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Balancing of HVAC systems

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70 TONS OF BRASS DAILY

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A TURNOVER CLOSE TO **200** millions

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Energy Management. Balancing: applications, control loops and solutions.

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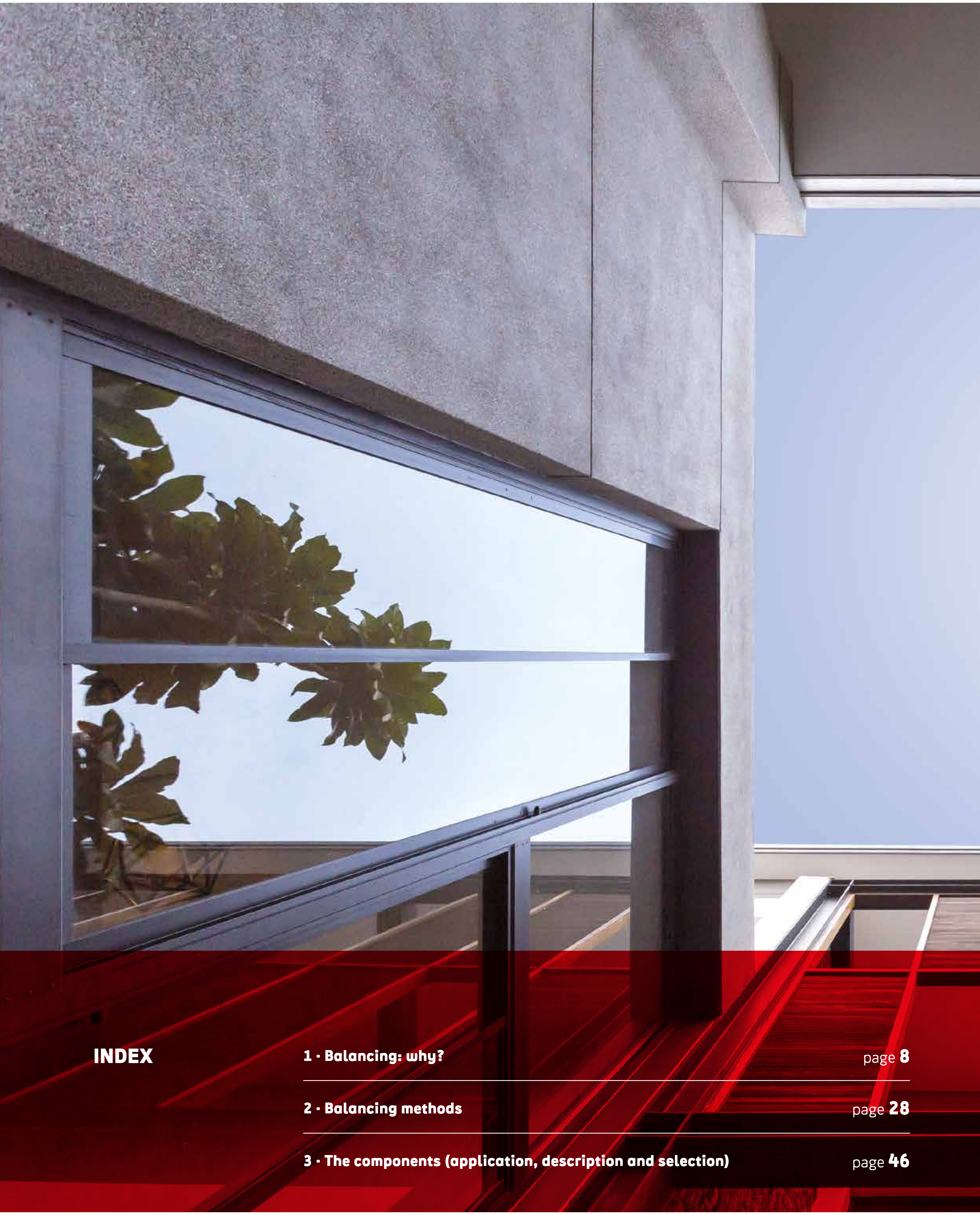

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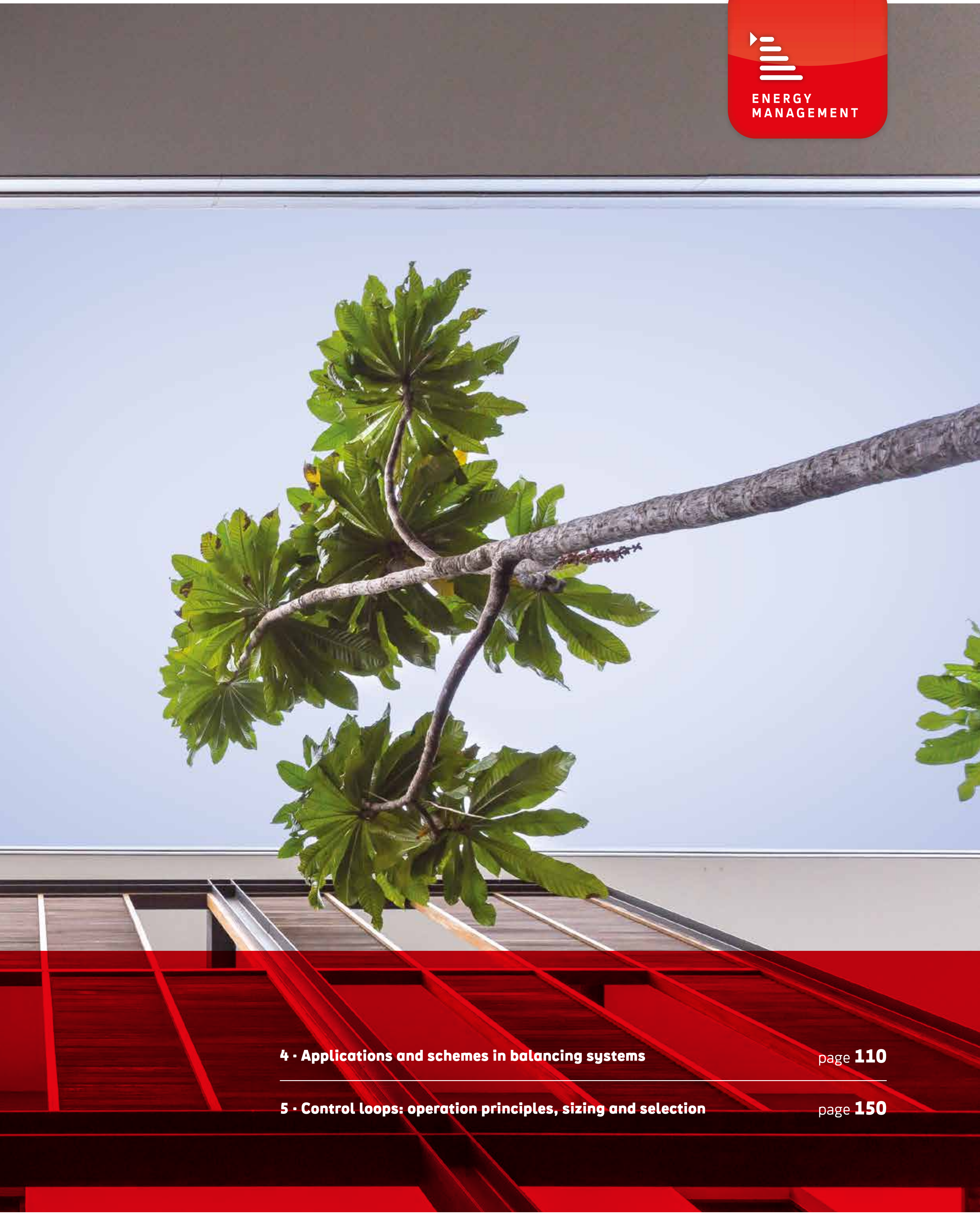
ENERGY MANAGEMENT



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Providing heat where required. Supplying each terminal unit with the appropriate water flow-rate. Balancing is key to ensure the ideal level of comfort for each room, just as planned.

Chapter 1

Balancing: why?

BALANCING: WHY?

BENEFITS TO EXPECT FROM BALANCED PLANTS

A balancing valve is a device that controls various physical parameters to balance thermal energy distribution (in heating and cooling/conditioning systems) in different zones.

The purpose of these valves is to provide the correct thermal energy value in every part of the building. An unbalanced plant is basically an inefficient system.

There are typically three types of balancing devices in thermal systems: static balancing valves (*SBV*), dynamic balancing pressure independent control valves (*PICV*) and differential pressure control valves (*DPCV*).

Static balancing valves are engineered to keep the system flow-rate constant under design conditions and are set during commissioning. Dynamic balancing valves are designed to maintain a constant flow-rate regardless of differential pressure, as system conditions may vary. Finally, differential pressure control valves keep the delta-p dynamically constant between specific points of the installation.

From the theoretical point of view, modern air conditioning systems can meet the most demanding requirements of indoor climate comfort and operating costs.

However, even the most sophisticated controllers do not always behave as promised. Consequently, comfort is not ideal and operating costs are higher than expected.

This is often the case, since the mechanical design (layout and dimensioning) of the plant does not meet certain specific conditions for a stable and accurate system control. Among these conditions, the three most important are:

- the design flow-rate must be available to all terminals, even the farthest ones
- the differential pressure of the control valves must not vary excessively, specifically they should not exceed the maximum and minimum levels of work
- flow-rates must be compatible at the system interfaces

When the first of the basic conditions is not respected (design flow-rate unavailable at terminals), specific issues arise, such as: energy costs higher than expected; installed power not available at medium and/or high loads; too hot in some parts of the building, too cold in others; extended delay before reaching the desired temperatures when restarting the system after a pause or night setback.

Typical problems of differential pressure out of control are noise, vibrations, undesired flow-rates and mechanical damage to the terminals. These problems can be significant for new installations, but may be even worse after energy-efficiency upgrading as the system switches from manual to thermostatic regulation. In this situation, dynamic balancing is the only solution that can guarantee an optimal system performance.

The power transmitted by a terminal unit depends on delivery temperature and flow-rate of the heat transfer fluid. For this reason, in this discussion, we will not only talk about flow-rate balancing but in a dedicated section we will also focus on temperature control loops and the parameters examined to obtain the desired room temperatures. However, such temperature control is only possible if the required flow-rates are available.

Balancing devices can control the flow-rates but cannot create the flow-rate or the differential pressure. These functions are handled by the pumping system of the plant.

Correct operation of each plant definitely starts with correct design, understood as positioning and sizing of the components; however, it often happens that, notwithstanding accurate calculations, control valves with the required Kv flow coefficients are not available on the market. Therefore, most control valves are oversized. Full opening of the control valves cannot be avoided in many situations for example: during start-up, when some thermostats are set to the minimum/ maximum value or even when some coils have been undersized. In these situations, and when balancing valves are not installed, overflows will occur in certain coils, thus reducing the flow-rates in others.

Inserting a variable speed pump will not solve this problem: it is effective for energy saving but not for balancing, since all the flow-rates change proportionally when the pump hydraulic head is altered in the system.

In addition, the pump can only "see" an average overview of the parameters it certainly fails to handle what happens in a single branch.

Trying to avoid overflows in this way would, unfortunately, make the reduced flow-rates even more critical.

Underflows are practically a waste of time and energy as the required power is delayed.

On the other hand, overflows are intrinsically inefficient as excessive power is not needed.

The entire plant is designed to provide maximum power at maximum load. It is therefore indispensable that this maximum power is available when required. Hydronic balancing, achieved under design conditions, ensures that all terminals receive the proper flow-rate, thus justifying the investments made.

With partial loads, when some control valves close, the differential pressures available on the circuits can only increase. The starting point of balancing is therefore: avoid reduced flow-rates under design conditions and prevent them from being created in all other conditions.

HOW TO OBTAIN THE THREE BASIC CONDITIONS FOR BALANCING

First condition: The design flow-rate must be available to all terminals, even the farthest

Effective control of a thermal system is only possible if the required flow-rates of the heat transfer fluid are available at the terminals: once the required flow-rates have been obtained, these must be measured and adjusted. This is why hydronic balancing is essential.

The basic question is: how do you get correct balancing?

The starting point is to get a proper flow distribution by dimensioning the plant carefully. This is true only in theory: in fact, heat generators, piping, pumps and terminals are designed to cover maximum demand. If a chain ring is not properly dimensioned, the others will not work optimally and consequently the desired indoor climate and comfort will not be achieved.

Designing the plant with certain safety factors would prevent some of the problems, but would create other larger ones, especially on the control side.

However, some overdimensioning cannot be avoided as components must be selected from existing business dimensions that typically do not match exactly the calculations made. Also, during design, the characteristics of some components are unknown as they are selected only during installation.

Therefore, it would be necessary to modify the original system taking into account on-site installation, often different from the initial design.

Hydronic balancing allows to obtain the required flow-rates in real installations, preventing overdimensioning and justifying the investment made.

Situation A

Constant flow-rate distribution systems

In a constant flow-rate distribution system (fig. 1.1a), the three-way control valve is calculated to generate a pressure drop at least equal to the design pressure drop in terminal U. This means a control valve with an authority of at least 0.5, an essential value for proper regulation.

Practically, the pressure drop on the control valve must be the same of the downstream pipe.

If the pressure drop in the pipe, plus the pressure drop of the control valve, is 20 kPa and the differential pressure available (ΔH) is 80 kPa, then the 60 kPa difference must be removed from SBV1. Otherwise, this circuit will create a flow-rate that is 200 % that of the design flow.

This situation will make control difficult and affect the rest of the system.

In fig. 1.1b, SBV2 is essential. Without it, bypass AB will be a short circuit with an extreme overflow, creating underflows elsewhere in the plant.

With SBV2, the primary flow-rate q_p is measured and set to be a bit bigger than the secondary design flow-rate q_s, measured and set with SBV3.

Balancing ensures correct flow-rate distribution, prevents operational problems and allows regulators to actually work without significant oscillations.

