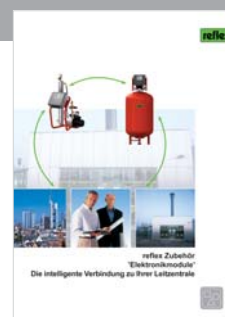
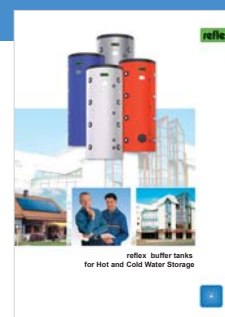
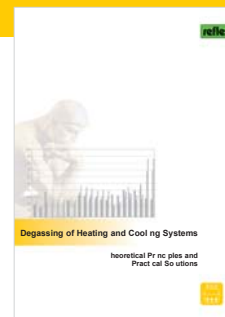
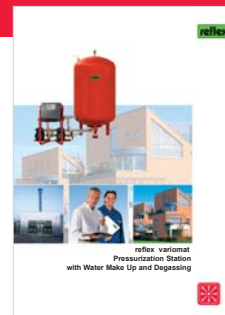
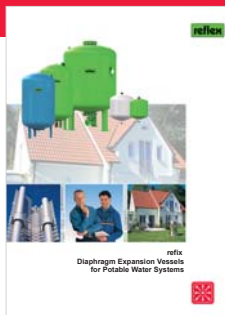
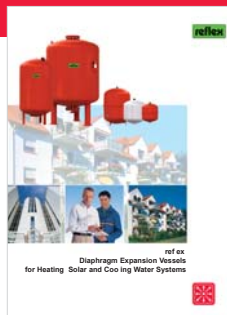


Pressurization, degassing, make-up and heat exchanger systems

Planning, calculation, equipment



Technical planning documentation



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

Calculation procedures 4



Pressurization systems

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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.

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

► Calculation forms
Auxiliary variables

► 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 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.



► Special pressure
maintenance
 +49 2382 7069-536

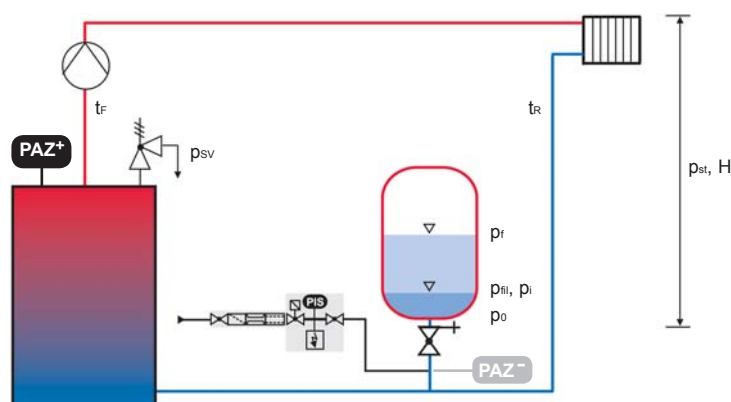
Role of pressurization systems

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.

5

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.

p_{sv}	Safety valve actuation pressure	The permissible excess operating pressure must not be exceeded at any point within the system.	
PAZ⁺	= PL _{max} Pressure limiter		PL _{max} required in accordance with DIN EN 12828 if individual boiler output > 300 kW
p_f	Final pressure	Pressure in the system at maximum temperature	Normal pressure range = Pressure maintenance setpoint value between p _i and p _f
p_{fil}	Filling pressure	Pressure in the system at filling temperature	
p_i	Initial pressure	Pressure in the system at minimum temperature	
p₀	Minimum operating pressure	Minimum pressure to avoid - Vacuum formation - Evaporation - Cavitation	Water seal V_{ws} to cover system-related water losses PL _{min} acc. to DIN EN 12828; to ensure p ₀ in hot water systems, an automatic water make-up system is recommended, along with an optional minimum pressure limiter.
p_{st}	Static pressure	Pressure of liquid column based on static height (H)	

reflex

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/m ³	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/m ³	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/m ³	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 = $\dot{Q}_{\text{tot}} \times V_s$ + pipelines + other → for systems with natural circulation boilers

► V_s = $\dot{Q}_{\text{tot}} (V_s - 1.4 \text{ l})$ + pipelines + other → for systems with heat exchangers

► V_s = $\dot{Q}_{\text{tot}} (V_s - 2.0 \text{ l})$ + pipelines + other → for systems without heat exchangers

↑ 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 V _s ** = 20 l/kW $\frac{\eta_{FH}}{n}$
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

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

► Approx. water content of heating pipes

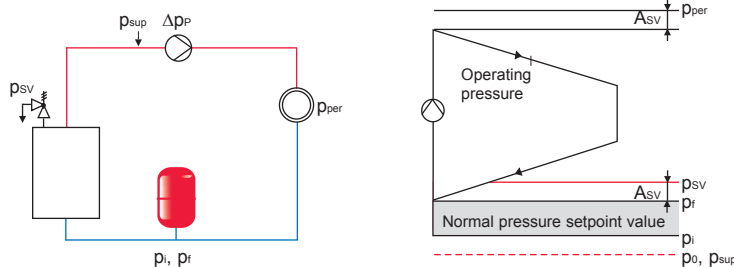
DN	10	15	20	25	32	40	50	60	65	80	100	125	150	200	250	300
Liters/m	0.13	0.21	0.38	0.58	1.01	1.34	2.1	3.2	3.9	5.3	7.9	12.3	17.1	34.2	54.3	77.9

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.

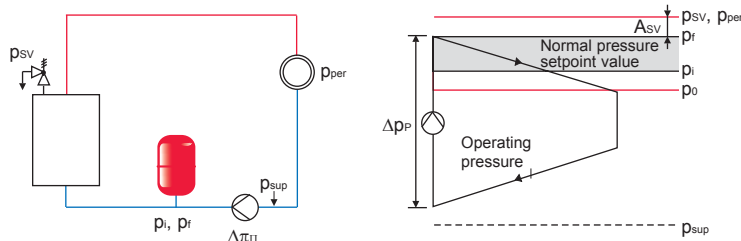
Input pressure maintenance (suction pressure maintenance)

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.



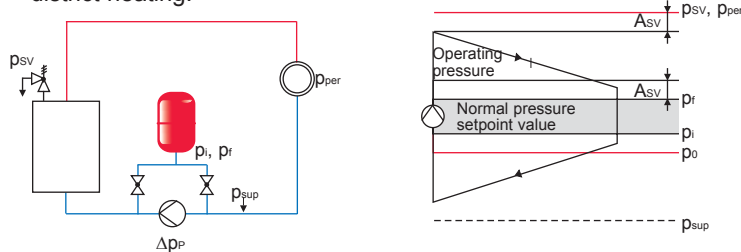
- Advantages:
 - Low normal pressure level
 - Operating pressure > normal pressure, thus no risk of vacuum formation
- Disadvantages:
 - High operating pressure in the case of high circulating pump pressure (large-scale systems); p_{per} must be observed

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.

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.

8

- ▶ **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

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



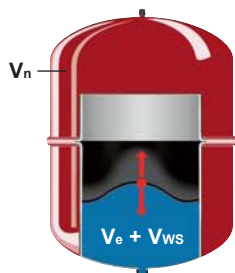
Standard pressure maintenance Flow temp. up to 120°C		Pressure maint.	Autom. operation with make-up	Central deaeration and degassing	Preferred output range	
'reflex' expansion vessel	- Without additional equipment	X	---	---	Up to 1,000 kW	
	- With 'control' make-up	X	X	---		
	- With 'servitec'	X	X	X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

* 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 ($p \times V = \text{constant}$). Therefore, it is not possible to use the entire nominal volume for water intake purposes. The nominal volume is greater than the water intake volume $V_e + V_{ws}$ by a factor of $\frac{p_f + 1}{p_f - p_0}$.

This is one reason why dynamic 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.

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 Δp_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.

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

Filling pressure p_{fi}

The filling pressure p_{fi} 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.

**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

Without degassing

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

With reflex 'servitec'

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

Input pressure maintenance

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

$p_0 \geq 1 \text{ bar}$ Reflex recommendation

Follow-up pressure maintenance

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

Reflex formula for initial pressure

$$p_i \geq p_0 + 0.3 \text{ bar}$$

Reflex recommendation

$$p_f = p_{sv} - A_{sv}$$

$$p_{sv} \geq p_0 + 1.5 \text{ bar}$$

for $p_{sv} \leq 5 \text{ bar}$

$$p_{sv} \geq p_0 + 2.0 \text{ bar}$$

for $p_{sv} > 5 \text{ bar}$

Closing pressure difference

acc. to TRD 721 A_{sv}

SV-H 0.5 bar

SV-D/G/H 0.1 p_{sv}

0.3 bar for

$p_{sv} < 3 \text{ bar}$

Heating systems

Calculation According to DIN 4807 T2 and DIN EN 12828

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

Properties n , p_0 Generally properties for pure water without antifreeze additive → page 6

Expansion volume V_e Calculation of percentage expansion, usually between lowest temperature
Highest temperature t_{TR} = 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.

Filling pressure p_{fi} 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.

Initial pressure p_a 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

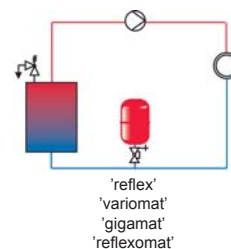
In systems with oxygen-rich water (e.g. floor heating with non-diffusion-resistant pipes), 'refix D', 'refix DE' or 'refix DE junior' are used up to 70°C (all water-carrying parts corrosion-resistant).

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.

