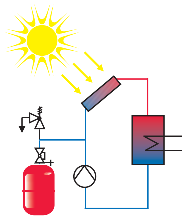
For collectors with stagnation temperatures in excess of 200°C, evaporation in the collector cannot be excluded. In this case, the evaporation pressure is only included in the calculation up to the desired evaporation point (110 - 120°C). When calculating the nominal volume of the expansion vessel, the entire collector volume $V_C$ is included in addition to the expansion volume Ve 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 with evaporation

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

**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.


'reflex S'

**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 in accordance with manufacturer specifications.
→ 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.

**With evaporation**
$p_e^* = 0$
$n^* = f$ (boiling temp.)

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

**Without evaporation**
$p_e^* = f$ (stagnation temp.)
$n^* = f$ (stagnation temp.)

**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 $\Delta pP$ must be taken into account since the expansion vessel is integrated on the pressure side of the circulating pump (follow-up pressure maintenance).

**Without evaporation**
$p_0 = p_{st} + p_e^*(\text{stagnation}) + \Delta p_P$

**With evaporation**
$p_0 = p_{st} + p_e^*(\text{boiling}) + \Delta p_P$

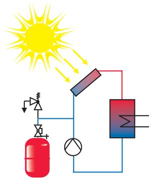
- Enter set input pressure on name plate

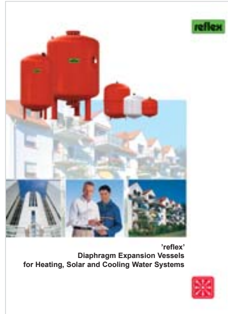
**Filling pressure $p_{fil}$**
**Initial pressure $p_a$**
As a rule, the filling temperature (10°C) is much higher than the lowest system temperature, such that the filling pressure is greater than the initial pressure.

**Pressure maintenance**
Generally in the form of static pressure maintenance with 'reflex S', also in combination with 'magcontrol' make-up stations.

**In-line vessels**
If a stable return temperature ≤ 70°C cannot be guaranteed on the consumer side, an in-line vessel must be fitted to the expansion vessel. → p. 39

### 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, expansion vessel in return to collector.

**Object:**

#### Initial data

| | | | | |
|---|---|---|---|---|
| Number of collectors | z | .......... units | | |
| Collector surface area | $A_C$ | .......... m² | $A_{Ctot} = z \times A_C$   $A_{Ctot}$ = .......... m² | $A_{Ctot}$ = ......... bar |
| Water content per collector | $V_C$ | ......... liters | $V_{Ctot} = z \times A_C$   $V_{Ctot}$ = .......... liters | $V_{Ctot}$ = ......... liters |
| Highest flow temperature<br>Lowest ambient temperature<br>Antifreeze additive | $t_F$<br>$t_a$ | 110°C or 120°C<br>- 20°C<br>.......... % | → p. 6 Percentage expansion n* and evaporation pressure $p_e$* | n* = .......... %<br>$p_e$* = .......... bar |
| Static pressure | $p_{st}$ | .......... bar | | $p_{st}$ = .......... bar |
| Difference at circulating pump | $\Delta p_P$ | .......... bar | | $\Delta p_P$ = .......... bar |

▶ Check compliance with minimum supply pressure $p_{sup}$ for circulating pumps acc. to manufacturer specifications.
$p_{sup} = p_0 - \Delta p_P$

#### Pressure calculation

| | | | |
|---|---|---|---|
| **Input pressure** | $p_0$<br>$p_0$ | = stat. pressure $p_{st}$ + pump pressure $\Delta p_P$ + evaporation pressure $p_e$*<br>= .......................... + ............................. + ...................................<br>= .......... bar | $p_0$ = .......... bar |
| **Safety valve actuation pressure** | $p_{SV}$<br>$p_{SV}$<br>$p_{SV}$<br>$p_{SV}$ | → Reflex recommendation<br>≥ input pressure $p_0$ + 1.5 bar for $p_{SV}$ ≤ 5 bar<br>≥ input pressure $p_0$ + 2.0 bar for $p_{SV}$ > 5 bar<br>≥ ................. + .......................................... = .......... bar | $p_{SV}$ = .......... bar |
| **Final pressure** | $p_f$<br>$p_f$<br>$p_f$<br>$p_f$ | ≤ safety valve $p_{SV}$ – Closing pressure difference acc. to TRD 721<br>≤ $p_{SV}$ – 0.5 bar for $p_{SV}$ ≤ 5 bar<br>≤ $p_{SV}$ – 0.1 bar x $p_{SV}$ > 5 bar<br>≤ ............................. – ................................ = .......... bar | $p_f$ = .......... bar |

▶ Check compliance with perm. operating pressure

#### Vessel

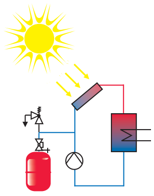
| | | | |
|---|---|---|---|
| **System volume** | $V_s$<br>$V_s$ | = collector vol. $V_{Ctot}$ + pipelines + buffer tank + other<br>= ........................... + ............. + ............... + ...............<br>= .......... liters | $V_s$ = ......... liters |
| **Expansion volume** | $V_e$ | $= \frac{n^*}{100} \times V_s$ = ..................... + ................. = .......... liters | $V_e$ = ......... liters |
| **Water seal** | $V_{WS}$<br>$V_{WS}$<br>$V_{WS}$ | = 0.005 x $V_s$ for $V_n$ > 15 liters with $V_{WS}$ ≥ 3 liters<br>≥ 0.2 x $V_n$ for $V_n$ ≤ 15 liters<br>≥ .......... x .... = .......... x ................. = .......... liters | $V_{WS}$ = ......... liters |
| **Nominal volume** | $V_n$<br>$V_n$ | $= (V_e + V_{WS} + V_{Ctot}) \times \frac{p_f + 1}{p_f - p_0}$<br>≥ ............................ x ................................ = .......... liters<br>Selected $V_n$ 'reflex S' = .......... liters | $V_n$ = ......... liters |
| **Check of initial pressure** | $p_i$<br>$p_i$ | $= \frac{p_f + 1}{1 + \frac{(V_e + V_{Ctot})(p_f + 1)}{V_n (p_0 + 1)}} - 1\ \text{bar}$<br>$= \frac{\text{..............................}}{1 + \frac{\text{..........................}}{\text{..........................}}} - 1\ \text{bar}$ = .......... bar | $p_i$ = .......... bar |
| Condition: | $p_i$ | ≥ $p_0$ + 0.25...0.3 bar, otherwise calculation for greater nominal volume | |
| **Percentage expansion** | | Between lowest temperature (- 20°C) and filling temperature (usually 10°C)<br>→ p. 6 $n^*_F$ = .......... % | $n^*_F$ = .......... % |
| **Filling pressure** | | $p_{fil} = V_n \times \frac{p_0 + 1}{V_n - V_s \times n_F^* - V_{WS}} - 1\ \text{bar}$<br>$p_{fil}$ = ............................ x .................... – 1 bar = .......... liters | $p_{fil}$ = .......... bar |

#### Result summary

'reflex S'/10 bar .......... liters

Input pressure $p_0$ = ......... bar → check before commissioning
Initial pressure $p_i$ = ......... bar → check make-up configuration
Filling pressure $p_{fil}$ = ......... bar → refilling of system
Final pressure $p_f$ = ......... bar

## 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 ≤ 150°C.

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

**Object:**


### Initial data

| | | | | | |
|---|---|---|---|---|---|
| Number of collectors | z | .......... units | | | |
| Collector surface area | $A_C$ | .......... m² | $A_{Ctot} = z \times A_C$ | $A_{Ctot}$ = .......... m² | **$A_{Ctot}$ = ......... bar** |
| Water content per collector | $V_C$ | ......... liters | $V_{Ctot} = z \times A_C$ | $V_{Ctot}$ = .......... liters | **$V_{Ctot}$ = ......... liters** |
| Highest advance temperature | $t_F$ | | → p. 6 Percentage expansion n* and evaporation pressure $p_e$* | | **n* = .......... %** |
| Lowest ambient temperature | $t_a$ | - 20°C | | | **$p_e$* = .......... bar** |
| Antifreeze additive | | .......... % | | | |
| Static pressure | $p_{st}$ | .......... bar | | | **$p_{st}$ = .......... bar** |
| Difference at circulating pump | $\Delta p_P$ | .......... bar | | | **$\Delta p_P$ = .......... bar** |

▸ Check compliance with minimum supply pressure $p_{sup}$ for circulating pumps acc. to manufacturer specifications. $p_{sup} = p_0 - \Delta p_P$

▸ Check compliance with perm. operating pressure

### Pressure calculation

**Input pressure**
$p_0$ = stat. pressure $p_{st}$ + pump pressure $\Delta p_P$ + evaporation pressure $p_e$*
$p_0$ = .......................... + ............................ + ..................................
= .......... bar
**$p_0$ = .......... bar**

**Safety valve actuation pressure**
$p_{SV}$ → Reflex recommendation
$p_{SV}$ ≥ input pressure $p_0$ + 1.5 bar for $p_{SV} \leq 5$ bar
$p_{SV}$ ≥ input pressure $p_0$ + 2.0 bar for $p_{SV} > 5$ bar
$p_{SV}$ ≥ ................. + ................................................ = .......... bar
**$p_{SV}$ = .......... bar**

**Final pressure**
$p_f$ ≤ safety valve $p_{SV}$ – Closing pressure difference acc. to TRD 721
$p_f$ ≤ $p_{SV}$ – 0.5 bar for $p_{SV} \leq 5$ bar
$p_f$ ≤ $p_{SV}$ – 0.1 bar x $p_{SV} > 5$ bar
$p_f$ ≤ ............................. – ................................ = .......... bar
**$p_f$ = .......... bar**



### Vessel

**System volume**
$V_s$ = collector vol. $V_{Ctot}$ + pipelines + buffer tank + other
$V_s$ = .......................... + ............ + ................. + ...............
= .......... liters
**$V_s$ = ......... liters**

**Expansion volume**
$$V_e = \frac{n^*}{100} \times V_s$$
= ..................... + ................. = .......... liters
**$V_e$ = ......... liters**

**Water seal**
$V_{WS} = 0.005 \times V_s$ for $V_n > 15$ liters with $V_{WS} \geq 3$ liters
$V_{WS} \geq 0.2 \times V_n$ for $V_n \leq 15$ liters
$V_{WS}$ ≥ .......... x .... = .......... x ................. = .......... liters
**$V_{WS}$ = ......... liters**

**Nominal volume**
$$V_n = (V_e + V_{WS}) \times \frac{p_f + 1}{p_f - p_0}$$
$V_n$ ≥ ............................ x ................................ = .......... liters
Selected $V_n$ 'reflex S' = .......... liters
**$V_n$ = ......... liters**

**Check of initial pressure**
$$p_i = \frac{p_f + 1}{1 + \frac{V_e\,(p_f + 1)}{V_n\,(p_0 + 1)}} - 1 \text{ bar}$$
$$p_i = \frac{\text{..............................}}{1 + \frac{\text{..........................}}{\text{..........................}}} - 1 \text{ bar} = \text{.......... bar}$$
**$p_i$ = .......... bar**

Condition: $p_i \geq p_0$ + 0.25...0.3 bar, otherwise calculation for greater nominal volume

**Percentage expansion** Between lowest temperature (- 20°C) and filling temperature (usually 10°C)
→ p. 6 $n^*_F$ = .......... %
**$n^*_F$ = .......... %**

**Filling pressure**
$$p_{fil} = V_n \times \frac{p_0 + 1}{V_n - V_s \times n_F^* - V_{WS}} - 1 \text{ bar}$$
$p_{fil}$ = ............................ x .................... – 1 bar = .......... liters
**$p_{fil}$ = .......... bar**

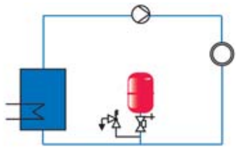
### Result summary

'reflex S'/10 bar .......... liters

Input pressure $p_0$ = ......... bar → check before commissioning
Initial pressure $p_i$ = ......... bar → check make-up configuration
Filling pressure $p_{fil}$ = ......... bar → refilling of system
Final pressure $p_f$ = ......... bar

## Cooling water systems

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


'reflex'

**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 in accordance with manufacturer specifications.
For Antifrogen N → p. 6

**Expansion volume $V_e$** 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 $p_0$** Since no temperatures > 100°C are used, no special margins are required.

▶ Enter set input pressure on name plate

**Filling pressure $p_{fil}$ Initial pressure $p_i$** 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.

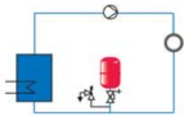
**Degassing, deaeration, water make-up** To ensure ongoing safe and automatic operation in cooling water systems, the pressurization units should be equipped with make-up systems and supplemented with 'servitec' degassing systems. This is particularly important with cooling water systems, since no thermal deaeration effects apply. More information can be found on page 28.

**In-line 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 a 'V in-line vessel' in the return to the refrigerating machine at temperatures ≤ 0°C. → page 39

**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, expansion vessel on suction side, circulating pump, observe information on page 9 for follow-up pressure maintenance.



**Object:**


### Initial data

Return temperature to refrigerating machine $t_R$ = .......... °C
Advance temperature to refrigerating machine $t_F$ = .......... °C
Lowest system temperature $t_{Smin}$ = ......... liters (e.g. winter downtime)
Highest system temperature $t_{Smax}$ = ......... liters (e.g. summer downtime)
Antifreeze additive = .......... %
Percentage expansion n* → . 6 n* = n* at highest temp. ($t_{Smax}$ or $t_R$) - n* at lowest temp. ($t_{Smin}$ or $t_F$) n* = ..................................... - ............................ = .......... °C — **n* = .......... %**
Percentage expansion between lowest temperature and filling temperature = .......... °C — **$n_F$* = .......... %**
Static pressure $p_{st}$ = .......... bar — **$p_{st}$ = .......... bar**

▶ If $_R$ > 70°C, 'V in-line vessel' required

### Pressure calculation

**Input pressure** $p_0$ = static pressure $p_{st}$ + (0.2 bar)[1]
$p_0$ = ............................ + (0.2 bar)[1] = .......... bar — **$p_0$ = .......... bar**

**Safety valve actuation pressure**
$p_{SV}$ → Reflex recommendation
$p_{SV}$ ≥ input pressure $p_0$ + 1.5 bar for $p_{SV}$ ≤ 5 bar
$p_{SV}$ ≥ input pressure $p_0$ + 2.0 bar for $p_{SV}$ ≤ 5 bar
$p_{SV}$ ≥ ............................ + ................................ = .......... bar — **$p_{SV}$ = .......... bar**

**Final pressure** $p_f$ ≤ safety valve $p_{SV}$ – Closing pressure difference acc. to TRD 721
$p_f$ ≤ $p_{SV}$ – 0.5 bar for $p_{SV}$ ≤ 5 bar
$p_f$ ≤ $p_{SV}$ – 0.1 bar for $p_{SV}$ ≤ 5 bar
$p_f$ ≤ ............................ – ................................ = .......... bar — **$p_f$ = .......... bar**

[1] Recommendation

▶ Check rec. supply pressure of circulation pump as per manufacturer specifications

▶ Check compliance with perm. operating pressure

### Vessel

**System volume** $V_s$
Refrigerating machines: .............. liters
Cooling registers : .................. liters
Buffer tanks : .................. liters
Pipelines : .................. liters
Other : .................. liters
System volume $V_s$ : .................. liters — **$V_s$ = ......... liters**

**Expansion volume** $V_e = \frac{n^*}{100} \times V_s$ = ................................ = .......... liters — **$V_e$ = ......... liters**

**Water seal** $V_{WS} = 0.005 \times V_s$ for $V_n$ > 15 liters with $V_{WS}$ ≥ 3 liters
$V_{WS} \geq 0.2 \times V_n$ for $V_n$ ≤ 15 liters
$V_{WS}$ ≥ ......... x ................ = ................................ = .......... liters — **$V_{WS}$ = ......... liters**

**Nominal volume**
Without 'servitec' $V_n = (V_e + V_{WS}) \times \frac{p_f + 1}{p_f - p_0}$
With 'servitec' $V_n = (V_e + V_{WS} + 5 \text{ liters}) \times \frac{p_f + 1}{p_f - p_0}$
$V_n$ ≥ ............................ x ................................ = .......... liters
Selected $V_n$ 'reflex' = .......... liters — **$V_n$ = ......... liters**

**Initial pressure check**
Without 'servitec' $p_i = \frac{p_f + 1}{1 + \frac{V_e (p_f + 1)}{V_n (p_0 + 1)}} - 1 \text{ bar}$

$p_i = \frac{p_f + 1}{1 + \frac{(V_e + 5 \text{ liters}) (p_f + 1)}{V_n (p_0 + 1)}} - 1 \text{ bar}$

$p_i$ = ......................... / (1 + ......................... / .........................) – 1 bar = .......... bar

$p_i = p_0$ + 0.25...0.3 bar, otherwise calculation for greater nominal volume — **$p_i$ = .......... bar**

**Filling pressure**
$p_{fil} = V_n \times \frac{p_0 + 1}{V_n - V_s \times n_F^* - V_{WS}} - 1 \text{ bar}$
$p_{fil}$ = ............................ x .................... – 1 bar = .......... liters — **$p_{fil}$ = .......... bar**

### Result summary

'reflex' ..... / ..... bar .......... liters

Input pressure $p_0$ = ......... bar → check before commissioning
Initial pressure $p_i$ = ......... bar → check make-up configuration
Filling pressure $p_{fil}$ = ......... bar → refilling of system
Final pressure $p_f$ = ......... bar

## Reflex pressurization systems with external pressure generation
## Types: 'variomat', 'gigamat', 'minimat', 'reflexomat'

**Application**

In principle, the same applies as for the selection and calculation of Reflex diaphragm expansion vessels.