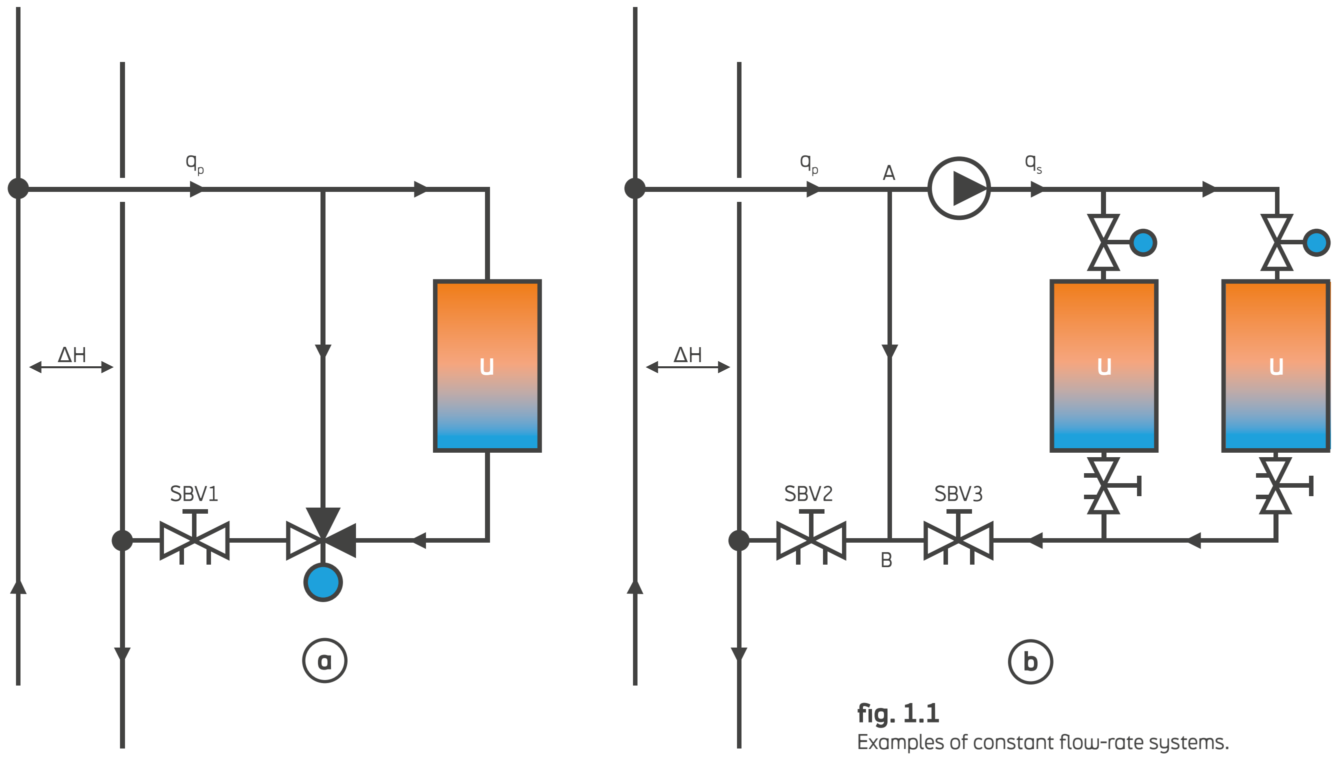


fig. 1.1
Examples of constant flow-rate systems.

Situation B

Variable flow-rate distribution systems

In a variable flow-rate distribution system, insufficient flow-rate problems occur basically when high loads are required.

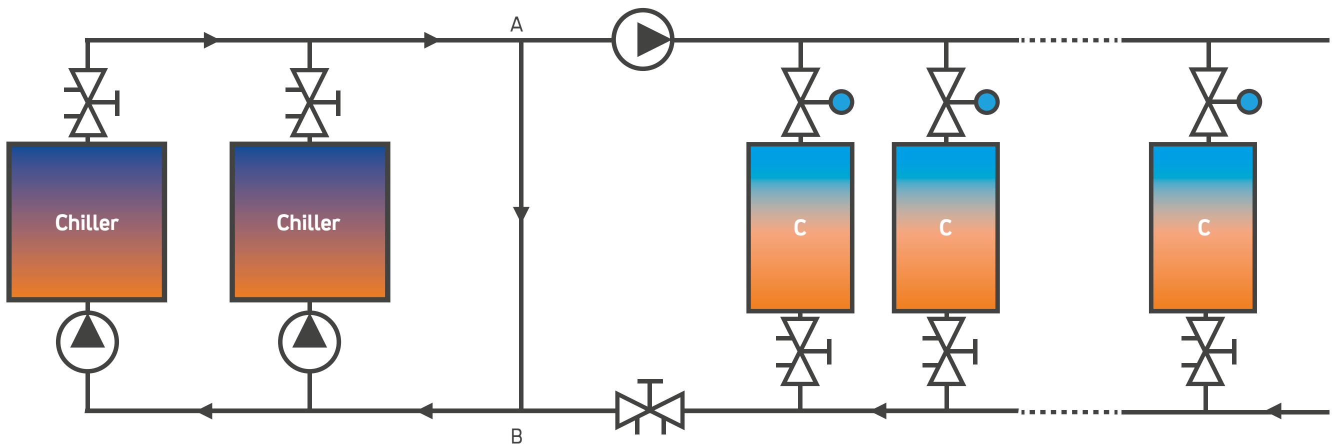


fig. 1.2
Example of variable flow distribution system.

In theory, there would be no justification for balancing a system with two-way control valves on the terminals, since these valves are designed to modulate the flow-rate to the required level.

Hydronic balancing should therefore be obtained automatically.

However, as soon as the proportional valves begin to close, the differential pressure can increase considerably, generating noise and regulation disturbances before the pump can react.

Trying to avoid overflows this way will simply make the problem of an inadequate flow-rate worse: specific devices, i.e. differential pressure control valves (DPCVs), are specially designed to handle this situation.

DPCVs set the differential pressure to a desired level. This level should be adequate to obtain the design flow-rate in the farthest pipes while not exceeding the maximum value associated with the valve/actuator combination (based on the maximum force of the actuator itself).

Situation C

Start-up

In variable flow-rate distribution systems, start-up after each shutdown represents a delicate operation as most control valves are activated while fully open.

This situation generates overflows that cause excessive pressure drops in some parts of the pipeline network, while not supplying the terminals of less favored sections of the plant. Disadvantaged circuits will not reach a sufficient flow-rate until the privileged rooms have reached the thermostat set-point (assuming the set-point has been selected in a reasonable manner). This allows the control valves of said circuits to start working properly.

Start-up is therefore difficult and takes longer than expected.

This results in heavy energy consumptions. In addition, uneven start-up makes management by a central controller and any form of optimization practically impossible.

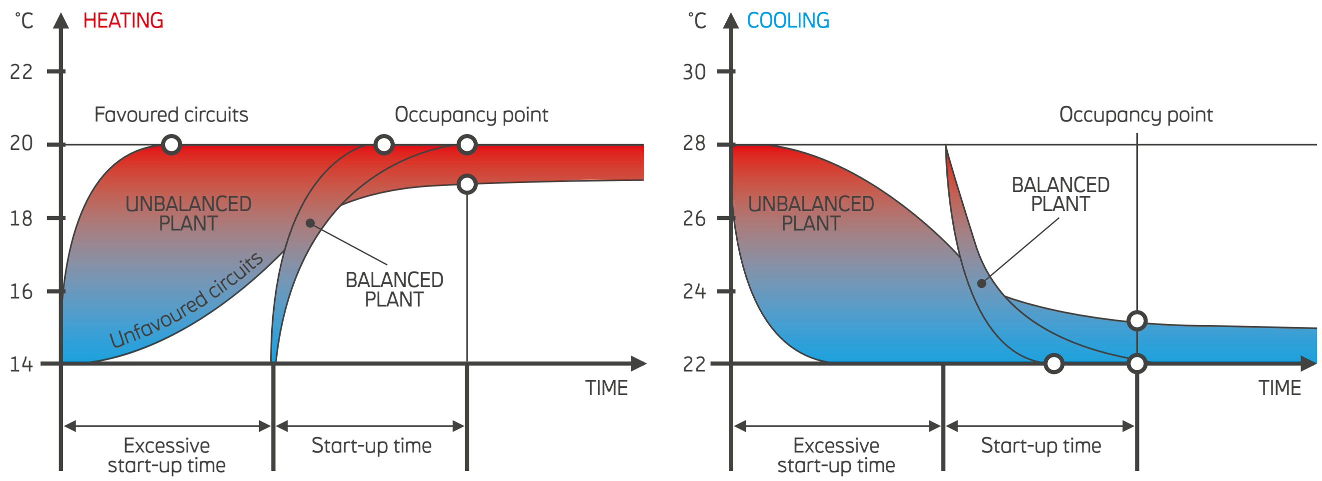


fig. 1.3
An unbalanced plant must start in advance, increasing energy consumption.

In a constant flow-rate distribution system, insufficient flow-rates and overflows both remain present during and after start-up, making the problem much more difficult.

Second condition: Differential pressures of control valves must not vary excessively and, more importantly, they must not exceed maximum and minimum levels of work

Variable flow-rate systems are becoming more and more popular, especially for the advantages they offer compared to constant flow-rate systems, such as:

- reduced pumping costs (electronic pumps, mandatory in many countries and applications)
- return temperature that is minimized in heating systems (application for condensing boilers)
- return temperature that is maximized in cooling systems

However, there is a considerable disadvantage: the differential pressure of the plant can vary significantly during operation.

The negative impact of this disadvantage on system operation and performance can be reduced and even minimized.

The main objective in designing any heating and air conditioning system is to achieve a comfortable indoor climate while minimizing operating costs and maintenance problems.

In theory, modern control technologies are designed to meet the most demanding requirements and provide opportunities to increase comfort while achieving real energy saving.

However, in terms of actual application, even the most sophisticated controllers cannot achieve their best performance if their operation conditions are not correct. These conditions are obtained right from design of the hydronic system. Simply installing control valves cannot compensate for a poorly designed system, and this is the reason why a system has to be designed as controllable as possible.

Circuit characteristic

An important quality check of the hydronic system design is represented by the characteristic of the circuit.

Fig. 1.4 shows a typical hydronic circuit for an air heating/cooling system coil. The circuit characteristic is the relationship between the control signal and the thermal power generated by the coil.

It defines the controllability of the system.

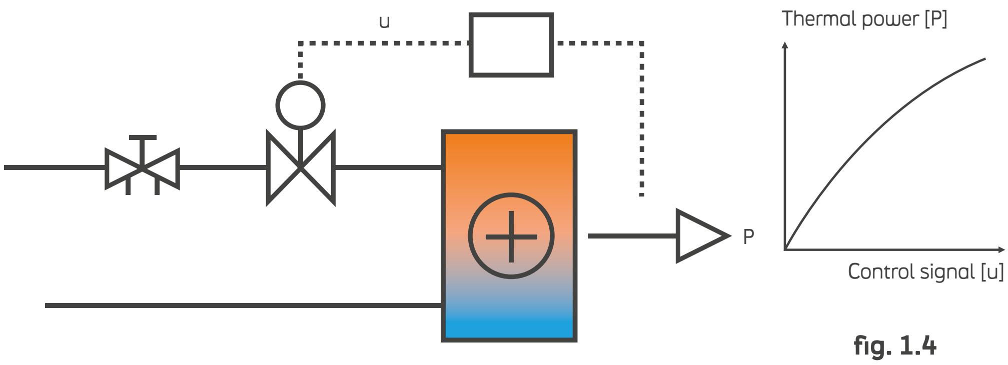


fig. 1.4
Circuit characteristic

The higher the slope of the circuit characteristic curve, the higher the risk of control instability and, as a result, the control itself becomes more difficult. Even minimum changes in the control signal will result in significant variations in thermal output, making the system sensitive and quite unstable.

With a low slope, however, no control action will create very significant thermal output changes and, consequently, the system will be quite static and somewhat indifferent. To avoid instabilities, actually able to affect the control function, a low gain setting (corresponding to a wide proportional band) is required in the controller. On the other hand, a low controller gain involves a less precise control and a slower response to disturbances.

It is therefore very important to avoid steep slopes of the circuit characteristic curve. The objective should be to obtain a linear circuit characteristic as it will minimize the slope throughout the setting range.

Circuit compound characteristic

The circuit compound characteristic consists of the:

- actuator characteristic
- valve intrinsic characteristic
- terminal characteristic
- valve authority

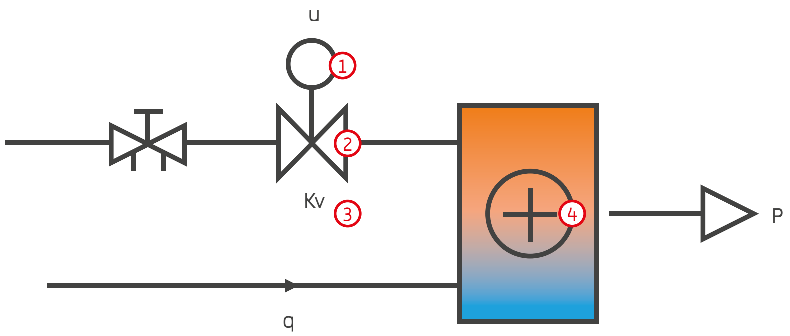
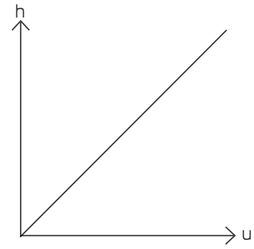


fig. 1.5

The actuator characteristic shows the relationship between the control input signal (from the controller to the actuator) and the resulting valve movement (h). Usually, the characteristic is linear, but for simple actuators the characteristic curve may be fairly nonlinear.

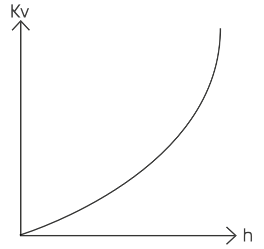
The intrinsic characteristic of the valve, which shows the relationship between the valve opening and its flow coefficient (Kv value), depends only on the mechanical configuration of the control valve. There are only a few different types of valve characteristics on the market. The most common are the linear and the equal-percentage characteristics, or to be more exact the equal-percentage modified ones (*EQM*).