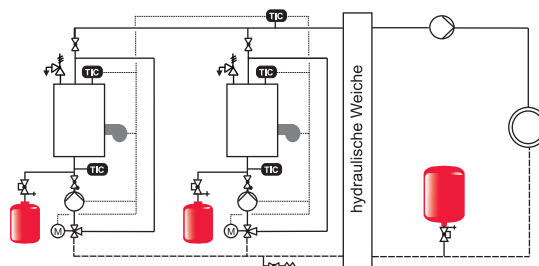


► **Caution** with roof-mounted systems and low-rise buildings

Reflex recommendation:

$p_0 \geq 1 \text{ bar}$

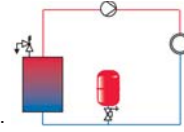
► In the case of corrosion risk, use 'refix'



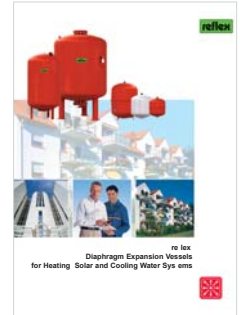
'reflex N, F, G' in heating systems

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

► If $R > 70^\circ\text{C}$,
'V in-line vessel'
required

Pressure calculation

Input pressure	$p_0 = \text{stat. pressure } p_{st} + \text{evaporation pressure } p_e + (0.2 \text{ bar})^{1)}$	$p_0 = \dots\dots\dots$ bar
	$p_0 = \dots\dots\dots + \dots\dots\dots + (0.2 \text{ bar})^{1)}$	
Reflex recommendation	$p_0 \geq 1.0 \text{ bar}$	
Safety valve actuation pressure	$p_{SV} \rightarrow$ Reflex recommendation	
	$p_{SV} \geq \text{input pressure } p_0 + 1.5 \text{ bar for } p_{SV} \leq 5 \text{ bar}$	$p_{SV} = \dots\dots\dots$ bar
	$p_{SV} \geq \text{input pressure } p_0 + 2.0 \text{ bar for } p_{SV} > 5 \text{ bar}$	
	$p_{SV} \geq \dots\dots\dots + \dots\dots\dots = \dots\dots\dots$ bar	
Final pressure	$p_r \leq \text{safety valve } p_{SV} - \text{closing pressure difference acc. to TRD 721}$	
	$p_r \leq p_{SV} - 0.5 \text{ bar for } p_{SV} \leq 5 \text{ bar}$	$p_r = \dots\dots\dots$ bar
	$p_r \leq p_{SV} - 0.1 \times p_{SV} \text{ for } p_{SV} > 5 \text{ bar}$	
	$p_r \leq \dots\dots\dots - \dots\dots\dots = \dots\dots\dots$ bar	

¹⁾ Recommendation
► Check rec. supply pres-
sure of circulation pump
as per manufacturer
specifications
► Check compliance
with perm. operat-
ing pressure

11

Vessel

Expansion volume	$V_e = \frac{n}{100} \times V_s = \dots\dots\dots \times \dots\dots\dots = \dots\dots\dots$ liters	$V_e = \dots\dots\dots$ 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	$V_{WS} = \dots\dots\dots$ liters
	$V_{WS} \geq \dots\dots\dots \times \dots\dots\dots = \dots\dots\dots$ liters	
Nominal volume		
Without 'servitec'	$V_n = (V_e + V_{WS}) \times \frac{p_r + 1}{p_r - p_0}$	
With 'servitec'	$V_n = (V_e + V_{WS} + 5 \text{ liters}) \times \frac{p_r + 1}{p_r - p_0}$	$V_n = \dots\dots\dots$ liters
	$V_n \geq \dots\dots\dots \times \dots\dots\dots = \dots\dots\dots$ liters	
	Selected V_n 'reflex' = $\dots\dots\dots$ liters	

Initial pressure check

Without 'servitec'	$p_i = \frac{p_r + 1}{1 + \frac{V_e(p_r + 1)(n + n_R)}{V_n(p_0 + 1) 2n}} - 1 \text{ bar}$	
With 'servitec'	$p_i = \frac{p_r + 1}{1 + \frac{(V_e + 5 \text{ liters})(p_r + 1)(n + n_R)}{V_n(p_0 + 1) 2n}} - 1 \text{ bar}$	$p_i = \dots\dots\dots$ bar
	$p_i = \frac{\dots\dots\dots}{1 + \dots\dots\dots} - 1 \text{ bar} = \dots\dots\dots$ bar	

Condition: $p_i \geq p_0 + 0.25 \dots 0.3 \text{ bar}$, otherwise calculation for greater nominal volume

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

Result summary

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

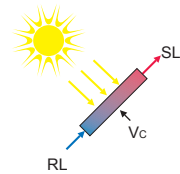
reflex

Solar heating plants (solar energy systems)

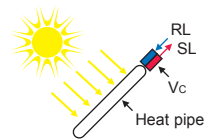
Calculation On the basis of VDI 6002 and DIN 4807 T2

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

$$V_n = (V_e + V_{ws}) \frac{p_r + 1}{p_r - p_0}$$

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 V_e and the water seal V_{ws} .

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

Nominal volume with evaporation

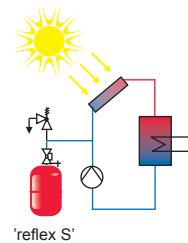
$$V_n = (V_e + V_{ws} + V_c) \frac{p_r + 1}{p_r - p_0}$$

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.

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.

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



With evaporation

$p_e^* = 0$
 $n^* = f(\text{boiling temp.})$

Without evaporation

$p_e^* = f(\text{stagnation temp.})$
 $n^* = f(\text{stagnation temp.})$

Input pressure p_0 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 Δp_P 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_{fi} 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.
Initial pressure p_i

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 $\leq 70^\circ\text{C}$ cannot be guaranteed on the consumer side, an in-line vessel must be fitted to the expansion vessel. → p. 39



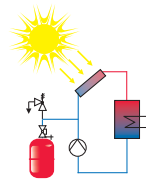
Pressurization systems

Heating and cooling circuits

reflex 'S' in solar energy systems with evaporation

Calculation method:

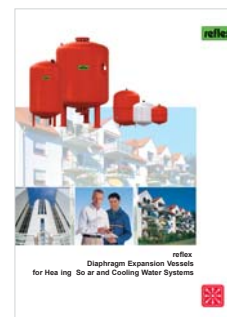
The minimum operating pressure p_0 is calculated such that no evaporation occurs up to flow temperatures of 110°C or 120°C – i.e. **evaporation is permitted in the collector** at stagnation temperature.



Configuration

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

Object:



Initial data					
Number of collectors	z	..... units			
Collector surface area	A_c	..... m ²	$A_{Ctot} = z \times A_c$	$A_{Ctot} =$ m ²	$A_{Ctot} =$ bar
Water content per collector	V_c	..... liters	$V_{Ctot} = z \times A_c$	$V_{Ctot} =$ liters	$V_{Ctot} =$ liters
Highest flow temperature	t_f	110°C or 120°C	→ 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	Δp_p	..... bar			$\Delta p_p =$ bar

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

Pressure calculation					
Input pressure	p_0	= stat. pressure p_{st} + pump pressure Δp_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_r	≤ safety valve p_{sv} – Closing pressure difference acc. to TRD 721			
	p_r	≤ p_{sv} – 0.5 bar for $p_{sv} \leq 5$ bar			
	p_r	≤ p_{sv} – 0.1 bar x $p_{sv} > 5$ bar			$p_r =$ bar
	p_r	≤ – = bar			

► Check compliance with perm. operating pressure

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			$V_{ws} =$ liters
	$V_{ws} \geq$ x	= x = liters			
Nominal volume	$V_n = (V_e + V_{ws} + V_{Ctot}) \times \frac{p_r + 1}{p_r - p_0}$				$V_n =$ liters
	$V_n \geq$ x = liters				
	Selected V_n 'reflex S' = liters				
Check of initial pressure	$p_i = \frac{p_r + 1}{1 + \frac{(V_e + V_{Ctot})(p_r + 1)}{V_n(p_0 + 1)}} - 1$ bar				
	$p_i = \frac{p_r + 1}{1 + \frac{(V_e + V_{Ctot})(p_r + 1)}{V_n(p_0 + 1)}} - 1$ bar	= bar			$p_i =$ bar
	Condition: $p_i \geq p_0 + 0.25 \dots 0.3$ 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	$p_{fil} = V_n \times \frac{p_0 + 1}{V_n - V_s \times n^*_F - V_{ws}} - 1$ bar				$p_{fil} =$ bar
	$p_{fil} =$ x - 1 bar = liters				

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 $p_r =$ 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 $\leq 150^\circ\text{C}$.

Configuration

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

Object:

Initial data

Number of collectors	z	..... units			
Collector surface area	A_c	..... \text{m^2	$A_{\text{Ctot}} = z \times A_c$	$A_{\text{Ctot}} =$ m^2	$A_{\text{Ctot}} =$ bar
Water content per collector	V_c	..... liters	$V_{\text{Ctot}} = z \times A_c$	$V_{\text{Ctot}} =$ liters	$V_{\text{Ctot}} =$ liters
Highest advance temperature	t_f		→ p. 6 Percentage expansion n^* and evaporation pressure p_e^*		
Lowest ambient temperature	t_a	- 20°C			
Antifreeze additive		..... %			$n^* =$ % $p_e^* =$ bar
Static pressure	p_{st}}	..... bar			$p_{\text{st}} =$ bar
Difference at circulating pump	Δp_p	..... bar			$\Delta p_p =$ bar

Pressure calculation

Input pressure	$p_0 = \text{stat. pressure } p_{\text{st}} + \text{pump pressure } \Delta p_p + \text{evaporation pressure } p_e^*$ $p_0 =$ + + $=$ bar	$p_0 =$ bar
Safety valve actuation pressure	$p_{\text{sv}} \rightarrow$ Reflex recommendation $p_{\text{sv}} \geq \text{input pressure } p_0 + 1.5 \text{ bar for } p_{\text{sv}} \leq 5 \text{ bar}$ $p_{\text{sv}} \geq \text{input pressure } p_0 + 2.0 \text{ bar for } p_{\text{sv}} > 5 \text{ bar}$ $p_{\text{sv}} \geq$ + = bar	$p_{\text{sv}} =$ bar
Final pressure	$p_f \leq \text{safety valve } p_{\text{sv}}$ – Closing pressure difference acc. to TRD 721 $p_f \leq p_{\text{sv}}$ – 0.5 bar for $p_{\text{sv}} \leq 5 \text{ bar}$ $p_f \leq p_{\text{sv}}$ – 0.1 bar x $p_{\text{sv}} > 5 \text{ bar}$ $p_f \leq$ – = bar	$p_f =$ bar

Vessel

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

Result summary

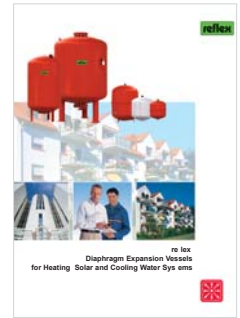
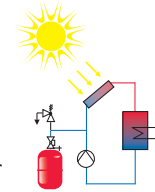
'reflex S'/10 bar liters

Input pressure $p_0 =$ bar → check before commissioning

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

Filling pressure $p_{\text{fil}} =$ bar → refilling of system

Final pressure $p_f =$ bar



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

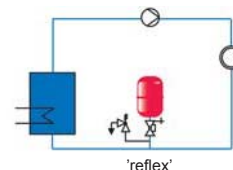
► Check compliance with perm. operating pressure

Cooling water systems

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

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

Properties n* When determining the percentage expansion n^* , antifreeze additives appropriate for the lowest system temperature must be included 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 $+40^{\circ}\text{C}$).

