Pressurization systems

Heating , cooling & potable

Planning, calculating and equipment

reflex

in partnership with

altecnic

Contents

altecnic

reflex

Calculation procedures

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

- Calculation forms
- Auxiliary variables

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

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.altecnic.co.uk'.

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.

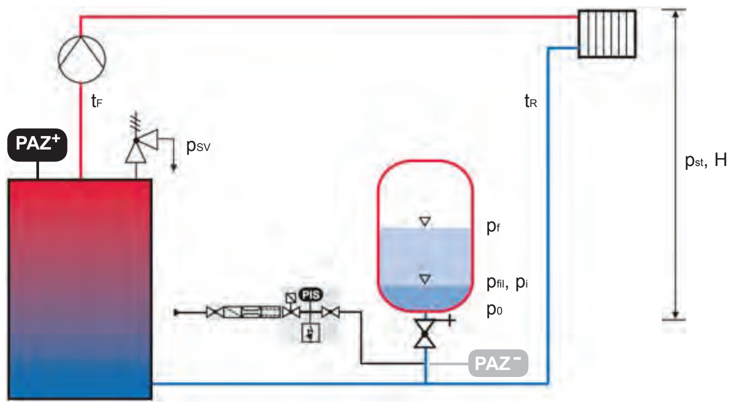
Role of pressurization systems

Pressurization systems play a central role in heating and cooling circuits and perform three main tasks:

1. They keep the pressure within permissible limits at all points of the system, thus ensuring that the authorized excess operating pressure is maintained while safeguarding a minimum pressure to prevent vacuums, cavitation and evaporation.
2. They compensate for volume fluctuations of the heating or cooling water as a result of temperature variations.
3. Provision for system-based water losses by means of a water seal.

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

Calculation parameters



Most common configuration:

- Circulating pump in advance
- Expansion vessel in return
  =
  suction pressure maintenance

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

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

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

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

0.2 bar

p_f Final pressure — Pressure in the system at **maximum temperature**

Setpoint value range for pressure maintenance= normal pressure level

V_e Expansion volume

p_{fil} Filling pressure — Pressure in the system at **filling temperature**

p_i Initial pressure — Pressure in the system at **minimum temperature**

Normal pressure range

= Pressure maintenance setpoint value between p_i and p_f

≥ 0.3 bar

V_{WS} Water seal

Water seal V_{WS} to cover system-related water losses

p_0 Minimum operating pressure — Minimum pressure to avoid
- Vacuum formation
- Evaporation
- Cavitation

= Input pressure for expansion vessel

PAZ− = PL_{min} Minimum pressure limiter

≥ 0.2 bar + p_e

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)

Properties and auxiliary variables

Properties of water and water mixtures

Pure water without antifreeze additive

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

Water with antifreeze additive* 20% (vol.)
Lowest permissible system temperature -10°C

t / °C	0	10	20	30	40	50	60	70	80	90	100	105	110	120	130	140	150	160
n* / % (- 10°C of t)	0.07	0.26	0.54	0.90	1.33	1.83	2.37	2.95	3.57	4.23	4.92	---	5.64	6.40	7.19	8.02	8.89	9.79
p_e* / bar						-0.9	-0.8	-0.7	-0.6	-0.4	-0.1	---	0.33	0.85	1.52	2.38	3.47	4.38
ρ / kg/m³	1039	1037	1035	1031	1026	1022	1016	1010	1004	998	991	---	985	978	970	963	955	947

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

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

n - Percentage expansion for water based on a minimum system temperature of +10°C (generally filling water)
n* - Percentage expansion for water with antifreeze additive* based on a minimum system temperature of -10°C or -20°C
Δv - Percentage expansion for water for calculation of temperature layer containers between 70°C and max. return temperature
p_e - Evaporation pressure for water relative to atmosphere
p_e* - Evaporation pressure for water with antifreeze additive
ρ - Density
* - Antifreeze Antifrogen N; when using other antifreeze additives, the relevant properties must be obtained from the manufacturer

Approximate calculation of water content V_s of heating systems

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

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

V_s = -------------------- + -------------------- + -------------------- = -------------------- liters

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

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

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

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

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

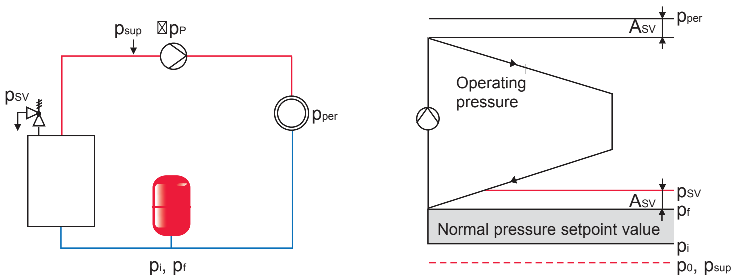
- Approx. water content of heating pipes