→ Heating systems page 10
→ Solar energy systems page 12
→ Cooling water systems page 16


However, such systems generally cover higher output ranges. → page 8


**Nominal volume $V_n$**

The main feature of pressurization 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 Vn 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.

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

**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.

Suction pressure maintenance

$p_0 \geq p_{st} + p_e + 0.2$ bar

Final pressure maintenance

$p_0 \geq p_{st} + p_e + \Delta p_P$

**Initial pressure $p_a$**

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 being 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.

$p_i \geq p_0 + 0.3$ bar

$p_f \geq p_i + A_p$

**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. in accordance with TRD 721. The overflow or discharge mechanism must open, at the very latest, when the final pressure is exceeded.

Condition: $p_f \leq p_{SV} - A_{SV}$

Closing pressure difference acc. to TRD 721 $A_{SV}$

| | |
|---|---|
| SV-H | 0.5 bar |
| SV-D/G/H | 0.1 $p_{SV}$<br>0.3 bar for<br>$p_{SV}$ < 3 bar |

**Working range $A_p$ 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.

| | $A_p = p_f - p_i$ |
|---|---|
| 'variomat' | ≥ 0.4 bar |
| 'gigamat' | ≥ 0.4 bar |
| 'reflexomat' | ≥ 0.2 bar |

**Degassing Deaeration**

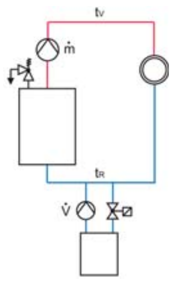
Targeted venting is very important, particularly in the case of closed systems; otherwise, accumulations of nitrogen in particular can lead to troublesome malfunctions and customer dissatisfaction. reflex 'variomat' systems are pre-equipped with integrated make-up and degassing functions, while reflex 'gigamat' and reflex 'reflexomat' pressurization systems are ideally supplemented with reflex 'servitec' make-up and degassing stations.

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

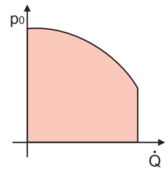
→ p. 28

**Compensating volume flow V̇**

In the case of heating systems that are equipped with pressurization 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 $\dot{Q}$ 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 $\dot{Q}$.




**Redundancy due to partial load behavior**

To improve partial load behavior for pump-controlled systems in particular, we recommend that 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 recommendation:
Configuration
50% + 50% = 100%
as of 2 MW dual-pump systems
→ 'variomat 2-2'



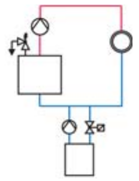
'variomat' ≤ 8 MW
pump-controlled

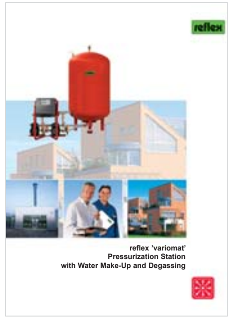
'gigamat' ≤ 60 MW
pump-controlled

'minimat' ≤ 2 MW
compressor-controlled

'reflexomat' ≤ 24 MW
compressor-controlled

### reflex 'variomat' in heating and cooling systems






**Configuration** Input pressure maintenance, 'variomat' in return, circulating pump in advance, observe information on page 9 for follow-up pressure maintenance

**Object:**

### Initial data

| | | | 1 | 2 | 3 | 4 | | |
|---|---|---|---|---|---|---|---|---|
| Heat generator | | | | | | | | |
| Heat output | $\dot{Q}_h$ | = .......... kW | | .......... kW | .......... kW | .......... kW | $\dot{Q}_{tot}$ | = .......... kW |
| Water content | $V_W$ | = .......... liters | | | | | | |
| System flow temperature | $t_F$ | = .......... °C | → p. 6 | Approximate water content $V_s = f(t_F, t_R, \dot{Q})$ | | | $V_s$ | = .......... liters |
| System return temperature | $t_R$ | = .......... °C | | | | | | |
| Water content known | $V_s$ | = .......... liters | | | | | | |
| Highest setpoint value adjustment Temperature regulator | $t_{TR}$ | = .......... °C | → p.. 6 | Percentage expansion n (with antifreeze additive n*) | | | n | = .......... % |
| Antifreeze additive | | = .......... % | | | | | | |
| Safety temperature limiter | $t_{STL}$ | = .......... °C | → p. 6 | Evaporation pressure $p_e$ at > 100°C (with antifreeze additive $p_e$*) | | | $p_e$ | = .......... bar |
| Static pressure | $p_{st}$ | = .......... bar | | | | | $p_{st}$ | = .......... bar |

▶ If $t_R$ > 70°C, 'V in-line vessel' required

▶ $t_{TR}$ max. 105°C

▶ If 110 < STL ≤ 120°C, contact our specialist department

### Pressure calculation

**Minimum operating pressure** $p_0$ = stat. pressure $p_{st}$ + evaporation pressure $p_e$ + (0.2 bar)[1]

$p_0$ = ..................... + ...................................... + (0.2 bar)[1] = ............ bar

Condition $p_0$ ≥ 1.3 bar

$p_0$ = .......... bar

**Final pressure** $p_f$ ≥ minimum operating pressure $p_0$ + 0.3 bar + working range 'reflexomat' $A_p$

$p_f$ ≥ .... ...................................... + 0.3 bar + 0.4 bar = ............ bar

$p_f$ = .......... bar

**Safety valve actuation pressure** $p_{SV}$ ≥ final pressure + closing pressure difference $A_{SV}$

$p_{SV}$ ≥ $p_f$ + 0.5 bar for $p_{SV}$ ≤ 5 bar

$p_{SV}$ ≥ $p_f$ + 0.1 x $p_{SV}$ for $p_{SV}$ > 5 bar

$p_{SV}$ ≥ ........................ + ....................................................... = ............ bar

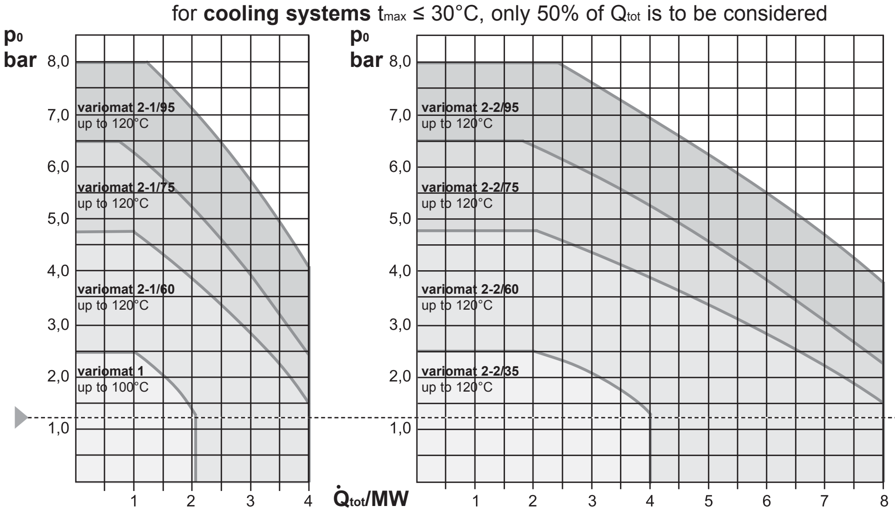
$p_{SV}$ = .......... bar

[1] The higher the value of $p_0$ over $p_{st}$, the better the degassing function; 0.2 bar is required as a minimum

▶ Check compliance with perm. operating pressure

### Control unit selection

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



Total heat output of heat generation system

'variomat 2-2' recommended for:
▶ Special requirements with regard to supply reliability
▶ Outputs ≥ 2 MW

▶ Automatic, load-specific activation and fault changeover of pumps and overflow units for 'variomat 2-2'

$p_0$ = 1.3 bar min. setting value for continuous degassing

| | 'variomat 1' | 'variomat 2-1' | 'variomat 2-2/35' | 'variomat 2-2/60-95' |
|---|---|---|---|---|
| $\dot{V}$ | 2 m³/h | 4 m³/h | 2 m³/h | 4 m³/h |

◀ Minimum volume flow $\dot{V}$ in system circuit at integration point of 'variomat'

### Vessel

**Nominal volume** $V_n$ taking water seal into account

$V_n = 1.1 \times V_s \frac{n + 0.5}{100}$ = 1.1 x .................... x ....................= ............ bar

$V_n$ = .......... liters

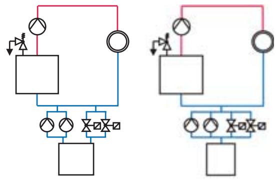
▶ The nominal volume can be distributed across multiple vessels.

### Result summary

| | | | |
|---|---|---|---|
| 'variomat' | .................. liters | Minimum operating pressure $p_0$ | .................. bar |
| VG basic vessel | .................. liters | Final pressure $p_f$ | .................. bar |
| VF secondary vessel | .................. liters | | |
| VW thermal insulation (for heating systems only) | .................. liters | | |

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

## reflex 'gigamat' in heating and cooling systems



**Configuration** Input pressure maintenance, 'gigamat' in return, circulating pump in advance, observe information on page 9 for follow-up pressure maintenance

**Object:**


### Initial data

| | | | | | |
|---|---|---|---|---|---|
| Heat generator | | 1 | 2 | 3 | 4 | |
| Heat output | $\dot{Q}_h$ = .......... kW | .......... kW | .......... kW | .......... kW | | $\dot{Q}_{tot}$ = .......... kW |
| Water content | $V_W$ = .......... liters | | | | | |
| System water content | $V_s$ = .......... °C | → p. 6 | Approximate water content $V_s = f(t_F, t_R, \dot{Q})$ | | | $V_s$ = .......... liters |
| Highest setpoint value adjustment<br>Temperature regulator<br>Antifreeze additive | $t_{TR}$ = .......... °C<br>= .......... % | → p. 6 | Percentage expansion n (with antifreeze additive n*) | | | n = .......... % |
| Safety temperature limiter | $t_{STL}$ = .......... °C | → p. 6 | Evaporation pressure $p_e$ at > 100°C with antifreeze additive $p_e$*) | | | $p_e$ = .......... bar |
| Static pressure | $p_{st}$ = .......... bar | | | | | $p_{st}$ = .......... bar |

▶ If $_R$ > 70°C, 'V in-line vessel' required

▶ $t_{TR}$ max. 105°C

▶ If 110 < STL ≤ 120°C, contact our specialist department

### Specific values

**Minimum operating pressure** $p_0$ = stat. pressure $p_{st}$ + evaporation pressure $p_e$ + (0.2 bar)[1]
$p_0$ = ......................+.....................................+ (0.2 bar)[1] = ............ bar
Condition $p_0$ ≥ 1.3 bar → $p_0$ = .......... bar

**Final pressure** $p_f$ ≥ minimum operating pressure $p_0$ + 0.3 bar + working range 'reflexomat' $A_p$
$p_f$ ≥ .... ................................ + 0.3 bar + 0.4 bar = ............ bar → $p_f$ = .......... bar

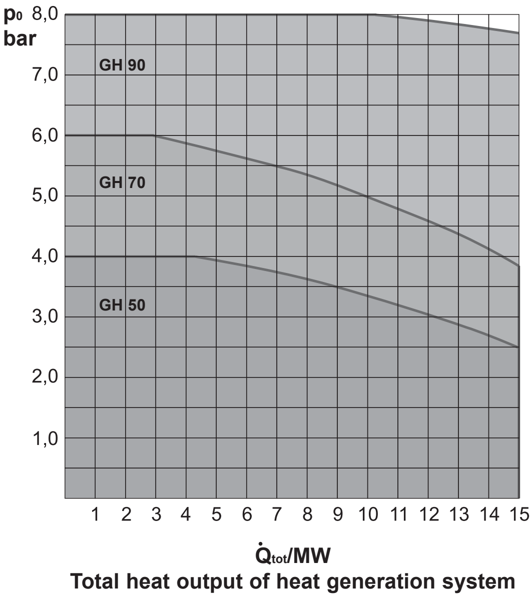
**Safety valve actuation pressure** $p_{SV}$ ≥ final pressure + closing pressure difference $A_{SV}$
$p_{SV}$ ≥ $p_f$ + 0.5 bar for $p_{SV}$ ≤ 5 bar
$p_{SV}$ ≥ $p_f$ + 0.1 x $p_{SV}$ for $p_{SV}$ > 5 bar
$p_{SV}$ ≥ ...................... +........................................................ = ............ bar → $p_{SV}$ = .......... bar

[1] Recommendation

▶ Check compliance with perm. operating pressure

### Control unit selection

Diagram valid for **heating systems STL ≤ 120°C**
for **cooling systems** $t_{max}$ ≤ 30°C, only 50% of $\dot{Q}_{tot}$ is to be considered




For systems outside the displayed output ranges, please contact us

✆ +49 2382 7069-536

### Vessel

**Nominal volume** $V_n$ taking water seal into account

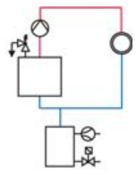
$V_n = 1.1 \times V_s \frac{n + 0.5}{100} = 1.1 \times$ .................... x ....................= ............ bar → $V_n$ = .......... liters

▶ The nominal volume can be distributed across multiple vessels.