Minimum operating pressure p_0 Since no temperatures $> 100^{\circ}\text{C}$ are used, no special margins are required.

► Enter set input pressure on name plate

Filling pressure p_{fill} 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.

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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.



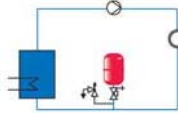
In-line vessels Although 'reflex' diaphragms are suitable for temperatures down to -20°C and vessels to -10°C , the possibility of the diaphragms freezing to the container cannot be excluded. We therefore recommend the integration of a 'V in-line vessel' in the return to the refrigerating machine at temperatures $\leq 0^{\circ}\text{C}$. → 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

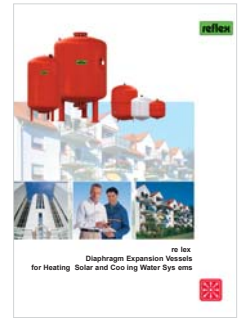
'reflex N, F, S, G' in cooling water systems

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 $n^* \rightarrow .6$	$n^* = n^*$ 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 $t_R > 70^\circ\text{C}$, 'V in-line vessel' required

Pressure calculation

Input pressure	$p_0 = \text{static pressure } p_{st} + (0.2 \text{ bar})^{1)}$ $p_0 =$ + (0.2 bar) ¹⁾ = bar	$p_0 =$ bar
Safety valve actuation pressure	$p_{sv} \rightarrow$ Reflex recommendation $p_{sv} \geq \text{input pressure } p_0 + 1.5 \text{ bar for } p_{sv} \leq 5 \text{ bar}$ $p_{sv} \geq \text{input pressure } p_0 + 2.0 \text{ bar for } p_{sv} \leq 5 \text{ bar}$ $p_{sv} \geq$ + = bar	$p_{sv} =$ bar
Final pressure	$p_r \leq \text{safety valve } p_{sv}$ - Closing pressure difference acc. to TRD 721 $p_r \leq p_{sv}$ - 0.5 bar for $p_{sv} \leq 5 \text{ bar}$ $p_r \leq p_{sv}$ - 0.1 bar for $p_{sv} \leq 5 \text{ bar}$ $p_r \leq$ - = bar	$p_r =$ 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 $V_{WS} \geq 3$ liters $V_{WS} \geq 0.2 \times V_n$ for $V_n \leq 15$ liters $V_{WS} \geq$ x = liters	$V_{WS} =$ liters
Nominal volume	Without 'servitec' $V_n = (V_e + V_{WS}) \times \frac{p_r + 1}{p_r - p_0}$ With 'servitec' $V_n = (V_e + V_{WS} + 5 \text{ liters}) \times \frac{p_r + 1}{p_r - p_0}$ $V_n \geq$ x = liters Selected V_n 'reflex' = liters	$V_n =$ liters
Initial pressure check	Without 'servitec' $p_i = \frac{p_r + 1}{1 + \frac{V_e (p_r + 1)}{V_n (p_0 + 1)}} - 1 \text{ bar}$ $p_i = \frac{p_r + 1}{1 + \frac{(V_e + 5 \text{ liters}) (p_r + 1)}{V_n (p_0 + 1)}} - 1 \text{ bar}$ $p_i = \frac{p_r + 1}{1 + \frac{V_n (p_r + 1)}{V_n (p_0 + 1)}} - 1 \text{ bar} =$ bar $p_i = p_0 + 0.25 \dots 0.3 \text{ bar}$, 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 \rightarrow check before commissioning
	Initial pressure $p_i =$ bar \rightarrow check make-up configuration
	Filling pressure $p_{fil} =$ bar \rightarrow refilling of system
	Final pressure $p_r =$ 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 V_n can be used for water intake purposes ($V_e + V_{ws}$). This represents a significant advantage of this method over pressure maintenance with expansion vessels.

$$V_n = 1.1 (V_e + V_{ws})$$

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

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

Final pressure maintenance

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

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Initial pressure p_i

This restricts the lower setpoint value range of the pressure maintenance. If the pressure falls below the initial pressure, the pressure pump or compressor is activated before 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.

$$p_i \geq p_0 + 0.3 \text{ bar}$$

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.

$$p_f \geq p_i + A_p$$

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

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.

Closing pressure difference acc. to TRD 721 A_{sv}

SV-H	0.5 bar
SV-D/G/H	0.1 p_{sv}
	0.3 bar for $p_{sv} < 3 \text{ bar}$

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.

$$A_p = p_f - p_i$$

'variomat'	$\geq 0.4 \text{ bar}$
'gigamat'	$\geq 0.4 \text{ bar}$
'reflexomat'	$\geq 0.2 \text{ bar}$

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

→ p. 28

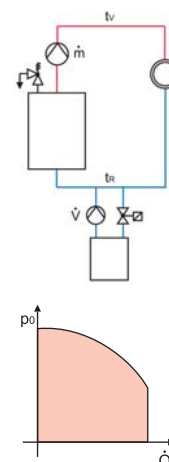
Compensating volume flow \dot{V}

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

Pressurization systems

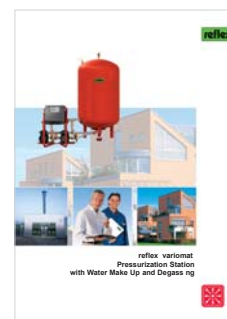
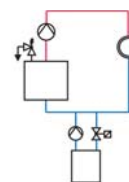
Heating and cooling circuits

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

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

- If $R > 70^\circ\text{C}$, 'V in-line vessel' required
- t_{TR} max. 105°C
- If $110 < STL \leq 120^\circ\text{C}$, contact our specialist department

Pressure calculation

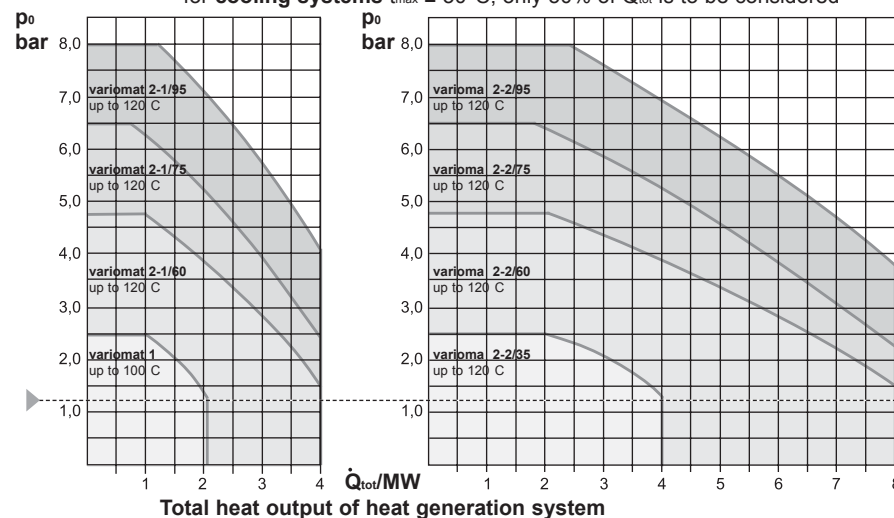
Minimum operating pressure	$p_0 = \text{stat. pressure } p_{st} + \text{evaporation pressure } p_e + (0.2 \text{ bar})^{1)}$	$p_0 = \dots\dots\dots$ bar
Condition	$p_0 \geq 1.3 \text{ bar}$	
Final pressure	$p_f \geq \text{minimum operating pressure } p_0 + 0.3 \text{ bar} + \text{working range 'reflexomat' } A_p$	$p_f = \dots\dots\dots$ bar
	$p_f \geq \dots\dots\dots + 0.3 \text{ bar} + 0.4 \text{ bar} = \dots\dots\dots \text{ bar}$	
Safety valve actuation pressure	$p_{sv} \geq \text{final pressure } + \text{closing pressure difference } A_{sv}$	$p_{sv} = \dots\dots\dots$ bar
	$p_{sv} \geq p_f + 0.5 \text{ bar for } p_{sv} \leq 5 \text{ bar}$	
	$p_{sv} \geq p_f + 0.1 \times p_{sv} \text{ for } p_{sv} > 5 \text{ bar}$	
	$p_{sv} \geq \dots\dots\dots + \dots\dots\dots = \dots\dots\dots \text{ bar}$	

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 $t_{max} \leq 30^\circ\text{C}$, only 50% of \dot{Q}_{tot} is to be considered



'variomat 2-2' recommended for:

- Special requirements with regard to supply reliability
- Outputs $\geq 2 \text{ MW}$

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

$p_0 = 1.3 \text{ bar}$
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

$$V_n = 1.1 \times V_s \frac{n + 0.5}{100} = 1.1 \times \dots\dots\dots \times \dots\dots\dots = \dots\dots\dots \text{ bar}$$

$V_n = \dots\dots\dots$ liters

- The nominal volume can be distributed across multiple vessels.

Result summary

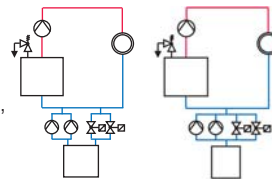
'variomat'	$\dots\dots\dots$ liters	Minimum operating pressure $p_0 \dots\dots\dots$ bar
VG basic vessel	$\dots\dots\dots$ liters	Final pressure $p_f \dots\dots\dots$ bar
VF secondary vessel	$\dots\dots\dots$ liters	Note: Due to the excellent degassing performance of 'variomat', we generally recommend individual protection of the heat generator using 'reflex' diaphragm expansion vessels.
VW thermal insulation (for heating systems only)	$\dots\dots\dots$ liters	

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

- If $R > 70^\circ\text{C}$, 'V in-line vessel' required
- t_{TR} max. 105°C
- If $110 < STL \leq 120^\circ\text{C}$, contact our specialist department

Specific values

Minimum operating pressure	$p_0 = \text{stat. pressure } p_{st} + \text{evaporation pressure } p_e + (0.2 \text{ bar})^{1)}$	$p_0 = \dots\dots\dots$ bar
Condition	$p_0 \geq 1.3 \text{ bar}$	
Final pressure	$p_f \geq \text{minimum operating pressure } p_0 + 0.3 \text{ bar} + \text{working range 'reflexomat' } A_p$	$p_f = \dots\dots\dots$ bar
	$p_f \geq \dots\dots\dots + 0.3 \text{ bar} + 0.4 \text{ bar} = \dots\dots\dots \text{ bar}$	
Safety valve actuation pressure	$p_{sv} \geq \text{final pressure } + \text{closing pressure difference } A_{sv}$	$p_{sv} = \dots\dots\dots$ bar
	$p_{sv} \geq p_f + 0.5 \text{ bar for } p_{sv} \leq 5 \text{ bar}$	
	$p_{sv} \geq p_f + 0.1 \times p_{sv} \text{ for } p_{sv} > 5 \text{ bar}$	
	$p_{sv} \geq \dots\dots\dots + \dots\dots\dots = \dots\dots\dots \text{ bar}$	