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

Hydraulic integration

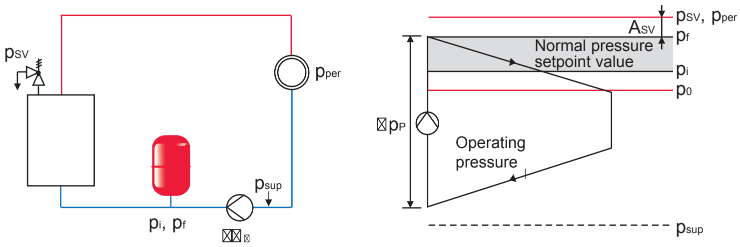
The hydraulic integration of pressure maintenance in the overall system greatly influences the pressure profile. This is made up of the normal pressure level of the pressure maintenance and the differential pressure generated when the circulating pump is running. Three main types of pressure maintenance are distinguished, although additional variants exist in practice.

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



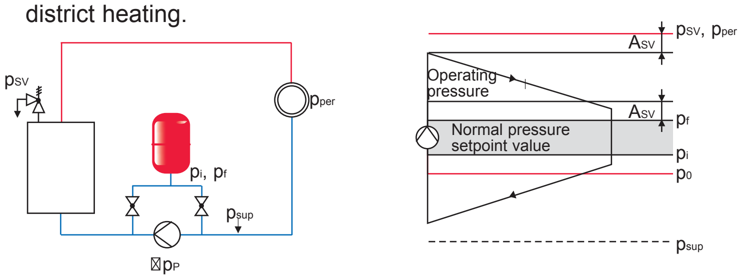
- Advantages:
  - Low normal pressure level
  - Operating pressure > normal pressure, thus no risk of vacuum formation
- Disadvantages:
  - High operating pressure in the case of high circulating pump pressure (large-scale systems); p_{per} must be observed

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

- **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

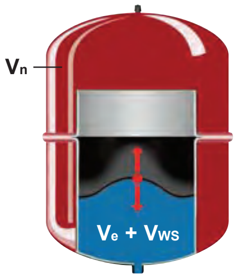
- **'Degassing of heating and cooling systems'**
This brochure explains when and why the use of degassing systems is required, particularly in closed systems.

	Standard pressure maintenance Flow temp. up to 120°C	Pressure maint.	Autom. operation with make-up	Central deaera-tion and degassing	Preferred output range	
'reflex' expan-sion 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 x V = constant). Therefore, it is not possible to use the entire nominal volume for water intake purposes. The nominal volume is greater than the water intake volume $V_e + V_{WS}$ by a factor of $\frac{p_f + 1}{p_f - p_0}$.

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

Without degassing

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

With reflex 'servitec'

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

Pressure monitoring
Input pressure p_0
Minimum operating pressure

The gas input pressure must be manually checked before commissioning and during annual maintenance work; it must be set to the minimum operating pressure of the system and entered on the name plate. The planner must specify the gas input pressure in the design documentation. To avoid cavitation on the circulating pumps, we recommend that the minimum operating pressure not be set to less than 1 bar, even in the case of roof-mounted systems and heating systems in low-rise buildings. The expansion vessel is usually integrated on the suction side of the circulating pump (input pressure maintenance). In the case of pressure-side integration (follow-up pressure maintenance) the differential pressure of the circulating pumps 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.

Input pressure maintenance

$p_0 \geq p_{st} + p_e + 0.2$ bar
$p_0 \geq 1$ bar Reflex recommendation

Follow-up pressure maintenance

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

Initial pressure p_a
Water make-up

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

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

reflex 'control' make-up stations automatically monitor and secure the initial or filling pressure. → reflex 'control' make-up stations

Reflex formula for initial pressure

$p_i \geq p_0 + 0.3$ bar

Filling pressure p_{fil}

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

Final pressure p_f

The final pressure restricts the upper setpoint value range of the pressure maintenance. It must be set such that the pressure on the system safety valve is lower by at least the closing pressure difference A_{SV} in accordance with TRD 721. The closing pressure difference depends on the type of the safety valve.

Reflex recommendation

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

$p_{SV} \geq p_0 + 1.5$ bar
for $p_{SV} \leq 5$ bar
$p_{SV} \geq p_0 + 2.0$ bar
for $p_{SV} > 5$ bar

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

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

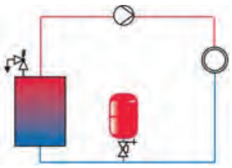
Degassing
Deaeration

Targeted venting is very important, particularly in the case of closed systems; otherwise, accumulations of nitrogen in particular can lead to troublesome malfunctions and customer dissatisfaction. reflex 'servitec' degases and makes up water automatically.

