

reflex

Thinking solutions.

Intelligent pressurisation of combined Heating-cooling Systems

Automated change-Over-Systems



Compact solutions for hydraulic design
of circulating systems with
combined heating/cooling elements

Reflex— a powerful brand for decades

Reflex Winkelmann GmbH—part of the Building+Industry division—is a leading provider of high-quality heating and hot-water supply technology systems. Under its Reflex brand, the company, which has its headquarters in Ahlen in the German region of Westphalia, develops, produces and sells not only diaphragm expansion vessels, but also innovative components and holistic solutions for pressure maintenance, make-up, degassing and water treatment, storage water heaters and plate heat exchangers, as well as hydraulic manifold and vessel components. Reflex Winkelmann GmbH has over 1,500 employees worldwide, giving it an international presence in all major markets.

With its energy-efficient and sustainable products, the company is already doing its bit to help the environment, as evidenced by its commitment to sustainability and the climate policy goals agreed by the German Federal Government. This support is built on proven technologies and future-oriented innovations. What's more, Reflex Winkelmann GmbH works together with others as equals, always maintains its focus on the customer and offers additional services such as its own factory service centre fleet and a comprehensive range of training options.





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General information

Basics

The heating and cooling of spaces using the same transfer devices is an approach that is becoming increasingly common, particularly in commercial buildings, where state of the art technology is used to maintain a comfortable and safe working climate.

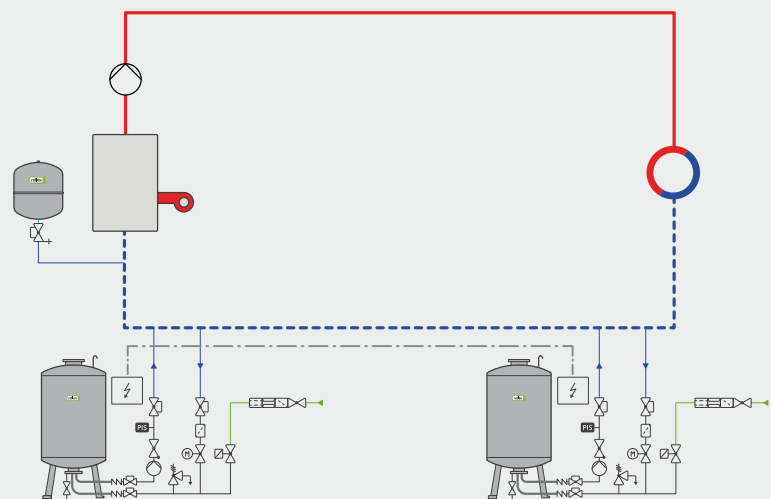
This architecturally influenced comfort requirement is achieved by using either heating or chilled water beams, when the concrete structure, is used as an active component, or space heating/cooling devices located in the void above suspended ceilings. The units known as Fan Coil Units, or FCUs. The FCUs have fans that blow a combination of fresh and recirculated air across heating and cooling heat exchangers. On a 'wet' system, there will be connection to

a four-pipe supply, with flow and return for both heating and cooling. Modulation of valves changes the space temperature, this can be either through the setting of thermostats by the space users, or as is becoming more prevalent, active monitoring by the Building Management System (BMS). Compatible components such as 6-way ball-valves are available in the market, in a wide range. Despite the shared consumers/FCUs, the design phase is based simply on the assumption of separate boiler/chiller circuits. In most instances, on these apparently complex systems, simple heating or cooling circuits are from and back to these devices in parallel. The fresh and exhaust air, to and from the FCUs, is ducted

Typical schemes for connected consumer/producer circuits

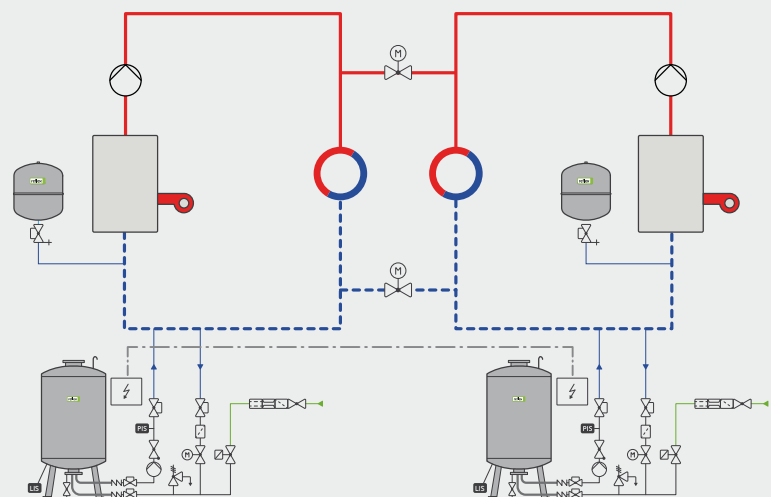
Consumer/producer

Redundant or connected pressurisation



Connected systems with redundant/alternative heat supply

with system-independent or connected pressurisation

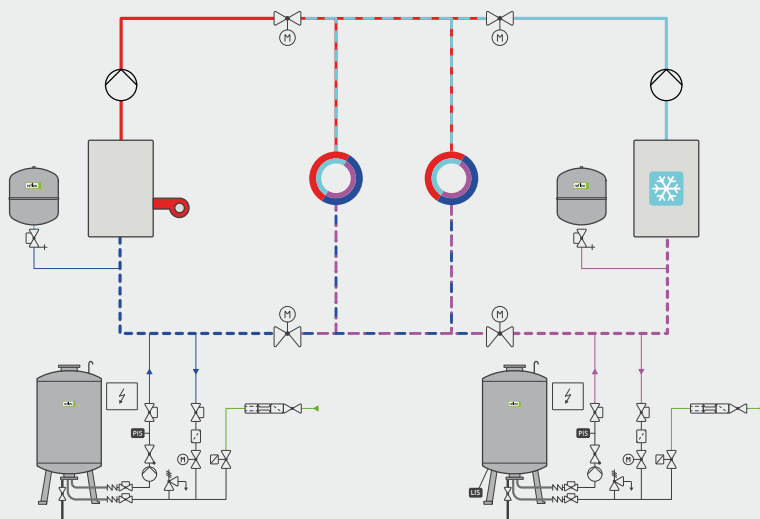
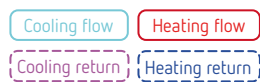


from and back to units known as Air Handling Units (AHUs). These are generally located in a plantroom, with fresh air being ducted in from outside the building. Fans are used to both draw the fresh air in, and force it out to the FCUs, located around the building. Dependant on the outside ambient temperature, the fresh air supply may be pre-heated/cooled by passing through heat exchangers. The BMS dictates which heat exchangers are to be active and modulates control valves accordingly. Exhaust air also passes through the AHUs, where sometimes, heat is reclaimed.