### Result summary

| | | | |
|---|---|---|---|
| GH hydraulic unit | .................. | Minimum operating pressure $p_0$ | .......... bar |
| GG basic vessel | .................. liters | Final pressure $p_f$ | .................. bar |
| GF secondary vessel | .................. liters | | |

### reflex 'minimat' and 'reflexomat' in heating and cooling systems




**Configuration** Input pressure maintenance, 'minimat', 'reflexomat' in return, circulating pump in advance, observe information on page 9 for follow-up pressure maintenance

**Object:**

## Initial data

| | | | 1 | 2 | 3 | 4 | | |
|---|---|---|---|---|---|---|---|---|
| Heat generator | | | | | | | | |
| Heat output | $\dot{Q}_h$ | = .......... kW | | .......... kW | .......... kW | .......... kW | $\dot{Q}_{tot}$ = .......... kW | |
| Water content | $V_W$ | = .......... liters | | | | | | |

| | | | | | |
|---|---|---|---|---|---|
| System flow temperature | $t_F$ | = .......... °C | → p. 6 | Approximate water content $v_s = f(t_F, t_R, \dot{Q})$ | $V_s$ = .......... liters |
| System return temperature | $t_R$ | = .......... °C | | | |
| Water content known | $V_s$ | = .......... liters | | | |
| Highest setpoint value adjustment Temperature regulator | $t_{TR}$ | = .......... °C | → p. 6 | Percentage expansion n (with antifreeze additive n*) | n = .......... % |
| Antifreeze additive | | = .......... % | | | |
| Safety temperature limiter | $t_{STL}$ | = .......... °C | → p. 6 | Evaporation pressure $p_e$ at > 100°C with antifreeze additive $p_e$*) | $p_e$ = .......... bar |
| Static pressure | $p_{st}$ | = .......... bar | | | $p_{st}$ = .......... bar |

▶ If $t_R$ > 70°C, 'V in-line vessel' required

▶ $t_{TR}$ max. 105°C

▶ If 110 < STL ≤ 120°C, contact our specialist department

## Pressure calculation

**Minimum operating pressure** $p_0$ = stat. pressure $p_{st}$ + evaporation pressure $p_e$ + (0,2 bar)[1)]
$p_0$ = ..........................+.........................................+ (0.2 bar)[1)] = ........ bar
Recommendation $p_0 \geq 1.0$ bar
$p_0$ = .......... bar

**Final pressure** $p_f \geq$ minimum operating pressure $p_0$ + 0.3 bar + working range 'reflexomat' $A_p$
$p_f \geq$ .... ........................................ + 0.3 bar + 0.2 bar = ............. bar
$p_f$ = .......... bar

**Safety valve actuation pressure** $p_{SV} \geq$ final pressure + closing pressure difference $A_{SV}$
$p_{SV} \geq$ $p_f$ + 0.5 bar for $p_{SV} \leq 5$ bar
$p_{SV} \geq$ $p_f$ + 0.1 x $p_{SV}$ for $p_{SV} > 5$ bar
$p_{SV} \geq$ ......................+......................................................... = ............. bar
$p_{SV}$ = .......... bar

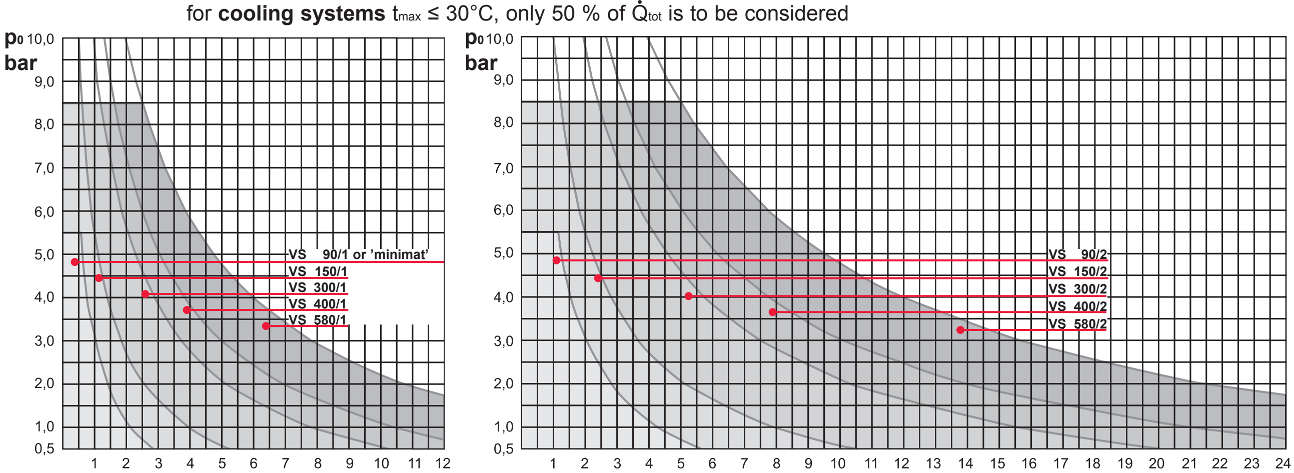
1) Recommendation

▶ Check compliance with perm. operating pressure



## Control unit selection

Diagram valid for **heating systems**
for **cooling systems** $t_{max} \leq 30$°C, only 50 % of $\dot{Q}_{tot}$ is to be considered




**$\dot{Q}_{tot}$/MW**
**Total heat output of heat generation system**

▶ Automatic, load-specific activation and fault changeover of compressors for VS .../2 control units

## Vessel

**Nominal volume** $V_n$ taking water seal into account

$V_n = 1.1 \times V_s \frac{n + 0.5}{100}$ = 1.1 x .................... x ....................= ............. bar

$V_n$ = .......... liters

▶ The nominal volume can be distributed across multiple vessels.

## Result summary

| | | | |
|---|---|---|---|
| 'reflexomat' with | | Minimum operating pressure $p_0$ .......... bar | |
| Control unit VS | ............/..... | Final pressure $p_f$ | .................. bar |
| RG basic vessel | .................. liters | | |
| or | | | |
| 'minimat' MG | .................. liters | | |

## 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.

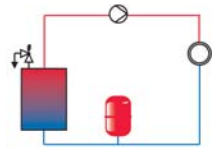
Contact us for more information!

▶ Special pressure maintenance
+49 2382 7069-536

**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.

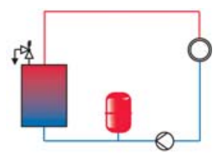
**Input pressure maintenance**



**Properties n, $p_e$**

As a rule, properties for pure water without antifreeze additive are used.

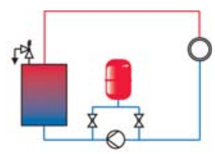
**Follow-up pressure maintenance**



**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.

**Medium pressure maintenance**



'reflex'
'variomat'
'gigamat'
'reflexomat'
special stations

**Minimum operating pressure $p_0$**

The minimum operating pressure must be adapted to the safety temperature of the heat exchanger 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 $p_a$**

In the case of pressurization 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 $p_0$ (= $PL_{min}$) should then be at least 0.5 ... 1 bar.

**Pressure maintenance**

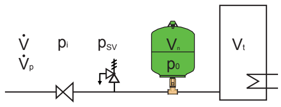
In the case of larger networks, almost exclusively in the form of pressure maintenance with external pressure generation, e.g. 'variomat', 'gigamat', 'minimat' or 'reflexomat'. With operating temperatures over 105°C or safety temperatures STL > 110°C, the special requirements of DIN EN 12952, DIN EN 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.

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.

## Hot water systems




**Calculation** According to DIN 4807 T5 → see 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 'DT5', 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. 1,000 l water heater |
| Rp 1¼ | max. 5,000 l water heater |

'refix DT5' flow fitting Rp 1¼:
max. 5,000 l water heater

**Properties n, $p_e$** 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.

▶ Enter set input pressure on name plate

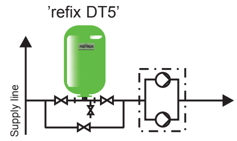


**Initial pressure $p_a$** The initial pressure is identical to the set pressure of the pressure reducing valve. Pressure reducing valves are required in accordance with DIN 4807 T5 to ensure a stable initial pressure and thus achieve the full capacity of the 'refix' unit.

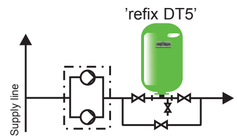
**Expansion vessel** In potable water systems according to DIN 1988, only water-carrying 'refix' vessels meeting the specifications of DIN 4807 T5 must be used. In the case of non-potable water systems, 'refix' units with a single connection are sufficient.

## Pressure booster systems

**Calculation** According to DIN 1988 T5: Technical rules for drinking water installations, pressure increase and reduction
→ see form on p. 26

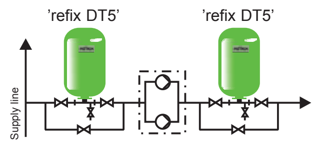



**Configuration** **On the input pressure side of a PBS,** 'refix' expansion vessels relieve the connection line and the supply network. The use of these units must be agreed with the relevant water utility company.




**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 $p_0$**
**Initial pressure $p_a$**
The minimum operating pressure or input pressure $p_0$ in the 'refix' vessel must be set approx. 0.5 ... 1 bar below the minimum supply pressure on the suction side and 0.5 ... 1 bar below the switch-on pressure on the pressure side of a PBS.

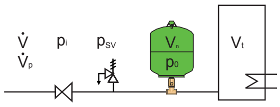
Since the initial pressure pi is at least 0.5 bar higher than the input pressure, a sufficient water seal is always ensured; this is an important prerequisite for low-wear operation.

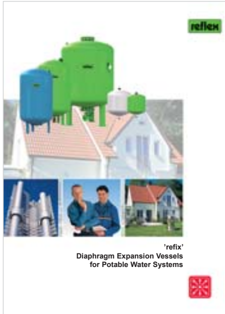
▶ Enter set input pressure on name plate

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 hot water systems

**Object:**




### Initial data

| | | | | |
|---|---|---|---|---|
| Tank volume | $V_t$ | = .......... liters | | |
| Heating output | $\dot{Q}$ | = .......... kW | | |
| Water temperature in tank | $t_{WW}$ | = .......... °C | As per controller setting 50...60°C → p. 6 Percentage expansion n | n = .......... % |
| Set pressure of pressure reducing valve | $p_i$ | = .......... bar | | |
| Safety valve setting | $p_{SV}$ | = .......... bar | Reflex recommendation: $p_{SV}$ = 10 bar | |
| Peak flow | $\dot{V}_p$ | = .......... m³/h | | |

### Selection according to nominal volume $V_n$

**Input pressure** $p_0$ = set pressure of pressure reducing valve $p_i$ – (0.2...1.0 bar)

$p_0$ = ................................................. – .............. = ............ bar

$p_0$ = .......... bar

**Nominal volume** $V_n = V_t \dfrac{n \times (p_{SV} + 0.5)(p_0 + 1.2)}{100 \times (p_0 + 1)(p_{SV} - p_0 - 0.7)}$

$V_n$ = ................................................. – .............. = ............ liters

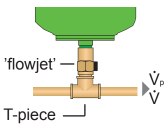
Selection according to brochure = ............ liters

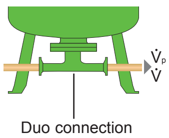
$V_n$ = .......... liters

▶ Set input pressure 0.2...1 bar below pressure reducing valve (depending on distance between pressure reducing valve and 'refix')

### Selection according to peak volume flow $\dot{V}_p$

When the nominal volume of the 'refix' unit has been selected, it must be checked for water-carrying vessels whether the peak volume flow $\dot{V}_p$ resulting from the piping calculation according to DIN 1988 can be implemented on the 'refix' unit. If this is the case, the 8-33 liter vessel of the 'refix DD' unit may have to be replaced with a a 60 liter 'refix DT5' vessel to enable a higher flow rate. Alternatively, a 'refix DD' unit with an appropriately dimensioned T-piece may be used.




| | Recomm. max. peak flow $\dot{V}_p$* | Actual pressure loss with volume flow $\dot{V}$ |
|---|---|---|
| **'refix DD' 8 - 33 Liter**<br>With or without 'flowjet'<br>T-piece duct Rp ¾ = standard<br>T-piece Rp 1 (on-site) | <br><br>≤ 2.5 m³/h<br>≤ 4.2 m³/h | $\Delta p = 0.03\ \text{bar} \cdot \left(\frac{\dot{V}\ [m^3/h]}{2.5\ m^3/h}\right)^2$<br>negligible |
| **'refix DT5' 60 - 500 liters**<br>With 'flowjet' Rp 1¼ | ≤ 7.2 m³/h | $\Delta p = 0.04\ \text{bar} \cdot \left(\frac{\dot{V}\ [m^3/h]}{7.2\ m^3/h}\right)^2$ |
| **'refix DT5' 80 - 3000 liters**<br>Duo connection DN 50 | ≤ 15 m³/h | $\Delta p = 0.14\ \text{bar} \cdot \left(\frac{\dot{V}\ [m^3/h]}{15\ m^3/h}\right)^2$ |
| Duo connection DN 65 | ≤ 27 m³/h | $\Delta p = 0.11\ \text{bar} \cdot \left(\frac{\dot{V}\ [m^3/h]}{27\ m^3/h}\right)^2$ |
| Duo connection DN 80 | ≤ 36 m³/h | negligible |
| Duo connection DN 100 | ≤ 56 m³/h | |
| **'refix DE, DE junior'**<br>(non water-carrying) | Unlimited | $\Delta p = 0$ |

Δp = .......... bar

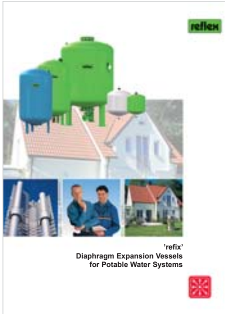
G = ..........

* calculated for a speed of 2 m/s



### Result summary

| | | | | | |
|---|---|---|---|---|---|
| 'refix DT5' | ........... | liters | Nominal volume | $V_n$ | ............ liters |
| | | | Input pressure | $p_0$ | ............ bar |
| 'refix DD' | ........... | liters, G = .......... (standard Rp ¾ included) | | | |
| 'refix DT5' | ........... | liters | | | |




### 'refix' in Pressure Booster Systems (PBS)

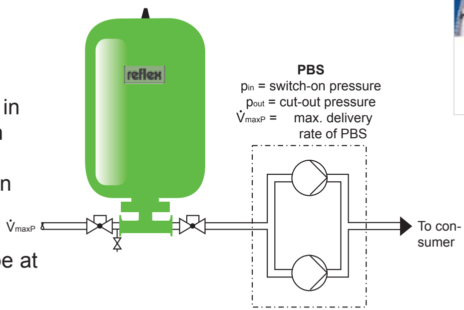
**Object:**

### Configuration 'refix' on input pressure side of PBS

**Installation:** As agreed with the relevant water utility company

**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 below 50% of the minimum value $p_{minS}$ and must be at least 1 bar




**Initial data:**

Min. supply pressure $p_{minS}$ = .......... bar

Max. delivery rate $\dot{V}_{maxP}$ = .......... m³/h

Selection acc. to DIN 1988 T5

| Max. delivery rate $\dot{V}_{maxP}$ / m³/h | 'refix DT5' with duo connection $V_n$ / liters | 'refix DT5' $V_n$ / liters |
|---|---|---|
| ≤ 7 | 300 | 300 |
| > 7 ≤ 15 | 500 | 600 |
| > 15 | --- | 800 |

**$V_n$ = .........liters**

Input pressure $p_0$ = min. supply pressure – 0.5 bar

$p_0$ = ..................................... – 0.5 bar = ........... bar

**$p_0$ = ......... bar**

### Configuration 'refix' on follow-up pressure side of PBS



- To restrict the switch frequency of pressure-controlled systems

Max. delivery head of PBS $H_{max}$ = .......... mWs

Max. supply pressure $p_{maxS}$ = .......... bar

Switch-on pressure $p_{in}$ = .......... bar

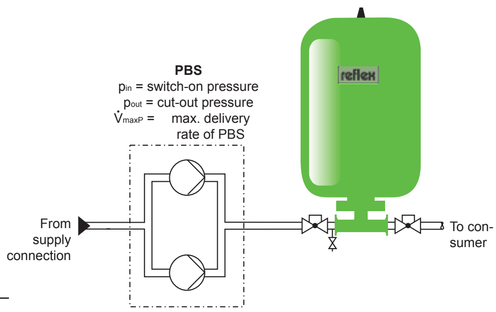
Cut-out pressure $p_{out}$ = .......... bar

Max. delivery rate $\dot{V}_{maxP}$ = .......... m³/h

Switch frequency s = .......... 1/h

Number of pumps n = ..........