Heating systems

Calculation According to DIN 4807 T2 and DIN EN 12828

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



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

Properties n, p_e Generally properties for pure water without antifreeze additive → page 4

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

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

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

Reflex recommendation:

$p_0 \geq 1$ bar

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

Pressure maintenance In the form of static pressure maintenance with 'reflex N, F, S, G' also in combination with the make-up and degassing stations 'control' and 'servitec', or from approx. 150 kW as a 'variomat' pressurization station for pressure maintenance, degassing and water make-up, or in the form of a compressor-controlled 'reflexomat' pressurization station. → page 16

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

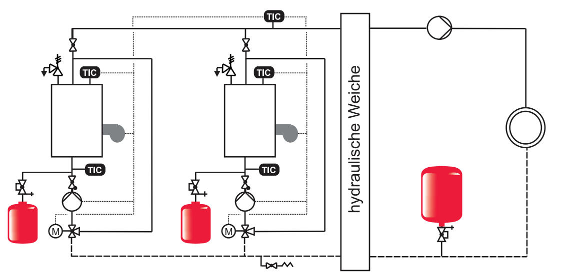
▶ In the case of corrosion risk, use 'refix'

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

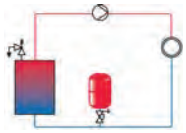
In-line vessels If a temperature of 70°C is permanently exceeded by the pressure maintenance, an in-line vessel must be installed to protect the diaphragms in the expansion vessel.

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

Due to the excellent degassing performance of 'variomat', we recommend that the switch frequency be minimized by also fitting a diaphragm expansion vessel (e.g. 'reflex N') to the heat generator in this case.



'reflex N, F, G' in heating systems



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

Object:

Initial data

		1	2	3	4		
Heat generator		1	2	3	4		
Heat output	Q_h =	.... kW	.... kW	.... kW	.... kW	**Q_{tot} = ... kW**	
Water content	V_W =	.... liters					
System flow temperature	t_F =	.... °C	→ p. 4	Approximate water content $V_s = f(t_F, t_R, Q)$		**V_s = ... liters**	▶ If $_R$ > 70°C, 'V in-line vessel' required
System return temperature	t_R =	.... °C					
Water content known	V_s =	.... liters					
Highest setpoint value adjustment Temperature regulator	t_{TR} =	.... °C	→ p. 4	Percentage expansion n (with antifreeze additive n*)		**n = ... %**	
Antifreeze additive	=	.... %					
Safety temperature limiter	t_{STL} =	.... °C	→ p. 4	Evaporation pressure p_e at > 100°C with antifreeze additive p_e*)		**p_e = ... bar**	
Static pressure	p_{st} =	.... bar				**p_{st} = ... bar**	

Pressure calculation

Input pressure p_0 = stat. pressure p_{st} + evaporation pressure p_e + (0.2 bar)[1]
p_0 = ...+......................................+ (0.2 bar)[1] = ... bar
Reflex recommendation p_0 ≥ 1.0 bar
p_0 = ... bar

[1] Recommendation

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

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

▶ Check compliance with perm. operating pressure

Final pressure p_f ≤ safety valve p_{SV} - closing pressure difference acc. to TRD 721
p_f ≤ p_{SV} - 0.5 bar for p_{SV} ≤ 5 bar
p_f ≤ p_{SV} - 0.1 x p_{SV} for p_{SV} > 5 bar
p_f ≤ .... - .... = ... bar
p_f = ... bar

Vessel

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

Water seal V_{WS} = 0.005x V_s for V_n > 15 liters with V_{WS} ≥ 3 liters
V_{WS} ≥ 0.2 x V_n for V_n ≤ 15 liters
V_{WS} ≥ ....x .... = ... x .... = ... liters
V_{WS} = ... liters

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

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

V_n ≥ .... x .... = ... liters
Selected V_n 'reflex' = ... liters
V_n = ... liters

Initial pressure check

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

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

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

p_i = ... bar

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

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

Result summary

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

altecnic

reflex

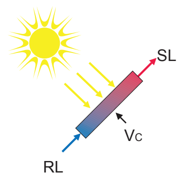
Solar heating plants (solar energy systems)

Calculation

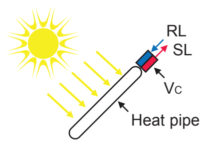
On the basis of VDI 6002 and DIN 4807 T2

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

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

Nominal volume

Calculation with evaporation in the collector

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

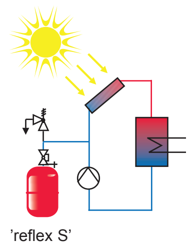
This is the preferred option, as the lower temperature has a lesser impact on the heat transfer medium and the antifreeze effect is maintained for a longer period.