The AHUs are generally fed by the same boilers and chillers, as the FCUs, so when calculating system content at the design stage, the potential volume of associated pipework and heat exchangers, should be allowed for.

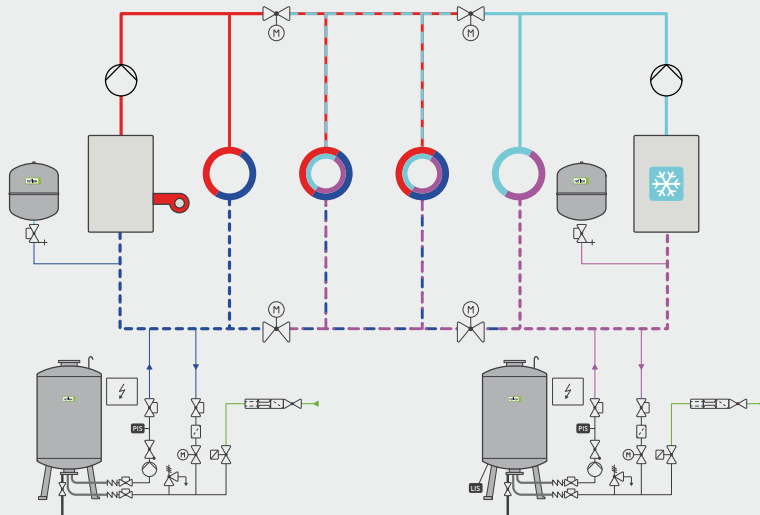
Caution!

When talking about heating/cooling systems or change-over-systems, supply networks with consumers are meant, which are used for both heating and cooling purposes and are supplied by different generator circuits.



Change-Over-System

connected system, heating/cooling, temporary switch-over with generator circuit-specific pressure maintenance incl. heat transfer mass compensation



Change-Over-System

Additionally, with pure cooling or heating consumers, pressurisation in the generator circuit incl. heat transfer mass compensation

Hydraulic circuits

Connection of the combined consumers to the producer circuit

Illustration 1

4-pipe system with four 2-way actuators for flow and return connections.

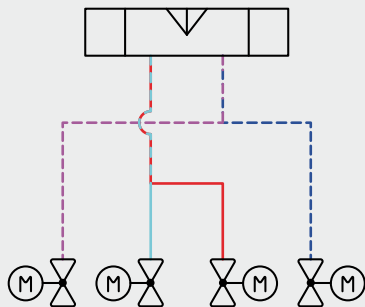


Illustration 2

4-pipe system with two motor-controlled 2-way actuators and one 3-way actuator for the returns.

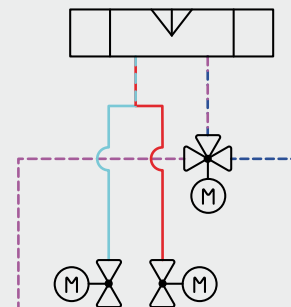


Illustration 3

4-pipe system with a motor-controlled 6-way actuator.

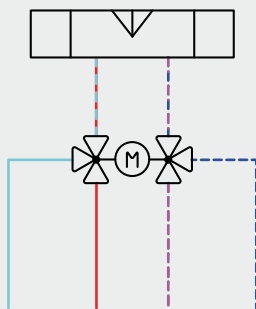
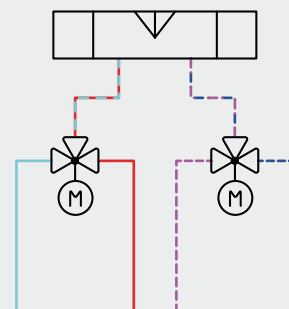


Illustration 4

4-pipe system with two motor-controlled 3-way actuators.



The diagrams serve only to illustrate the connections. They must be adapted and specified according to local conditions.



Examples of potentially occurring operating problems

If the examples of hydraulic circuits on the previous pages are not fully implemented or if there is a lack of correct function, hydraulic problems almost always occur. Just as frequently these result in assumed malfunctions in the pressurisation system.

1. Volume flow in transfer pipe

A permanent volume flow in an existing transfer pipe indicates a simultaneously existing but negatively acting other connection between heating and cooling circuits. This can be an indicator for incorrect functioning of the heating and cooling systems.

Example:

In the heating system the pump delivers the medium to the consumer. At the consumer, the heating return valve is not open, rather the cooling return valve and the circuit is closed by the 'balance' pipe/'balance' line.
→ Flow via transfer pipe!

2. Pressure maintenance without hydraulic connection of the circuits (transfer pipe)

If a transfer pipe is not used for static pressurisation in both networks or in mixed systems with dynamic and static pressurisation, temporary very large pressure differences can occur between the circuits, e.g. due to a temperature-induced mass transfer of the heat transfer medium.

Example:

These may then be reduced by switching or valve leakage rates. This can lead, among other things, to un-desired water hammer and the associated noises. If the corresponding valve design prevents overflow in the event of changeover, a medium-term negative pressure formation is to be expected due to emptying, especially in the cooling water circuit.

3. Filling level in the pressure maintenance system

Repeated overfilling during heating-water pressurisation or necessary make-up in the cooling-water network.

Example:

Return of the displaced water is not possible because there is no permanent hydraulic connection of the circuits and the necessary communication of the pressurisation system is also missing.

Planning guidelines

Initial situation

Systems that are obviously hydraulically separate (e.g., heating circuit, cooling circuit) but which are temporarily using the same consumers (change-over) are already included in the mass-balance

of the systems associated with the heat transfer medium solely as a result of the thermal load cases in the consumers, and must also be treated accordingly:




Principles

1. Mass transfer

Each time the consumers are switched (from cooling to heating – or heating to cooling), heat transfer medium (e.g. water) is moved from one circuit to the other. Due to the different temperatures of the heating or cooling medium, it then has a different density dependent on the previous operating case.

As a result, if the medium content (volume) in the heating/cooling element remains constant, the corresponding differential water mass must be replaced or discharged by the respective active system. When switching from cooling to heating, more mass of the heat transfer medium is displaced than when switching from heating to cooling. Especially the latter changeover type and the associated mass transfer can lead to a pressure drop or disfunction of the pressurisation system up to and including the pressure loss below the allowed minimum working pressure in the cooling circuit.

Also, the mass of water received by the heating system may not be problem-free from the pressurisation point of view and may overfill the system. This normal behaviour must be taken into account accordingly.