Electrical power of most powerful pump $P_{el}$ = .......... kW




| s - switch frequency 1/h | | 20 | 15 | 10 |
|---|---|---|---|---|
| Pump output | kW | ≤ 4.0 | ≤ 7.5 | ≤ 7.5 |

Nominal volume $V_n = 0.33 \times \dot{V}_{maxP} \dfrac{p_{out} + 1}{(p_{out} - p_{in}) \times s \times n}$

$V_n$ = 0.33 x ......................... x ............................= ............ liters

**$V_n$ = .........liters**

- To store the minimum supply volume $V_e$ between activation and deactivation of the PBS

Switch-on pressure $p_{in}$ = .......... bar

Cut-out pressure $p_{out}$ = .......... bar

Input pressure 'refix' $p_0$ = .......... bar → Reflex recommendation: $p_0 = p_{in}$ - 0.5 bar

Storage capacity $V_e$ = .......... m³

**$p_0$ = ......... bar**

Nominal volume $V_n = V_e \dfrac{(p_{in} + 1)\ (p_{out} + 1)}{(p_0 + 1)\ (p_{out} - p_{in})}$

$V_n$ = .................................... x ............................= ............ liters

Selection according to brochure = ............ liters

**$V_n$ = .........liters**

Check of perm. excess operating pressure

$p_{max} \leq 1.1\ p_{per} \dfrac{H_{max}\ [mWs]}{10}$

$p_{max} = p_{maxS}$ + bar = ............................= ............ bar

**$p_{max}$ = .......... bar**

### Result summary

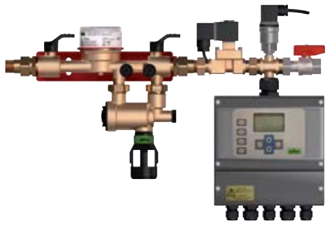
| | | | |
|---|---|---|---|
| 'refix DT5' ........... liters | 10 bar ☐ | Nominal volume $V_n$ | ............ liters |
| With duo connection DN 50 liters | 10 bar ☐ | Usable volume $V_0$ | ............ liters |
| 'refix DT5' ........... liters | 16 bar ☐ | Input pressure $p_0$ | ............ liters |

Make-up and degassing systems can automate system operation and make a significant contribution to operational reliability.

While ’variomat’ pressurization 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 ’gigamat’ pressurization stations.

reflex ’control’ 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, but 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/liter, which is 2.5 times higher than the natural concentration of potable water. → p. 29



reflex ’fillset’ reflex ’magcontrol’

## Water make-up systems

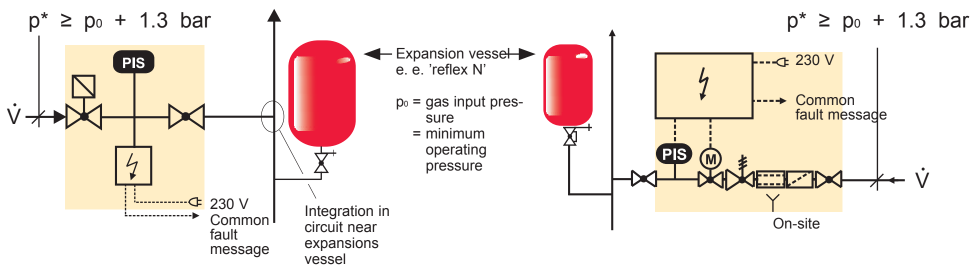
The system pressure is indicated on the display and monitored by the controller. If the pressure falls below the initial value $p < p0 + 0.3$ bar, controlled water make-up takes place. Faults are displayed and can be transferred via a signal contact. In the case of potable water make-up, a reflex ’magcontrol’ 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’.
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 on the basis of the $k_{vs}$ value.

reflex ’fillcontrol’

Make-up volume

$$\dot{V} \approx \sqrt{p^* - (p_0 + 0.3)} \times k_{vs}$$

Setting values
$p_0$ = ........... bar
$p_{sv}$ = ........... bar




’magcontrol’ diagram ’fillcontrol’ diagram

| | $k_{vs}$ |
|---|---|
| ’fillcontrol’ | 0.4 m³/h |
| ’magcontrol’ | 1.4 m³/h |
| ’magcontrol’ + ’fillset’ | 0.7 m³/h |

* p = overpressure immediately before make-up station in bar

**reflex ’control P’** ’control P’ 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.

’control P’ 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 ’control P’

# Make-up and degassing systems

## 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.

Gas-rich, cloudy sample

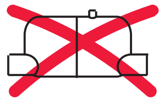
**'servitec' in 'magcontrol' mode** for 'reflex' and other expansion vessels

The pressure is indicated on the display and monitored by the controller (min/max fault message). If the pressure falls below the initial value ($p < p_0 + 0.3$ 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 minimize the amount of oxygen injected into the system.

Setting values
$p_0$ = .......... bar
$p_{SV}$ = .......... bar

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' pressurization stations and represents a cost-effective alternative particularly in the sub-500 kW output range.
→ 'reflex' calculation, page 9
→ 'servitec' as per table below



Traditional air separators are not required, thus saving installation and maintenance costs

**'servitec' in 'levelcontrol' mode** for 'reflexomat' and 'gigamat' pressurization stations

The functionality is similar to that of 'servitec' in 'magcontrol' mode, except that the water is made up on the basis of the water level in the expansion vessel of the pressurization 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 pressurization 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.

reflex 'servitec'

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 of the 'servitec' 60/gl system.

| Type | System volume $V_s$* | Make-up rate | Operating pressure |
|---|---|---|---|
| **For water up to 70°C** | | | |
| servitec 30 | up to 8 m³ | up to 0.05 m³/h | 0.5 to 3.0 bar |
| servitec 35 | up to 60 m³ | up to 0.35 m³/h | 1.3 to 2.5 bar |
| servitec 60 | up to 100 m³ | up to 0.55 m³/h | 1.3 to 4.5 bar |
| servitec 75 | up to 100 m³ | up to 0.55 m³/h | 1.3 to 5.4 bar |
| servitec 95 | up to 100 m³ | up to 0.55 m³/h | 1.3 to 7.2 bar |
| servitec 120 | up to 100 m³ | up to 0.55 m³/h | 1.3 to 9.0 bar |
| **For water/glycol mixtures up to 70°C** | | | |
| servitec 30 / gl | up to 2 m³ | up to 0.05 m³/h | 0.5 to 2.5 bar |
| servitec 60 / gl | up to 20 m³ | up to 0.55 m³/h | 1.3 to 4.5 bar |
| servitec 75 / gl | up to 20 m³ | up to 0.55 m³/h | 1.3 to 4.9 bar |
| servitec 95 / gl | up to 20 m³ | up to 0.55 m³/h | 1.3 to 6.7 bar |
| servitec 120 / gl | up to 20 m³ | up to 0.55 m³/h | 1.3 to 9.0 bar |

'servitec' units for higher system volumes and temperatures up to 90°C are available on request.

The operating pressure must be within the working range of the pressure maintenance = $p_i$ to $p_f$.

* $V_s$ = max. system volume with continuous degassing over 2 weeks

Make-Up and Degassing Stations
+49 2382 7069-567

## From our joint research with the technical university of Dresden

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.

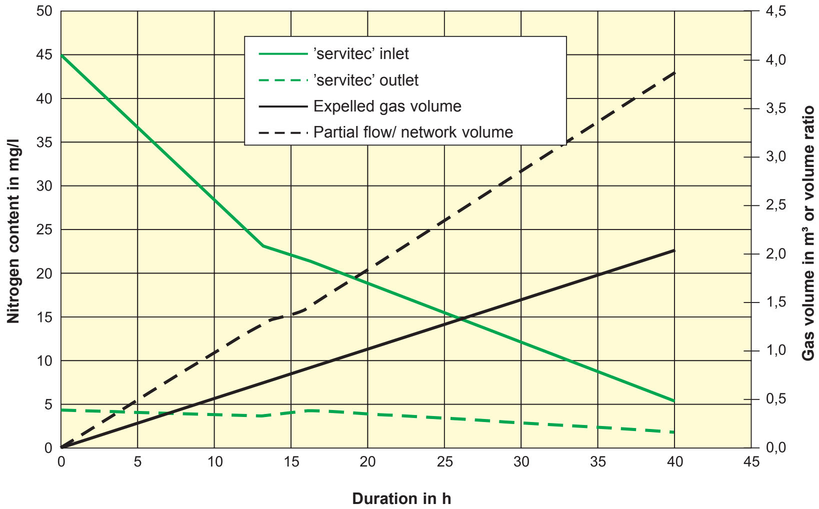
Figure 1:
’servitec’ test system in a heat transfer station of the Halle energy utility

| | | |
|---|---|---|
| Heat output | : | 14.8 MW |
| Water content | : | approx. 100 m³ |
| Return temperature | : | ≤ 70°C |
| Return pressure | : | approx. 6 bar |



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 $N_2$




Nitrogen-rich, cloudy sample

Clear, translucent sample

Both samples are virtually oxygen-free

- In 40 hours, ’servitec’ reduced the $N_2$ 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

reflex

## 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, Part 1, as well as the specifications of the relevant manufacturers.

**Necessity:**
VDI 2035, Part 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, Part 1, was revised in December 2005 to address this matter in a more focused manner and provide recommendations for damage prevention.

**Calcification:**
$Ca^{2+} + 2HCO_3^- \rightarrow CaCO^3 + CO_2 + H_2O$

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.

| Group | Total heating output | Total hardness [dGH] Based on spec. system volume $v_s$ (system volume/lowest individual heating output) | | |
|---|---|---|---|---|
| | | < 20 l/kW | ≥ 20 l/kW and < 50 l/kW | ≥ 50 l/kW |
| 1 | < 50 kW | ≤ 16.8 dGH for circulation heaters | ≤ 11.2 dGH | < 0.11 dGH |
| 2 | 50 - 200 kW | ≤ 11.2 dGH | ≤ 8.4 dGH | < 0.11 dGH |
| 3 | 200 - 600 kW | ≤ 8.4 dGH | ≤ 0.11 dGH | < 0.11 dGH |
| 4 | > 600 kW | < 0.11 dGH | < 0.11 dGH | < 0.11 dGH |

**Initial data**
Heat output
Output-specific system volume
Output-specific heat generator content

Circulating water heaters or devices with electric heating elements
$v_b < 0.3$ l/kW

**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 specific 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 utility or established on-site by means of a test (reflex 'total 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.

reflex 'GH total hardness testing kit' for independent measurement of local water hardness

## Softening processes

There 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.

**Decarbonization** With decarbonization, 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.

Decarbonization 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 (demineralized 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 demineralized water, a ph adjustment function must be implemented in the system.

**Hardness stabilization** Hardness stabilization 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 stabilizing 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.

▸ Soften your water with the reflex ’fillsoft’ cation exchanger

’fillsoft I’

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

Using the appropriate reflex ’fillsoft’ cation exchanger, fully or partially demineralized water can be produced to exact requirements.

**Filling and make-up water**

This term from VDI 2035, Part 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 value for the amount of soft water that a softening system can produce is the soft water capacity $K_w$ [l*dGH]. The filling and make-up water is not always to be fully demineralized, nor does it always have to be. Water that has not been completely freed of hardening minerals is also referred to as partially demineralized water.



| Type | Soft water capacity $K_w$ [l* dGH] | $k_{vs}$ [m³/h] | $\dot{V}_{max}$ [l/h] |
|---|---|---|---|
| ’fillsoft I’ | 6,000 | 0.4 | 300 |
| ’fillsoft II’ | 12,000 | 0.4 | 300 |

’fillsoft II’

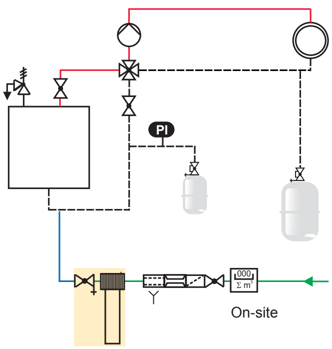



Diagram for ’fillsoft I’ +’fillset compact’

’FS softmix’

▸ reflex ’softmix’ produces partially demineralized water

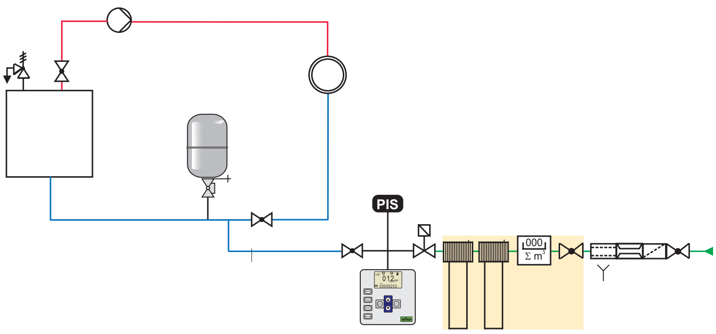



Diagram for
’magcontrol’ + ’fillsoft II’ + ’fillmeter’ + ’fillset compact’

’fillmeter’

▸ reflex ’fillmeter’ monitors the capacity of ’fillsoft’

## reflex 'fillsoft'


**Object:**

### Initial data

| | | 1 | 2 | 3 | 4 | |
|---|---|---|---|---|---|---|
| Heat generator | | | | | | |
| Heat output | $\dot{Q}_b$ | = .......... kW | .......... kW | .......... kW | .......... kW | **$\dot{Q}_{tot}$ = .......... kW** |
| Water content | $V_W$ | = .......... liters | .......... l | .......... l | .......... l | **$\dot{Q}_{min}$ = .......... kW** |
| Water content known | $V_s$ | = .......... liters → p. 6 | Approximate water content $v_s = f(t_F, t_R, \dot{Q}_{tot})$ | | | **$V_s$ = .......... liters** |

▶ $\dot{Q}_{min}$ = lowest value of $\dot{Q}_b$

### Specific values

| | | | |
|---|---|---|---|
| **Output-specific boiler water content** | $v_b$ | $= \frac{V_C}{\dot{Q}_b} = \frac{\quad}{\quad}$ = .......... l / kW | **$v_b$ = .......... l/kW** |
| **Output-specific system content** | $v_s$ | $= \frac{V_s}{\dot{Q}_{min}} = \frac{\quad}{\quad}$ = .......... l / kW | **$v_s$ = .......... l/kW** |

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

### Water hardness

| | | | | |
|---|---|---|---|---|
| Regional total water hardness | $GH_{act}$ | = .......... dGH | Information from water utility or self-measurement → p. 30 | **$GH_{act}$ = ......... dGH** |
| Target total water hardness | $GH_t$ | = .......... dGH | → table on p.30 or details from relevant manufacturer | **$GH_t$ = ..........dGH** |
| **Soft water capacity of:** | | | | **$K_W$ = ..........l*dGH** |
| 'fillsoft I' | $K_W$ | = 6,000 l * dGH | | |
| 'fillsoft II' | $K_W$ | = 12,000 l * dGH | | |
| 'fillsoft FP' | $K_W$ | = 6,000 l * dGH/unit | | |