The terminal characteristic can vary greatly depending on shape, size and temperature, but it is definitely nonlinear. A typical characteristic provides 50 % power to 20 % of the flow-rate and 80 % power to 50 % of the flow-rate, tendentially with a shape opposite to the characteristic of an EQM. This is also why, when choosing a



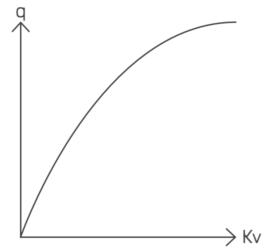
(1) Actuator characteristic

+



(2) Valve characteristic (inherent)

+



(3) Valve authority effect

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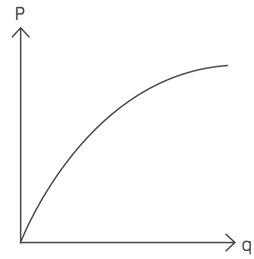

(4) Terminal charateristic

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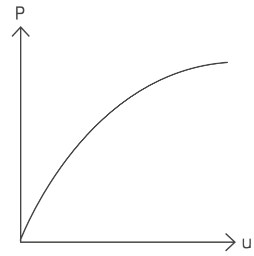


Circuit charateristic

control valve, an EQM characteristic is usually preferable, as it can counteract the terminal nonlinearity.

The valve authority is a measure of differential pressure variation through a control valve during operation.

The flow-rate through a control valve depends on the differential pressure through the valve and its Kv value. The Kv value is given by the intrinsic characteristic of the valve at each of its opening levels. If differential pressure is constant during operation, the Kv/water flow-rate ratio would be completely linear. However, in variable flow-rate systems, the differential pressure varies during operation, which means that the relationship becomes more or less nonlinear.

The magnitude of nonlinearity is expressed by the valve's authority:

$$ß = \frac{\Delta pV_{design}}{\Delta pV_{shut}}$$

$ß_{design}$ = Valve authority [-]

ΔpV_{design} = Differential pressure through fully open control valve at design flow-rate [kPa]

ΔpV_{shut} = Differential pressure through fully closed control valve [kPa]

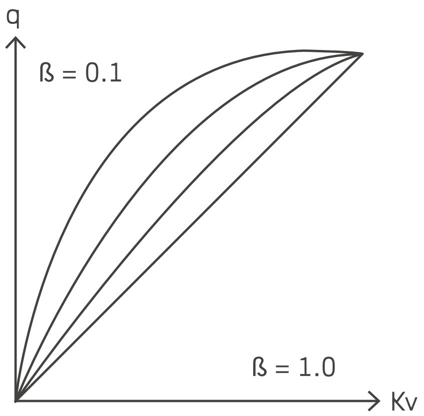


fig. 1.6

A high valve authority value means that the differential pressure is almost constant and that the relationship between the Kv value and the water flow-rate becomes fairly linear. A low value, however, indicates that the differential pressure will increase considerably when the valve closes, resulting in a significant non-linearity between the Kv value and the flow-rate.

The lower the valve authority, the more nonlinear the flow-rate/Kv curve. Therefore, with a low control valve authority, large h movements of the valve do not generate significant changes until the end of the stroke, where even a small movement results in large flow changes.

By simply looking at the composition of the circuit characteristic, it is fairly clear that a low control valve authority will disadvantage the characteristic curve of the circuit.

This way, an excessive differential pressure variation through a control valve leads to low authority, a distorted circuit characteristic and regulation difficulties. In addition, large variations in differential pressure will lead to interactivity between the circuits, making control even more difficult.

This means, in practice, that the pressure drop through the valve must be at least equal to that of the controlled circuit.

Design authority and minimum valve authority

The differential pressure available in the hydronic circuit is transferred to the control valve when closed: this means that the system sizing, diagram and control determine the differential pressure through the fully closed control valve.

Therefore, as system circumstances at any time determine the differential pressure available through the circuits, the valve authority varies during operation.

For example, if only one control valve closes in a system while the others are completely open, differential pressure across that specific valve will become significantly lower than if all the control valves were closed at the same time.

This leads to two further definitions of valve authority: design authority and minimum authority.

For two-way valves in variable flow-rate systems, these definitions become the following:

$$ß_{design} = \frac{\Delta pV_{design}}{\Delta H_{design}} \qquad ß_{min} = \frac{\Delta pV_{design}}{\Delta H_{max}}$$

$ß_{design}$ = Valve authority in design conditions [-]

ΔH_{design} = Differential pressure available through circuit in design conditions [kPa]

$ß_{min}$ = Valve minimum authority [-]

ΔH_{max} = Maximum differential pressure available through circuit during operation [kPa]

Both authority definitions should be taken into account during design, as the level of valve authority will vary between design authority (highest possible level) and minimum authority (lowest possible level) during actual operation.

The influence of the valve authority variation on the circuit characteristic during operation is shown in the following figure.

The ideal situation is represented by the circuit characteristic with reference to the design authority of the valve considered, corresponding to a situation where all other control valves of the system are kept completely open (design conditions). The worst scenario would be a circuit characteristic with minimum valve authority when all other control valves are kept completely closed (system almost satisfied).

This latter case produces a much higher differential pressure in the circuit and, consequently, a steeper slope of the circuit characteristic

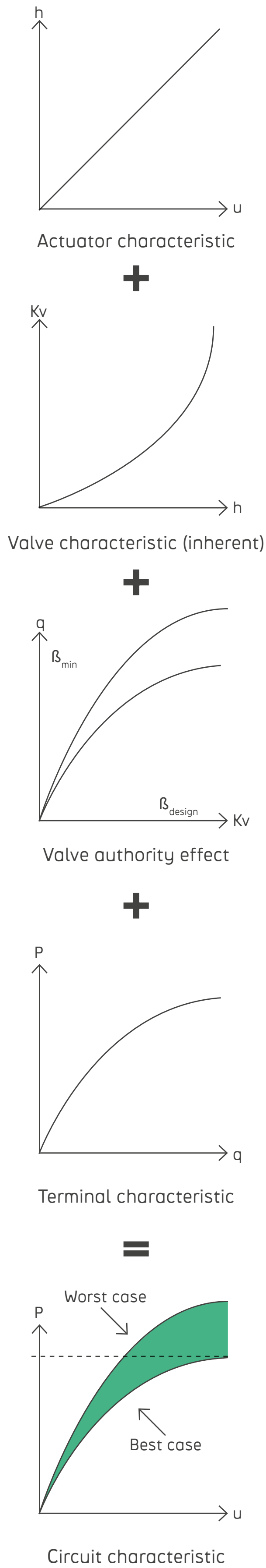


fig. 1.7

as well as a substantial overflow when the control valve is fully open. In this situation, typically, there will be problems such as: continuous oscillations of room temperature; frequent maintenance of control valves and actuators due to fatigue in reaching the set-point; energy costs higher than expected, given the disadvantageous control settings needed to avoid instability.

Basic principles of hydronic design

The impact of the selected control valve on the circuit compound characteristic, and thus on the system's controllability, is fairly clear, given the incidence of both the intrinsic characteristic and the valve's authority.

When choosing the control valves, all these aspects must be taken into consideration:

- the design flow-rate must be obtained with the valve fully open under design conditions
- to facilitate regulation, the valve characteristic must compensate for the nonlinearity of the terminal
- to maintain a favorable circuit characteristic, the valve authority should not be too low

To prevent the valve authority from deforming the circuit characteristic too much, the lower values of design authority and minimum authority must be:

$$ß_{design} \geq 0.5 \qquad ß_{min} \geq 0.25$$

The design authority of a control valve must not be less than 0.5 and this means in practical terms that the design pressure drop through the fully open (two-way) valve must be at least equal to half the differential pressure available on the circuit under project conditions.

The purpose of this first guideline is to make sure that the circuit characteristic in the best conditions has an almost linear pattern, assuming that the control valve has been chosen with an appropriate intrinsic characteristic.

The second condition, that is, a minimum authority of not less than 0.25, sets the lowest level of the circuit characteristic under the worst operating condition.

Clearly, this restriction is the most important because it actually defines the limit for the stability of the regulation.

In addition to carefully selecting the control valves, there are other measures to be implemented during design to avoid a low authority:

- avoid large pipe pressure drops
- use variable speed pumps
- use differential pressure control valves (DPCVs) when needed

Although the control valve is selected with great care, its authority may still become too low, simply because it depends not only on sizing of the valve but also on the design of the rest of the system. An effective solution in such cases is the installation of differential pressure control valves (DPCVs), which are useful in improving the situation, especially if the downstream system is statically balanced or even pre-set.

Third condition: flow-rates must be compatible with system interfaces

In many systems, the installed power exceeds the required maximum value by more than 30 % but the distribution circuits still do not receive enough power. The power produced by boilers and chillers simply does not reach the heating or cooling circuits.

This problem can be particularly critical in systems with multiple boilers or chillers working sequentially.

The reason is generally due to a lack of compatibility of the interfaces between the production system and the distribution system.

With a heat exchanger between production and distribution, such as in district heating, water flow-rates can of course be different without causing problems. In most systems, however, there are production and distribution circuits in direct contact with each other: this can cause serious disturbances, often difficult to detect, unless effective measures are taken to prevent and avoid them.

Hydraulic interactivity

Hydraulic interactivity occurs between multiple parallel units that share a common resistance: any variation of the flow-rate through a single circuit affects the others'. The greater the shared resistance, the greater the interactivity between the circuits.

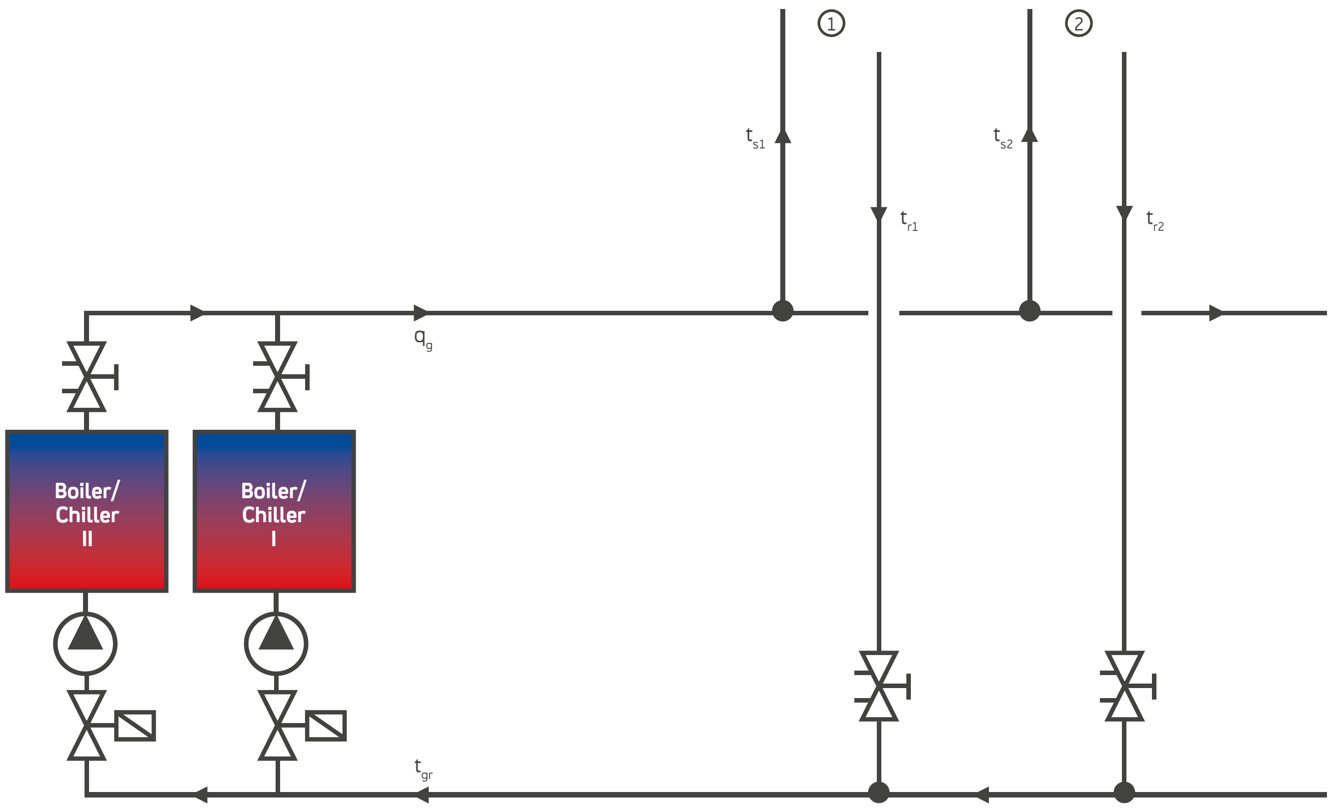


fig. 1.8
Two generators (boilers / chillers) in parallel

The two boilers/chillers create a shared resistance for the distribution circuits, and therefore any flow-rate change in a circuit will naturally affect the flow-rate in the others.

In addition, variable flows should run through boilers, but this situation is not acceptable for standard models.

In the case of chillers, when the second chiller turns on, the total flow-rate will not change significantly, as most of the pressure drop occurs in the distribution. Then, suddenly, the flow-rate in the first chiller decreases and, since the power of the chiller does not decrease at the same time, the temperature in the evaporator can reach the freezing point (a situation that must be avoided).

By-pass separation

A low pressure drop by-pass line (or even, typically, a hydraulic separator) between production and distribution, solves these interactivity problems: however, the compatibility between production and distribution flow-rates must be ensured.