Nominal volume with evaporation

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

Configuration

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



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. 4, properties for water mixtures with Antifrogen N

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

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

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

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

Input pressure p_0
Minimum operating pressure

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

Without evaporation

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

With evaporation

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

▶ Enter set input pressure on name plate

Filling pressure p_{fil}
Initial pressure p_a

As a rule, the filling temperature (10°C) is much higher than the lowest system temperature, such that the filling pressure is greater than the initial pressure.

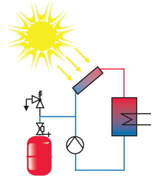
Pressure maintenance

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

In-line vessels

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

reflex 'S' in solar energy systems with evaporation



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

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

Object:

Initial data

Number of collectors	z	.... units			
Collector surface area	A_C	.... m²	A_{Ctot} = z x A_C	A_{Ctot} = ... m²	**A_{Ctot} = ... bar**
Water content per collector	V_C	.... liters	V_{Ctot} = z x A_C	V_{Ctot} = ... liters	**V_{Ctot} = ... liters**
Highest flow temperature Lowest ambient temperature Antifreeze additive	t_F t_a	110°C or 120°C - 20°C .... %	→ p. 4 Percentage expansion n* and evaporation pressure p_e*		**n* = ... %** **p_e* = ... bar**
Static pressure	p_{st}	.... bar			**p_{st} = ... bar**
Difference at circulating pump	Δp_P	.... bar			**Δp_P = ... bar**

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

Pressure calculation

Input pressure
p_0 = stat. pressure p_{st} + pump pressure Δp_P + evaporation pressure p_e*
p_0 = ... + ... + ...
= .... bar
p_0 = ... bar

▶ Check compliance with perm. operating pressure

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

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

Vessel

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

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

Water seal
V_{WS} = 0.005 x V_s for V_n > 15 liters with $V_{WS} \ge 3$ liters
$V_{WS} \ge 0.2$ x V_n for $V_n \le 15$ liters
V_{WS} ≥ .... x .... = ... x .... = ... liters
V_{WS} = ... liters

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

Check of initial pressure
$$p_i = \frac{p_f + 1}{1 + \frac{(V_e + V_{Ctot})(p_f + 1)}{V_n (p_0 + 1)}} - 1 \text{ bar}$$
p_i = ... / (1 + ... / ....) – 1 bar = ... bar
p_i = ... bar

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

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

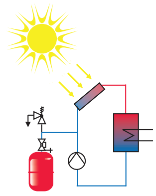
Filling pressure
$$p_{fil} = V_n \times \frac{p_0 + 1}{V_n - V_s \times n_F^* - V_{WS}} - 1 \text{ bar}$$
p_{fil} = ... x .... – 1 bar = ... liters
p_{fil} = ... bar

Result summary

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

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

reflex 'S' in solar energy systems without evaporation



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

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

Object:

Initial data

Number of collectors	z	.... units			
Collector surface area	A_C	.... m²	$A_{Ctot} = z \times A_C$	A_{Ctot} = ... m²	A_{Ctot} = ... bar
Water content per collector	V_C	.... liters	$V_{Ctot} = z \times A_C$	V_{Ctot} = ... liters	V_{Ctot} = ... liters
Highest advance temperature	t_F		→ p. 4 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			Δp_P = ... bar

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

Pressure calculation

Input pressure
p_0 = stat. pressure p_{st} + pump pressure Δp_P + evaporation pressure p_e*
p_0 = ... + ... + ...
= .... bar
p_0 = ... bar

▶ Check compliance with perm. operating pressure

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

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

Vessel

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

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

Water seal
V_{WS} = 0.005 x V_s for V_n > 15 liters with V_{WS} ≥ 3 liters
V_{WS} ≥ 0.2 x V_n for V_n ≤ 15 liters
V_{WS} ≥ .... x .... = ... x .... = ... liters
V_{WS} = ... liters

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

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

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

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

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

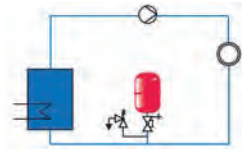
Result summary

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

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

Cooling water systems

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



'reflex'

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

Properties n* When determining the percentage expansion n*, antifreeze additives appropriate for the lowest system temperature must be included in accordance with manufacturer specifications.
For Antifrogen N → p. 5

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

Minimum operating pressure p_0 Since no temperatures > 100°C are used, no special margins are required.

▶ Enter set input pressure on name plate

Filling pressure p_{fil} Initial pressure p_i In many cases, the lowest system temperature is less than the filling temperature, meaning that the filling pressure is higher than the initial pressure.

Pressure maintenance Generally in the form of static pressure maintenance with 'reflex', also in combination with 'control' and 'servitec' make-up and degassing stations.

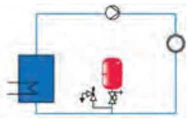
Degassing, deaeration, water make-up To ensure ongoing safe and automatic operation in cooling water systems, the pressurization units should be equipped with make-up systems and supplemented with 'servitec' degassing systems. This is particularly important with cooling water systems, since no thermal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

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

Individual protection As in the case of heating systems, we recommend the use of individual protection for multiple refrigerating machines.
→ Heating systems, p. 8.