▶ Water softening is required when $GH_{act} > GH_t$



### Possible filling and make-up water volumes

| | | | | |
|---|---|---|---|---|
| Possible filling water volume (mixed) | $V_F$ | $= \frac{K_W}{(GH_{act} - GH_t)} =$ <br> $= \frac{\quad}{\quad} = ...$ | For $GH_{act} > GH_t$ | **$V_F$ = .......... liters** |
| Possible make-up water volume | $V_m$ | $= \frac{K_W}{(GH_{act} - 0.11\ dGH)}$ <br> $= \frac{\quad}{\quad} = ...$ | For $GH_{act} > 0.11$ dGH | **$V_m$ = .......... liters** |
| No. of cartridges required to fill system | n | $= \frac{V_s\ (GH_{act} - GH_t)}{K_W} =$ <br> $= \frac{\quad}{\quad} = ...$ | | **n[1] = .......... liters** |
| Possible residual make-up volume after filling | $V_m$ | $= \frac{n * 6{,}000\ l\ dGH - (V_s * (GH_{act} - GH_t))}{(GH_{act} - 0.11\ dGH)}$ <br> $= \frac{\quad}{\quad} = ...$ | For $GH_{act} > 0.11$ dGH | **$V_m$ = .......... liters** |

▶ [1] Round cartridge no. n up to the nearest whole number

### Result summary

| | | | |
|---|---|---|---|
| 'fillsoft' ............................ | Type | System content $V_s$ ........... | liters |
| 'FP replacement cartridge' ................ | Quantity | Possible filling water volume (partially/fully demineralized)........... | liters |
| 'softmix' ............................ | ☐ Yes ☐ No | Possible residual make-up volume (fully demineralized)........... | liters |
| 'fillmeter' ............................ | ☐ Yes ☐ No | Possible residual make-up volume (partially demineralized)........... | liters |
| 'GH hardness testing kit' ...... | Quantity | | |

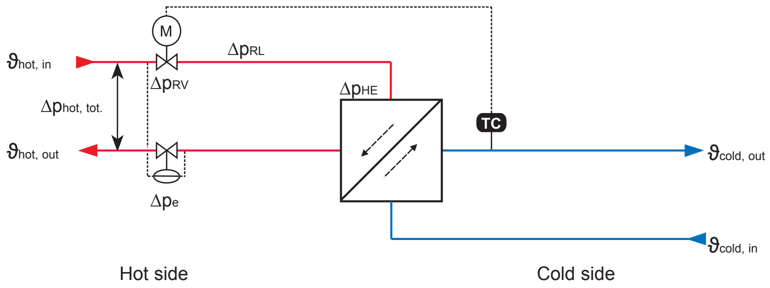
reflex

## Heat exchangers

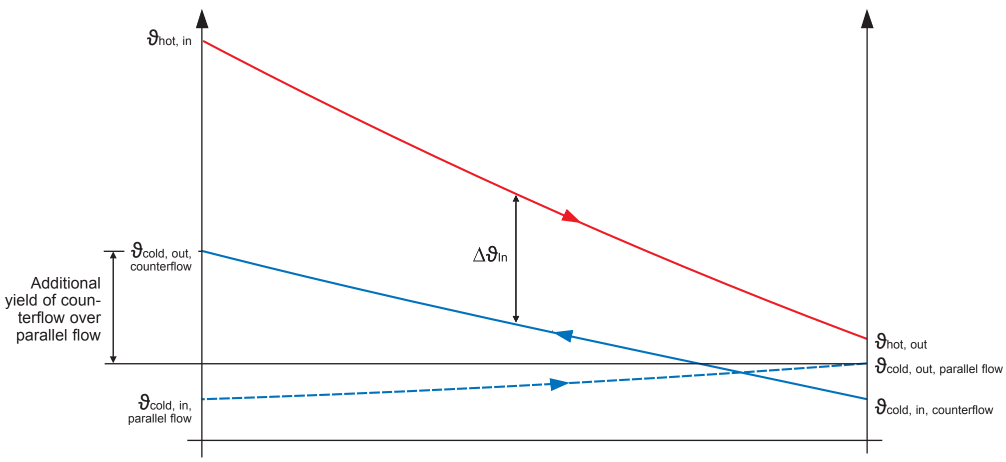
**Heat balances** The role of a heat exchanger is to transfer a specific heat quantity from the hot to the cold side. The transfer capacity is not only device-specific but also dependent on the required temperatures. As a result, we do not speak of ... kW heat exchangers, but rather that a device can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

**Applications**
- As a means of system separation for media that must not be mixed, e.g.
  - Heating and potable water
  - Heating and solar energy system water
  - Water and oil circuits
- To separate circuits with different operating parameters, e.g.
  - Excess operating pressure on side 1 exceeds permissible excess operating pressure on side 2
  - Water volume of side 1 is significantly higher than that of side 2
- To minimize interference between the two circuits

Example applications:
- Indirect district heating connections
- Floor heating
- Potable water heating
- Solar energy systems
- Machine cooling




**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.

**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.

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

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 linearized under the term “log mean temperature difference $\Delta\vartheta_{ln}$”.

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

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 is to be, 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 ≥ 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.

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



**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.

## Physical principles

**Heat balances**

Heat emission and absorption of heat transfer media

$$\dot{Q} = \dot{m} \times c \times (\vartheta_{IN} - \vartheta_{OUT})$$

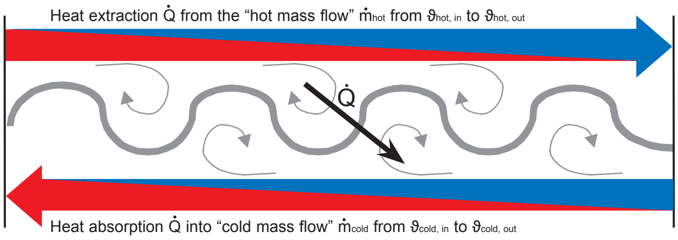
Based on the specified temperature spread and the circulated mass, the above formula can be used to calculate the capacity to be transferred.

Heat transport via heat exchanger plates

$$\dot{Q} = k \times A \times \Delta\vartheta_{ln}$$

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 $\Delta\vartheta_{ln}$ is a pure system variable resulting from the established 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.

Heat flows on heating surface A






**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**

Optimum configuration of reflex ’longtherm’ heat exchangers is ensured by our Reflex calculation program, which is supplied on our DVD or available for download at www.reflex.de. Your specialist advisor will also be happy to help you devise individual solutions.

Your specialist adviser
✆ → p. 55

## 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” on p.40 et seqq.
- 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.

$$\text{Valve authority} = \frac{\Delta p_{RV}\ (100\%\ \text{stroke})}{\Delta p_{hot,\ tot.}} \geq 30...40\ \%$$

(see also page 30)

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.

$$k_{VS} \geq k_V = \dot{V}_{hot} \sqrt{\frac{1\ \text{bar}}{\Delta p_{RV}}} = \frac{\dot{m}_{hot}}{\rho_{hot}} \sqrt{\frac{1\ \text{bar}}{\Delta p_{RV}}}$$

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.

▶ Regulating valve must not be oversized

**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 instable control behavior 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.

**Caution!**

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.

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 40-43 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. A key can be found on page 49.

## Safety valves (SV)

Safety valves protect heat (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.

▶ The Reflex product range does not include safety valves

**Hot water generators**

**DIN EN 12828**: 'All heat generators in a heating system must be protected by at least one safety valve in order to prevent the maximum operating pressure from being exceeded.'
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/(hkW).

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 of 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 in accordance with the Pressure Equipment Directive 97/23/EC (DRGL) and should be type 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 in accordance with 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**

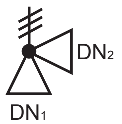
If the permissible excess operating pressure of expansion vessels is below the permissible operating pressure of the system, intrinsic safeguarding is required. The loading conditions must be calculated specifically. Suitable valves are H, D/G/H and safety valves according to the AD data sheet A2 (e.g. F). Although Reflex expansion vessels for pump-controlled pressurization systems are depressurized in normal operation, pressurization 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/(hkW) relative to the connected overall heat output.

**Safety valves on heat generators** according to DIN EN 12828, TRD 721***

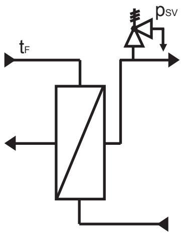
**Code letter H**, blow-off pressure $p_{SV}$ 2.5 and 3.0 bar

| Inlet connection [G] - outlet connection [G] | ½ - ¾ | ¾ - 1 | 1 - 1¼ | 1¼ - 1½ | 1½ - 2 | 2 - 2½ |
|---|---|---|---|---|---|---|
| **Blow-off rate for steam and water/kW** | ≤ 50 | ≤ 100 | ≤ 200 | ≤ 350 | ≤ 600 | ≤ 900 |

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




| DN1/DN2 | 20x32 | 25x40 | 32x50 | 40x65 | 50x80 | 65x100 | 80x125 | 100x150 | 125x200 | 150x250 | 20x32 | 25x40 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **pSV/bar** | Steam outflow ← | | | | | Blow-off rate/kW | | | | | → Water outflow | |
| **2.5** | 198 | 323 | 514 | 835 | 1291 | 2199 | 3342 | 5165 | 5861 | 9484 | 9200 | 15100 |
| **3.0** | 225 | 367 | 583 | 948 | 1466 | 2493 | 3793 | 5864 | 6654 | 10824 | 10200 | 16600 |
| **3.5** | 252 | 411 | 652 | 1061 | 1640 | 2790 | 4245 | 6662 | 7446 | 12112 | 11000 | 17900 |
| **4.0** | 276 | 451 | 717 | 1166 | 1803 | 3067 | 4667 | 7213 | 8185 | 13315 | 11800 | 19200 |
| **4.5** | 302 | 492 | 782 | 1272 | 1966 | 3344 | 5088 | 7865 | 8924 | 14518 | 12500 | 20200 |
| **5.0** | 326 | 533 | 847 | 1377 | 2129 | 3621 | 5510 | 8516 | 9663 | 15720 | 13200 | 21500 |
| **5.5** | 352 | 574 | 912 | 1482 | 2292 | 3898 | 5931 | 9168 | 10403 | 16923 | 13800 | 22500 |
| **6.0** | 375 | 612 | 972 | 1580 | 2443 | 4156 | 6322 | 9773 | 11089 | 18040 | 14400 | 23500 |
| **7.0** | 423 | 690 | 1097 | 1783 | 2757 | 4690 | 7135 | 11029 | 12514 | 20359 | 15800 | 25400 |
| **8.0** | 471 | 769 | 1222 | 1987 | 3071 | 5224 | 7948 | 12286 | 13941 | 22679 | 16700 | 27200 |
| **9.0** | 519 | 847 | 1346 | 2190 | 3385 | 5759 | 8761 | 13542 | 15366 | 24998 | 17700 | 28800 |
| **10.0** | 563 | 920 | 1462 | 2378 | 3676 | 6253 | 9514 | 14705 | 16686 | 27146 | 18600 | 30400 |




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

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

| $p_{SV}$ / bar | 2.5 | 3.0 | 3.5 | 4.0 | 4.5 | 5.0 | 5.5 | 6.0 | 7.0 | 8.0 | 9.0 | 10.0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $t_V$ / °C | ≤ 138 | ≤ 143 | ≤ 147 | ≤ 151 | ≤ 155 | ≤ 158 | ≤ 161 | ≤ 164 | ≤ 170 | ≤ 175 | ≤ 179 | ≤ 184 |



**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*

| Inlet connection G | Tank volume liters | Max. heating capacity kW |
|---|---|---|
| ½ | ≤ 200 | 75 |
| ¾ | > 200 ≤ 1000 | 150 |
| 1 | > 1000 ≤ 5000 | 250 |
| 1¼ | > 5000 | 30000 |

**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)

| Inlet port | DN | 15 | 20 | 25 | 32 | 40 |
|---|---|---|---|---|---|---|
| **Collector inlet surface** | **m²** | ≤ 50 | ≤ 100 | ≤ 200 | ≤ 350 | ≤ 600 |

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

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

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

| Inlet connection | ½ | ¾ | 1 | 1¼ | 1½ | 2 |
|---|---|---|---|---|---|---|
| **$p_{SV}$ / bar** | **Blow-off rate / m³/h** | | | | | |
| **4.0** | 2.8 | 3.0 | 9.5 | 14.3 | 19.2 | 27.7 |
| **4.5** | 3.0 | 3.2 | 10.1 | 15.1 | 20.4 | 29.3 |
| **5.0** | 3.1** | 3.4 | 10,6** | 16.0 | 21.5 | 30.9 |
| **5.5** | 3.3 | 3.6 | 11.1 | 16.1 | 22.5 | 32.4 |
| **6.0** | 3.4 | 3.7 | 11.6 | 17.5 | 41.2 | 50.9 |

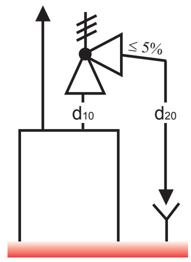
* Contact the manufacturer for up-to-date values

** Protection of Reflex expansion vessels in pressurization systems
Vessels up to1000 liters, Ø 740 mm, G ½ = 3100 kW = 3100 l/h
as of1000 liters, Ø 1000 mm, G 1 = 10600 kW = 10600 l/h

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

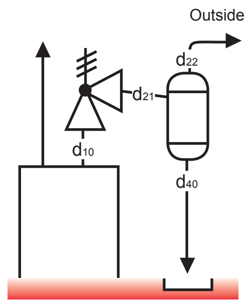
## Exhaust lines from safety valves, expansion traps

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 35



### Exhaust lines and reflex 'T expansion traps' in systems according to DIN EN 12828

Safety valves with code letter H, blow-off pressure $p_{SV}$ 2.5 and 3.0 bar

| Safety valve $d_1$ DN | $d_2$ DN | Nominal output of heat generator Q kW | SV without 'T expansion trap' – Exhaust line $d_{20}$ DN | Length m | No. of bends | SV with or without 'T expansion trap' – SV supply $d_{10}$ DN | Length m | No. of bends | Type T | SV with 'T expansion trap' – SV – T line $d_{21}$ DN | Length m | No. of bends | Exhaust line $d_{22}$* DN | Length m | No. of bends | Water discharge line $d_{40}$* DN |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 15 | 20 | ≤ 50 | 20 | ≤ 2 | ≤ 2 | 15 | ≤ 1 | ≤ 1 | --- | --- | --- | --- | --- | --- | --- | --- |
| | | | 25 | ≤ 4 | ≤ 3 | | | | | | | | | | | |
| 20 | 25 | ≤ 100 | 25 | ≤ 2 | ≤ 2 | 20 | ≤ 1 | ≤ 1 | --- | --- | --- | --- | --- | --- | --- | --- |
| | | | 32 | ≤ 4 | ≤ 3 | | | | | | | | | | | |
| 25 | 32 | ≤ 200 | 32 | ≤ 2 | ≤ 2 | 25 | ≤ 1 | ≤ 1 | --- | --- | --- | --- | --- | --- | --- | --- |
| | | | 40 | ≤ 4 | ≤ 3 | | | | | | | | | | | |
| 32 | 40 | ≤ 350 | 40 | ≤ 2 | ≤ 2 | 32 | ≤ 1 | ≤ 1 | 270 | 65 | ≤ 5 | ≤ 2 | 80 | ≤ 15 | ≤ 3 | 65 |
| | | | 50 | ≤ 4 | ≤ 3 | | | | | | | | | | | |
| 40 | 50 | ≤ 600 | 50 | ≤ 2 | ≤ 4 | 40 | ≤ 1 | ≤ 1 | 380 | 80 | ≤ 5 | ≤ 2 | 100 | ≤ 15 | ≤ 3 | 80 |
| | | | 65 | ≤ 4 | ≤ 3 | | | | | | | | | | | |
| 50 | 65 | ≤ 900 | 65 | ≤ 2 | ≤ 4 | 50 | ≤ 1 | ≤ 1 | 480 | 100 | ≤ 5 | ≤ 2 | 125 | ≤ | ≤ 3 | 100 |
| | | | 80 | ≤ 4 | ≤ 3 | | | | | | | | | | | |