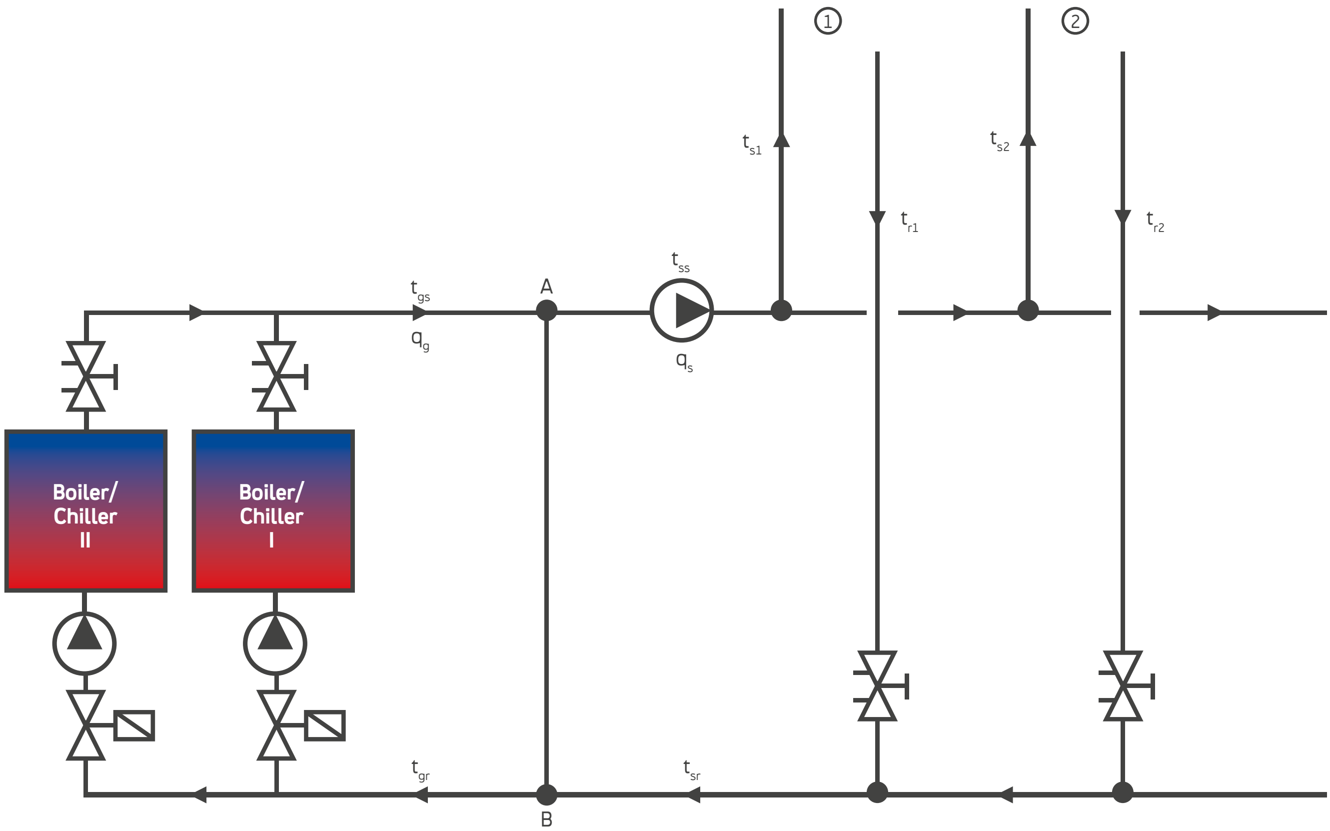


fig. 1.9
By-pass separation

A by-pass between A and B keeps the differential pressure between these points close to zero and there will be no interactivity between the circuits, or between boilers/chillers.

Therefore, there will be a constant flow-rate in each boiler and there will be no risk of freezing in the case of the chiller.

The by-pass avoids any interactivity, but since the pressure drop between A and B is non-existent (or very low), a secondary pump is required. However, solving interactivity problems with a by-pass creates compatibility issues, unless correct measures are taken.

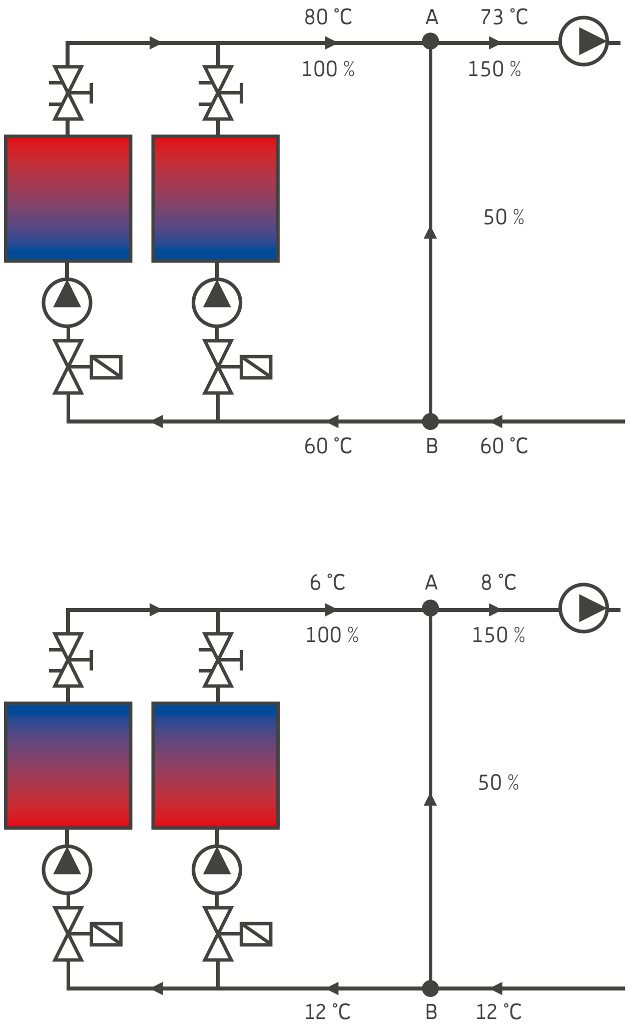


fig. 1.10
Problems of incompatibility in heating and cooling

In the examples in fig. 1.10, the secondary pump is oversized and the distribution takes up 150 % of the flow-rate while the production units provide only 100 %. The difference, amounting to 50 %, has to go through the by-pass from B to A, creating a mixing point (not controlled) between supply water and return water in A, making it impossible to reach the correct delivery temperature. In the heating example, the delivery temperature will be only 73 °C instead of the desired 80 °C, while in the case of cooling, the delivery temperature will be 8 °C instead of the 6 °C produced.

This may also occur if the secondary pump is not oversized, for example if the distribution is not adequately balanced.

If so, there would probably be an overflow at each start-up, creating the same problem described above.

Since the required power is not fully transmitted, especially at high loads when it is really needed, the room temperature would be too low in the case of heating and too high in cooling.

Corrective actions. Increase the pump?

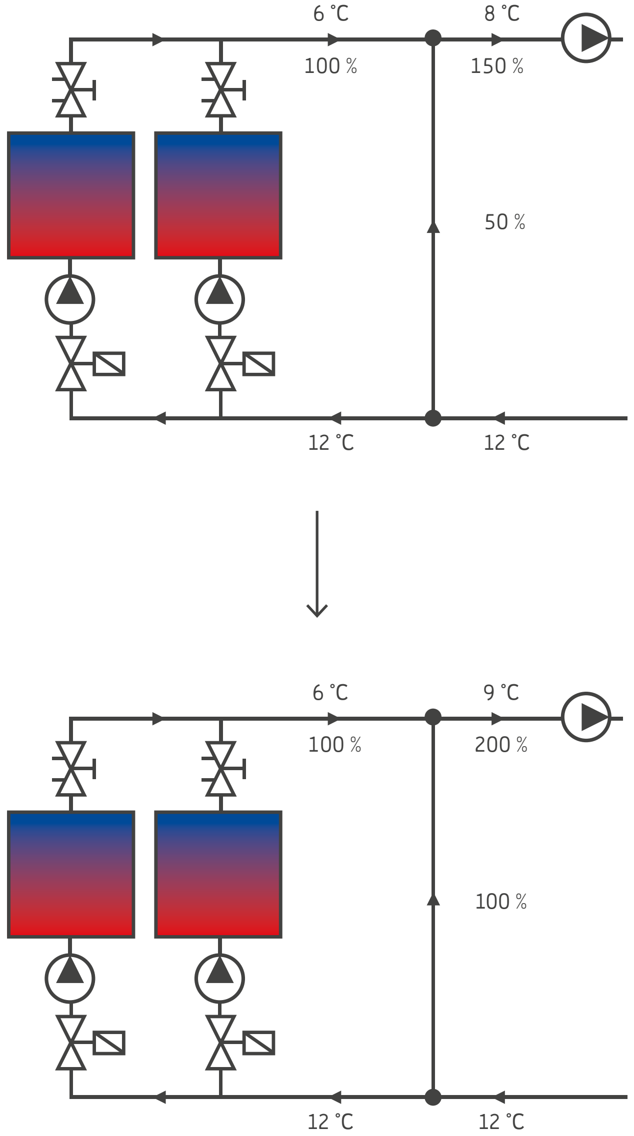


fig. 1.11
Increasing the secondary pump hydraulic head

Increasing the hydraulic head of the distribution pump could be thought of as a first attempt at solving this problem, but it actually only worsens the situation. The original cause of the problem is an excessive secondary flow-rate, so an even higher delivery flow-rate will only increase flow incompatibility and therefore mixing. The delivery water temperature will further decrease in heating and increase further in cooling, in this case from 8 °C to 9 °C.

Add power from the primary circuit?

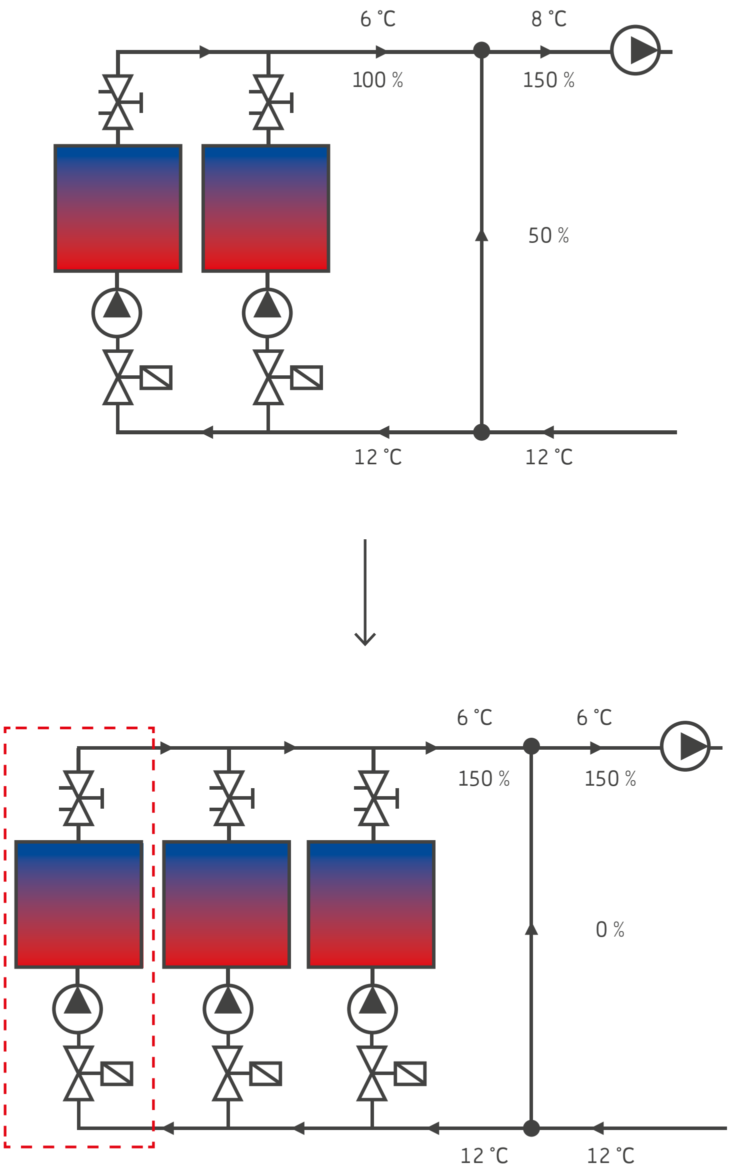


fig. 1.12
Adding power to the primary circuit

Introducing extra power output through an additional unit can solve the problem of incompatibility, but at the very high cost of unnecessary installation. In the example in fig. 1.12, adding another 50 % flow-rate thanks to the new generator, aligns the flow-rates between production and distribution, thus making it possible to reach the design delivery temperature.

This just described solution is naturally not a good one, as it does not deal with a lack of installed capacity, but with an excessive flow-rate in distribution. The system thus created will be characterized by high costs, first in installation and then in operation, since, normally, oversizing in energy production reduces efficiency.

Change the set-point?

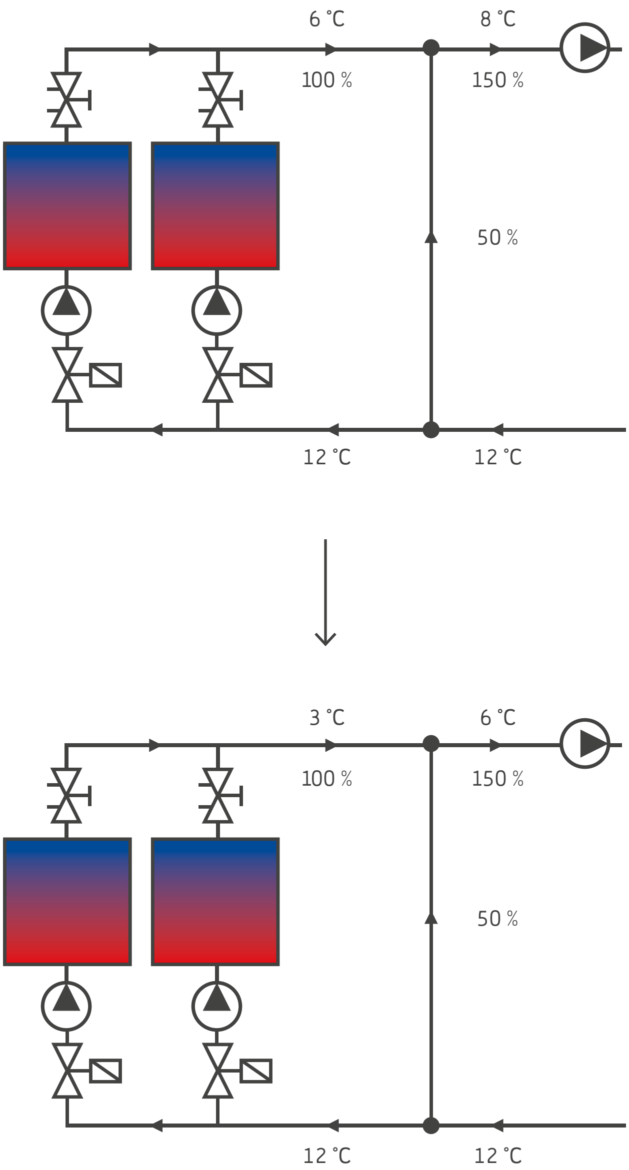


fig. 1.13
Decreasing the set-point

Decreasing (or increasing in case of heating) the set-point of the production unit can compensate for incompatibility and will provide the correct supply temperature. However, this will result in drastic energy costs in the plant and therefore is not a recommended solution.