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

Configuration Input pressure maintenance, expansion vessel on suction side, circulating pump, observe information on page 7 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* →. 4 n* = n* at highest temp. (t_{Smax} or t_R) - n* at lowest temp. (t_{Smin} or t_F) n* = ... - .... = ... °C — **n* = ... %**
Percentage expansion between lowest temperature and filling temperature = ... °C — **n_F* = ... %**
Static pressure p_{st} = ... bar — **p_{st} = ... bar**

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

Pressure calculation

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

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

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

[1] Recommendation

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

▶ Check compliance with perm. operating pressure

Vessel

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

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

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

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

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

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

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

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

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

Result summary

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

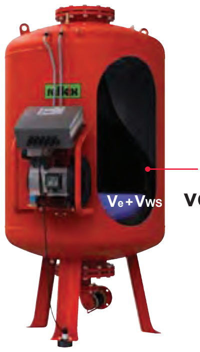
Reflex pressurization systems with external pressure generation
Types: 'variomat', 'gigamat', 'minimat', 'reflexomat'

Application

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

→ Heating systems page 8
→ Solar energy systems page 10
→ Cooling water systems page 14

However, such systems generally cover higher output ranges. → page 6



Nominal volume V_n

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

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

Pressure monitoring Minimum operating pressure p_0

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

Suction pressure maintenance

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

Final pressure maintenance

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

Initial pressure p_a

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

$p_i \geq p_0 + 0.3$ bar

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

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 bar

Working range A_p of pressure maintenance

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

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

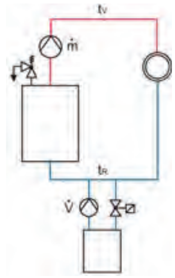
Degassing Deaeration

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

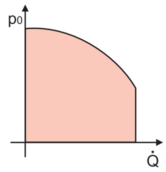
Partial flow degassing is only useful when integrated in the representative main flow of the system.

Compensating volume flow V̇

In the case of heating systems that are equipped with pressurization systems controlled by an external energy source, the required compensating volume flow must be determined on the basis of the installed nominal heat output of the heat generators.
For example, with a homogeneous boiler temperature of 140°C, the specific volume flow required is 0.85 l/kW. Deviations from this value are possible upon verification.
Cooling circuits are generally operated in a temperature range < 30°C. The compensating volume flow is approximately half that of heating systems. Therefore, when making selections using the heating system diagram, only half of the nominal heat output $\dot{Q}$ must be taken into account.



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



Redundancy due to partial load behavior

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

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

▶ Reflex recommendation:
Configuration
50% + 50% = 100%
as of 2 MW dual-pump systems
→ 'variomat 2-2'

'variomat' ≤ 8 MW
pump-controlled

'gigamat' ≤ 60 MW
pump-controlled

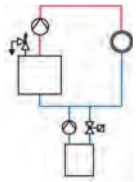
'minimat' ≤ 2 MW
compressor-controlled

'reflexomat' ≤ 24 MW
compressor-controlled

altecnic
reflex

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 7 for follow-up pressure maintenance

Object:

Initial data

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

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

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

▶ t_{TR} max. 105°C

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

Pressure calculation

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

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

Condition p_0 ≥ 1.3 bar

p_0 = ... bar

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

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

p_f = ... bar

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

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

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

p_{SV} ≥ .... + ... = ... bar

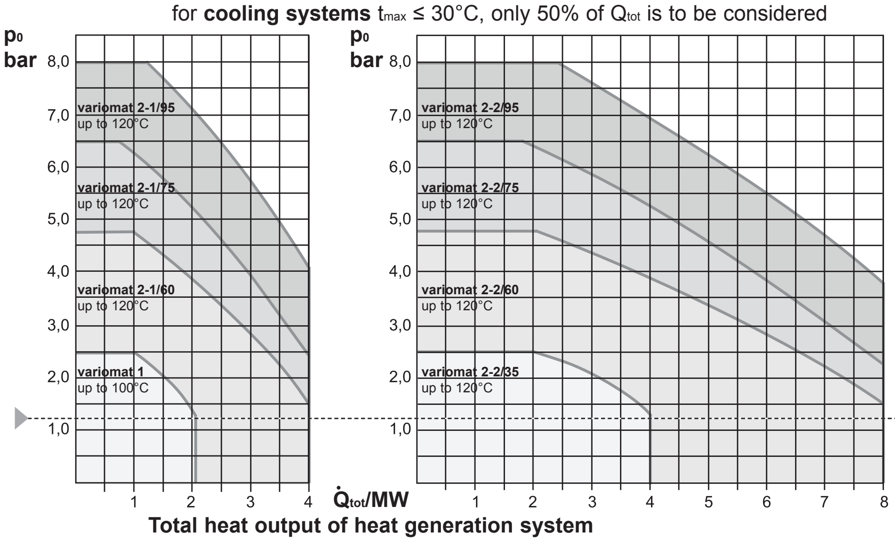
p_{SV} = ... bar

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

▶ Check compliance with perm. operating pressure

Control unit selection

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



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

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

p_0 = 1.3 bar min. setting value for continuous degassing

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

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

Vessel

Nominal volume V_n taking water seal into account

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

V_n = ... liters

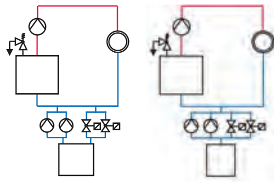
▶ The nominal volume can be distributed across multiple vessels.

Result summary

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

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

reflex 'gigamat' in heating and cooling systems



Configuration Input pressure maintenance, 'gigamat' in return, circulating pump in advance, observe information on page 7 for follow-up pressure maintenance

Object:

Initial data

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

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

▶ t_{TR} max. 105°C

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

Specific values

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

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

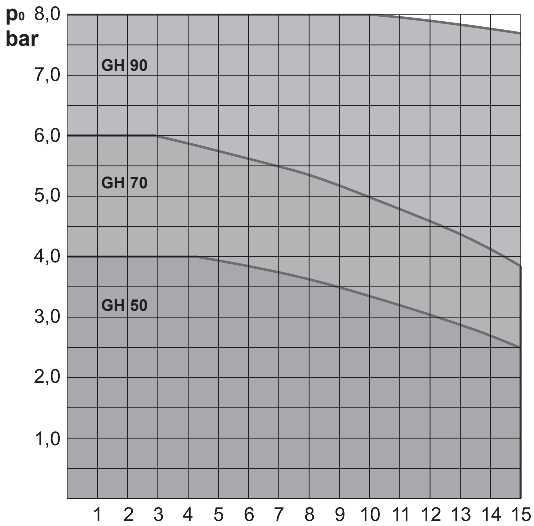
Safety valve actuation pressure p_{SV} ≥ final pressure + closing pressure difference A_{SV}
p_{SV} ≥ p_f + 0.5 bar for p_{SV} ≤ 5 bar
p_{SV} ≥ p_f + 0.1 x p_{SV} for p_{SV} > 5 bar
p_{SV} ≥ .... +... = ... bar — **p_{SV} = ... bar**

[1] Recommendation

▶ Check compliance with perm. operating pressure

Control unit selection

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



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

For systems outside the displayed output ranges, please contact us

Vessel

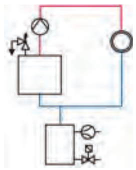
Nominal volume V_n taking water seal into account
$V_n = 1.1 \times V_s \frac{n + 0.5}{100}$ = 1.1 x .... x ....= .... bar — **V_n = ... liters**

▶ The nominal volume can be distributed across multiple vessels.

Result summary

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

reflex ’minimat’ and ’reflexomat’ in heating and cooling systems



Configuration Input pressure maintenance, ’minimat’, ’reflexomat’ in return, circulating pump in advance, observe information on page 7 for follow-up pressure maintenance

Object:

Initial data

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

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

▶ t_{TR} max. 105°C

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

Pressure calculation

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

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

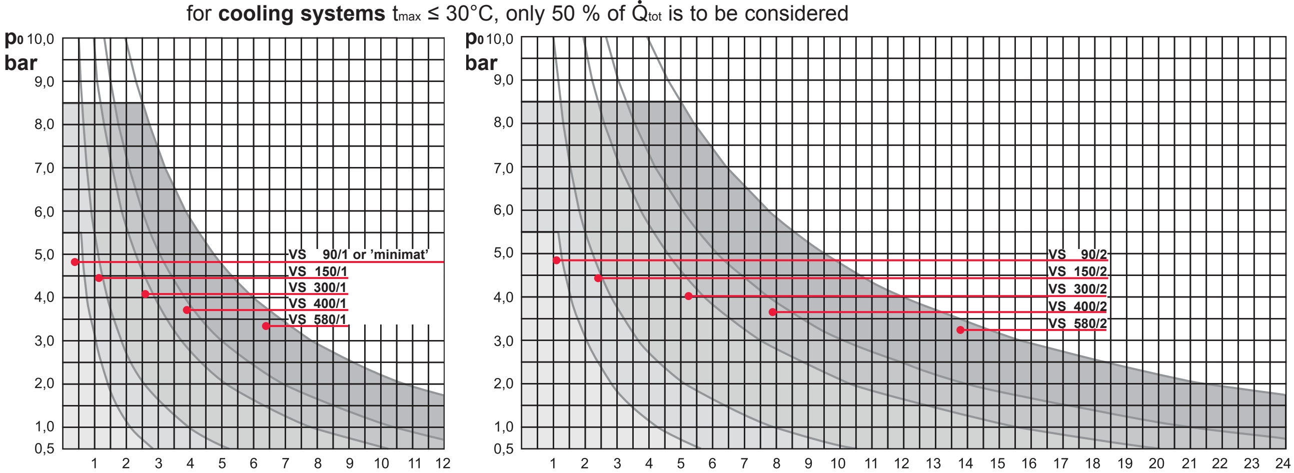
Safety valve actuation pressure $p_{SV} \geq$ final pressure + closing pressure difference A_{SV}
$p_{SV} \geq$ p_f + 0.5 bar for $p_{SV} \leq$ 5 bar
$p_{SV} \geq$ p_f + 0.1 x p_{SV} for p_{SV} > 5 bar
$p_{SV} \geq$ ....+... = ... bar **p_{SV} = ... bar**