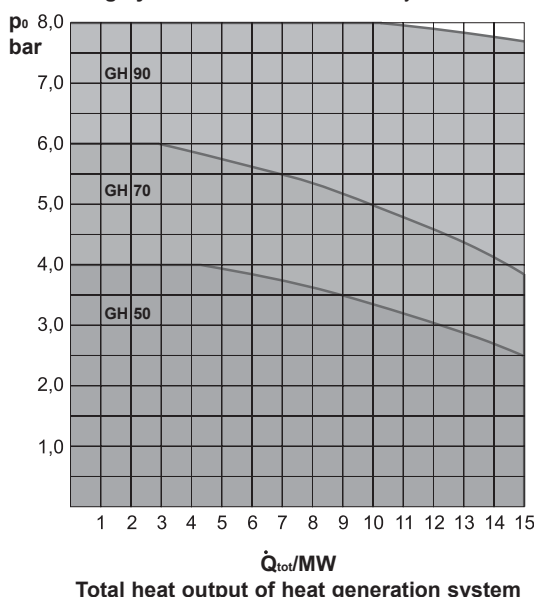
¹⁾ Recommendation

- Check compliance with perm. operating pressure

21

Control unit selection

Diagram valid for **heating systems** $STL \leq 120^\circ\text{C}$
for **cooling systems** $t_{max} \leq 30^\circ\text{C}$, 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

$$V_n = 1.1 \times V_s \frac{n + 0.5}{100} = 1.1 \times \dots\dots\dots \times \dots\dots\dots = \dots\dots\dots \text{ bar}$$

$V_n = \dots\dots\dots$ liters

- The nominal volume can be distributed across multiple vessels.

Result summary

GH hydraulic unit	$\dots\dots\dots$	Minimum operating pressure p_0	$\dots\dots\dots$ bar
GG basic vessel	$\dots\dots\dots$ liters	Final pressure p_f	$\dots\dots\dots$ bar
GF secondary vessel	$\dots\dots\dots$ liters		

reflex

Pressurization systems

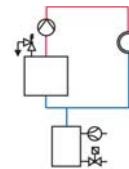
Heating and cooling circuits

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

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

► If $R > 70^\circ\text{C}$, 'V in-line vessel' required

► t_{TR} max. 105°C

► If $110 < STL \leq 120^\circ\text{C}$, contact our specialist department

Pressure calculation

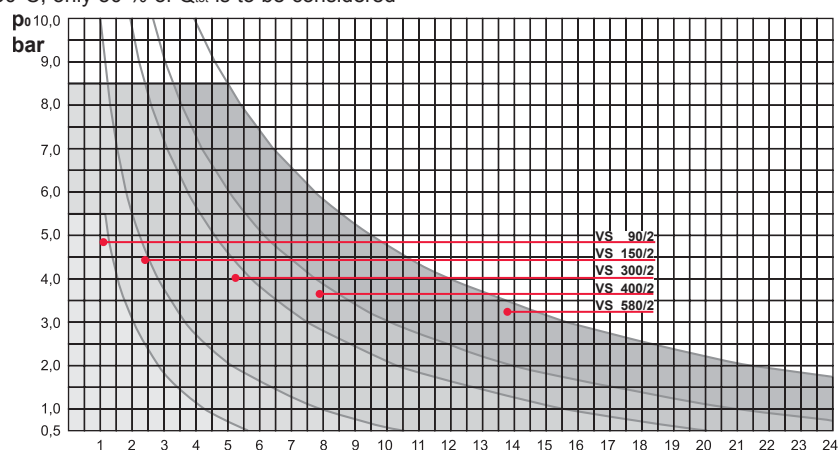
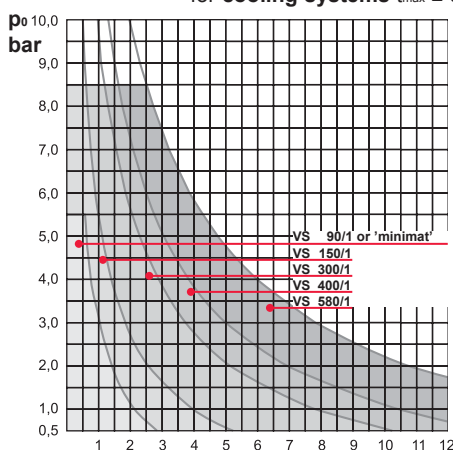
Minimum operating pressure	$p_0 = \text{stat. pressure } p_{st} + \text{evaporation pressure } p_e + (0,2 \text{ bar})^{1)}$	$p_0 = \dots\dots\dots$ bar
Recommendation	$p_0 \geq 1.0 \text{ bar}$	
Final pressure	$p_f \geq \text{minimum operating pressure } p_0 + 0.3 \text{ bar} + \text{working range 'reflexomat' } A_p$	$p_f = \dots\dots\dots$ bar
Safety valve actuation pressure	$p_{sv} \geq \text{final pressure} + \text{closing pressure difference } A_{sv}$	$p_{sv} = \dots\dots\dots$ bar
	$p_{sv} \geq p_f + 0.5 \text{ bar for } p_{sv} \leq 5 \text{ bar}$	
	$p_{sv} \geq p_f + 0.1 \times p_{sv} \text{ for } p_{sv} > 5 \text{ bar}$	
	$p_{sv} \geq \dots\dots\dots + \dots\dots\dots = \dots\dots\dots \text{ bar}$	

¹⁾ Recommendation

► Check compliance with perm. operating pressure

Control unit selection

Diagram valid for heating systems
for cooling systems $t_{max} \leq 30^\circ\text{C}$, 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

$$V_n = 1.1 \times V_s \times \frac{n + 0.5}{100} = 1.1 \times \dots\dots\dots \times \dots\dots\dots = \dots\dots\dots \text{ bar}$$

$V_n = \dots\dots\dots$ 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.

► Special pressure maintenance
 +49 2382 7069-536

Contact us for more information!

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

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

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

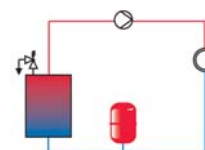
Minimum operating pressure p_o The minimum operating pressure must be adapted to the safety temperature of the heat exchanger and determined such that the permitted normal and operating pressures are maintained throughout the network and cavitation on the pumps and control fittings is avoided.

Initial pressure p_i 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_o (= PL_{min}) should then be at least 0.5 ... 1 bar.

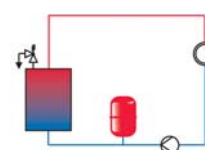
Pressure maintenance In the case of larger networks, almost exclusively in the form of pressure maintenance with external pressure generation, e.g. 'variomat', 'gigamat', 'minimat' or 'reflexomat'. With operating temperatures over 105°C or safety temperatures STL > 110°C, the special requirements of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

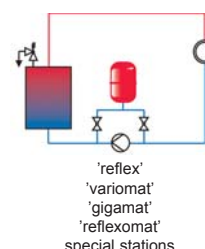
Input pressure maintenance



Follow-up pressure maintenance



Medium pressure maintenance



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 $\frac{3}{4}$ max. 200 l water heater

Rp 1 max. 1,000 l water heater

Rp $1\frac{1}{4}$ max. 5,000 l water heater

'refix DT5' flow fitting Rp $1\frac{1}{4}$:

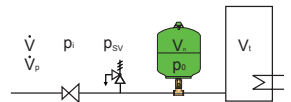
max. 5,000 l water heater

Properties n, p₀ Generally calculation between cold water temperature of 10°C and max. hot water temperature of 60°C.

Input pressure p₀ Minimum operating pressure The minimum operating pressure or input pressure p₀ in the expansion vessel must be at least 0.2 bar below the minimum flow pressure. Depending on the distance between the pressure reducing valve and the 'refix' unit, the input pressure must be adjusted to between 0.2 and 1.0 bar below the set pressure of the pressure reducing valve.

Initial pressure p_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.



► Enter set input pressure on name plate



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.

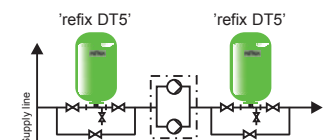
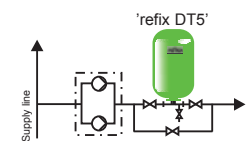
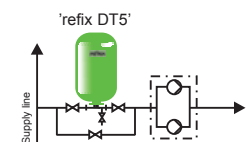
On the follow-up pressure side of a PBS, 'refix' vessels are installed to reduce the switch frequency, particularly in the case of cascade control systems.

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

Input pressure p₀ The minimum operating pressure or input pressure p₀ 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 p_i is at least 0.5 bar higher than the input pressure, a sufficient water seal is always ensured; this is an important prerequisite for low-wear operation.

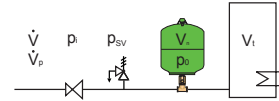
In potable water systems according to DIN 1988, only water-carrying 'refix' vessels meeting the specifications of DIN 4807 T5 must be used. In the case of non-potable water systems, 'refix' units with a single connection are sufficient.