 For corresponding recommendations see **variants for integration** p. 16 – 19

2. Media mixing

Due to the mass displacement that occurs and the resulting mixing of the media from both generating circuits, the media must have the same properties from the outset (e.g. water quality, glycol concentration). For this reason, the corresponding underlying planning principles and/or materials used must also be adapted.

3. Pressurisation when the consumer is at a standstill

It must be ensured that a combined heating/cooling element with shutoffs in both flow and return, especially at a standstill, cannot build up a high or low pressure (valve's own relief circuit, secure permanent connection to a pressurised generator circuit).

- I. It is possible to equip supply networks with thematically separate generator hydraulic systems, which can, however, act temporarily and separately on the same consumers, each with system-specific pressurisation of the same design and function.
 - a. Pump pressurisation with connected head-symmetrical expansion vessels at the same installation level and in the same location.

or
 - b. Dynamic pressurisation systems are connected electronically (master/slave) and a connection (transfer pipe) is created between the circuits at the respective hydraulic zero point.

or
 - c. Static pressurisation systems (diaphragm expansion vessels) must be combined into a pressurisation system indirectly via a transfer pipe that connects the circuits at the respective hydraulic zero point.
- II. The objective is to ensure that networks with thematically separate generation hydraulics which, however, temporarily and separately act on the same consumers, are given a common pressurisation system and are thus hydraulically connected or must be connected at a defined point.
- III. Heating-cooling-systems (change-over systems) should be planned hydraulically in such a way that the participating generating circuits apply the same basic hydraulic principles (admission pressurisation, holding pressurisation position of hydraulic zero point in the circuit, e.g. upstream of the generator, at the hydraulic zero point).



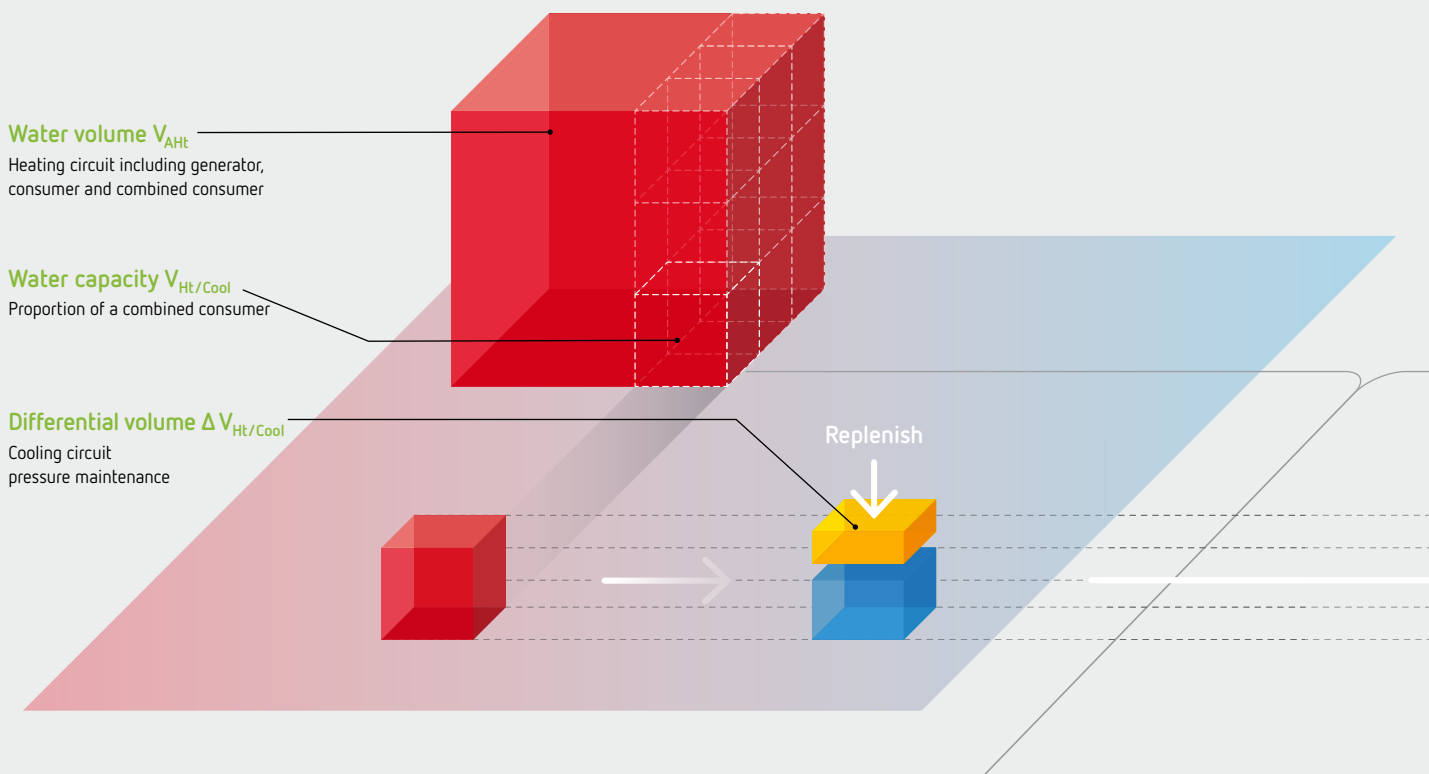
Note!

Mass transfer in the heat transfer medium

Temperature-induced heat transfer medium mass-transfer in heating/cooling operation

Case 1:

Switching from heating to cooling mode



Common consumer contents

Common consumer contents can be temporarily assigned to the heating circuit, the cooling circuit or no circuit (standstill). There can also be several consumers at different **stages**.



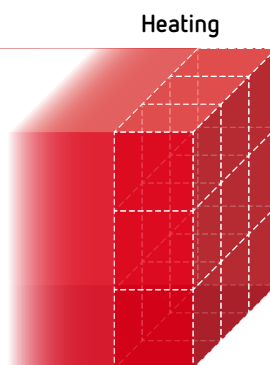
Common consumer content assigned to the **heating circuit**



Common consumer content that is assigned to the **cooling circuit**



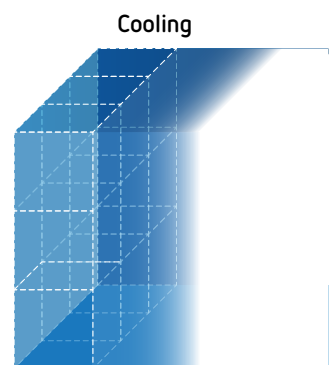
Common consumer content, which is at **standstill**