Safety valves with code letter D/G/H, blow-off pressure $p_{SV}$ ≤ 10 bar

| Safety valve $d_1$ DN | $d_2$ DN | SV without 'T expansion trap' – Exhaust line $d_{20}$ DN | Length m | No. of bends | Blow.press. bar | SV with or without 'T expansion trap' – SV supply $d_{10}$ DN | Length m | No. of bends | Type T | Blow.press. bar | SV with 'T expansion trap' – SV – T line $d_{21}$ DN | Length m | No. of bends | Exhaust line $d_{22}$* DN | Length m | No. of bends | Water discharge line $d_{40}$* DN |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 25 | 40 | 40 | ≤ 5.0 | ≤ 2 | ≤ 5 | 25 | ≤ 0.2 | ≤ 1 | 170 | ≤ 5 | 40 | ≤ 5.0 | ≤ 2 | 50 | ≤ 10 | ≤ 3 | 50 |
| | | 50 | ≤ 7.5 | ≤ 3 | > 5 ≤ 10 | 32 | ≤ 1.0 | ≤ 1 | 170 | > 5 ≤ 10 | 50 | ≤ 7.5 | ≤ 2 | 65 | ≤ 10 | ≤ 3 | 65 |
| 32 | 50 | 50 | ≤ 5.0 | ≤ 2 | ≤ 5 | 32 | ≤ 0.2 | ≤ 1 | 170 | ≤ 5 | 50 | ≤ 5.0 | ≤ 2 | 65 | ≤ 10 | ≤ 3 | 65 |
| | | 65 | ≤ 7.5 | ≤ 3 | > 5 ≤ 10 | 40 | ≤ 1.0 | ≤ 1 | 270 | > 5 ≤ 10 | 65 | ≤ 7.5 | ≤ 2 | 80 | ≤ 10 | ≤ 3 | 80 |
| 40 | 65 | 65 | ≤ 5.0 | ≤ 2 | ≤ 5 | 40 | ≤ 0.2 | ≤ 1 | 270 | ≤ 5 | 65 | ≤ 5.0 | ≤ 2 | 80 | ≤ 10 | ≤ 3 | 80 |
| | | 80 | ≤ 7.5 | ≤ 3 | > 5 ≤ 10 | 50 | ≤ 1.0 | ≤ 1 | 380 | > 5 ≤ 10 | 80 | ≤ 7.5 | ≤ 2 | 100 | ≤ 10 | ≤ 3 | 100 |
| 50 | 80 | 80 | ≤ 5.0 | ≤ 2 | ≤ 5 | 50 | ≤ 0.2 | ≤ 1 | 380 | ≤ 5 | 80 | ≤ 5.0 | ≤ 2 | 100 | ≤ 10 | ≤ 3 | 100 |
| | | 100 | ≤ 7.5 | ≤ 3 | > 5 ≤ 10 | 65 | ≤ 1.0 | ≤ 1 | 480 | > 5 ≤ 10 | 100 | ≤ 7.5 | ≤ 2 | 125 | ≤ 10 | ≤ 3 | 125 |
| 65 | 100 | 100 | ≤ 5.0 | ≤ 2 | ≤ 5 | 65 | ≤ 0.2 | ≤ 1 | 480 | ≤ 5 | 100 | ≤ 5.0 | ≤ 2 | 125 | ≤ 10 | ≤ 3 | 125 |
| | | 125 | ≤ 7.5 | ≤ 3 | > 5 ≤ 10 | 80 | ≤ 1.0 | ≤ 1 | 480 | > 5 ≤ 10 | 125 | ≤ 7.5 | ≤ 2 | 150 | ≤ 10 | ≤ 3 | 150 |
| 80 | 125 | 125 | ≤ 5.0 | ≤ 2 | ≤ 5 | 80 | ≤ 0.2 | ≤ 1 | 480 | ≤ 5 | 125 | ≤ 5.0 | ≤ 2 | 150 | ≤ 10 | ≤ 3 | 150 |
| | | 150 | ≤ 7.5 | ≤ 3 | > 5 ≤ 10 | 100 | ≤ 1.0 | ≤ 1 | 550 | > 5 ≤ 10 | 150 | ≤ 7.5 | ≤ 2 | 200 | ≤ 10 | ≤ 3 | 200 |
| 100 | 150 | 150 | ≤ 5.0 | ≤ 2 | ≤ 5 | 100 | ≤ 0.2 | ≤ 1 | 550 | ≤ 5 | 150 | ≤ 5.0 | ≤ 2 | 200 | ≤ 10 | ≤ 3 | 200 |

* 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. As such, the limiters used must bear a CE mark and should undergo component testing. If the pressure is exceeded or falls too low, the heating system is immediately switched off and locked.

▶ The Reflex product range does not include pressure limiters

**Maximum pressure limiters $PL_{max}$**

**DIN EN 12828**: “All heat generators with a nominal heat output of $PL_{max}$ 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 limiters $PL_{min}$**

DIN EN 12828, the standard for systems with operating temperatures $PL_{min}$ ≤ 105°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 pressurization systems that are not supported by an automatic make-up system.

## Expansion lines, shut-off, 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 ($PL_{max}$) and safety valves ($p_{SV}$) do not respond."

The base volume flow to be applied is 1 liter/(hkW) relative to the nominal heat output of the heat generator $\dot{Q}$.

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:

$$\Delta p \text{ (1 liter/(hkW))} = \Sigma \text{ (Rl + Z)}.$$


'reflex N' with 'SU quick coupling'


'reflex G' with 'AG connection assembly'

Verification is not necessary if the following table values are used. In the case of 'variomat' pressurization stations, the expansion lines are also dimensioned according to the degassing performance.
→ reflex 'variomat' brochure

| Expansion line | DN 20 ¾" | DN 25 1" | DN 32 1¼" | DN 40 1½" | DN 50 2" | DN 65 | DN 80 | DN 100 |
|---|---|---|---|---|---|---|---|---|
| $\dot{Q}$/kW Length ≤ 10 m | 350 | 2100 | 3600 | 4800 | 7500 | 14000 | 19000 | 29000 |
| $\dot{Q}$/kW Length > 10 m ≤ 30 m | 350 | 1400 | 2500 | 3200 | 5000 | 9500 | 13000 | 20000 |



Incidentally, it is both permissible and common for expansion lines on expansion vessel or pressurization 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 liters, the bypass lines for repair purposes (closed during operation) should generally be one dimension smaller than the main line. 'refix DT5' 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 pressurization 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.


'refix DT5' with flow fitting


'refix DD' with T-piece

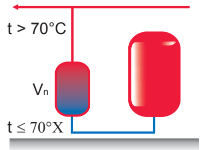
In the case of 'refix DT5' 60-500 liters, a 'flowjet' flow fitting Rp 1¼ is supplied for on-site installation, which combines the shut-off function, draining and bypass in a single unit.
For 'refix DD' 8-33 liters, our 'flowjet' flow fitting Rp ¾ with protected shut-off and draining is available as an 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 DT5' 80-3000 liters, the required fittings must be procured by the customer. In this case we recommend that the supplied fittings be used for installation.

## reflex 'V In-line vessels'

'V in-line 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 in-line 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 in-line 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.

$$V_n = \frac{\Delta\nu}{100} V_s \,(0.5...1.0)$$

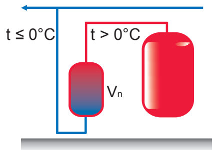
- 0.5 if return 50% of $V_s$
- 1.0 in case of heat reservoir with 100% $V_s$
- Use factor 1 for safety reasons

→ Δn, see "Properties and Auxiliary Variables" on p. 6
→ $V_s$ system volume

**In cooling circuits**

If the temperature drops to ≤ 0°C, we recommend that the in-line vessel be dimensioned as follows.

$$V_n = 0.005\ V_s$$



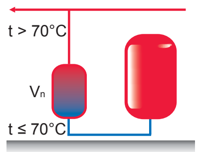

**In solar energy systems**

Without evaporation

$$V_n = \frac{\Delta\nu}{100} V_s$$

With evaporation

$$V_n = \frac{\Delta\nu}{100} V_s + V_C$$



## Safety equipment of hot water heating systems according to DIN EN 12828 – operating temperatures up to 105°C

| | **Direct heating** (heated with oil, gas, coal or electric energy) | | **Indirect heating** (heat generators heated with liquids or steam) | |
|---|---|---|---|---|
| **Temperature protection** | | | | |
| **Temperature measuring device** | Thermometer, display range ³ 120% of max. operating temperature | | | |
| **Safety temperature limiter,** or monitor, acc. to EN 60730-2-9 | STL<br>Temperature overshoot max. 10 K | | STL with $t_{PR} > t_{dSec}$ ($p_{SV}$), STL not required if primary temperature ≤ 105°C or use of STM if $t_{PR} > t_{Smax}$ [1] | |
| **Temperature regulator** [2] | As of heating medium temperatures > 100°C, setpoint value ≤ 60°C, maximum value 95°C (not applicable for gr. I) | | | |
| **Low-water protection**<br>- Low boiler level | $\dot{Q}_n \leq 300$ kW<br>Not required if no permissible heating with low water level | $\dot{Q}_n > 300$ kW<br>LWP or SPLmin or flow restrictor | To preserve controllability, a **minimum volume flow** via the heat exchanger must be ensured. [3] | |
| - Boilers in roof-mounted systems | LWB or SPLmin 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** | | | | |
| **Pressure measuring system** | Pressure gauge, display range ≥ 150% of max. operating pressure | | | |
| **Safety valve**<br>In accordance with prEN 1268-1 or prEN ISO 4126-1, TRD 721 | Calculation for steam outflow | | $t_{PR} > t_{dSec}$ ($p_{SV}$) [3]<br>Calculation for steam outflow with $\dot{Q}_n$ | $t_{PR} \leq t_{dSec}$ ($p_{SV}$) [3]<br>water outflow<br>1 l/(hkW) |
| **'T expansion trap'** per SV | 'T' for $\dot{Q}_n > 300$ kW, or substitute 1 STL + 1 $SPL_{max}$ | | | --- |
| **Pressure limiter** max.<br>TÜV-approved | Per heat generator for $\dot{Q}_n > 300$ kW,<br>$SPL_{max} = p_{SV}$ - 0.2 bar | | --- | --- |
| **Pressure maintenance**<br>Expansion vessel | - Pressure regulation within boundaries of $p_i$ ... $p_f$ as expansion vessel or EV with external pressure generation<br>- Protected shut-off and draining of EVs should be possible for maintenance purposes | | | |
| **Filling systems** | - Assurance of operational min. water seal Vws, autom. make-up with water meter<br>- Connections to potable water systems must comply with prEN 806-4, or DIN 1988 or DIN EN 1717 | | | |
| **Heating** | | | | |
| | | | Primary shut-off valve, if $t_{PR} > t_{dSec}$ ($p_{SV}$)<br>Recommendation: primary shut-off valve also for $t_{PR} > t_{per\ sec}$ | |

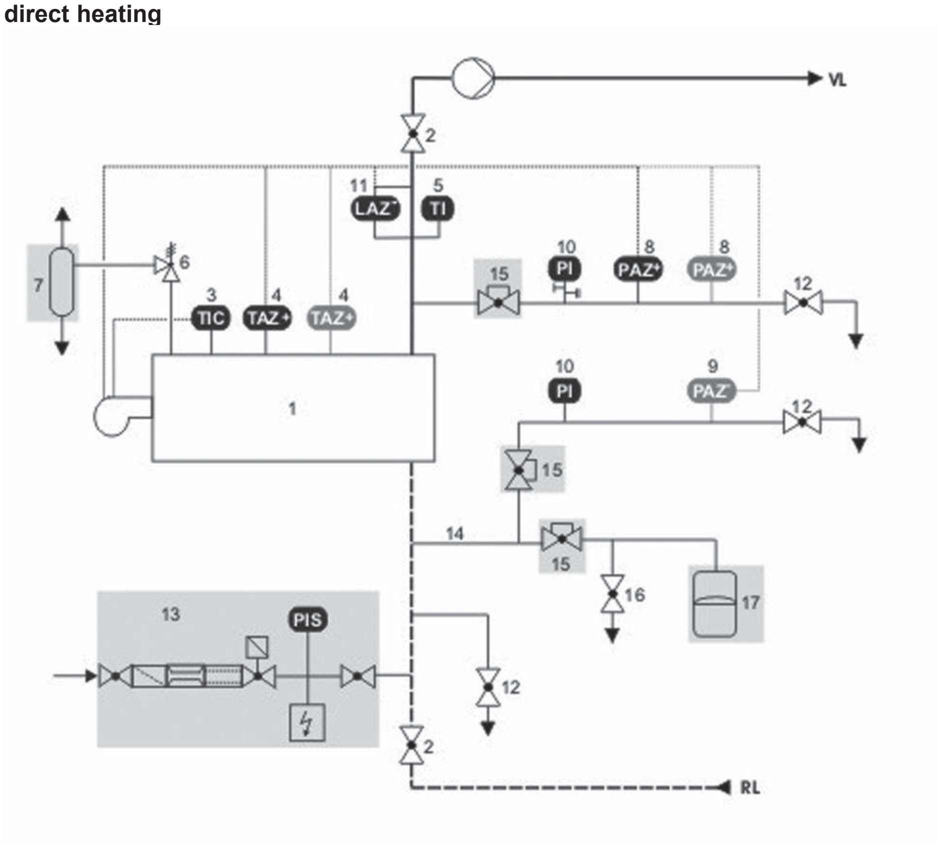
[1] STL recommended as STM automatically releases heating when temperature drops below limit, thus "sanctioning" the failure of the regulator

[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 of hot water heating systems according to 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 [1) 2)] |
| 8 | $SPL_{max}$ [1)], Q > 300 kW |
| 9 | $SPL_{min}$, as optional substitute for low-water protection |
| 10 | Pressure gauge |
| 11 | Low-water protection, up to 300 kW also as substitute for $SPL_{min}$ or flow monitor or other permitted measures |
| 12 | Filling/draining system (filling/draining tap) |
| 13 | Automatic water make-up ('magcontrol' + 'fillset' + 'fillcontrol') |
| 14 | Expansion line |
| 15 | Protected shut-off valve ('SU quick coupling', 'MK cap ball valve') |
| 16 | Deaeration/draining before expansion vessel |
| 13 | Expansion vessel (e.g. 'reflex N') |
| 14 | Pressure reducing valve |

1) Not required for indirect heating, if SV (7) can be dimensioned for water outflow (→ p. 34)

2) Not required if additional STL and $SPL_{max}$ fitted

Code letters, symbols → page 53

Optional components

Part of Reflex product range

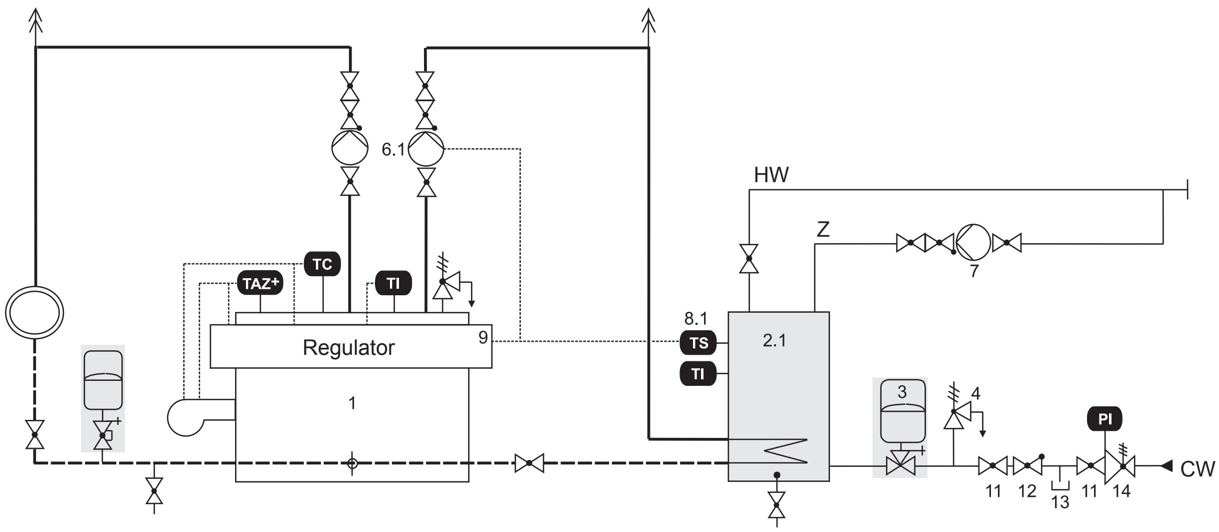
## Safety equipment of hot water systems according to DIN 4753 T1