Balancing the flow-rates?

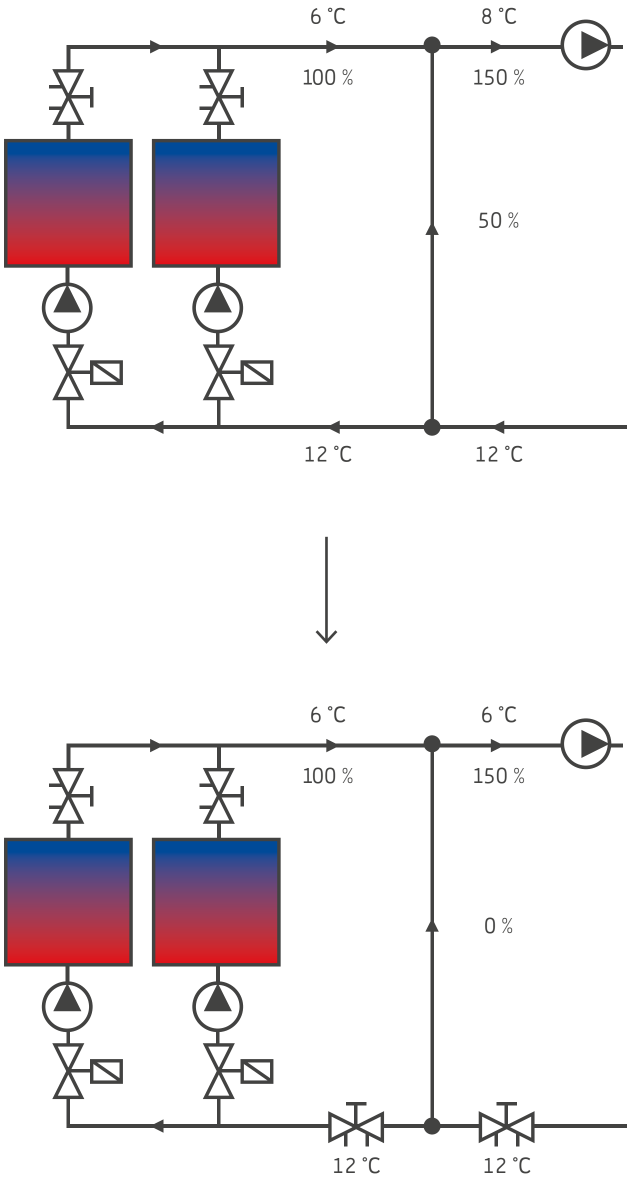


fig. 1.14
Balancing of production and distribution flow-rates

The incompatibility problems described above depend only on overly high flow-rates in distribution: it is inevitable that the correct measure of intervention is to equilibrate production and distribution flow-rates by balancing.

By doing so, there will be no flow in the by-pass line and so the correct flow-rate and delivery temperature will be transferred from production to distribution.

This approach is not only valid between production and distribution: it should be used in any system interface, or where different circuits are in contact with each other.

NOTES

GIACOMINI
WATER E-MOTION

Targeted actions for a top-notch performance of thermal plants. Procedures and methods suitable for all types of systems. Like the proportional method or the fast and efficient compensated method which can be applied to any existing system.

ENERGY MANAGEMENT

Chapter 2

Balancing methods

BALANCING METHODS

INTRODUCTION

It is well-known that in sizing a hydronic circuit, it is of particular importance that the hydraulic head of the circulator is calculated so as to provide sufficient differential pressure to the most disadvantaged terminal units.

Due to the pressure drop in the supply pipes, the loss of pressure for the different units is reduced in proportion to its greater distance from the circulator.

Generally, the terminal units closest to the pump operate at an excessive differential pressure, thus risking the generation of an excessive flow-rate.

To solve such a widespread problem, it is necessary to increase the pressure drop of the terminal units: in other words, additional resistance is required. The value of this resistance must be both known and changeable. The ideal device for practicing this compensation is the balancing valve, which also allows to verify that the calibration is correct when reading the instantaneous flow-rate. Let us now consider the circuit shown in fig. 2.1 and suppose that the pressure drop between the pump and the most distant unit is 50 kPa.

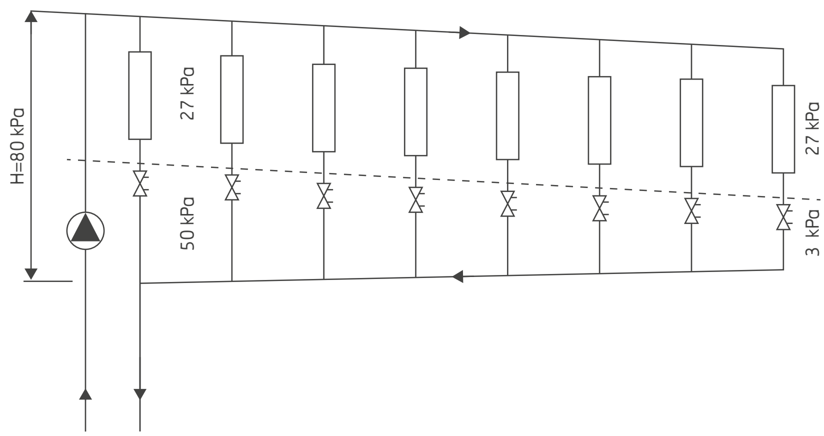


fig. 2.1

If all terminal units are equivalent and each requires a differential pressure of 30 kPa (including pressure drops for the accessories and the control valve), the hydraulic head from the pump must be at least 80 kPa.

In this situation, the differential pressure across the terminal units is between 0 and 50 kPa, depending on their distance from the pump. To compensate for this imbalance, it is sufficient to insert valves that can absorb such difference.

The only exception is the most disadvantaged terminal unit which, having the exact differential pressure and therefore the exact flow-rate, does not need any additional correction.

However, although not necessary for system balancing purposes, the valve is installed nonetheless, for *compensated balancing*, a method which will be introduced later on.

If automatic setting of the units is carried out with a three-way valve (e.g. a diverter), insert a balancing valve into the constant flow circuit to reduce the differential pressure in excess without changing the regulation valve authority.

On the contrary, when using a two-way valve in variable flow-rate systems, the valve must be recalculated based on the additional pressure drop produced by the balancing valve.

Normally, the diameter and setting of the balancing valves are calculated during the planning phase and are therefore indicated on the system drawings.

In the construction phase you only need to check the setting values and correct the minor changes according to the variants under construction. The balancing procedure described above is the so-called “pre-regulation method”.

If the data required to define the balancing valve setting values is unavailable, the related balancing operations must be performed using a specific procedure called “compensated method”, which will be described later on.

PRELIMINARY ACTIONS ON THE SYSTEM

To prepare the system for accurate balancing:

- divide the distribution circuit, as much as possible, into similar and homogeneous operational areas in terms of pressure variation and to which an automatic control system can normally be applied. Each of these areas must be defined based on the hydronic point of view, the pump, the control valve, the main distribution lines, the secondary branches and, finally, the terminal units
- define the installation of balancing valves on the main columns, branch lines, and the major terminal units

During sizing of the automatic control valves that must control these terminal units, we recommend providing a differential pressure to the hydraulic head of the valves themselves, to give an authority value greater than 0.5. For the control valves of the terminal units, sizing is based on the different type of distribution:

- for installation in radiator systems, the thermostatic valves must be selected based on a differential pressure of about 8 to 10 kPa in order to obtain fairly small Kv values that ensure correct operation with any given pressure
- for two-way valves, sizing must ensure a pressure drop, with a fully open valve and a nominal flow-rate corresponding to:

  - at least 50 % of the differential pressure on the closed valve

  - at least 25 % of the pump hydraulic head, where possible
- sizing of the three-way valve must guarantee a valve pressure drop equal to the total pressure drop of all the elements part of the controlled circuit. For mixing valves, these items are installed upstream (e.g. boiler), while for diverters they are installed downstream (e.g. air treatment unit coil)
- calculate and size the pipes according to standard procedures. In particular, a contemporaneity factor must be considered in order to minimize pipe diameters. This coefficient should be identified pipe by pipe and the flow-rates should be corrected according to the factor selected

  Note: an excessive pressure drop in the piping affects the smooth operation of the terminal unit control system, especially if we consider a variable flow-rate distribution.

- choose the pump with total nominal flow-rate and hydraulic head sufficient to supply the most disadvantaged circuit. Any over-dimensioning is useless as the system will be balanced
- during the design phase, provide for balancing of the system flow-rate and drawing up of a technical report on the balancing procedure. This test report includes the flow-rate values obtained and the settings of all balancing devices

SIZING THE BALANCING VALVES

A balancing valve, such as all passive resistances of a circuit, creates a pressure drop. This fundamental feature, used in a proper way, enables to correct the differential pressure values and thus obtain the correct flow-rate within the circuits. Passive resistances generate a pressure drop that modifies the flow-rate according to the following equation:

$$dP = \left(\frac{10q}{Kv}\right)^2$$

dP = resistance pressure drop in kPa

q = flow-rate in m^3/h

And with dP expressed in bar:

$$dP = \left(\frac{q}{Kv}\right)^2$$

The Kv coefficient in a valve depends substantially on the section useful for the passage of the flow between the seat and stopper. This section provides the surface through which water can flow. The maximum Kv value, called Kvs, represents the flow-rate in m^3/h through the valve when the differential pressure is 1 bar between the upstream and downstream sections of the valve.The balancing valve is generally chosen to have a desired setting value close to 75 % of the valve opening.

This allows to get the maximum precision while keeping investment costs under control. Normally, the diameter of the valve can be less than the pipe diameter. In existing installations, it is often difficult to calculate the required setting value. In order to avoid over-dimensioning, we recommend to check that, in fully open position and with nominal flow-rate, the pressure drop is at least 3 kPa.

PRE-REGULATION METHOD

The pre-regulation method is a calculation method to define the balancing valve setting in advance when sizing distribution lines, based on the nominal flow-rate and pressure drop of each circuit. The pump is selected to meet the needs of the most disadvantaged unit. Its hydraulic head, which is able to supply this unit, generates therefore undesirable overpressure for the other units, thus causing excessive flow-rates.

The basic objective of this method is to define the value of the additional pressure drop (corresponding to the balancing valve setting value), which eliminates overpressure and obtain the correct flow-rate in all units. In other words, the goal is to standardize the deltaP of the circuits referring to the same node.

The actions provided for application of this method are as follows:

- calculate the pressure drop considering the entire length of the circuit that the fluid must follow from circulator to circulator. The value obtained will be the sum of the dP of all elements installed in series in the circuit considered:
  - circuit
  - control valve
  - localized pressure drops
  - deliver and return pipes to and from boiler room (considering the total flow-rate);
- repeat this operation for all circuits in parallel by comparing the values obtained and identifying the most disadvantaged ones. This is when the reference pressure drop is identified and therefore so is the pump hydraulic head. It is now necessary to calculate the difference in the reference dP (related to the most disadvantaged circuit) and the total of all the other circuits. The values thus obtained represent the imbalances that need to be compensated by the dP introduced with the balancing valves. A similar result can be obtained by calculating the differential pressure available at each node of the main line and by sizing the balancing valves based on the difference between the dP at the node and the one required for the branch. To better clarify this concept, an example is given by applying the two systems. The circuit shown in fig. 2.2 consists of three coils supplied in parallel circuits and having the following characteristics (automatic setting valves have been omitted to make the calculation simpler):

- coil 1: Q = 5 m³/h; dP = 20 kPa

- coil 2: Q = 7 m³/h; dP = 30 kPa

- coil 3: Q = 7 m³/h; dP = 30 kPa

And the upstream pipes have the following hydronic characteristics:

pipe a: Q = 7 + 7 + 5 = 19 m³/h; dP = 15 kPa

pipe b = e: Q = 7 + 7 = 14 m³/h; dP = 8 kPa

pipe c = d: Q = 7 m³/h; dP = 8 kPa

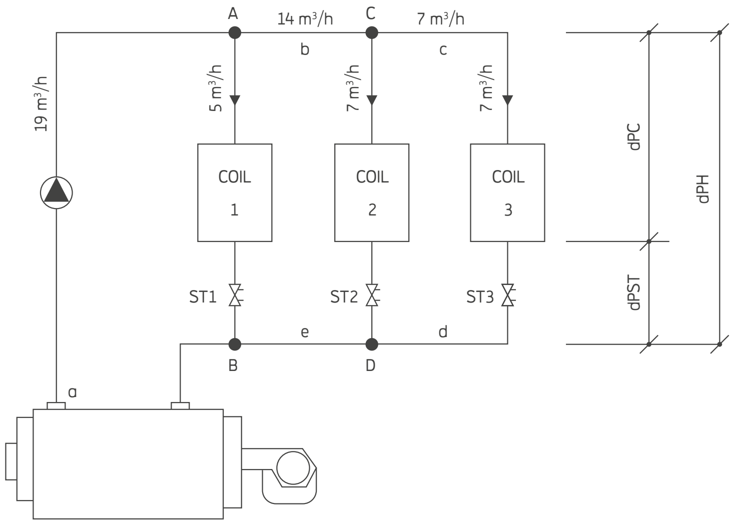


fig. 2.2

The balancing valve is installed in series with the most disadvantaged circuit. In this situation, number 3 has a diagnostic function and is selected to have the lowest possible pressure drop (however, not less than 3 kPa) and to ensure accurate reading with the differential pressure gauge. Based on the setting parameters given in Giacomini's technical sheet, the diameters and setting values are defined as follows:

ST3 = 2" set to position 90 with dP = 6 kPa

Now, we can define the operating characteristics of the pump:

Flow-rate q = qcoil 1 + qcoil 2 + qcoil 3 = 5 + 7 + 7 = 19 m^3/h

Hydraulic head H = a + b + c + coil 3 + ST3 + d + e = 15 + 8 + 8 + 30 + 6 + 8 + 8 = 83 kPa

According to the first system, the total dP for each unit can be calculated, considering the entire route from circulator to circulator:

circuit 3 total dP = a + b + c + coil 3 + ST3 + d + e = 15 + 8 + 8 + 30 + 6 + 8 + 8 = 83 kPa

circuit 2 total dP = a + b + coil 2 + e = 15 + 8 + 30 + 8 = 61 kPa

circuit 1 total dP = a + coil 1 = 15 + 20 = 35 kPa

The differential pressures of coils 1 and 2 must be compensated by regulating the corresponding balancing valves (ST1 and ST2).