[1)] Recommendation

▶ Check compliance with perm. operating pressure

Control unit selection

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



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

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

Vessel

Nominal volume V_n taking water seal into account

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

▶ The nominal volume can be distributed across multiple vessels.

Result summary

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

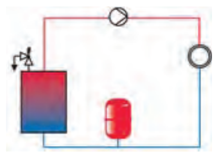
District heating systems, large-scale and special systems

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

Contact us for more information!

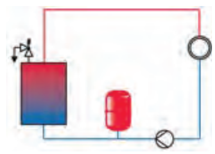
Configuration
In many cases, the configurations for district heating systems differ from those used for heating installations. As a result, systems with follow-up and medium pressure maintenance are used in addition to classic input pressure maintenance. This has a direct impact on the calculation procedure.

Input pressure maintenance



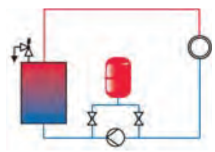
Properties n, p_e
As a rule, properties for pure water without antifreeze additive are used.

Follow-up pressure maintenance



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

Medium pressure maintenance



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

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

Initial pressure p_a
In the case of pressurization stations, the pressure pump is activated if the pressure falls below the initial value. Particularly in the case of networks with large circulating pumps, dynamic start-up and shutdown procedures must be taken into account. The difference between p_i and p_0 (= PL_{min}) should then be at least 0.5 ... 1 bar.

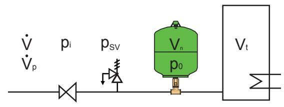
Pressure maintenance
In the case of larger networks, almost exclusively in the form of pressure maintenance with external pressure generation, e.g. 'variomat', 'gigamat', 'minimat' or 'reflexomat'. With operating temperatures over 105°C or safety temperatures STL > 110°C, the special requirements of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

Degassing
We recommend that heat generation systems that do not have a thermal degassing system be equipped with a 'servitec' vacuum spray-tube degassing unit.

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

Hot water systems

Calculation According to DIN 4807 T5 → see form on p. 23



Configuration As per adjacent diagram.
As a rule, the safety valve should be installed directly at the cold water inlet of the water heater. In the case of ’refix DD’ and ’DT5’, the safety valve can also be fitted directly before the flow fitting (in water flow direction), provided that the following conditions are met:

’refix DD’ with T-piece:

Rp ¾	max. 200 l water heater
Rp 1	max. 1,000 l water heater
Rp 1¼	max. 5,000 l water heater

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

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

▶ Enter set input pressure on name plate

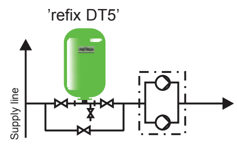
Input pressure p_0
Minimum operating pressure

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

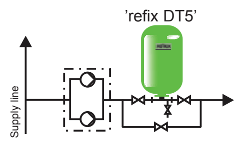
Initial pressure p_a The initial pressure is identical to the set pressure of the pressure reducing valve. Pressure reducing valves are required in accordance with DIN 4807 T5 to ensure a stable initial pressure and thus achieve the full capacity of the ’refix’ unit.

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

Pressure booster systems



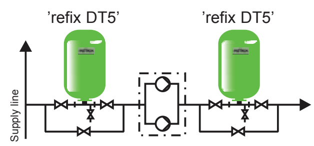
Calculation According to DIN 1988 T5: Technical rules for drinking water installations, pressure increase and reduction



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

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

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



Input pressure p_0
Initial pressure p_a

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

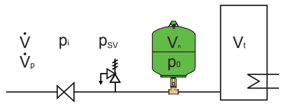
Since the initial pressure pi is at least 0.5 bar higher than the input pressure, a sufficient water seal is always ensured; this is an important prerequisite for low-wear operation.