**Requirements of potable water systems**
Potable water heater closed, indirect heating
Grouping according to DIN 4753 T1: Gr. I p x l ≤ 300 bar x liters whereby $\dot{Q}$ ≤ 10 kW or V ≤ 15 l and $\dot{Q}$ ≤ 50 kW
Gr. II if gr. I thresholds exceeded

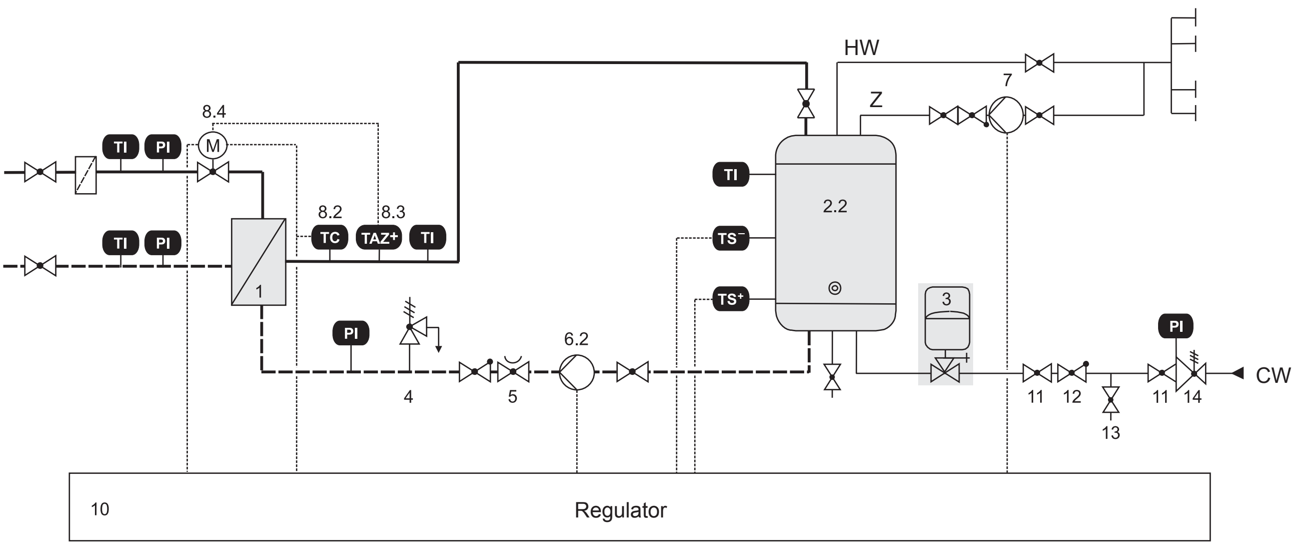
| | |
|---|---|
| **Temperature protection** | DIN 4753 T1, DIN 4747 |
| **Thermometer** | May be part of regulator, not required for gr. I |
| **Temperature regulator** type-tested | As of heating medium temperatures > 100°C, setpoint value ≤ 60°C, maximum value 95°C (not applicable for gr. I) |
| **Safety temperature limiter**<br>According to DIN 3440 | As of heating medium temperatures > 110°C, setpoint value ≤ 95°C, maximum value 110°C<br>for V < 5000 l and $\dot{Q}$ ≤ 250 kW, no intrinsic safety according to DIN 3440 required;<br>for district heating systems, control valve with safety function according to DIN 32730 |
| **Pressure protection** | DIN 4753 T1 |
| **Pressure gauge** | Required for tanks > 1000 l; general installation near safety valve,<br>recommended for cold water systems |
| **Safety valve** | - Installation in cold water line<br>- No shut-offs or impermissible narrowing between water heater and safety valve |
| | Nominal content of water space / Max. heating output / Connection nominal diameter<br>≤ 200 l / 75 kW / DN 15<br>≤ 1000 l / 150 kW / DN 20<br>≤ 5000 l / 250 kW / DN 25<br>> 5000 l / Selection according to max. heating capacity |
| **Pressure reducing valve**<br>DVGW-approved | Required: - If pressure cold water supply > 80% of safety valve actuation pressure<br>- In case of installation of diaphragm expansion vessels (expansion vessel-W acc. to DIN 4807 T5) to ensure a constant normal pressure level before the vessel |
| **Diaphragm expansion vessels**<br>expansion vessel-W acc. to DIN 4807 T5 | - Requirements of DIN 4807 T5: Water flow under defined conditions<br>Green color<br>Diaphragms and non-metallic parts acc. to KTW-C as a minimum<br>Installation of pressure reducing valve<br>Protected shut-off of expansion vessel<br>- Input pressure set to 0.2 bar below pressure reducing valve |
| **Potable water protection** | DIN 1988 T2, T4 or DIN EN 1717 |
| **Backflow preventer**<br>DVGW-approved | Prescribed for potable water heaters > 10 liters, shut-off on both sides, test system to be implemented after first shut-off |
| **Design type of potable water heaters**<br>According to 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 sulfate solution); see DIN for other media and designs | **Design type B**, corrosion-resistant heating surfaces and linings (copper, stainless steel, enameled)<br>e.g. plate heat exchanger reflex 'longtherm'<br>Permissible for max. operating pressure on heating side ≤ 3 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)<br>e.g. tube heat exchanger<br>Also permissible for max. operating pressure on heating side > 3 bar |

## 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) |
| 2.1 | HW tank with integrated heating surface |
| 2.2 | HW tank without heating surface |
| 3 | Diaphragm expansion vessel for potable water (see also p. 24-25) |
| 4 | Diaphragm SV, code letter W |
| 5 | Volume adjusting valve |
| 6.1 | Charge pump, heating side |
| 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 |
| 9 | Boiler regulation with actuation of hot water supply |
| 10 | Heating regulation with actuation of storage charging system |
| 11 | Shut-off valve |
| 12 | Check valve |
| 13 | Test system |
| 14 | Pressure reducing valve |

Items 11–14: Also possible as combined fitting with safety valve 4

▶ Code letters, symbols
→ page 53

## 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 example 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, commissioning and operation of pressure vessels and complete systems.

**Manufacture according to DGRL**

Since 06/01/2002, 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.

| | |
|---|---|
| CE | 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 for customers 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 52



> 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 standardized set of regulations on 01/01/2003.

The necessity of inspections prior to commissioning and that of recurring checks, as well as the relevant inspecting authority are defined on the basis of the risk potential in accordance with the specifications of the **DGRL** and **BetrSichV**. For this purpose, the categories medium (fluid), pressure, volume and temperature are applied in accordance with 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. 50). 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 categorizing 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 commissioning**

- Assembly, installation
- Installation conditions
- Safe function

**§ 15 Recurring inspections**

- Documentation and organization 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 valuation** and the applicable maximum intervals (Tables 1 and 2, → p. 50)

If the system is to be commissioned by an authorized 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 bottle 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 12/31/2007.

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 minimizing faults. System maintenance is performed by a **specialist** commissioned by the operator. This may be a plumber or a Reflex service representative (→ p. 50).

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 pressurization, 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. 52) containing all relevant information for the plumber and operator.

# Equipment - accessories - safety technology - inspection

**Table 1:** **Inspection of Reflex pressure vessels in accordance with BetrSichV, edition dated 09/27/2002, as amended on 12/23/2004, with operation according to Reflex assembly, operating and maintenance instructions**

Applicable for all
- ’reflex’, ’refix’, ’variomat’, ’gigamat’, ’reflexomat’, ’minimat’ vessels as well as the ’servitec’ spray tube

and
- ’V in-line vessels’, ’EB dirt collectors’ and ’longtherm’ plate heat exchangers at permissible operating temperatures > 110°C of the system (e.g. STL setting)

**Classification** in fluid group 2 acc. to DGRL - (e.g. water, air, nitrogen = non-explosive, non-toxic, not easily flammable).

| **Assessment/category**<br>As per diagram 2 in Appendix II of DGRL | **Pre-commis-sioning, § 14** | **Recurring inspections, § 15** | | | |
|---|---|---|---|---|---|
| | **Inspecting party** | **Inspecting party** | **Maximum intervals in years** | | |
| | | | **External**[1] | **internal**[2] | **Strength**[2] |
| V ≤ 1 liter and<br>PS ≤ 1000 bar | 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 manual[3] | | | | |
| PS x V ≤ 50 bar x liters | | | | | |
| **’reflex’, ’refix’, ’V’, ’EB’, ’longtherm’, ’variomat’-, ’gigamat’-, ’reflexomat’-, ’minimat’ vessels** | | | | | |
| PS x V > 50 ≤ 200 bar x liters | QP | QP | No maximum intervals defined[4] | | |
| PS x V > 200 ≤ 1000 bar x liters | AIB** | QP | No maximum intervals defined[4] | | |
| PS x V > 1000 bar x liters | AIB** | AIB** | --- | 5*/** | 10 |

* Recommendation:
Max. 10 years for ’reflex’ and ’refix’ with bubble diaphragms as well as ’variomat’ and ’gigamat’ vessels, but at the very least when opening for repair purposes (e.g. diaphragm replacement) in accordance with 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’, ’minimat’, ’reflexomat’ or ’gigamat’ 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 in accordance with BetrSichV, edition dated 09/27/2002, as amended on 12/23/2004, with operation according to Reflex assembly, operating and maintenance instructions**

Applicable for all
- ’V in-line vessels’, ’EB dirt collectors’ and ’longtherm’ plate heat exchangers at permissible 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).

| **Assessment/category**<br>As per diagram 4 in Appendix II of DGRL | **Pre-commis-sioning, § 14** | **Recurring inspections, § 15** | | | |
|---|---|---|---|---|---|
| | **Inspecting party** | **Inspecting party** | **Maximum intervals in years** | | |
| | | | **External**[1] | **internal**[2] | **Strength**[2] |
| PS ≤ 10 bar or<br>PS x V > 10000 bar x liters<br>If PS ≤ 1000 bar | 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 manual[3] | | | | |
| 10 < PS ≤ 500 bar and<br>PS x V > 10000 bar x liters | AIB | QP | No maximum intervals defined[4] | | |

**Table 3:** **Inspection in accordance with BetrSichV, edition dated 09/27/2002, as amended on 12/23/2004, 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 acc. to DGRL - (e.g. gasoline = explosive, highly flammable, toxic, oxidizing). This fluid group is only permitted for 'longtherm'!

Applicable for permissible operating temperatures $t > t_{boiling}$ at atmospheric pressure + 0.5 bar.

| **Assessment/category**<br>As per diagram 1 in Appendix II of DGRL | **Pre-commissioning, § 14**<br>**Inspecting party** | **Recurring inspections**<br>**Inspecting party** | **Maximum intervals in years**<br>**External**[1] | **internal**[2] | **Strength**[2] |
|---|---|---|---|---|---|
| V ≤ 1 liter and<br>PS ≤ 200 bar<br>PS x V ≤ 25 bar x liters | 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 manual[3] | | | | |
| PS x V > 25 ≤ 1000 bar x liters<br>PS ≤ 200 bar | QP | QP | No maximum intervals defined[4] | | |
| PS x V > 200 ≤ 1000 bar x liters<br>PS ≤ 200 bar | AIB | QP | No maximum intervals defined[4] | | |
| PS x V > 1000 bar x liters | AIB | AIB | --- | 5 | 10 |

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, exceedance of one criterion must result in the application of the next highest category.

PS Maximum possible overpressure in bar resulting from the system configuration and operation

n Expansion coefficient for water

V Nominal volume in liters

t Operating temperature of fluid

$t_{boiling}$ 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 Authorized inspection body in accordance with § 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 permissible operating pressure of the equipment, this applies to the following products: 'reflex' up to N 12 liters/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 the mode of operation and supplied medium The inspection can be performed by a qualified person (QP) in accordance with § 2 (7) BetrSichV.

5) Irrespective of the permissible operating temperature

## 'reflex'

### Montage-, Betriebs- und Wartungsanleitung
### Installation, operating and maintenance instructions

reflex

#### Allgemeine Sicherheitshinweise

'reflex' Membran-Druckausdehnungsgefäße sind Druckgeräte. Eine Membrane teilt das Gefäß in einen Wasser- und einen Gasraum mit Druckpolster. Die Konformität im Anhang bescheinigt die Übereinstimmung mit der Richtlinie 97/23/EG. Der Umfang der Baugruppe ist der Konformitätserklärung zu entnehmen. Die gewählte technische Spezifikation zur Erfüllung der grundlegenden Sicherheitsanforderungen des Anhangs I der Richtlinie 97/23/EG ist dem Typenschild bzw. der Konformitätserklärung zu entnehmen.

**Montage, Betrieb, Prüfung vor Inbetriebnahme, wiederkehrende Prüfungen**
nach den nationalen Vorschriften, in Deutschland nach der Betriebssicherheitsverordnung. Entsprechend sind Montage und Betrieb nach dem Stand der Technik durch Fachpersonal und speziell eingewiesenes Personal durchzuführen. Erforderliche Prüfungen vor Inbetriebnahme, nach wesentlichen Veränderungen der Anlage und wiederkehrende Prüfungen sind vom Betreiber gemäß den Anforderungen der Betriebssicherheitsverordnung zu veranlassen. Empfohlene Prüffristen siehe Abschnitt „Prüffristen". Es dürfen nur 'reflex' ohne äußere sichtbare Schäden am Druckkörper installiert und betrieben werden.

**Veränderungen am 'reflex'**,
z. B. Schweißarbeiten oder mechanische Verformungen, sind unzulässig. Bei Austausch von Teilen sind nur die Originalteile des Herstellers zu verwenden.

**Parameter einhalten**
Angaben zum Hersteller, Baujahr, Herstellnummer sowie die technischen Daten sind dem Typenschild zu entnehmen. Es sind geeignete sicherheitstechnische Maßnahmen zu treffen, damit die angegebenen zulässigen max. und min. Betriebsparameter (Druck, Temperatur) nicht über- bzw. unterschritten werden. Eine Überschreitung des zulässigen Betriebsüberdruckes wasser- und gasseitig, sowohl im Betrieb als auch beim gasseitigen Befüllen, ist auszuschließen.
Der Vordruck $p_0$ darf keinesfalls den zul. Betriebsüberdruck überschreiten. Selbst bei Gefäßen mit zul. Betriebsüberdruck größer 4 bar darf der Vordruck bei Lagerung und Transport nicht mehr als 4 bar betragen. Zur Gasbefüllung ist ein Inertgas, z. B. Stickstoff, zu verwenden.

**Korrosion, Inkrustation**
'reflex' sind aus Stahl gefertigt, außen beschichtet und innen roh. Ein Abnutzungszuschlag (Korrosionszuschlag) wurde nicht vorgesehen. Der Einsatz darf nur in atmosphärisch geschlossenen Systemen mit nicht korrosiven und chemisch nicht aggressiven und nicht giftigen Wassern erfolgen. Der Zutritt von Luftsauerstoff in das gesamte Heiz- und Kühlwassersystem durch Permeation, Nachspeisewasser usw. ist im Betrieb zuverlässig zu minimieren. Wasseraufbereitungsanlagen sind nach dem aktuellen Stand der Technik auszulegen, zu installieren und zu betreiben.

**Wärmeschutz**
In Heizwasseranlagen ist bei Personengefährdung durch zu hohe Oberflächentemperaturen vom Betreiber ein Warnhinweis in der Nähe des 'reflex' anzubringen.