The introduced dP must be equal to the difference between the highest dP calculated (circuit 3 total dP) and that of the considered branch (circuit 1 total dP and circuit 2 total dP) so as to obtain:

ST1: q = 5 m^3/h dP = dP tot coil 3 - dP tot coil 1 = 85-35 = 48 kPa

By now choosing (or "**selecting**") the correct valve dimension, we have:

ST1 = 1 1/2" with setting 30

ST2: q = 7 m^3/h; dP = dP tot coil 3 - dP tot coil 2 = 83-61 = 22 kPa

By choosing (or "**selecting**") the correct valve size, we have:

ST2 = 1 1/2" with setting 70

Applying now the second calculation system, once the pump is selected, proceed with the differential pressure calculation on the nodes:

dP CD = c coil 3 + ST3 + d = 8 + 30 + 6 + 8 = 52 kPa

dP AB = b + dP CD + c = 8 + 52 + 8 = 68 kPa

The calculation of ST1 and ST2 valve setting values is given by subtracting from the dP value of the nodes connected to the branch the pressure drop of the circuit being considered.

ST1: q = 5 m³/h, dP = dP AB - dP coil 1 = 68-20 = 48 kPa

When selecting the correct valve size, we have:

ST1 = 1 1/2" with setting 30

ST2: q = 7 m³/h; dP = dP CD - dP COIL 2 = 52-30 = 22 kPa

When selecting the correct valve size, we have:

ST2 = 1 1/2" with setting 70

In the presence of a variable flow-rate circuit, with automatic two-way control valves, it is useful to recalculate them with greater pressure drops, thus containing most of the available overpressure. The remaining part will be eliminated by the balancing valve. It is important, in fact, not to reduce, with the series-connected balancing valve, the entire differential pressure so as not to undo the authority of the two-way control valve.

This concept becomes clearer with an example: by calculating a two-way valve with dP = 20 kPa, authority ß = 0.5 and total dP = 40 kPa. In the control calculation we have an overpressure of 40 kPa at the nodes corresponding to the branch considered. Under such conditions, when compensating for the imbalance with a balancing valve by introducing a 40 kPa dP, we could balance the branch, but doing so would greatly penalize the possibility to regulate the valve. In fact the authority would become:

$$ß = \frac{dP}{dP\ tot} = \frac{20}{20+20+40} = \frac{1}{4} = 0.25$$

If, in spite of this, we had adopted a control valve having a dP = 40 kPa and provided the remaining 20 kPa to the balancing valve, we could have obtained such an optimum authority:

$$ß = \frac{dP}{dP\ tot} = \frac{40}{20+20+40} = \frac{1}{2} = 0.50$$

If all terminal units of a main column have an excess of differential pressure above a specific value, for example 20 kPa, one can reduce the differential pressure by 20 kPa through the balancing valve installed in the same main column and compensate for the remaining part with the valves installed on the branches and terminal units. To calculate the Kv value required for balancing, we must first calculate the pressure drop to be balanced:

dP ST = dP H — dPr

where

dP ST = balancing valve pressure drop

dP H = pressure available on the nodes

dPr = circuit pressure drop

The Kv value will be given by the following equation:

$$Kv = 10 \frac{q}{\sqrt{dPST}}$$

For example, with dPH = 10 kPa dPr = 60 kPa, q = 5 m^3/h, we will have a balancing valve dP of 40 kPa and a Kv of 7.9. Now it is only necessary to define the valve setting position, which can be obtained from the technical documentation. As shown, the setting position corresponding to a previously calculated Kv of 7.9 can be obtained with a 1" Ø valve set to 100 or with a 1 1/4" Ø valve set to 85, or finally with a 1 1/2" Ø valve set to 30. This setting value, along with the flow-rate value, will be indicated on the project, after completion of the installation, to verify the exact flow-rate. If the terminal unit is a radiator with a thermostatic valve with adjustable Kv, presetting is generally calculated based on a 8 kPa pressure drop which, for a temperature difference between delivery and return of 20 °C, corresponds to a Kv:

$$Kv = 0.01 \frac{q}{\sqrt{8}} \quad \text{where} \quad q = \frac{0.86 * P(watt)}{dT}$$

$$\text{and so} \quad Kv = \frac{0.01 * 0.86 * P}{20 * \sqrt{8}} = \frac{P(watt)}{6578}$$

dT = difference between delivery and return temperature

Q = flow-rate expressed in l/h

The exact calculation of the differential pressure at each terminal unit is certainly complicated, but nevertheless it is absolutely necessary to balance the system.

The "presetting method" is a calculation method that corrects any imbalance during design and, of course, is ideal for new systems.

However, one must take into account that some modifications may be required during installation, even at the last minute, which may vary the contour conditions.

It is therefore necessary to check all the valves, once installed and set, to draw up a detailed report and, if necessary, to adjust the setting values appropriately.

THE PROPORTIONAL METHOD

As already discussed, when multiple terminal units connected to a branch are connected in parallel circuits, any change of the differential pressure value in the nodes may proportionally change the flow-rate in all units.

Consider the circuit shown in fig. 2.3, where the available differential pressure is expressed by dPa = dPh-dPstp and, change, for example, the setting and therefore the pressure drop of the ST-P balancing valve, so that dPa is four times larger: we will get twice the flow-rate in each terminal unit (Q1, Q2, Q3, Q4).

This means that any variation outside the dP value will change the flow-rate of parallel-connected terminal units in the same proportional way. This rule will of course be valid as long as the ST1, ST2, ST3, ST4 valve settings are not changed.

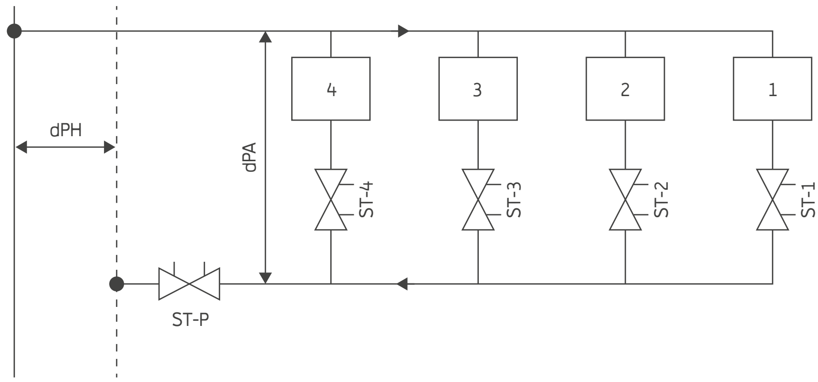


fig. 2.3

And even in a situation where there are changes on individual branches of the system (e.g. ST3), there will be a proportional change in the branches downstream (ST1, ST2) as well.

The proportional method works on this principle to balance the terminal units of a branch and, in the same way, the rule is valid for balancing the branches and the main pipelines.

Required tools

- two differential pressure gauges
- technical documentation by the manufacturer
- in large installations, it may be necessary to contact the technicians involved in the balancing operations (via mobile phone, etc.)

The balancing procedure

- choose the first column to be balanced. Close all the main valves of the other columns. Fully open the column valve to be balanced and all valves downstream of this circuit, thus obtaining an overflow
- define the exact order of the column branch balancing. By using the differential pressure gauge and measuring the instantaneous flow-rate, it is possible to calculate the relationship between the measured flow-rate qm and the design flow-rate qp in each branch:

$$r = \frac{qm}{qp}$$

balancing will start from the branches with the maximum value r and that, of course, are the most profitable. This will gradually increase the flow-rate available for the other system branches.

- balancing of the flow-rate to the terminal units of a branch:

A) measure the flow-rate of each terminal unit (q1, q2, q3 and q4) with the balancing valves fully open

B) calculate the r_u of each terminal unit:

$$r_u = \frac{qm(\text{measured flow})}{qp(\text{design flow})}$$

The unit with the smallest value r_u will be called $r_{u\ min}$

C) set ST-1 to get a r_u value ST-1 = 95 % of $r_{u\ min}$ and fix this setting that will be used as reference. A differential pressure gauge must be installed on the ST-1 valve to monitor the dP value during subsequent steps

D) set the next valve ST2 to obtain the same r_u value of ST-1 (reference valve). ST-1 r_u will increase slightly. Reset the ST-2 valve to obtain the same r_u value for ST-1

E) proceeding in reverse in the direction of the pump, switch to ST-3 and then to ST-4 to get the same value r_u for ST-1. Some changes upstream of the two terminal units will obviously affect and modify the downstream units by the same ratio

F) when all units are balanced one with the other, work on ST-1 to obtain ru ST-1 = 1 Automatically all other units will have the correct flow-rates

G) use the same balancing method for all terminal units of other branches in the same zone or column

- the second phase consists of balancing all the system branches as in fig. 2.4

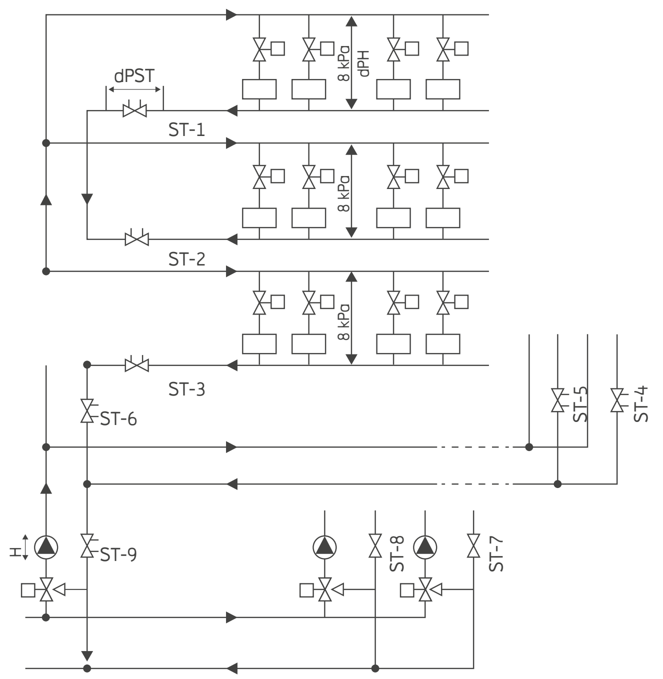


fig. 2.4

First, measure all the flow-rates with a differential pressure gauge and then calculate the following ratio for each balancing valve:

$$r_u = \frac{qm(\text{measured flow})}{qp(\text{design flow})}$$

B) use as r_{min} the smallest r value of r ratios calculated

C) set the ST-1 valve to obtain the value r ST-1 = 95 % of r_{min}, then block the valve and mount a differential pressure gauge on the same for continuous monitoring

D) set ST-2 (returning to the pump) to obtain r ST-2 = r ST-1. When doing this, the r ST-1 will slightly increase, so continue to reset ST -2 until r ST-2 = new value of r ST-1 is obtained. Now block ST-2 in this setting position

E) proceeding in reverse in the direction of the pump, switch to ST-3 which must be set to obtain R ST-1 = r ST-3 and then r ST-1 = r ST-2 = r ST-3

F) balance the ST-6 main valve to obtain r ST-1 = 1, all other flow-rates will automatically be corrected

G) The branches of all the other columns can be equally matched

> balance the columns between them:

A) in the third stage, the columns must be balanced between them. Measure the flow-rate in all columns (with all valves open)

B) define the smallest value of r that will be called r_{rmin}

C) set ST-4 (reference) to obtain r ST-4 = 95 % $_{min}$, then block the valve and mount a differential pressure gauge on the same for continuous monitoring

D) set ST-5 (returning to the pump) to get r ST-5 = r ST-4. When doing this, the r ST-4 will slightly increase, so continue to reset ST-5 until r ST-5 = new value of r ST-4 is obtained. Now block ST-5 in this setting position

E) proceeding in reverse in the direction of the pump, consider ST-6, which needs to be set to obtain R ST4 = r ST-5 = r ST-6

F) balance the ST-9 main valve to obtain r ST-4 = 1, all other flow-rates will automatically be corrected. The branches and all the terminal units are now correctly balanced

As shown, the proportional method requires a long preparation to determine which branch is the most convenient from which to start. Furthermore, the reference valve is arbitrarily chosen, so the balancing valve pressure drops are not minimized.

For this specific reason, the compensated method, as described below, is the fastest and more effective: it enables to reduce pressure drops of the balancing valves independently of the reference valve pressure drop, not going below the minimum value required to obtain an accurate measurement.

THE COMPENSATED METHOD

The "compensated method" can be applied to any existing system and no pre-setting calculations are required. This method offers two fundamental advantages:

- reduces commissioning and balancing times, as it requires only simple a setup for each valve without repetition
- reduces pump-related costs, minimizing balancing valve pressure drops

In addition, possible over-dimensioning of the pump can be compensated by the main balancing valve. If the imbalance is excessive, it may be appropriate to remove the valve and install a smaller pump or reduce the pump total hydraulic head to achieve maximum energy savings and reduce operating costs.

Preliminary actions

- identify the main circuits, columns, branches and terminal units on the system project. Check the flow-rate of each balancing valve. Verify that the flow-rates of each column are equal to the sum of the ones in their branches
- clean the filters and purge the air from the system
- open all shut-off and control valves to get the maximum flow-rate available. Use, if already calculated, the presetting values on each balancing valve. If this is not possible, all column balancing valves must be partially separated, excluding only the valve from which you want to start setting the various system units and areas
- make sure the pump rotates in the correct direction
- make sure you have all the tools required to proceed, that is:

  a) two differential pressure gauges to instantly read both the differential pressure and the flow-rate

  b) valve setting technical sheet

  c) if the system is very large, at least two people must be able to communicate via mobile phone

Reference valve and compensation valve

When changing a flow-rate through the balancing valve, the pressure drop of that circuit is changed and, consequently, since the hydronic circuits are connected to each other, also those of all branches. Any disturbance on a branch causes, in fact, a general modification of the flow-rates. This behaviour of the hydraulic circuits makes balancing difficult because after setting a single valve, any change that occurs on the following ones causes variations on the first and in turn on all the others. For this reason, several calibrations are required, with a consequent waste of time.