► Enter set input pressure on name plate

'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
Set pressure of pressure reducing valve	p_i	=	bar	n = %
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

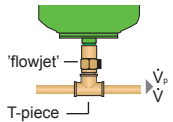
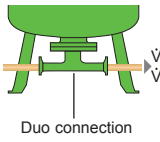
Input pressure	p_0	= set pressure of pressure reducing valve $p_i - (0.2...1.0 \text{ bar})$	p_0 = bar
	p_0	= - = bar	
Nominal volume	V_n	= $V_t \cdot \frac{n \times (p_{sv} + 0.5)(p_0 + 1.2)}{100 \times (p_0 + 1)(p_{sv} - p_0 - 0.7)}$	V_n = liters
	V_n	= - = liters	
		Selection according to brochure = 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 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 With or without 'flowjet' T-piece duct Rp ¾ = standard T-piece Rp 1 (on-site)	$\leq 2.5 \text{ m}^3/\text{h}$ $\leq 4.2 \text{ m}^3/\text{h}$	$\Delta p = 0.03 \text{ bar} \cdot \left(\frac{\dot{V} [\text{m}^3/\text{h}]}{2.5 \text{ m}^3/\text{h}} \right)^2$ negligible	Δp = bar
'refix DT5' 60 - 500 liters With 'flowjet' Rp 1¼	$\leq 7.2 \text{ m}^3/\text{h}$	$\Delta p = 0.04 \text{ bar} \cdot \left(\frac{\dot{V} [\text{m}^3/\text{h}]}{7.2 \text{ m}^3/\text{h}} \right)^2$	
 'refix DT5' 80 - 3000 liters Duo connection DN 50 Duo connection DN 65 Duo connection DN 80 Duo connection DN 100	$\leq 15 \text{ m}^3/\text{h}$ $\leq 27 \text{ m}^3/\text{h}$ $\leq 36 \text{ m}^3/\text{h}$ $\leq 56 \text{ m}^3/\text{h}$	$\Delta p = 0.14 \text{ bar} \cdot \left(\frac{\dot{V} [\text{m}^3/\text{h}]}{15 \text{ m}^3/\text{h}} \right)^2$ $\Delta p = 0.11 \text{ bar} \cdot \left(\frac{\dot{V} [\text{m}^3/\text{h}]}{27 \text{ m}^3/\text{h}} \right)^2$ negligible	G =
'refix DE, DE junior' (non water-carrying)	Unlimited	$\Delta p = 0$	

* 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				

reflex

'refix' in Pressure Booster Systems (PBS)

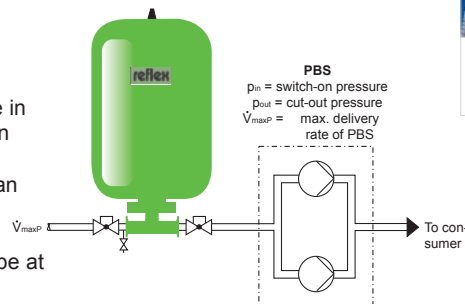
Object:

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 $p_{\min S}$ and must be at least 1 bar



Initial data:

Min. supply pressure
Max. delivery rate

$p_{\min S} = \dots \text{bar}$
 $V_{\max P} = \dots \text{m}^3/\text{h}$

Selection acc. to
DIN 1988 T5

Max. delivery rate $V_{\max P} / \text{m}^3/\text{h}$	'refix DT5' with duo connection V_n / liters	'refix DT5' V_n / liters
≤ 7	300	300
$> 7 \leq 15$	500	600
> 15	---	800

$V_n = \dots \text{liters}$

Input pressure

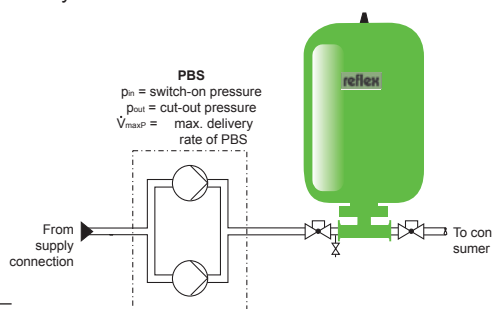
$p_0 = \text{min. supply pressure} - 0.5 \text{ bar}$
 $p_0 = \dots - 0.5 \text{ bar} = \dots \text{bar}$

$p_0 = \dots \text{bar}$

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

- To restrict the switch frequency of pressure-controlled systems

Max. delivery head of PBS $H_{\max} = \dots \text{mWs}$
Max. supply pressure $p_{\max S} = \dots \text{bar}$
Switch-on pressure $p_{\text{in}} = \dots \text{bar}$
Cut-out pressure $p_{\text{out}} = \dots \text{bar}$
Max. delivery rate $V_{\max P} = \dots \text{m}^3/\text{h}$
Switch frequency $s = \dots 1/\text{h}$
Number of pumps $n = \dots$
Electrical power of most powerful pump $P_{\text{el}} = \dots \text{kW}$



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

Nominal volume $V_n = 0.33 \times V_{\max P} \frac{p_{\text{out}} + 1}{(p_{\text{out}} - p_{\text{in}}) \times s \times n}$

$V_n = 0.33 \times \dots \times \dots = \dots \text{liters}$

$V_n = \dots \text{liters}$

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

Switch-on pressure $p_{\text{in}} = \dots \text{bar}$
Cut-out pressure $p_{\text{out}} = \dots \text{bar}$
Input pressure 'refix' $p_0 = \dots \text{bar} \rightarrow \text{Reflex recommendation: } p_0 = p_{\text{in}} - 0.5 \text{ bar}$
Storage capacity $V_e = \dots \text{m}^3$

$p_0 = \dots \text{bar}$

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

$V_n = \dots \times \dots = \dots \text{liters}$
Selection according to brochure = $\dots \text{liters}$

$V_n = \dots \text{liters}$

Check of perm. excess operating pressure

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

$p_{\max} = p_{\max S} + \dots \text{bar} = \dots \text{bar}$

$p_{\max} = \dots \text{bar}$

Result summary

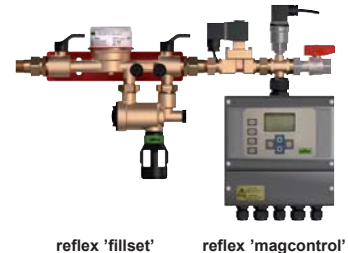
'refix DT5'	liters	10 bar <input type="checkbox"/>	Nominal volume V_n	liters
With duo connection DN 50	liters	10 bar <input type="checkbox"/>	Usable volume V_0	liters
'refix DT5'	liters	16 bar <input type="checkbox"/>	Input pressure p_0	liters

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 $p < p_0 + 0.3$ 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 \dot{V} can be determined on the basis of the k_{vs} value.



reflex 'fillcontrol'

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Make-up volume

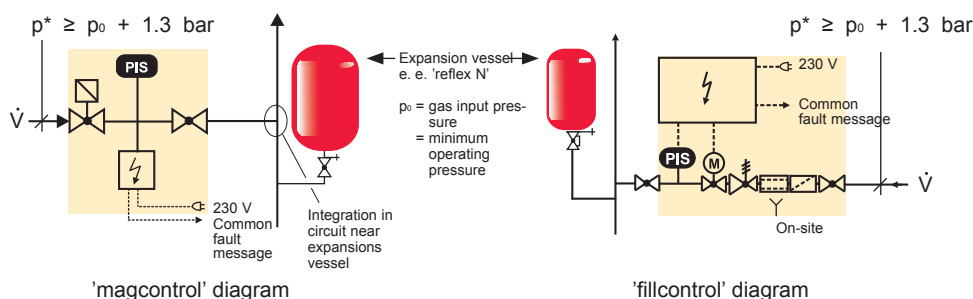
$$\dot{V} \approx \sqrt{p^* - (p_0 + 0.3)} \times k_{vs}$$

Setting values

$p_0 = \dots\dots\dots$ bar
 $p_{sv} = \dots\dots\dots$ bar

	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'



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

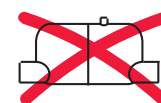
The pressure is indicated on the display and monitored by the controller (min/max fault message). If the pressure falls below the initial value ($p < p_0 + 0.3$ bar), the necessary checks are performed and degassed water made up by means of leakage volume monitoring. This also enables refilling of systems during manual operation. This helps to minimize the amount of oxygen injected into the system.

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

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Make-up volume System volume

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

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

Degassing of water-/glycol mixtures is a more elaborate process, a fact that is underlined by the special technical equipment of the 'servitec' 60/gl system.



reflex 'servitec'

► The operating pressure must be within the working range of the pressure maintenance = p_i to p_r .

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

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

► Make-Up and Degassing Stations

+49 2382 7069-567

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

From our joint research with the technical university of Dresden

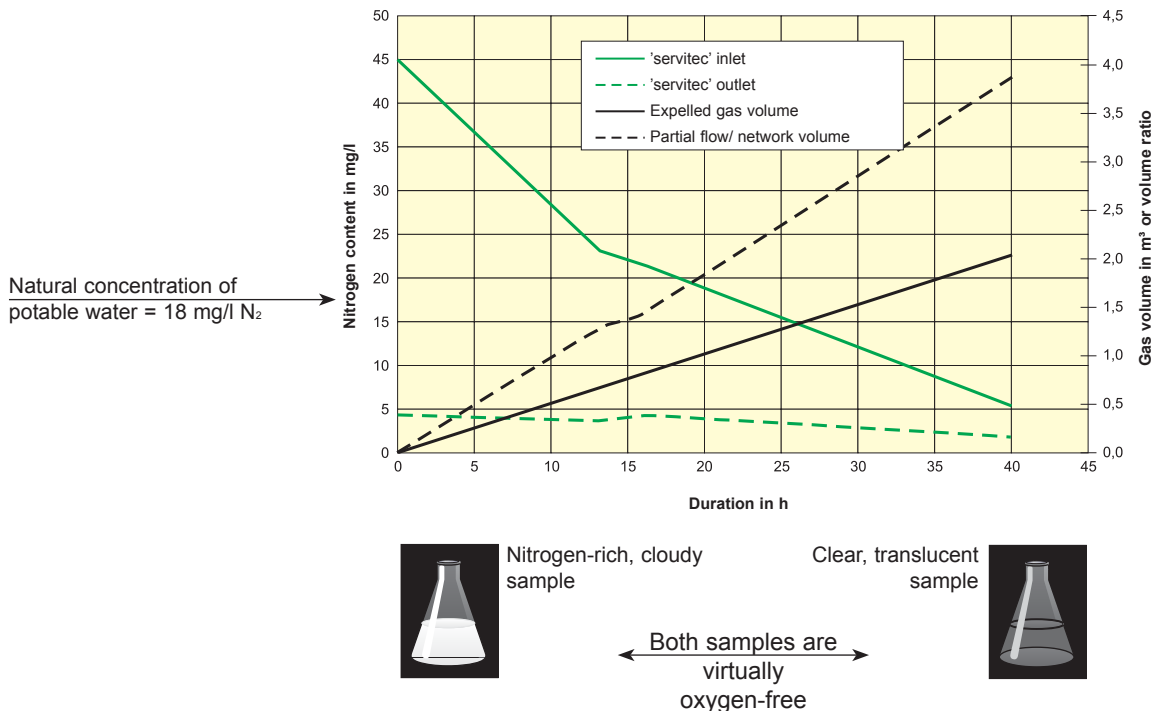
Many heating systems suffer from "air problems". Intensive research in conjunction with the Energy Technology Institute of the Technical University of Dresden has shown that nitrogen is one of the main causes of circulation problems. Measurements on existing systems produced nitrogen concentrations between 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

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



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

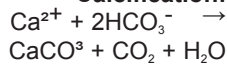
Water hardness

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: 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: 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
 $v_b < 0.3 \text{ l/kW}$

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/m^3 , while 1 mol/m^3 converts to 5.6 dGH.

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



Softening processes

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

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

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

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.