Water volume $V_{AHt/Cool}$
combined consumer assigned to **heating**

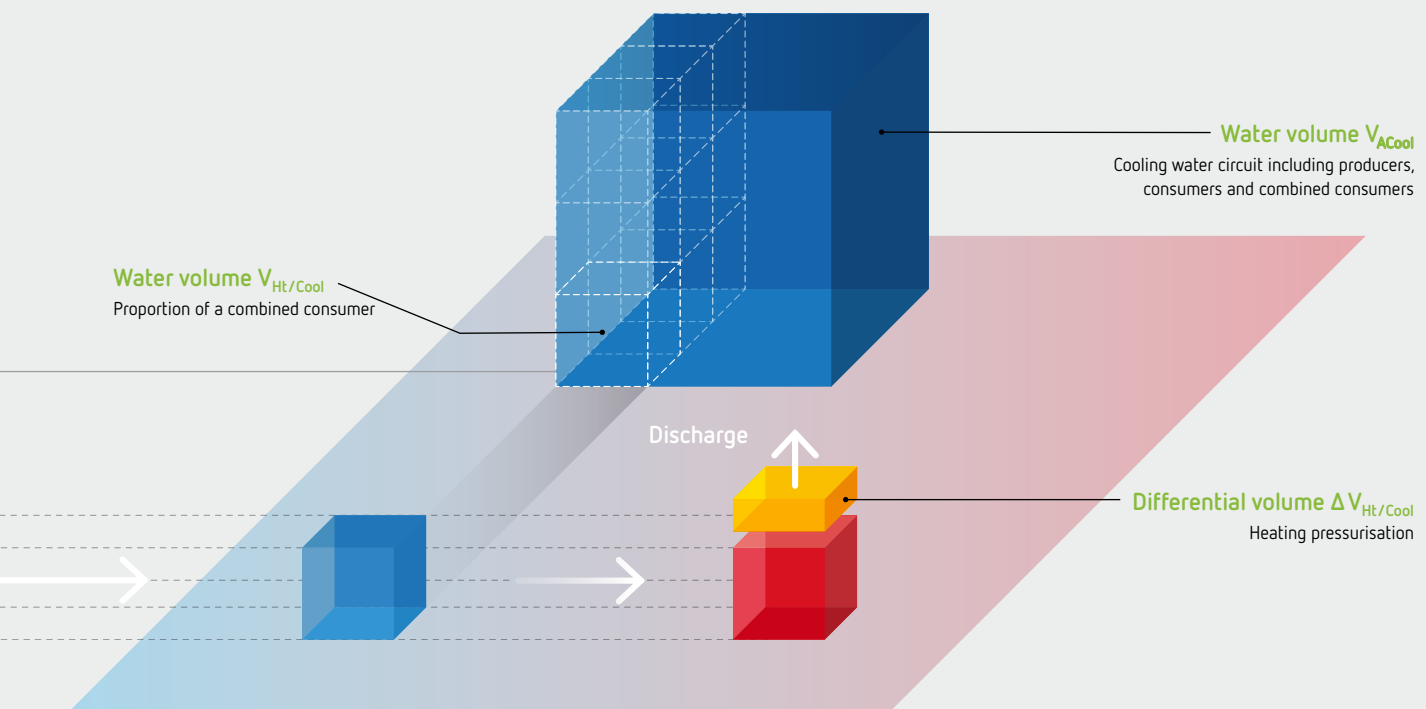


combined consumers in **mixed use**



combined consumers assigned to **cooling**

Case 2:
Switching from cooling to heating mode



Other causes for a heat transfer medium mass-transfer

- Incorrect timing when switching hydraulically from heating to cooling mode
- Leakage rate in control or shut-off devices between heating/cooling water circuit
- Defect in control or shut-off devices between heating/cooling circuit
- Unknown/undefined other hydraulic connections of the networks
- Strong pressure differences when connecting isolated heating surfaces

Summary:

For heating/cooling water circuits with change-over operation, mass return of the heat transfer medium must be provided



Example calculations

For possible temperature-related mass transfer

Key data

Office building with **120 offices** which are equipped with heating/cooling ceiling operating in change-over principle

Heating temperature program	$t_{HFL}/t_{HRL} = 35^{\circ}\text{C} / 30^{\circ}\text{C}$	Number of offices	$n = 120 \text{ Pcs.}$
Cooling temperature program	$t_{CFL}/t_{KRL} = 16^{\circ}\text{C} / 19^{\circ}\text{C}$	Average density of heating water in heating mode	$\rho_H = 993,0 \text{ kg/m}^3$
Ceiling temperature at standstill	$t_{CSt} = 20^{\circ}\text{C}$	Average density of heating water in cooling mode	$\rho_K = 999,0 \text{ kg/m}^3$
Water volume heating/cooling ceiling office	$V_C = 10 \text{ l/Pcs.}$	Density of heating/cooling water at standstill	$\rho_{St} = 998,3 \text{ kg/m}^3$



Calculation
example

1. Standstill → Heating mode

Transition from standstill to heating mode, calculation of the possible mass transfer into the active heating network during a heating process in all offices per day.

The heating network has to receive **6.0 litres per day** due to the density change during the heating process or compensate it by pressurisation assuming this process occurs in all offices. In **10 days** this amounts to **60 litres**. The filling level in the pressurisation unit in the heating circuit increases.

Calculation example

$$\Delta V_C = V_C \cdot \left(\frac{\rho_{St}}{\rho_H} \right) - V_C = 10 \text{ l} \cdot \left(\frac{998,3 \text{ kg/m}^3}{993,0 \text{ kg/m}^3} \right) - 10 \text{ l} = 0,05 \text{ l/Pcs.}$$

$$\Delta V_{Ctot} = \Delta V_C \cdot n = 0,05 \text{ l/Pcs.} \cdot 120 \text{ Pcs.} = \mathbf{6,0 \text{ l}}$$

2. Heating mode → Cooling mode

Transition from heating to cooling mode. Calculation of the possible mass transfer into the active cooling water circuit during a cooling process in all offices per day.

The cooling circuit must supply **7.2 litres per day** due to the change in density during the cooling process, or compensate for this by pressurisation, insofar as this process takes place in all offices, this equates to **72 litres** in **10 days**. The filling level in the pressurisation unit in the cooling water circuit decreases.

Calculation example

$$\Delta V_C = V_C \cdot \left(\frac{\rho_H}{\rho_K} \right) - V_C = 10 \text{ l} \cdot \left(\frac{993,0 \text{ kg/m}^3}{999,0 \text{ kg/m}^3} \right) - 10 \text{ l} = -0,06 \text{ l/Pcs.}$$

$$\Delta V_{Ctot} = \Delta V_C \cdot n = -0,06 \text{ l/Pcs.} \cdot 120 \text{ Pcs.} = \mathbf{-7,2 \text{ l}}$$

3. Cooling mode → Standstill

Transition from cooling mode to standstill, calculation of the possible mass transfer into the active cooling water circuit during a cooling process in all offices per day.