**Aufstellungsort**
Eine ausreichende Tragfähigkeit des Aufstellortes ist unter Beachtung der Vollfüllung des 'reflex' mit Wasser sicherzustellen. Für das Entleerungswasser ist ein Ablauf bereitzustellen, erforderlichenfalls ist eine Kaltwasserzumischung vorzusehen (siehe auch Abschnitt „Montage"). Eine Aufstellung in erdbebengefährdeten Gebieten ist nicht zulässig.

Das Missachten dieser Anleitung, insbesondere der Sicherheitshinweise, kann zur Zerstörung und Defekten am 'reflex' führen, Personen gefährden sowie die Funktion beeinträchtigen. Bei Zuwiderhandlung sind jegliche Ansprüche auf Gewährleistung und Haftung ausgeschlossen.

#### General safety instructions

'reflex' diaphragm pressure expansion vessels are pressure devices. They have an gas cushion. A diaphragm separates 'reflex' in a gas and a water space. The attached conformity certification certifies the compliance to the Pressure Equipment directive 97/23/EC. The scope of the subassembly can be found in the conformity declaration. The technical specification selected to fulfill the fundamental safety requirements of annex I of the directive 97/23/EC can be found on the nameplate or conformity declaration.

**Mounting, operation, test before operation, regular check-up**
According to the governing local regulations. The installation and the operation to be performed to the art of technique by professional installers and authorised technical personnel. Necessary tests before operation, after fundamental changes in the installation and periodic inspection have to be initiated by the user acc. to the requirements of the Operational Safety Regulation. Recommendations regarding periodic check-up: see paragraph „periodic check-up".
Only 'reflex' without visible external damage to the pressure body may be installed and operated.

**Changes to the 'reflex'**
for instance welding operations or mechanical deformations are impermissible. Only original parts of the manufacturer may be used when replacing parts.

**Observe the parameters**
Details concerning manufacturer, year of manufacture, serial number and the technical data are provided on the name plate. Suitable measures must be taken so that the specified permissible maximum and minimum operating parameters

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**'reflex'** — **Anhang 1 / Annex 1**

| | | |
|---|---|---|
| **Konformitätserklärung** für eine Baugruppe<br>**Declaration of conformity** of an assembly | Konstruktion, Fertigung, Prüfung von Druckgeräten<br>Design – Manufacturing – Product Verification | |
| Angewandtes Konformitätsbewertungsverfahren nach Richtlinie für Druckgeräte 97/23/EG des Europäischen Parlaments und des Rates vom 29. Mai 1997<br>Operative Conformity Assessment according to Pressure Equipment Directive 97/23/EC of the European Parliament and the Council of 29 May 1997 | | |
| **Membran-Druckausdehnungsgefäße: 'reflex F', 'N', 'NG', 'EN', 'S', 'G',** universell einsetzbar in Heiz-, Solar- und Kühlwassersystemen<br>**Diaphragm Pressure Expansion vessels: 'reflex F', 'N', 'NG', 'EN', 'S', 'G',** for operation in heating, solar and cooling systems | | |
| Angaben zu Behälter, Seriennummer, Typ und Betriebsgrenzen<br>Data about vessel, serial no., type and working limits | gemäß Typenschild<br>according to name plate | |
| Beschickungsgut<br>Operating medium | Wasser / Inertgas gemäß Typenschild<br>Water / Inertgas according to name plate | |
| Normen, Regelwerk<br>Standards | Druckgeräterichtlinie, prEN 13831:2000 gemäß Typenschild<br>Pressure Equipment Directive, prEN 13831:2000 according to name plate | |
| Druckgerät<br>Pressure equipment | **Baugruppe** nach Richtlinie 97/23/EG Artikel 3 Abs. 2.2 bestehend aus: Behälter, Membrane, Ventil und Manometer (soweit vorhanden)<br>**assembly** acc. to Directive 97/23/EC article 3 paragraph 2.2 consisting of: vessel, diaphragm, valve and manometer (as available) | |
| Fluidgruppe<br>Fluid group | 2 | |
| Konformitätsbewertungsverfahren nach Modul<br>Conformity assessment acc. to module | B + D | 'reflex N, NG, EN, S, G' |
| | A | 'reflex F' |
| Kennzeichnung gem. Richtlinie 97/23/EG<br>Label acc. to Directive 97/23/EC | CE 0045 | 'reflex N, NG, EN, S, G' |
| | CE | 'reflex F' |
| Zertifikat-Nr. der EG-Baumusterprüfung<br>Certificate No. of EC Type Approval | *→ Anhang 2*<br>*→ annex 2* | |
| Zertifikat-Nr. der Bewertung des QS-Systems (Modul D)<br>Certificate No. of certification of QS-System (module D) | 07 202 1403 Z 0836/9/D0045 | |
| Benannte Stelle für Bewertung des QS-Systems<br>Notified Body for certification of QS-System | TÜV Nord Systems GmbH + Co. KG<br>Große Bahnstraße 31, 22525 Hamburg | |
| Registrier-Nr. der Benannten Stelle<br>Registration No. of the Notified Body | 0045 | |
| Hersteller:<br>Manufacturer:<br>reflex **Reflex Winkelmann GmbH**<br>Gersteinstraße 19<br>59227 Ahlen - Germany<br>Telefon: +49 2382 7069-0<br>Telefax: +49 2382 7069-588<br>E-Mail: info@reflex.de | Der Hersteller erklärt, daß die Baugruppe die Anforderungen der Richtlinie 97/23/EG erfüllt.<br>The manufacturer herewith certifies this assembly is in conformity with directive 97/23/EC.<br>Manfred Nussbaumer Volker Mauel<br>Mitglieder der Geschäftsführung / Members of the Management | |

Example:
Reflex assembly, operating and maintenance instructions with declaration of conformity according to DGRL

## Terms

| Formula letter | Explanation | See page (among others) |
|---|---|---|
| $A_p$ | Working range of pressure maintenance | 18 |
| $A_{SV}$ | Closing pressure difference for safety valves | 5, 9 |
| n | Expansion coefficient for water | 6, 10, 24 |
| n* | Expansion coefficient for water mixtures | 6, 13, 16 |
| $n_R$ | Expansion coefficient relative to return temperature | 11 |
| $p_0$ | Minimum operating pressure | 5, 9, 18, 23, 24 |
| $p_i$ | Initial pressure | 5, 9, 18, 23, 24 |
| $p_e$ | Evaporation pressure for water | 6 |
| $p_e$* | Evaporation pressure for water mixtures | 6 |
| $p_f$ | Final pressure | 5, 9, 18 |
| $p_{fil}$ | Filling pressure | 5, 9 |
| $p_{st}$ | Static pressure | 5, 9 |
| $p_{SV}$ | Safety valve actuation pressure | 5, 9 |
| $p_{sup}$ | Minimum supply pressure for pumps | 7 |
| $p_{per}$ | Permissible excess operating pressure | 7 |
| V | Compensating volume flow | 19 |
| $V_s$ | System volume | 6 |
| $v_A$ | Specific water content | 6 |
| $V_e$ | Expansion volume | 5, 9, 23 |
| $V_C$ | Collector content | 12, 14, 39 |
| $V_n$ | Nominal volume | 9, 18 |
| $V_{WS}$ | Water seal | 5, 9 |
| $\Delta p_P$ | Pump differential pressure | 7 |
| ρ | Density | 6 |



## Code letters

**T – Temperature**

| | |
|---|---|
| T | Temperature test port |
| TI | Thermometer |
| TIC | Temperature regulator with display |
| TAZ+ | Temperature limiter, STL, STM |

**P – Pressure**

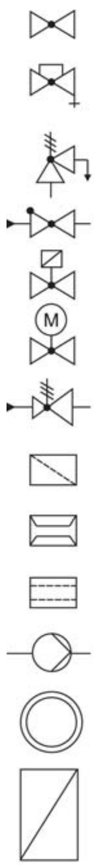
| | |
|---|---|
| P | Pressure test port |
| PI | Pressure gauge |
| PC | Pressure regulator |
| PS | Pressure switch |
| PAZ- | Pressure limiter - min, $SPL_{min}$ |
| PAZ+ | Pressure limited - max, $SPL_{max}$ |

**L – Water level**

| | |
|---|---|
| LS | Water level switch |
| LS+ | Water level switch- max |
| LS+ | Water level switch- min |
| LAZ- | Water level limiter - min |

- Code letters according to DIN 19227 T1, “Graphical symbols and code letters for process technology”

## Symbols



Shut-off valve

Fitting with protected shut-off and draining

Spring-loaded safety valve

Check valve

Solenoid valve

Motorized valve

Overflow valve

Dirt trap

Water meter

System separator

Pump

Heat consumer

Heat Exchangers

# In-house contacts

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# Quick selection table for ’reflex N’ and ’reflex S’

Heating systems : 90/70 °C

For detailed calculations, refer to our brochure “Pressurization Systems - Planning, Calculation, Equipment” or visit www.reflex.de to use or download our calculation software. Alternatively, you can also use our new **’reflex pro app’**!

| Safety valve $p_{SV}$ bar | 2.5 | | | $V_n$ | 3.0 | | | | $V_n$ | 4.0 | | | | $V_n$ | 5.0 | | | | | $V_n$ | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Input pressure $p_0$ bar | 0.5 | 1.0 | 1.5 | liters | 0.5 | 1.0 | 1.5 | 1.8 | liters | 1.5 | 2.0 | 2.5 | 3.0 | liters | 2.0 | 2.5 | 3.0 | 3.5 | 4.0 | liters | 2.0 | 2.5 | 3.0 | 3.5 | 4.0 | 5.0 |
| Content $V_s$ liters | 65 | 30 | --- | 8 | 85 | 50 | 19 | --- | 8 | 55 | 30 | 5 | --- | 8 | 55 | 37 | 16 | --- | --- | 8 | 75 | 60 | 41 | 24 | 7 | --- |
| | 100 | 45 | --- | 12 | 120 | 75 | 29 | --- | 12 | 80 | 45 | 7 | --- | 12 | 85 | 55 | 24 | --- | --- | 12 | 110 | 90 | 60 | 36 | 10 | --- |
| | 170 | 85 | --- | 18 | 200 | 130 | 60 | 17 | 18 | 140 | 85 | 28 | --- | 18 | 140 | 100 | 55 | 8 | --- | 18 | 190 | 150 | 110 | 70 | 32 | --- |
| | 270 | 150 | 33 | 25 | 320 | 220 | 120 | 55 | 25 | 230 | 150 | 70 | --- | 25 | 230 | 170 | 110 | 43 | --- | 25 | 290 | 240 | 180 | 130 | 75 | --- |
| | 410 | 240 | 80 | 35 | 470 | 340 | 200 | 110 | 33 | 330 | 240 | 130 | 25 | 33 | 360 | 270 | 180 | 95 | 5 | 33 | 440 | 370 | 290 | 220 | 140 | --- |
| | 610 | 380 | 110 | 50 | 700 | 510 | 320 | 200 | 50 | 540 | 380 | 230 | 70 | 50 | 550 | 420 | 300 | 170 | 43 | 50 | 660 | 560 | 450 | 350 | 240 | 24 |
| | 980 | 500 | 170 | 80 | 1120 | 840 | 440 | 260 | 80 | 870 | 650 | 410 | 120 | 80 | 890 | 710 | 530 | 320 | 95 | 80 | 1060 | 900 | 750 | 600 | 430 | 90 |
| | 1230 | 620 | 210 | 100 | 1400 | 1050 | 540 | 330 | 100 | 1090 | 820 | 430 | 150 | 100 | 1110 | 890 | 670 | 420 | 120 | 100 | 1320 | 1130 | 940 | 750 | 560 | 100 |
| | 1720 | 870 | 300 | 140 | 1960 | 1470 | 760 | 460 | 140 | 1530 | 1140 | 610 | 200 | 140 | 1560 | 1250 | 940 | 510 | 170 | 140 | 1850 | 1580 | 1320 | 1060 | 790 | 140 |
| | 2450 | 1240 | 420 | 200 | 2800 | 2100 | 1090 | 660 | 200 | 2180 | 1630 | 870 | 290 | 200 | 2230 | 1780 | 1340 | 720 | 240 | 200 | 2640 | 2260 | 1890 | 1510 | 1130 | 210 |
| | 3060 | 1550 | 530 | 250 | 3500 | 2630 | 1360 | 820 | 250 | 2720 | 2040 | 1090 | 370 | 250 | 2790 | 2230 | 1670 | 900 | 300 | 250 | 3300 | 2830 | 2360 | 1890 | 1410 | 260 |
| | 3680 | 1860 | 630 | 300 | 4200 | 3150 | 1630 | 990 | 300 | 3270 | 2450 | 1300 | 440 | 300 | 3340 | 2670 | 2010 | 1080 | 360 | 300 | 3960 | 3390 | 2830 | 2260 | 1700 | 310 |
| | 4900 | 2480 | 850 | 400 | 5600 | 4200 | 2180 | 1320 | 400 | 4360 | 3270 | 1740 | 580 | 400 | 4460 | 3570 | 2670 | 1440 | 480 | 400 | 5280 | 4520 | 3770 | 3020 | 2260 | 410 |
| | 6130 | 3100 | 1060 | 500 | 6920 | 5250 | 2720 | 1650 | 500 | 5450 | 4080 | 2170 | 730 | 500 | 5570 | 4460 | 3340 | 1800 | 600 | 500 | 6600 | 5660 | 4710 | 3770 | 2830 | 520 |
| | 7350 | 3720 | 1270 | 600 | 8400 | 6300 | 3260 | 1980 | 600 | 6540 | 4900 | 2610 | 880 | 600 | 6680 | 5350 | 4010 | 2170 | 730 | 600 | 7920 | 6790 | 5660 | 4520 | 3390 | 620 |
| | 9800 | 4970 | 1690 | 800 | 11200 | 8400 | 4350 | 2640 | 800 | 8710 | 6540 | 3480 | 1170 | 800 | 8910 | 7130 | 5350 | 2890 | 970 | 800 | 10560 | 9050 | 7540 | 6030 | 4520 | 830 |
| | 12250 | 6210 | 2120 | 1000 | 13830 | 10500 | 5440 | 3300 | 1000 | 10890 | 8170 | 4350 | 1460 | 1000 | 11140 | 8910 | 6680 | 3610 | 1210 | 1000 | 13200 | 11310 | 9430 | 7540 | 5660 | 1030 |


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Subject to technical change


**Selection example**

$p_{SV}$ = 3 bar
H = 13 m
$\dot{Q}$ = 40 kW (plates 90/70°C)
$V_{BW}$ = 1000 l (V buffer tank)

**Calculate:**

→ $V_s$ = 40 kW x 8.5 l/kW + 1000 = 1340 l

→ $p_0 \geq \left(\frac{13}{10} + 0.2 \text{ bar}\right) = 1.5$ bar

**From the table:**

With $p_{SV}$ = 3 bar, $p_0$ = 1.5 bar,

$V_s$ = 1340 l

→ **$V_n$ = 250 l** (for $V_s$ max. 1360)

**Selected:**

1 x ’reflex N’ 250, 6 bar → p.4

1 x ’SU R1’ cap ball valve → p.7

▶ Approximate water content:

| Radiators | Panel-type radiators |
|---|---|
| $V_s = \dot{Q}$ [kW] x 13.5 l/kW | $V_s = \dot{Q}$ [kW] x 8.5 l/kW |

**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: $p_0 \geq \frac{H\,[m]}{10} + 0.2$ bar
- Due to the required supply pressure for the circulating pumps, select an input pressure of at least 1 bar for roof-mounted systems also: $p_0 \geq 1$ bar
- In a vented system in cold conditions, set the water-side filling or initial pressure at least 0.3 bar higher than the input pressure: $p_{fil} \geq p_0 + 0.3$ bar