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

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

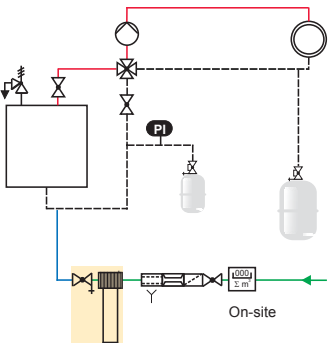


Diagram for 'fillsoft I' + 'fillset compact'

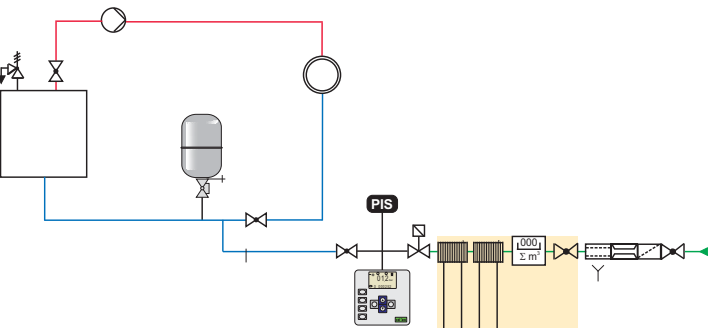


Diagram for 'magcontrol' + 'fillsoft II' + 'fillmeter' + 'fillset compact'



'fillsoft I'



'fillsoft II'



'FS softmix'

► reflex 'softmix' produces partially demineralized water



'fillmeter'

► reflex 'fillmeter' monitors the capacity of 'fillsoft'

reflex 'fillsoft'

Object:

Initial data					
Heat generator	1	2	3	4	
Heat output	$\dot{Q}_b = \dots\dots\dots$ kW	$\dots\dots\dots$ kW	$\dots\dots\dots$ kW	$\dots\dots\dots$ kW	$\dot{Q}_{tot} = \dots\dots\dots$ kW
Water content	$V_w = \dots\dots\dots$ liters	$\dots\dots\dots$ l	$\dots\dots\dots$ l	$\dots\dots\dots$ l	$\dot{Q}_{min} = \dots\dots\dots$ kW
Water content known	$V_s = \dots\dots\dots$ liters	→ p. 6 Approximate water content $V_s = f(t_F, t_R, \dot{Q}_{tot})$			$V_s = \dots\dots\dots$ liters
Specific values					
Output-specific boiler water content	$v_b = \frac{V_c}{\dot{Q}_b} = \dots\dots\dots$	$= \dots\dots\dots$ l / kW			$v_b = \dots\dots\dots$ l/kW
Output-specific system content	$v_s = \frac{V_s}{\dot{Q}_{min}} = \dots\dots\dots$	$= \dots\dots\dots$ l / kW			$v_s = \dots\dots\dots$ l/kW
Water hardness					
Regional total water hardness	$GH_{act} = \dots\dots\dots$ dGH	Information from water utility or self-measurement → p. 30			$GH_{act} = \dots\dots\dots$ dGH
Target total water hardness	$GH_t = \dots\dots\dots$ dGH	→ table on p.30 or details from relevant manufacturer			$GH_t = \dots\dots\dots$ dGH
Soft water capacity of:					
'fillsoft I'	$K_w = 6,000$ l * dGH				$K_w = \dots\dots\dots$ l*dGH
'fillsoft II'	$K_w = 12,000$ l * dGH				
'fillsoft FP'	$K_w = 6,000$ l * dGH/unit				
Possible filling and make-up water volumes					
Possible filling water volume (mixed)	$V_F = \frac{K_w}{(GH_{act} - GH_t)} = \dots\dots\dots$	For $GH_{act} > GH_t$			$V_F = \dots\dots\dots$ liters
Possible make-up water volume	$V_m = \frac{K_w}{(GH_{act} - 0.11 \text{ dGH})} = \dots\dots\dots$	For $GH_{act} > 0.11$ dGH			$V_m = \dots\dots\dots$ liters
No. of cartridges required to fill system	$n = \frac{V_s (GH_{act} - GH_t)}{K_w} = \dots\dots\dots$				$n^{1)} = \dots\dots\dots$ liters
Possible residual make-up volume after filling	$V_m = \frac{n * 6,000 \text{ l dGH} - (V_s * (GH_{act} - GH_t))}{(GH_{act} - 0.11 \text{ dGH})} = \dots\dots\dots$	For $GH_{act} > 0.11$ dGH			$V_m = \dots\dots\dots$ liters

Result summary			
'fillsoft'	Type	System content V_s	
'FP replacement cartridge'	Quantity	Possible filling water volume (partially/fully demineralized)	
'softmix'	<input type="checkbox"/> Yes <input type="checkbox"/> No	Possible residual make-up volume (fully demineralized)	
'fillmeter'	<input type="checkbox"/> Yes <input type="checkbox"/> No	Possible residual make-up volume (partially demineralized)	
'GH hardness testing kit'	Quantity		



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

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

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

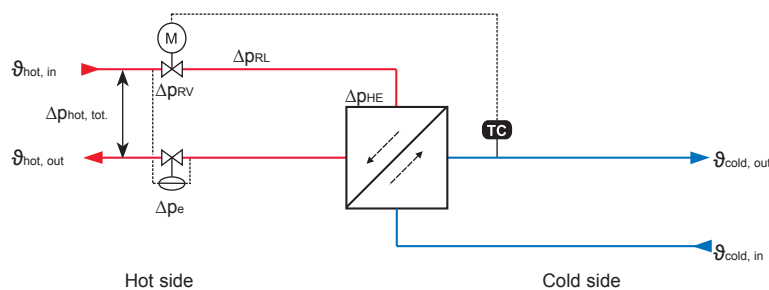
► ¹⁾ Round cartridge no. n up to the nearest whole number

Heat exchangers

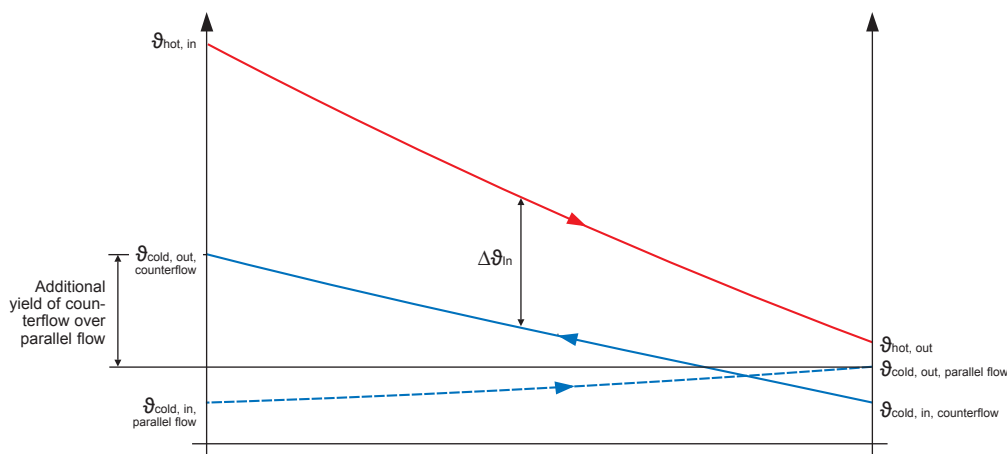
Heat balances The role of a heat exchanger is to transfer a specific heat quantity from the hot to the cold side. The transfer capacity is not only device-specific but also dependent on the required temperatures. As a result, we do not speak of ... kW heat exchangers, but rather that a device can transfer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

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

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

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

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

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.

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

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

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

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

Physical principles

Heat balances Heat emission and absorption of heat transfer media

$$\dot{Q} = \dot{m} \times c \times (\vartheta_{\text{in}} - \vartheta_{\text{out}})$$

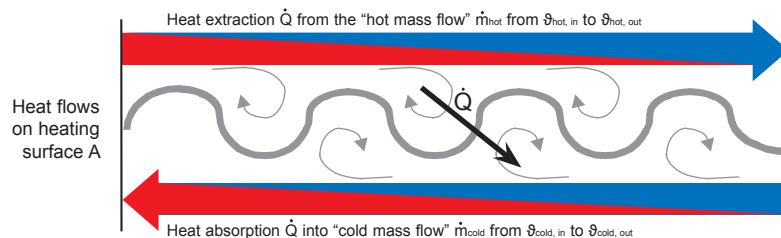
Based on the specified temperature spread and the circulated mass, the above formula can be used to calculate the capacity to be transferred.

Heat transport via heat exchanger plates

$$\dot{Q} = k \times A \times \Delta\vartheta_m$$

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 $\Delta\vartheta_m$ 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.



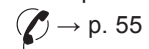
Initial data The following values must be known to be able to configure a heat exchanger:

- 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



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.

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

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.

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

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/(kW).

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

The technical specifications below are based on the rules already applied. The European standards to be applied in the future, e.g. EN ISO 4126-1 for safety valves, had not been accepted at the time of printing 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 to 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/(kW) relative to the connected overall heat output.

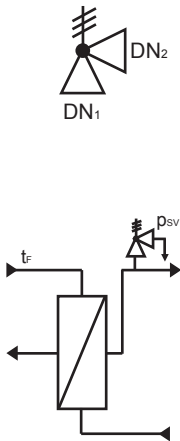
Safety valves on heat generators according to DIN EN 12828, TRD 721***

Code letter H, blow-off pressure p_{sv} 2.5 and 3.0 bar

Inlet connection [G] - outlet connection [G]	1/2 - 3/4	3/4 - 1	1 - 1 1/4	1 1/4 - 1 1/2	1 1/2 - 2	2 - 2 1/2
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
p_{sv} /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



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_f / °C	≤ 138	≤ 143	≤ 147	≤ 151	≤ 155	≤ 158	≤ 161	≤ 164	≤ 170	≤ 175	≤ 179	≤ 184

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

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
1/2	≤ 200	75
3/4	> 200 ≤ 1000	150
1	> 1000 ≤ 5000	250
1 1/4	> 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

Safety valves in cooling systems and on expansion vessels

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

Inlet connection	1/2	3/4	1	1 1/4	1 1/2	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	24.2	34.9

* Contact the manufacturer for up-to-date values

** Protection of Reflex expansion vessels in pressurization systems

Vessels up to 1000 liters, Ø 740 mm, G 1/2 = 3100 kW = 3100 l/h
as of 1000 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

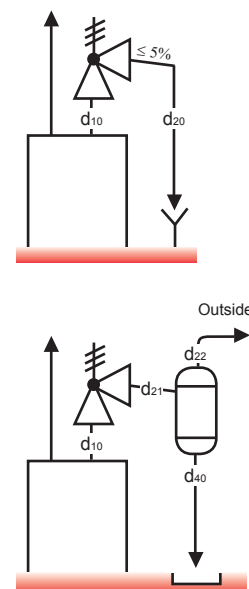
Exhaust lines must meet the conditions of DIN EN 12828, TRD 721 and – in the case of solar energy systems – VDI 6002. In accordance with DIN EN 12828, safety valves are to be fitted in such a way that the pressure loss in the connection line to the heat generator does not exceed 3% of the nominal pressure 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

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

Safety valve d ₁ d ₂ DN DN		Nominal output of heat generator Q kW	SV without 'T expansion trap'			SV with or without 'T expansion trap'			Type T	SV with 'T expansion trap'						
			Exhaust line			SV supply				SV – T line			Exhaust line			Water discharge line
			d ₂₀ DN	Length m	No. of bends	d ₁₀ DN	Length m	No. of bends		d ₂₁ DN	Length m	No. of bends	d ₂₂ * DN	Length m	No. of bends	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 $p_{SV} \leq 10$ bar

		SV without 'T expansion trap'				SV with or without 'T expansion trap'						SV with 'T expansion trap'							
Safety valve		Exhaust line				SV supply						SV – T line			Exhaust line			Water discharge line	
d ₁ DN	d ₂ DN	d ₂₀ DN	Length m	No. of bends	Blow.press. bar	d ₁₀ DN	Length m	No. of bends	Type T	Blow.press. bar	d ₂₁ DN	Length m	No. of bends	d ₂₂ * DN	Length m	No. of bends	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 $PL_{min} \leq 105^{\circ}\text{C}$ does not require a minimum pressure limiter in all cases. It is only required as a replacement measure for the water level limiter on directly heated heat generators.