The "compensated method" enables to prevent such a disadvantage, making it possible to perform a one-time setting of the balancing valve, even for very large systems. To achieve this, it is necessary to continuously monitor the dP of the valve already set and, step by step, cancel the changes caused by setting the others, by throttling a balancing valve (compensation valve) installed upstream of the circuit.

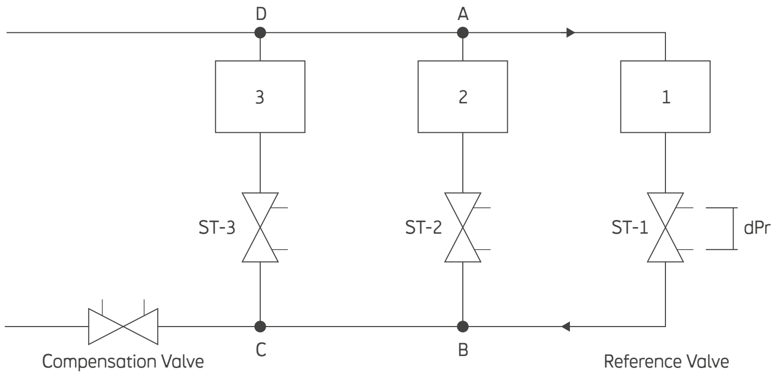


fig. 2.5

As shown in fig. 2.5, the variation, read as dP modification on the ends of the "reference valve", is compensated by a valve acting on the main flow.

This "compensation valve" allows in practice to maintain the reference valve dP constant and hence, indirectly, also all the branches that are in between. Fig. 2.5 shows a branch with multiple terminal units. The farthest unit from production is considered as a reference valve (ST-1). The flow-rate is set to the nominal flow-rate for unit 1. This value corresponds to a dP (dPr) value that must be continually kept under control. Now switching to the ST-2 setting, returning to the production, we will notice that any change in the unit 2 flow-rate will change the dPr.

The dPr value therefore needs to return to its original value by acting on the compensation valve. In practice, this means resetting the flow-rate of unit 1 to its correct value. The same procedure must be applied to unit 3. The flow-rate setting of this branch will also cause a variation in the two previous ones, highlighted by a dPr variation managed by the compensation valve.

The procedure is thus applicable to any number of terminal units served by the same branch. The same branches, as well as the columns, can be balanced between each other according to the same system. Setting operations must be performed starting from the farthest unit from production (reference valve) which moves to the nearest unit.

Setting the reference valve

The dP value, selected to obtain the correct flow-rate in the reference unit should be the lowest possible, while respecting the following limits:

- at least 3 kPa. This minimum value enables to obtain sufficiently accurate readings both with electronic devices and traditional differential pressure gauges. In practice, the reference valve minimum Kv must be at least 5.8 times larger than the passing nominal flow-rate (m^3/h)
- equal at least to the valve pressure drop in fully open position. If with a nominal flow-rate and a fully open valve the pressure drop is 5 kPa, it is obviously impossible to obtain a 3 kPa setting. The minimum acceptable pressure drop can be calculated with the following equation:

$$dP > \left(\frac{10\ qnom.}{Kvmax} \right)^2$$

where the dP value is expressed in kPa and $q_{nom.}$ in m^3/h

- equal at least to the pressure drop of the most disadvantaged unit when it is clear which it is and when it is different from the reference one. This situation is typical in lines with terminal units featuring very different pressure drops and where a dPr = 3kPa value may not be sufficient to define the differential pressure of the most disadvantaged ones. In such situations, the highest value is required

Balancing of units with the same dP

The sequence of the following actions is developed on a heating system as shown in fig. 2.6.

The same method, however, can be obviously applied to other types of systems.

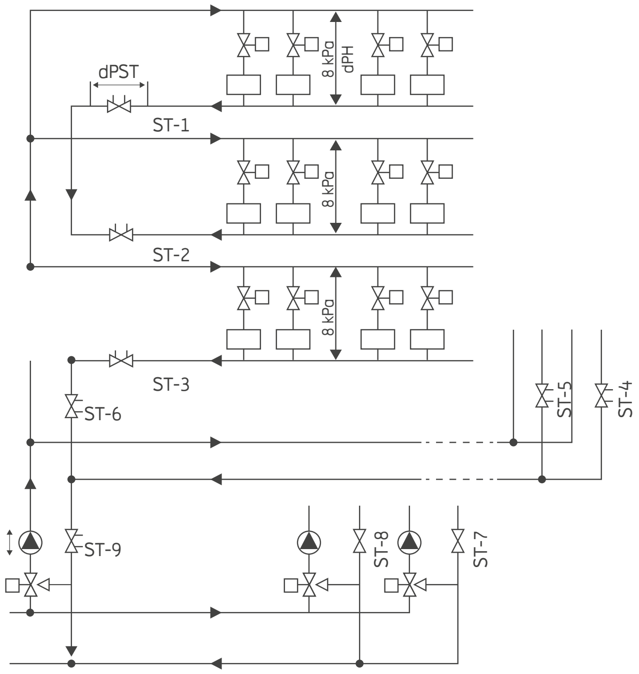


fig. 2.6

In the example, we will consider column 6 of secondary circuit 9.

- set the flow-rate of the terminal units as shown in the previous paragraph. In radiator applications, the method is simpler as the thermostatic valves are pre-set based on a 8 kPa pressure drop; under nominal flow-rate conditions, flow-rates are not measured in this application
- balance the branches between them. The reference valve in this situation is ST-1 which has to be set so as to obtain the nominal pressure drop and hence the nominal flow-rate for that branch. Fix the balancing valve setting and monitor the dP value (dP ST-1)
- connect a differential pressure gauge to ST-1 and make sure that the value read can be constantly verified also by those reading the ST-6 compensation valve. When using an electronic device, a simple extension cable should be sufficient to transfer the reading value; use of a standard differential pressure gauge will require two people
- use the ST-6 compensation valve knob to maintain the correct dPr value for the ST-1 reference valve heads. If the ST-2 and ST-3 valves are fully open, they may receive such a high flow-rate that could prevent the desired flow-rate to the reference valve dPr. In this situation, ST-3, and possibly also ST-2, must be divided to obtain this setting. Their regulation will be performed in the next step

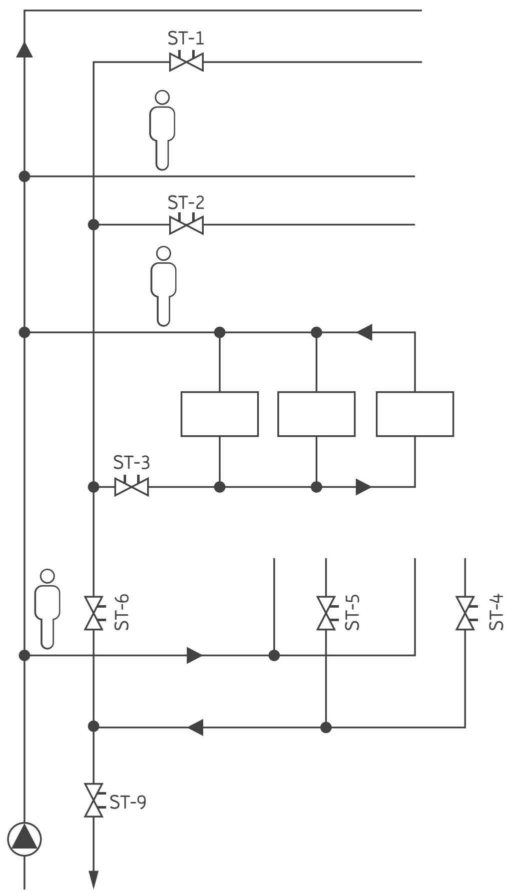


fig. 2.7

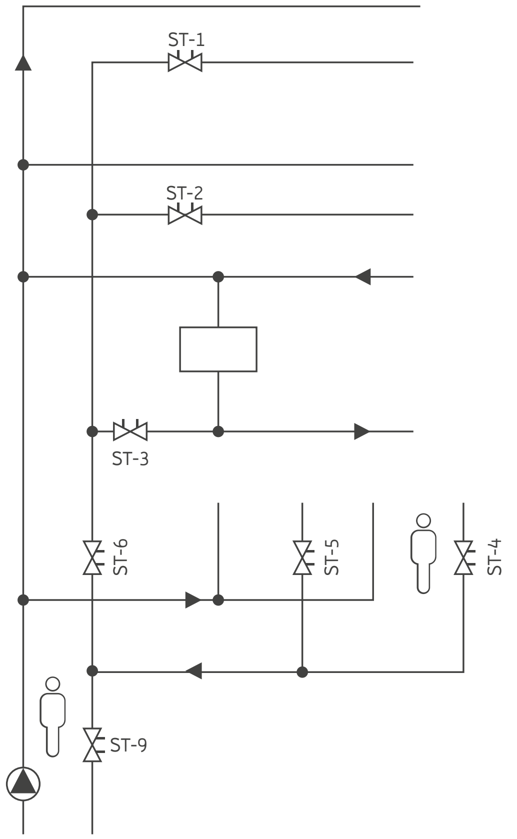


fig. 2.8

- balance the flow-rates in the other branches using the second differential pressure gauge, starting from ST-2 (see fig. 2.7) and proceeding upstream with ST-3, etc. At the same time, the dP variation, read on ST-1, must be corrected through ST-6 at each setting variation of ST-2 and ST-3
- once the last valve is set, the one closest to the compensation valve (ST-3 in the example), all the flow-rates will correspond to the design values
- proceed in the same way to set the terminal units of column ST-5 by opening it completely and repeat the operations described above, starting from number 2
- once the branches of the various columns are fully balanced, the columns must be balanced between them. The procedure is similar to the one used for the branches. The ST-4 valve of the last column is considered as "reference valve" (see fig. 2.8) while ST-9 will be the "compensation valve". At the end of the procedure, the ST-9 pressure drop will represent the excess value of the pump hydraulic head. Should this value be very high, one may replace the pump with a smaller one, or change the hydraulic head value of the circulator itself

Balancing with units featuring different and known dP (circuits, radiant systems)

In this situation, when setting the flow-rates of branch terminal units, the pressure drops of each unit must be known. This information is generally available in design documentations or in the suppliers' technical sheets.

This procedure is different from the previous one only for setting of the reference valve. Fig. 2.9 shows a branch with terminal units featuring different and known pressure drops.

- identify the unit with the maximum pressure drop (n. 3 in this example)

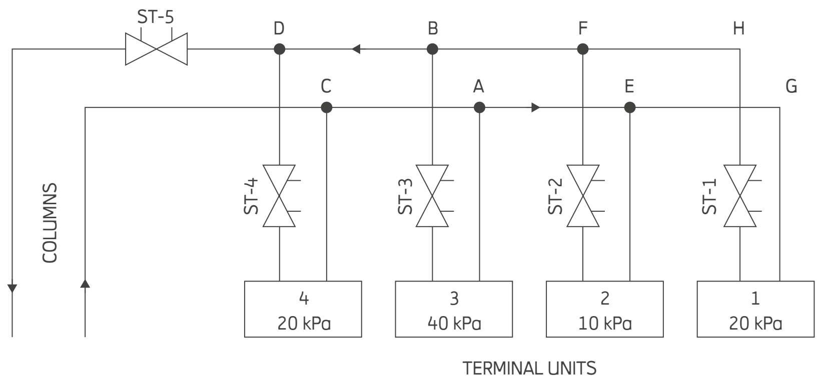


fig. 2.9

- define the pressure drop of the balancing valve installed on this circuit in fully open position (e.g. 5 kPa)
- calculate the dP at the nodes of the considered unit (dP AB = 40+5 = 45 kPa)
- define the pressure drop for the balancing valve of the first unit (n.1) by subtracting the pressure drops of the pipes downstream of unit 1 from the previously calculated dP. In the example 45-3-20 = 22 kPa
- set valve ST-1 to 22 kPa and proceed with the other units as described above

Balancing with units featuring different and unknown dP

In case of units featuring unknown and different nominal pressure drops, the one creating the highest pressure drop must be identified.

This cannot be achieved by simply comparing the actual flow-rates of the different units as some may create short circuits able to absorb most of the flow-rate.

A limited flow will pass through the farthest units in this situation and, as a consequence, the one with the highest resistance will be absent.

Let us consider once again fig. 2.9 assuming the coil pressure drops are unknown.

To identify the unit with the highest resistance, follow the steps below:

- open valve ST-5 completely and close all other balancing valves
- for each terminal unit of the branch, starting from unit 4 and proceeding downstream follow these steps;

  A) Close the balancing valve and measure value dP = dPmax

  B) Set the valve so as to obtain the nominal flow-rate and measure value dP = dP min

  C) The nominal pressure drop of the unit and its accessories will be approx. dPu = dPmax - dPmin

Since the pressure drops are known, it is necessary to proceed as described above.

GIACOMINI
WATER E-MOTION

Static or dynamic devices to balance constant or variable flow-rate systems.
All components in the right place for a state of the art result.

Chapter 3

The components (application, description and selection)

R206B
STATIC BALANCING VALVE WITH FIXED ORIFICE

The R206B is a static balancing valve for gradual and precise regulation of the flow-rate. Its main feature is the internal calibrated orifice, this means that the 'inner flowmeter part' of the valve has a fixed orifice and so a fixed Kv value for each dimension of the valve. This simplifies considerably the presetting and the measuring of the flow-rate: through the pressure plugs (depending on the versions, they are provided with or they are optional) and a simple analogue or digital differential pressure manometer, it is possible to carry out a quick and accurate measurement of the flow-rate that is circulating through the valve. Large databases with Kv values and complex procedures definitely belong to the past.

WHY CHOOSE IT?

- fix orifice
- DZR* brass body
- opening control through mechanical-memory mechanism

* Dezincification resistant (DZR) or corrosion resistant (CR) brasses are used in plants with large corrosion risks, like high temperature systems with soft water or chlorides present

fig. 3.1

The number of applications is numerous, but this kind of valve is typically used to balance the flows in the branches of *'parallel connection pipelines'* systems.