At this point, the focus should be on the fact that a change in density can also occur. In the neutral position of the control elements, the pressure increases in the heating and cooling ceiling associated with density change must be compensated.

 See Example No. 3 on p. 7

Calculation example

$$\Delta V_C = V_C \cdot \left(\frac{\rho_K}{\rho_{St}} \right) - V_C = 10 \text{ l} \cdot \left(\frac{999,0 \text{ kg/m}^3}{998,3 \text{ kg/m}^3} \right) - 10 \text{ l} = 0,007 \text{ l/Pcs.}$$

$$\Delta V_{Ctot} = \Delta V_C \cdot n = 0,007 \text{ l/Pcs.} \cdot 120 \text{ Pcs.} = \mathbf{0,8 \text{ l}}$$

4. Cooling mode → Heating mode

Transition from cooling to heating mode, calculation of the possible mass transfer into the active heating water circuit for a load case of this type per day in all offices per day.

The heating network must discharge **7.2 litres** per day due to the change in density during the heating process or compensate for this by pressurisation, assuming this process takes place in all offices, in **10 days** this equates to **72 litres**. The filling level in the pressurisation unit of the heating water circuit increases.

Calculation example

$$\Delta V_C = V_C \cdot \left(\frac{\rho_K}{\rho_H} \right) - V_C = 10 \text{ l} \cdot \left(\frac{999,0 \text{ kg/m}^3}{993,0 \text{ kg/m}^3} \right) - 10 \text{ l} = 0,06 \text{ l/Pcs.}$$

$$\Delta V_{Ctot} = \Delta V_C \cdot n = 0,06 \text{ l/Pcs.} \cdot 120 \text{ Pcs.} = \mathbf{7,2 \text{ l}}$$

Overview

Load case	Switching case	Active network	Pressurisation in the active network
1	standstill → heating	heating circuit	Filling level increases
2	heating → cooling	cooling circuit	Filling level decreases
3	cooling → standstill	–	Risk of overpressure or vacuum in the consumer if there is no pressurisation unit for standstill/shutdown operation.
4	cooling → heating	heating circuit	Filling level increases

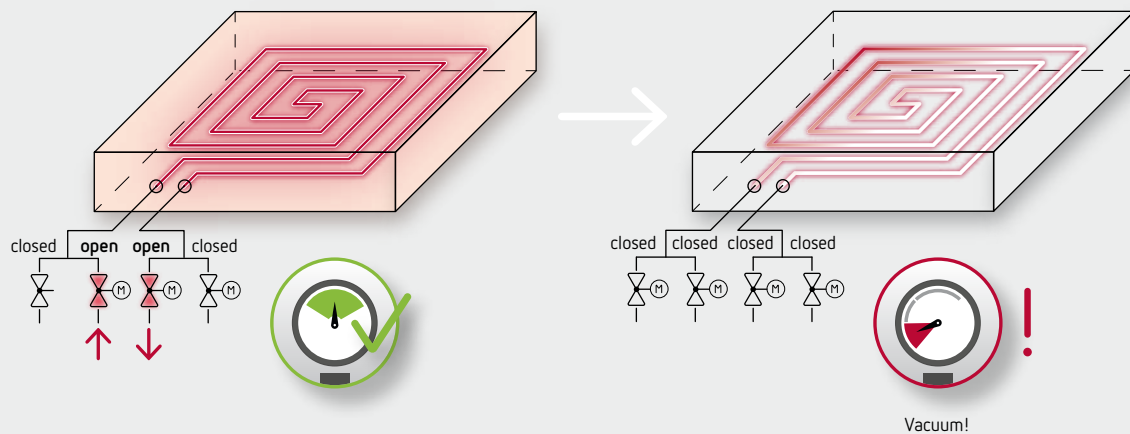
The observation shows that density changes alone tend to cause mass transfers from the cooling circuit to the heating circuit. Corresponding pressurisation measures are therefore necessary.

Standstill problem

Hydraulically insulated heating/cooling surface

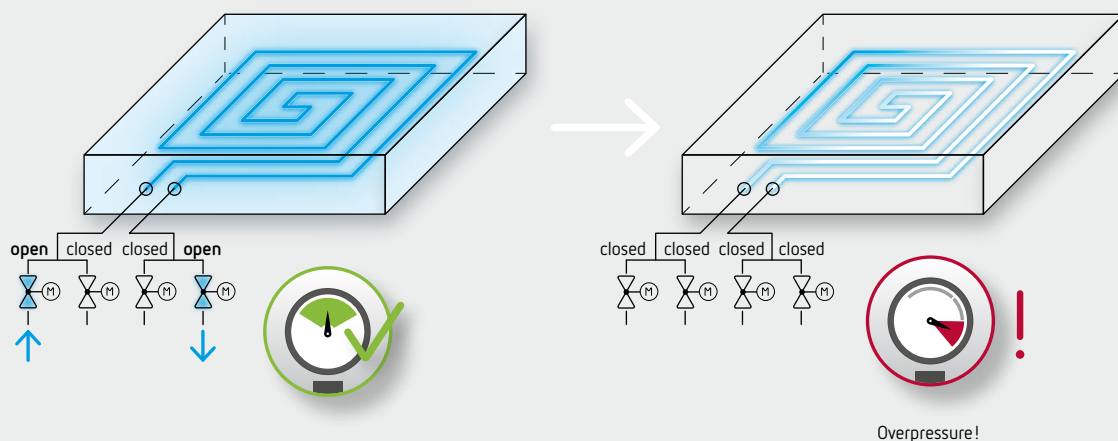
Case 1:

Switching from heating to cooling mode



Case 2:

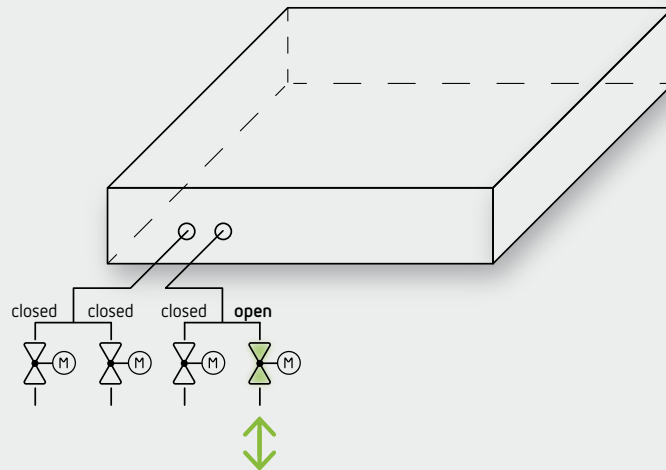
Switching from cooling mode to standstill