A minimum pressure limiter can also be used to monitor function in systems with pressurization systems that are not supported by an automatic make-up system.

Expansion lines, shut-off, draining

Expansion lines **DIN EN 12828:** "Expansion lines must be dimensioned such that their flow resistance Δp can only bring about a pressure increase to which the pressure limiters (PL_{max}) and safety valves (p_{sv}) do not respond."

Heat generators up to 120°C

The base volume flow to be applied is 1 liter/(h kW) relative to the nominal heat output of the heat generator Q.

In the case of suction pressure maintenance, the permissible pressure loss Δp 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:

$$\Delta p (1 \text{ liter}/(\text{h kW})) = \Sigma (RI + Z).$$

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
Q/kW Length ≤ 10 m	350	2100	3600	4800	7500	14000	19000	29000
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 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).

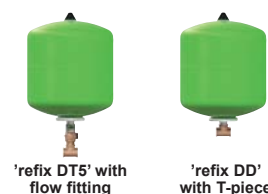
Draining

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

In the case of 'refix 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.

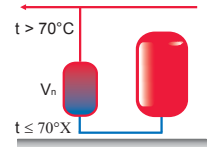


reflex 'V In-line vessels'

'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 $\leq 0^\circ\text{C}$ should be avoided.



In heating systems As a rule, heating systems are operated at return temperatures of $\leq 70^\circ\text{C}$. The installation of in-line vessels is not necessary. In the case of older systems and industrial plants, return temperatures $> 70^\circ\text{C}$ 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.

$$V_n = \frac{\Delta v}{100} V_s (0.5 \dots 1.0)$$

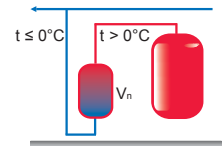
→ Δn , see "Properties and Auxiliary Variables" on p. 6

→ V_s system volume

- 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

In cooling circuits If the temperature drops to $\leq 0^\circ\text{C}$, we recommend that the in-line vessel be dimensioned as follows.

$$V_n = 0.005 V_s$$



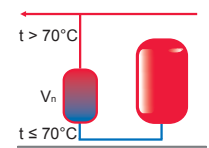
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In solar energy systems Without evaporation

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

With evaporation

$$V_n = \frac{\Delta v}{100} V_s + V_c$$



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

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 Temperature overshoot max. 10 K	STL with $t_{PR} > t_{dSec} (p_{SV})$, STL not required if primary temperature $\leq 105^{\circ}\text{C}$ or use of STM if $t_{PR} > t_{smax}^1)$		
Temperature regulator ²⁾	As of heating medium temperatures $> 100^{\circ}\text{C}$, setpoint value $\leq 60^{\circ}\text{C}$, maximum value 95°C (not applicable for gr. I)			
Low-water protection - Low boiler level	$\dot{Q}_n \leq 300 \text{ kW}$ Not required if no permissible heating with low water level	$\dot{Q}_n > 300 \text{ kW}$ LWP or SPLmin or flow restrictor	To preserve controllability, a minimum volume flow via the heat exchanger must be ensured. ³⁾	
	LWB or SPLmin or flow restrictor or suitable device		---	
- Boilers in roof-mounted systems	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 $\geq 150\%$ of max. operating pressure			
Safety valve In accordance with prEN 1268-1 or prEN ISO 4126-1, TRD 721	Calculation for steam outflow	$t_{PR} > t_{dSec} (p_{SV})$ ³⁾ Calculation for steam outflow with \dot{Q}_n	$t_{PR} \leq t_{dSec} (p_{SV})$ ³⁾ water outflow 1 l/(h·kW)	
'T' expansion trap' per SV	'T' for $\dot{Q}_n > 300 \text{ kW}$, or substitute 1 STL + 1 SPL _{max}		---	
Pressure limiter max. TÜV-approved	Per heat generator for $\dot{Q}_n > 300 \text{ kW}$, SPL _{max} = $p_{SV} - 0.2 \text{ bar}$		---	
Pressure maintenance Expansion vessel	- Pressure regulation within boundaries of p ₁ ... p ₂ as expansion vessel or EV with external pressure generation - Protected shut-off and draining of EVs should be possible for maintenance purposes			
Filling systems	- Assurance of operational min. water seal V _{ws} , autom. make-up with water meter - Connections to potable water systems must comply with prEN 806-4, or DIN 1988 or DIN EN 1717			
Heating				
			Primary shut-off valve, if $t_{PR} > t_{dSec} (p_{SV})$ Recommendation: primary shut-off valve also for $t_{PR} > t_{per \text{ sec}}$	

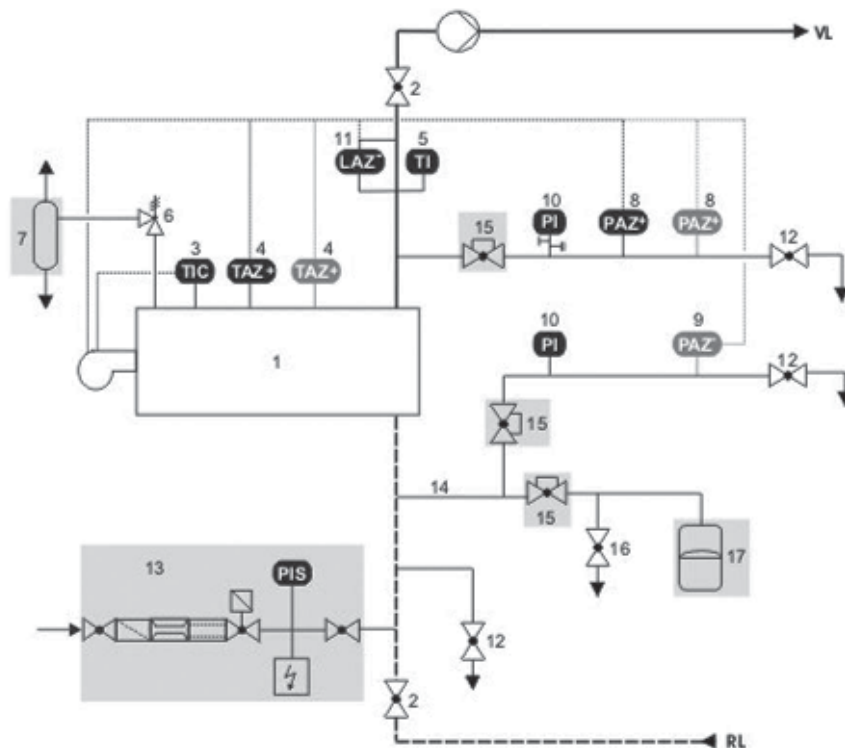
¹⁾ STL recommended as STM automatically releases heating when temperature drops below limit, thus "sanctioning" the failure of the regulator

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



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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/drainage 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/drainage 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

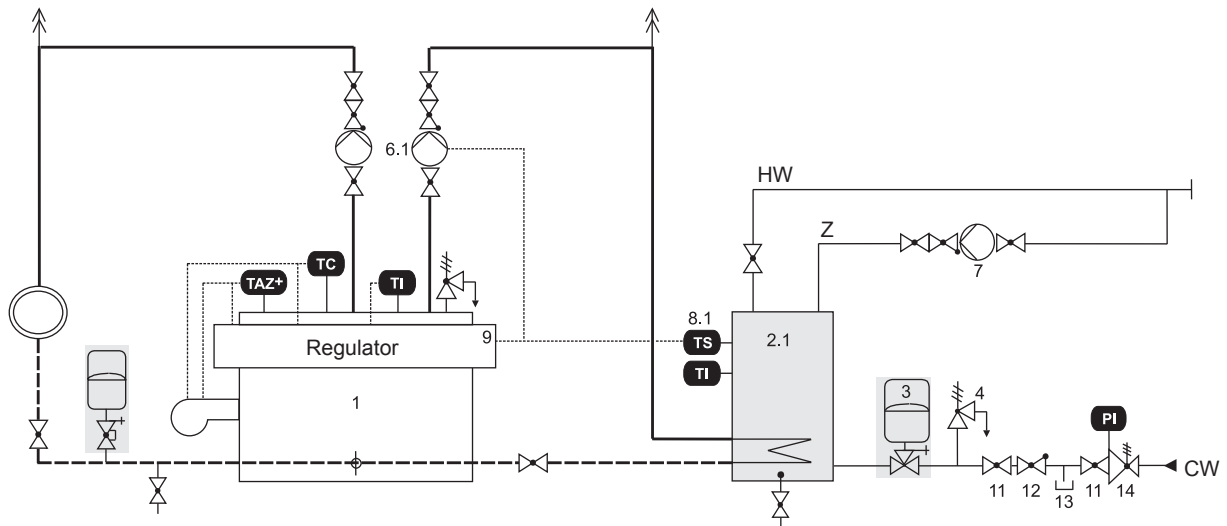
Potable water heater closed, indirect heating

Grouping according to DIN 4753 T1: Gr. I $p \times l \leq 300 \text{ bar} \times \text{liters}$ whereby $\dot{Q} \leq 10 \text{ kW}$ or $V \leq 15 \text{ l}$ and $\dot{Q} \leq 50 \text{ kW}$
Gr. II if gr. I thresholds exceeded