▶ Enter set input pressure on name plate

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

'refix' in hot water systems

Object:



Initial data

Tank volume	V_t	= .... liters		
Heating output	$\dot{Q}$	= .... kW		
Water temperature in tank	t_{ww}	= .... °C	As per controller setting 50...60°C → p. 4 Percentage expansion n	**n = ... %**
Set pressure of pressure reducing valve	p_i	= .... bar		
Safety valve setting	p_{sv}	= .... bar	Reflex recommendation: p_{sv} = 10 bar	
Peak flow	$\dot{V}_p$	= .... m³/h		

Selection according to nominal volume V_n

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

p_0 = ... – .... = ... bar

p_0 = ... bar

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

V_n = ... – .... = ... liters

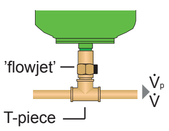
Selection according to brochure = ... liters

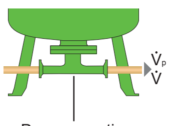
V_n = ... liters

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

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

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





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

Δp = ... bar

G = ...

* calculated for a speed of 2 m/s

Result summary

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

'refix' in Pressure Booster Systems (PBS)

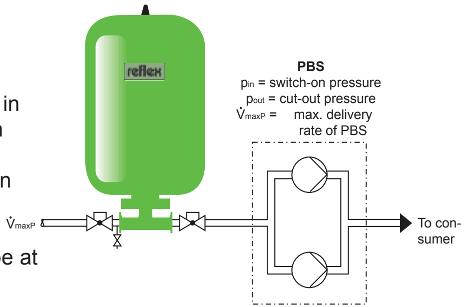
Object:

Configuration 'refix' on input pressure side of PBS

Installation: As agreed with the relevant water utility company

Necessity: Applies if the following criteria are not met

- In the event of the failure of a PBS pump, the flow rate in the PBS connection line must not change by more than 0.15 m/s
- If all pumps should fail, it must not change by more than 0.5 m/s
- During pump operation, the supply pressure must not drop below 50% of the minimum value p_{minS} and must be at least 1 bar



Initial data:

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

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

Selection acc. to DIN 1988 T5

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

V_n = ...liters

Input pressure p_0 = min. supply pressure – 0.5 bar

p_0 = ... – 0.5 bar = ... bar

p_0 = ... bar

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

- To restrict the switch frequency of pressure-controlled systems

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

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

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

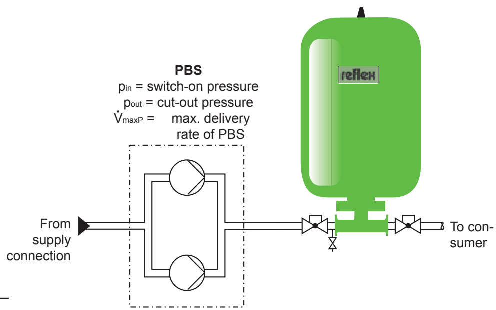
Cut-out pressure p_{out} = ... bar

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

Switch frequency s = ... 1/h

Number of pumps n = ...

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



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

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

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

V_n = ...liters

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

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

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

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

Storage capacity V_e = ... m³

p_0 = ... bar

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

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

Selection according to brochure = ... liters

V_n = ...liters

Check of perm. excess operating pressure

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

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

p_{max} = ... bar

Result summary

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

Terms

Formula letter	Explanation	See page (among others)
A_p	Working range of pressure maintenance	16
A_{SV}	Closing pressure difference for safety valves	3, 7
n	Expansion coefficient for water	4, 8, 24
n*	Expansion coefficient for water mixtures	4, 11, 13
n_R	Expansion coefficient relative to return temperature	9
p_0	Minimum operating pressure	3, 7, 16, 21, 22
p_i	Initial pressure	3, 7, 16, 21, 22
p_e	Evaporation pressure for water	4
p_e^*	Evaporation pressure for water mixtures	4
p_f	Final pressure	3, 7, 16
p_{fil}	Filling pressure	3, 7
p_{st}	Static pressure	3, 7
p_{SV}	Safety valve actuation pressure	3, 7
p_{sup}	Minimum supply pressure for pumps	5
p_{per}	Permissible excess operating pressure	5
V	Compensating volume flow	17
V_s	System volume	4
v_A	Specific water content	4
V_e	Expansion volume	3, 7, 21
V_C	Collector content	10, 12
V_n	Nominal volume	7, 16
V_{WS}	Water seal	3, 7
Δp_P	Pump differential pressure	5
ρ	Density	4

Code letters

T – Temperature

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

P – Pressure

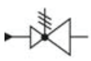
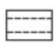
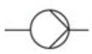
P	Pressure test port
PI	Pressure gauge
PC	Pressure regulator
PS	Pressure switch
PAZ-	Pressure limiter - min, SPL_{min}
PAZ+	Pressure limited - max, SPL_{max}

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

altecnic

reflex