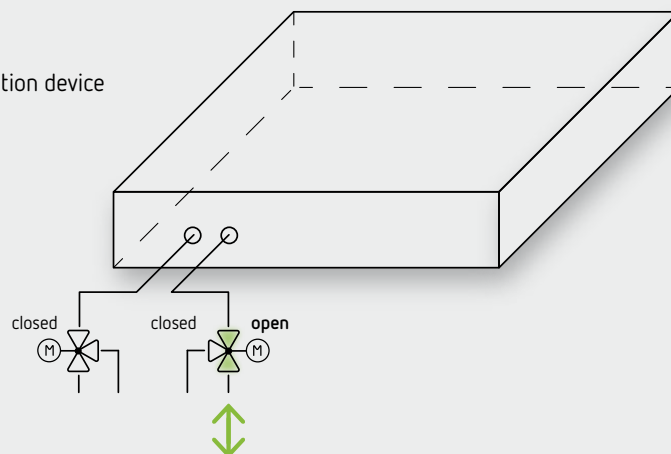
To provide pressure relief for combined heating/cooling surfaces, it must be ensured at all times that the corresponding consumers are connected to a pressurisation system, as otherwise unwanted under- or over-pressure may occur.

Hydraulically non-insulated heating/cooling surface – Solutions

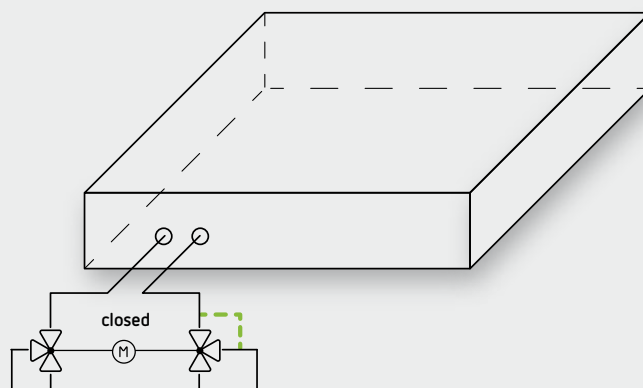
Solution 1:
4 × 2-way valve



Solution 2:
2 × 3-way valve
With pressure equalisation device

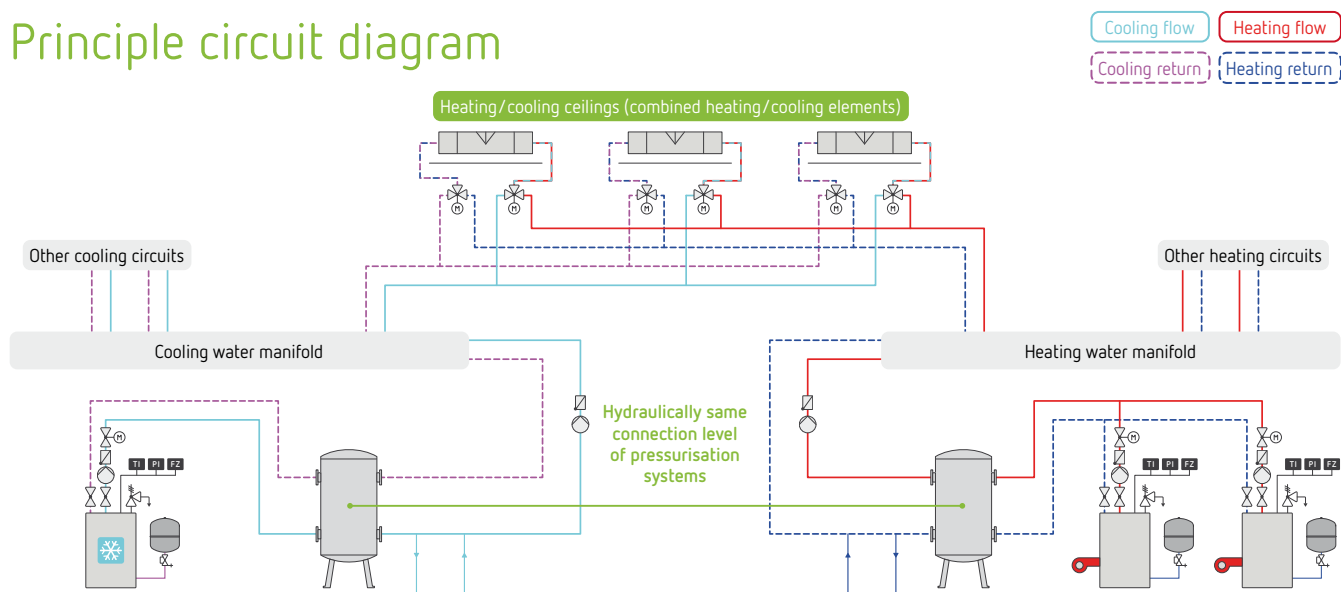


Solution 3:
6-way-ball-valve
With pressure relief



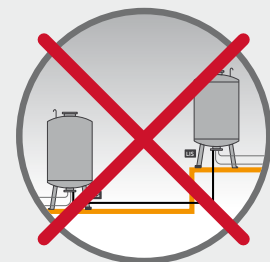
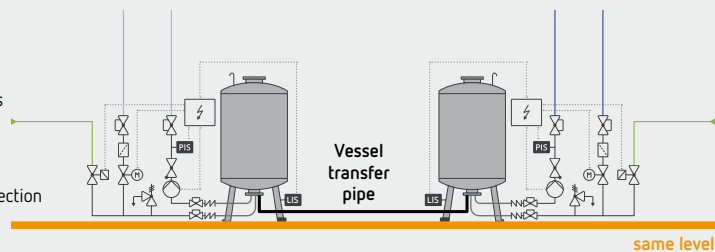
Integration options

Principle circuit diagram



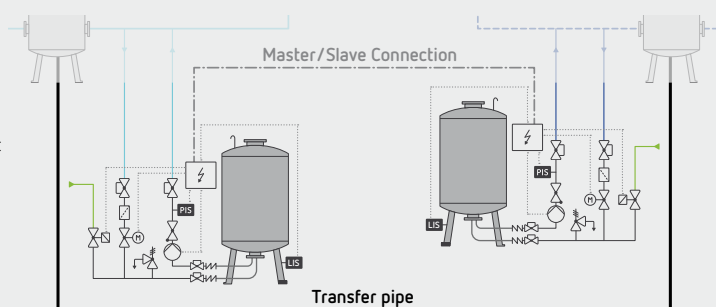
Independent pump pressurisation

- with associated extension vessels of the same geometry and at the same installation level
- without other fixed defined connection of the circuit hydraulic elements
- according to notes Ia Ib II