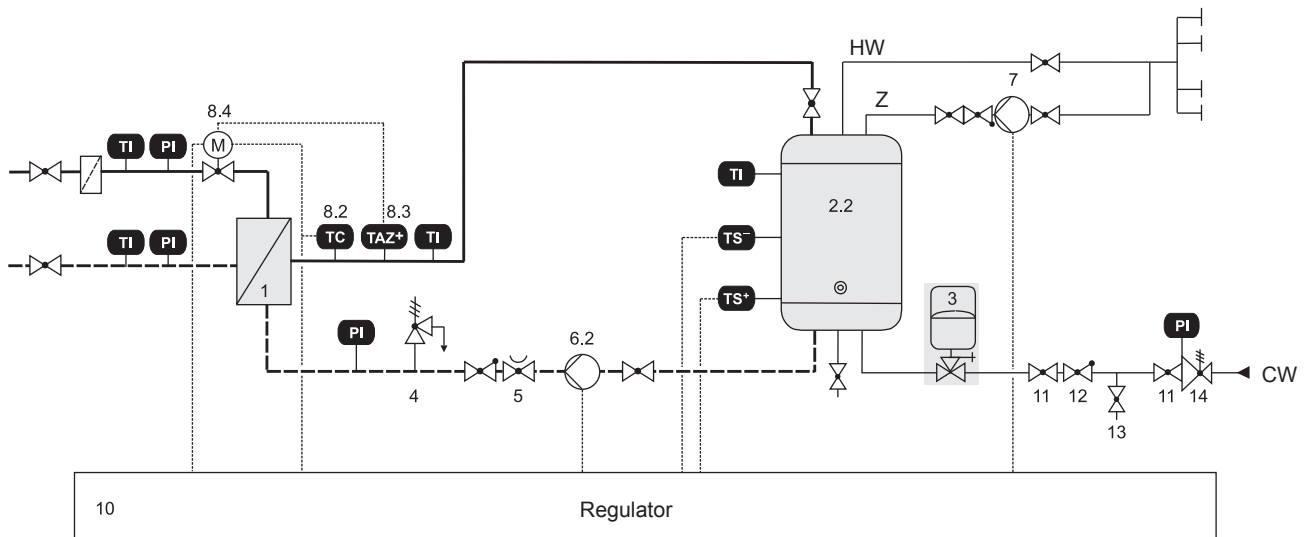
Temperature protection		DIN 4753 T1, DIN 4747															
Thermometer		May be part of regulator, not required for gr. I															
Temperature regulator type-tested		As of heating medium temperatures > 100°C, setpoint value ≤ 60°C, maximum value 95°C (not applicable for gr. I)															
Safety temperature limiter According to DIN 3440		As of heating medium temperatures > 110°C, setpoint value ≤ 95°C, maximum value 110°C for $V < 5000 \text{ l}$ and $\dot{Q} \leq 250 \text{ kW}$, no intrinsic safety according to DIN 3440 required; 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, recommended for cold water systems															
Safety valve		<ul style="list-style-type: none"> - Installation in cold water line - No shut-offs or impermissible narrowing between water heater and safety valve <table> <tr> <th>Nominal content of water space</th><th>Max. heating output</th><th>Connection nominal diameter</th></tr> <tr> <td>≤ 200 l</td><td>75 kW</td><td>DN 15</td></tr> <tr> <td>≤ 1000 l</td><td>150 kW</td><td>DN 20</td></tr> <tr> <td>≤ 5000 l</td><td>250 kW</td><td>DN 25</td></tr> <tr> <td>> 5000 l</td><td>Selection according to max. heating capacity</td><td></td></tr> </table>	Nominal content of water space	Max. heating output	Connection nominal diameter	≤ 200 l	75 kW	DN 15	≤ 1000 l	150 kW	DN 20	≤ 5000 l	250 kW	DN 25	> 5000 l	Selection according to max. heating capacity	
Nominal content of water space	Max. heating output	Connection nominal diameter															
≤ 200 l	75 kW	DN 15															
≤ 1000 l	150 kW	DN 20															
≤ 5000 l	250 kW	DN 25															
> 5000 l	Selection according to max. heating capacity																
Pressure reducing valve DVGW-approved		Required: <ul style="list-style-type: none"> - If pressure cold water supply > 80% of safety valve actuation pressure - 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 expansion vessel-W acc. to DIN 4807 T5		- Requirements of DIN 4807 T5: <ul style="list-style-type: none"> Water flow under defined conditions Green color Diaphragms and non-metallic parts acc. to KTW-C as a minimum Installation of pressure reducing valve Protected shut-off of expansion vessel 															
Potable water protection		- Input pressure set to 0.2 bar below pressure reducing valve															
Potable water protection		DIN 1988 T2, T4 or DIN EN 1717															
Backflow preventer 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 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) e.g. plate heat exchanger reflex 'longtherm' 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) e.g. tube heat exchanger 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 $\leq 100^\circ\text{C}$



Example B: Hot water systems in storage charging system, heating medium $> 110^\circ\text{C}$ 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

► Code letters, symbols
→ page 53

Also possible as combined fitting
with safety valve 4

Inspection and maintenance of systems and pressure vessels

What is tested and why

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

Specific legal requirements apply for the manufacture, 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.



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.

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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.

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 As per diagram 2 in Appendix II of DGRL		Pre-commissioning, § 14	Recurring inspections, § 15			
			Inspecting party	Inspecting party	Maximum intervals in years		Strength^{(2)}
				External ⁽¹⁾	internal ⁽²⁾	
V ≤ 1 liter and		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 ≤ 1000 bar						
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 As per diagram 4 in Appendix II of DGRL	Pre-commissioning, § 14 Inspecting party	Recurring inspections, § 15			
		Inspecting party	Maximum intervals in years		
			External ¹⁾	internal ²⁾	Strength ²⁾
PS ≤ 10 bar or PS x V > 10000 bar x liters 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 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 'longterm' 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 'longterm'!
Applicable for permissible operating temperatures $t > t_{\text{boiling}}$ at atmospheric pressure + 0.5 bar.

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

Note: 'longterm' 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 'longterm' 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

General safety instructions

'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 Prüfintervalle 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, Herstellername 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 Betriebsüberdrucks 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 Wässern erfolgen. Der Zutritt von Luftsaurestoff in das gesamte Heiz- und Kühlwassersystem durch Permeation, Nachspeisewasser usw. ist im Betrieb zu vermeiden, um die Lebensdauer zu verlängern. Wasseraufbereitungsanlagen sind nach dem aktuellen Stand der Technik auszuwählen, 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 Vorfüllmenge des 'reflex' mit Wasser sicherzustellen. Für das Entleeren/wässern ist ein Ablauf bereitzustellen, erforderlichenfalls ist eine Kaltwasserzuleitung 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.

'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'

Details concerning 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

Anhang 1 Annex 1

'reflex'

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

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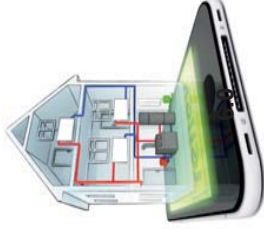
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Quick selection table for 'reflex N' and 'reflex S'

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 bar		2.5			3.0			4.0			5.0			V _n			V _n						
P _{sv}		0.5	1.0	1.5	liters	0.5	1.0	1.5	1.8	liters	1.5	2.0	2.5	3.0	3.5	4.0	liters	2.0	2.5	3.0	3.5	4.0	5.0
Input pressure p ₀ bar		65	30	---	8	85	50	19	---	8	55	30	5	---	---	---	8	75	60	41	24	7	---
		100	45	---	12	120	75	29	---	12	80	45	7	---	---	---	12	110	90	60	36	10	---
		170	85	---	18	200	130	60	17	18	140	85	28	---	---	---	18	190	150	110	70	32	---
		270	150	33	25	320	220	120	55	25	230	150	70	---	---	---	25	290	240	180	130	75	---
		410	240	80	35	470	340	200	110	33	330	240	130	25	---	---	33	440	370	290	220	140	---
		610	380	110	50	700	510	320	200	50	540	380	230	70	---	---	50	660	560	450	350	240	24
		980	500	170	80	1120	840	440	260	80	870	650	410	120	---	---	80	1060	900	750	600	430	90
		1230	620	210	100	1400	1050	540	330	100	1090	820	430	150	---	---	100	1320	1130	940	750	560	100
		1720	870	300	140	1960	1470	760	460	140	1530	1140	610	200	---	---	140	1850	1580	1320	1060	790	140
		2450	1240	420	200	2800	2100	1090	660	200	2180	1630	870	290	---	---	200	2640	2260	1890	1510	1130	210
Content V _s liters		3060	1550	530	250	3500	2630	1360	820	250	2720	2040	1090	370	---	---	250	3300	2830	2360	1890	1410	260
		3680	1860	630	300	4200	3150	1630	990	300	3270	2450	1300	440	---	---	300	3960	3390	2830	2260	1700	310
		4900	2480	850	400	5600	4200	2180	1320	400	4360	3270	1740	580	---	---	400	5280	4520	3770	3020	2260	410
		6130	3100	1060	500	6920	5250	2720	1650	500	5450	4080	2170	730	---	---	500	6600	5660	4710	3770	2830	520
		7350	3720	1270	600	8400	6300	3260	1980	600	6540	4900	2610	880	---	---	600	7920	6790	5660	4520	3390	620
		9800	4970	1690	800	11200	8400	4350	2640	800	8710	6540	3480	1170	---	---	800	10560	9050	7540	6030	4520	830
		12250	6210	2120	1000	13830	10500	5440	3300	1000	10890	8170	4350	1460	---	---	1000	13200	11310	9430	7540	5660	1030



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Selection example

p_{sv} = 3 bar
H = 13 m
Q̇ = 40 kW (plates 90/70°C)
V_{bw} = 1000 l (V_l buffer tank)

Calculate:

→ V_s = 40 kW x 8.5 l/kW + 1000
= 1340 l
→ p₀ ≥ (13/10 + 0.2 bar) = 1.5 bar

Reflex recommendations:

- Select sufficiently high safety valve actuation pressure $p_{sv} \geq p_0 + 1.5 \text{ bar}$
- If possible, apply a 0.2 bar margin when calculating the gas input pressure: $p_0 \geq \frac{H \text{ [m]} + 0.2 \text{ bar}}{10}$
- Due to the required supply pressure for the circulating pumps, select an input pressure of at least 1 bar for roof-mounted systems also: $p_0 \geq 1 \text{ bar}$
- 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: $p_{in} \geq p_0 + 0.3 \text{ bar}$

Approximate water content:

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