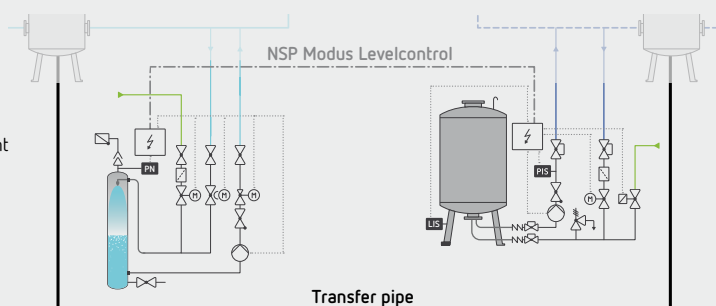
Pressurisation unit with master/slave

- with defined connection of the circuit at the hydraulic zero point
- according to notes Ia Ib II



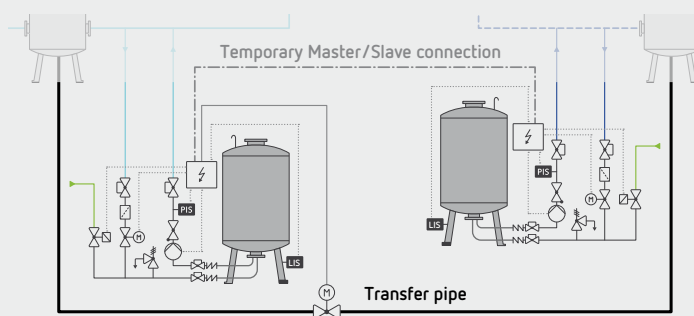
Independent pressurisation unit

- with defined connection of the circuits at the hydraulic zero point
- with degassing in the cooling water circuit
- optional pressurisation unit
- according to notes II

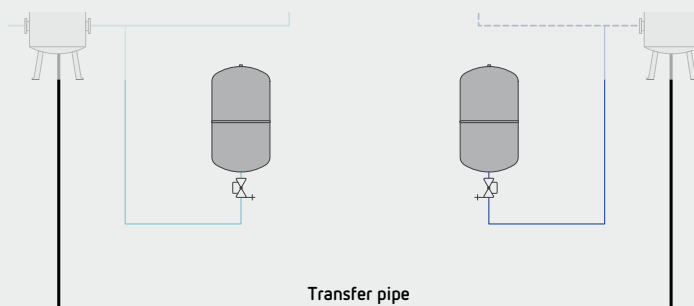


Summary:

Interconnected circuits with thematically separate generator circuits and common consumers must be connected in a targeted manner at one point due to unavoidable temperature-related heat transfer medium mass transfer processes.

**Pressurisation unit with temporary connection**

- with controlled temporary connection of the circuits at the hydraulic zero point
- according to notes
Ia Ib II

**Static pressurisation using diaphragm expansion vessel**

- with defined connection of the circuits at the hydraulic zero point
- according to notes
Ia Ib II

The diagrams serve only to illustrate the connections. They must be adapted and specified according to local conditions.

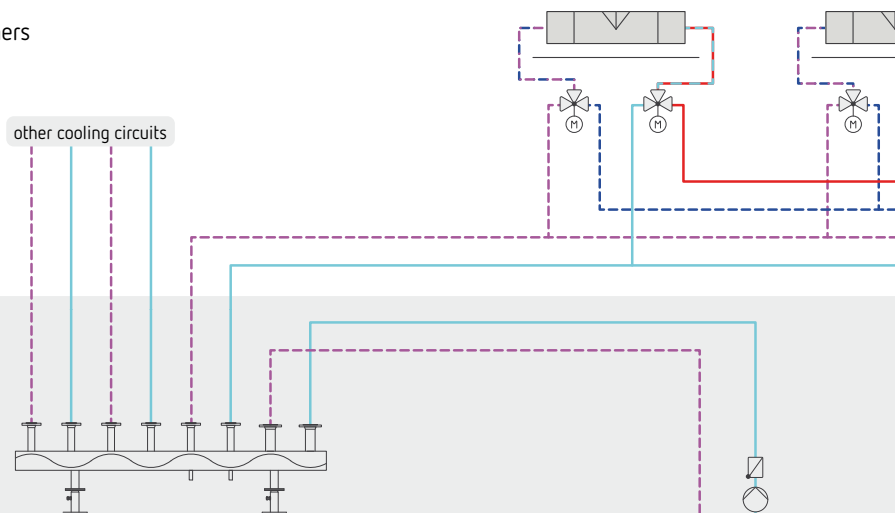
Installation example

Pressurisation, degassing, replenishment and heat flow distribution in a heating and cooling system with consumers in change-over principle.

Common pump controlled pressurisation with vacuum spray tube degassing in the cooling water circuit

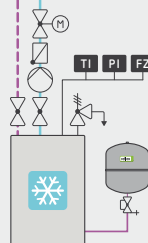
Sinus compact manifold

- as a link between the generator and the consumer circuit
- space-saving arrangement of flow and return
- good flow behaviour due to sinusoidal arrangement of the flow and return chamber
- easy to install, compact design



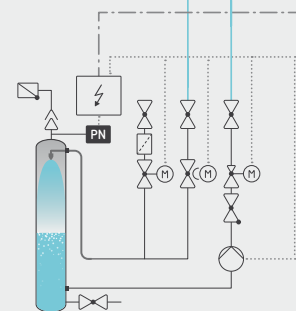
cooling water buffer tank

- hydraulically separates the generator circuit and the consumer circuits from each other and optimises the running time of the chilled water generators

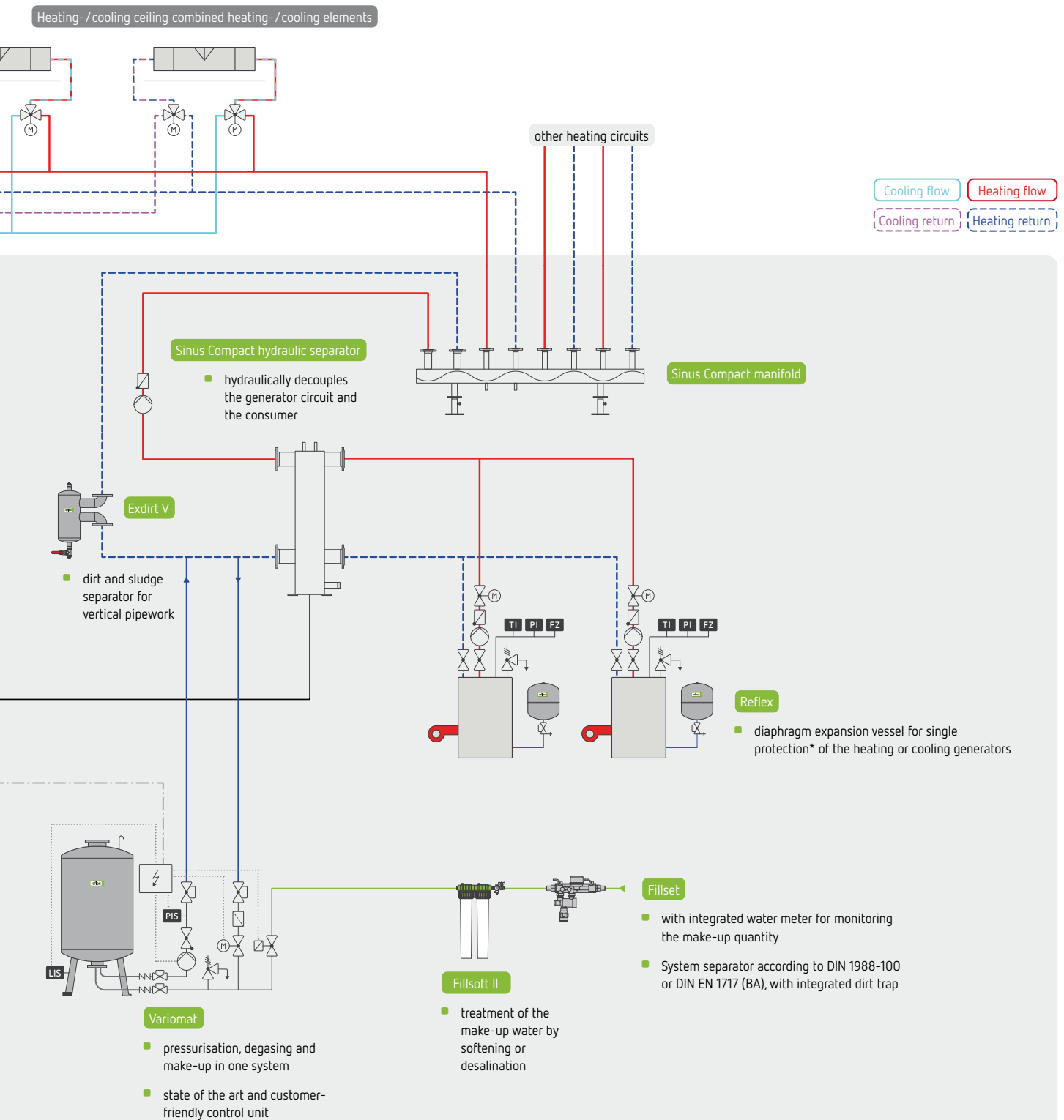


Servitec

- powerful central degassing of the system water (optionally the make-up water)
- permanent operational reliability of the entire heating/cooling system



The diagrams serve only to illustrate the connections. They must be adapted and specified according to local conditions.



*also serves as control vessel volume for Variomat

Reflex added values

Our digital services



Reflex pro –
award-winning configuration software

The Reflex Pro family for designing, dimensioning and offer preparation is available free of charge at reflex-winkelmann.com/en/services-downloads/planning-calculations-and-software/reflexpro. The configuration software allows qualified professionals, planners, plant constructors and engineers to plan and configure Reflex products and solutions effectively – from pressurisation, water make-up and degassing systems through to heat exchangers in the various areas of modern building and supply technology. Easy and intuitive – the entry of a few system parameters is all it takes for the tool to deliver the right product solution for your project.



ProSinusX –
the product configurator

From HydroFixx compact manifolds through to buffer storage tanks! ProSinusX allows qualified professionals and planners alike to individually configure Sinus products in just a few steps. The planner can start using the new Sinus product configurator after entering the project's name and location. Registered users can save relevant projects and manage them at any time. Highly compatible and easy to transfer – finalised plans can be transferred to the user's CAD drawing software via most commonly used interfaces. The web-based application ensures that configured projects can be accessed at any time and from anywhere in the world. Preparation of individual tender documents is also possible (including in GAEB).

Configure customised manifolds using ProSinusX at:
prosinusx.sinusverteiler.com

Customised planning with the
Reflex Pro calculation software:



[reflex-winkelmann.com/en/
services- downloads/planning-
calculations- and-software/reflex-pro](https://reflex-winkelmann.com/en/services-downloads/planning-calculations-and-software/reflex-pro)

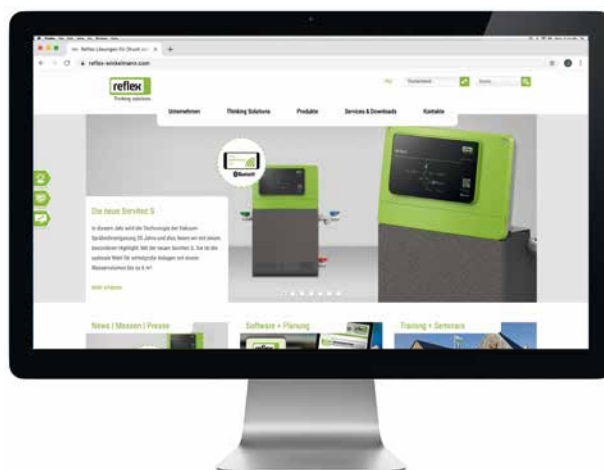


Practical digital sales support: the Reflex website

Everything you need to know for your day-to-day work

On www.reflex-winkelmann.com you will find a host of information to simplify your offer preparation, expand your technical expertise and support you quickly and easily in your day-to-day business:

- News
- Contact details, names of people who can help you, service telephone numbers
- Convenient product search
- Product literature, instructions for installation and use
- Tender texts
- 2-D and 3-D product drawings, BIM data (Revit format)
- Standards and certificates



Advantages through expertise: Reflex training

Contact the training team

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seminare@reflex.de



Reflex Training—Expertise gives us the edge

Close to our headquarters in Ahlen, professional craftsmen, planners and operators gear up to face the challenges posed by heating and hot water supply in modern building technology. From installation to planning, from consulting to technical operation, the Reflex Training Centre and its team aligns its programme to those partners who want to learn more about technology, standards and service from the horse's mouth. Newly acquired expertise is put into practice, trained and experienced straight away on Reflex facilities in a former manor house that has been refurbished to modern standards in the German region of Westphalia. Realistic simulations and a comprehensive portfolio of facilities help to put the content learned to practical use; theory



and practice are effectively combined. The venue represents a perfect symbiosis of traditional and high-tech—the building, ambience and equipment speak for themselves and provide a haven for successful learning far removed from hectic everyday life.

Your notes

Your notes

Always up to date



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Subject to technical modifications



Thinking solutions.

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