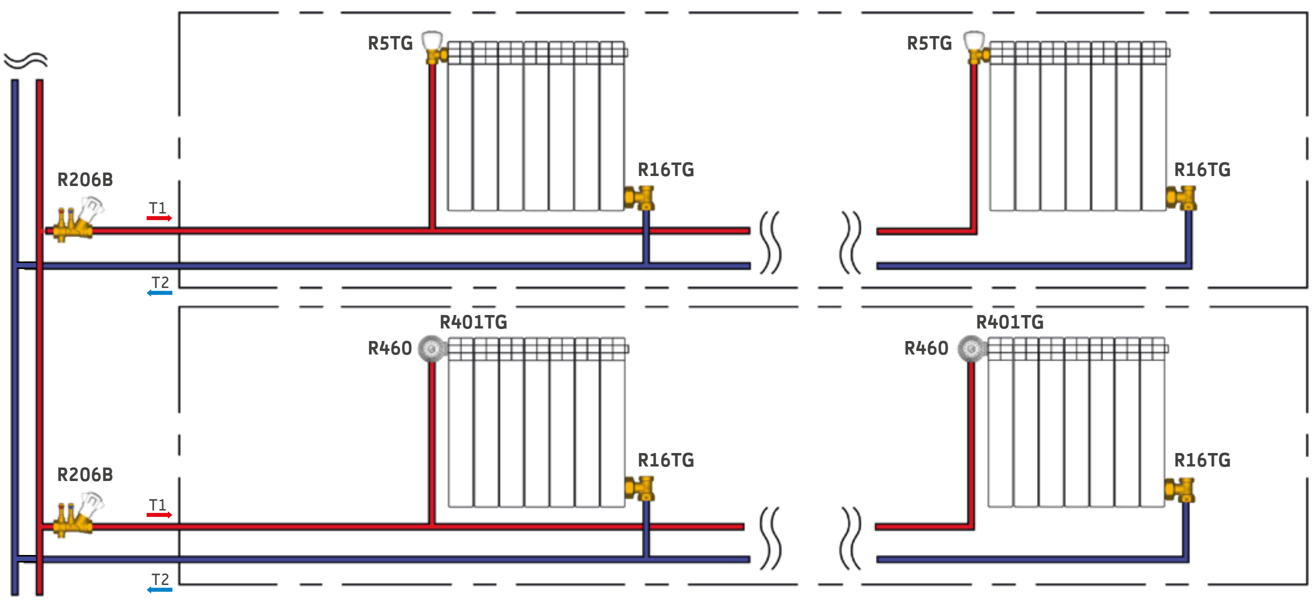


fig. 3.2 Application of R206B in balancing radiator distribution

The range includes sizes from 1/2" up to 2", with the respective Kv values ranging from 2,7 to 25,5.

Versions

product code		connections
with probes	without probes	
R206BY003	R206BY013	1/2"
R206BY004	R206BY014	3/4"
R206BY005	R206BY015	1"
R206BY006	R206BY016	1 1/4"
R206BY007	R206BY017	1 1/2"
R206BY008	R206BY018	2"

fig. 3.3

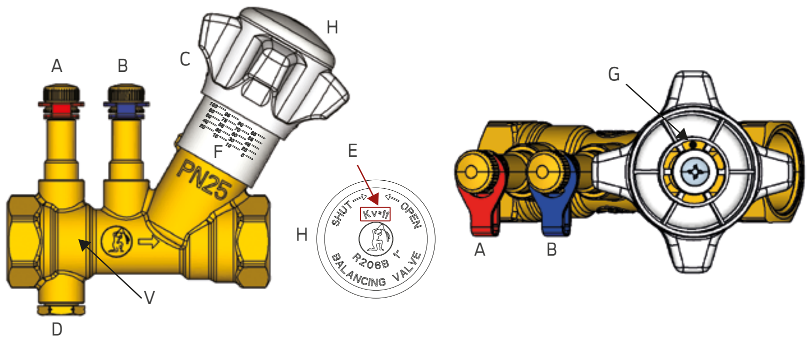
Valves Kv

product code	connections	Kv (Venturi flow meter)	Kv (complete valve)
R206BY003	1/2"	4,0	2,7
R206BY004	3/4"	7,5	5,5
R206BY005	1"	11,0	7,0
R206BY006	1 1/4"	13,5	9,5
R206BY007	1 1/2"	24	18,5
R206BY008	2"	31	25,5

fig. 3.4

Fig. 3.5 shows all the components of the static balancing valve. To ease presetting when installing the valve or adjusting presetting when changes in the installation are made afterwards, the Kv value of the Venturi is printed on the removable cap of the hand wheel.

Components



legend			
A	High pressure probe	**F**	Scale for 0÷100 % setting (20 positions)
B	Low pressure probe	**G**	Presetting screw (limiting the stroke)
C	Handwheel	**H**	Removable cap (for presetting) with imprinted Venturi Kv value
D	Drain 1/4"F		
E	Kv of the Venturi flow meter	**V**	Venturi flow meter

fig. 3.5
List of components and indication of the Kv value of the Venturi onto the handle of the valve

Presetting and operation – mechanical memory

All R206B valves are equipped with a mechanical memory mechanism for the presetting of the valve. This means that after the presetting, the positioning of the hand wheel can be limited in a way that it is still possible to shut-off the valve if maintenance has to be done, but that it is not possible to open the hand wheel further then the presetting position.

In practice, this is done as follows:

- use the diagram of fig. 3.7 to read the position of the hand wheel for the presetting, based on the desired flow Q in the circuit and the necessary pressure drop Δp for balancing
- make the regulation on the valve by means of the lower edge of the hand wheel (ref. C - fig. 3.5 and 3.6) and the scale (ref. F – fig. 3.5 and 3.6)
- disassemble the cap (ref. H - fig. 3.5 and 3.6) of the hand wheel and screw clockwise the presetting screw (ref. G – fig 3.5 and 3.6), by using an allen key of 1,5 mm for the versions 1/2" – 1 1/4" and 2 mm for the versions 1 1/2" – 2", until the end
- reassemble the cap on the hand wheel

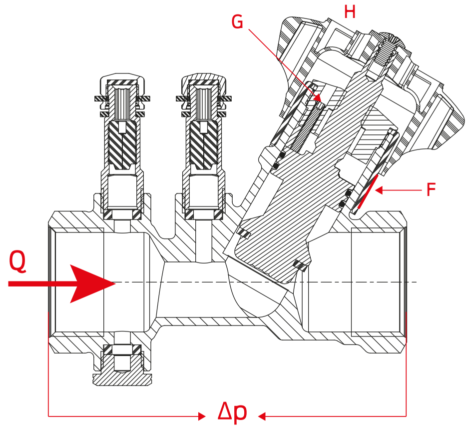


fig. 3.6
Section of the valve R206B

Dimensioning and selection procedure

The dimensioning and the selection procedure for static balancing valves is done through the following steps, using fig. 3.7:

- calculate the desired flow-rate in the circuit that needs to be balanced
- calculate the desired differential pressure over the balancing valve R206B in order to obtain a maximum regulation authority of the valve. A practical rule is to consider the same pressure drop over the balancing valve as over the complete circuit downstream, including the end user
- draw a line through both points; then, at the intersection with the vertical line which represents the Kv value draw a horizontal line
- finally, because of the accuracy of the control, select the smallest size among the possible valves and read the presetting. In the example on fig. 3.7 within the range of 1 1/4" – 1 1/2" – 2", the 1 1/4" valve will be selected, with presetting 85

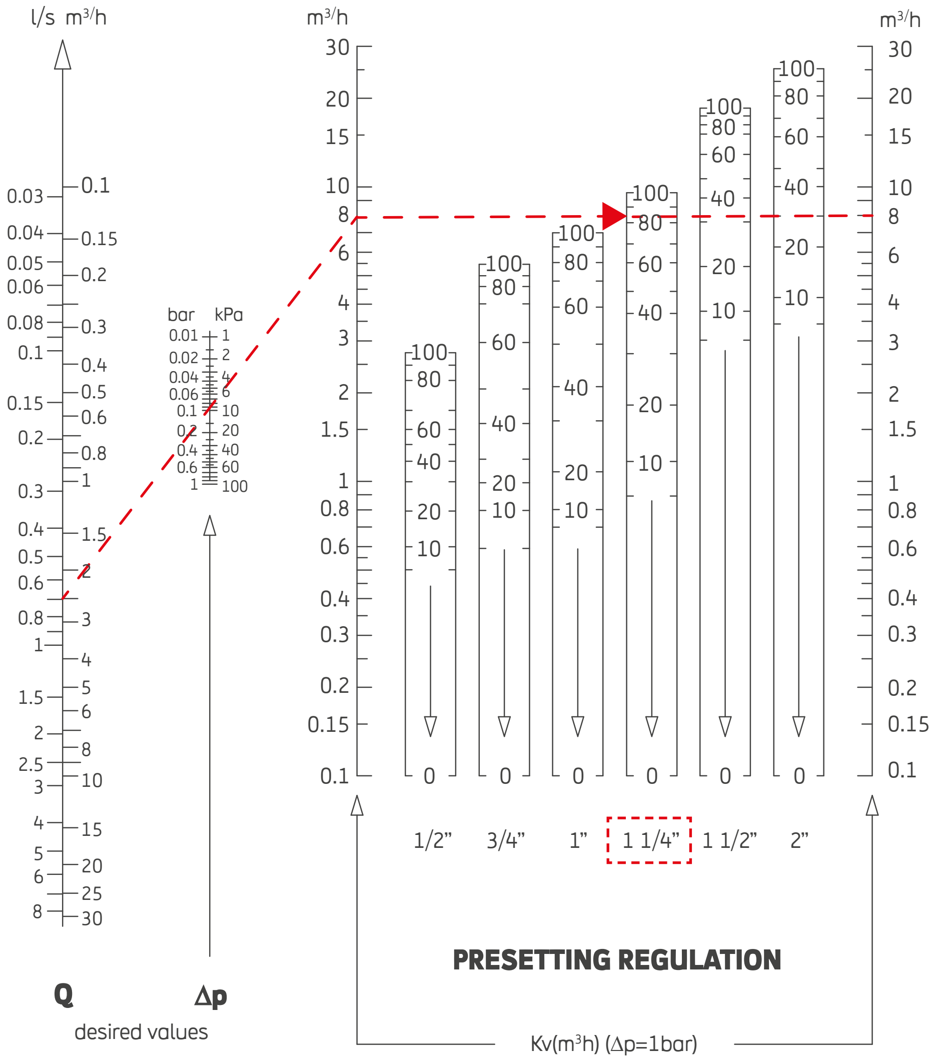


fig. 3.7
Selection diagram and procedure

Instant flow-rate calculation through measuring differential pressure

R206B balancing valves are equipped with an inner flowmeter having a calibrated orifice (Venturi principle) with one fixed Kv value per dimension, regardless of the position of the hand wheel. This allows a fast and easy calculation of the circulating flow-rate Q, based on the differential pressure Δp measured with a differential pressure manometer through the pressure plugs A and B (ref. A – fig 3.8), using the following equation:

$$Q = Kv_{Venturi} \sqrt{\Delta p}$$

with:

Q = flow-rate in m^3/h

$Kv_{Venturi}$ = Kv value of the Venturi - refer to the table fig. 3.4 - “Valves Kv”

Δp = pressure drop over the Venturi, measured through the pressure plugs A and B, in bar

For liquids with a density ρ different from water, the circulating flow-rate Q is calculated using the following equation:

$$Q = Kv_{Venturi} \sqrt{\Delta p / \rho}$$

with:

Q = flow-rate in m^3/h

$\mathbf{Kv_{Venturi}}$**=** Kv value of the Venturi - refer to the table fig. 3.4 - “Valves Kv”

Δp = pressure drop over the Venturi, measured through the pressure plugs A and B, in bar

ρ = density of the liquid in Kg/m^3

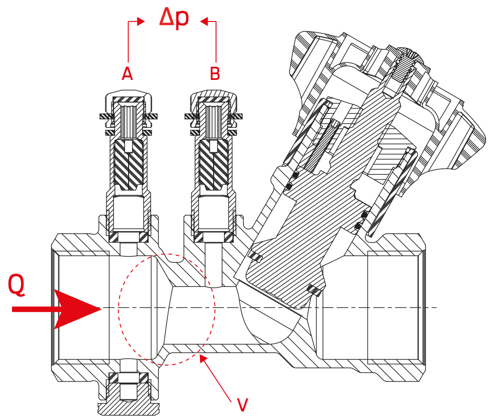


fig. 3.8
Measurement of the pressure drop over the Venturi with calibrated orifice V

Alternatively, after measuring the differential pressure Δp with a differential pressure manometer through the pressure plugs A and B (ref. A – fig 3.8), the flow-rate Q can be determined according to the valve size using the following diagram in fig. 3.9.

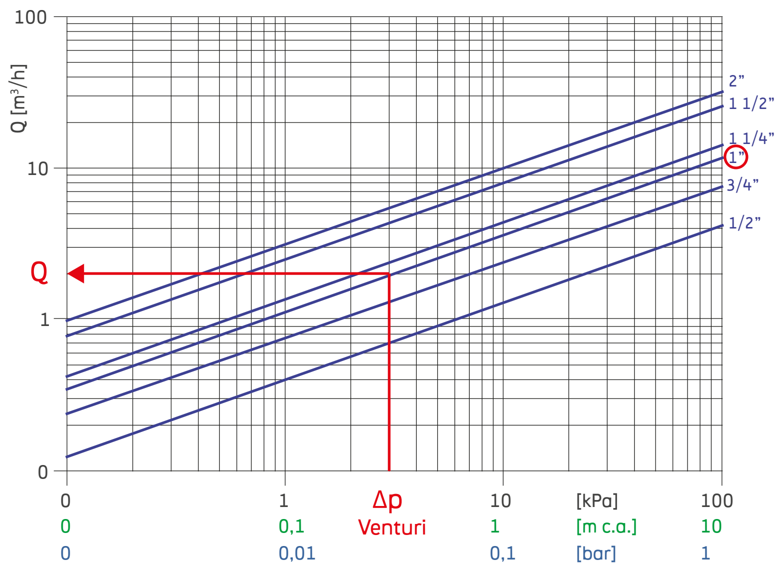
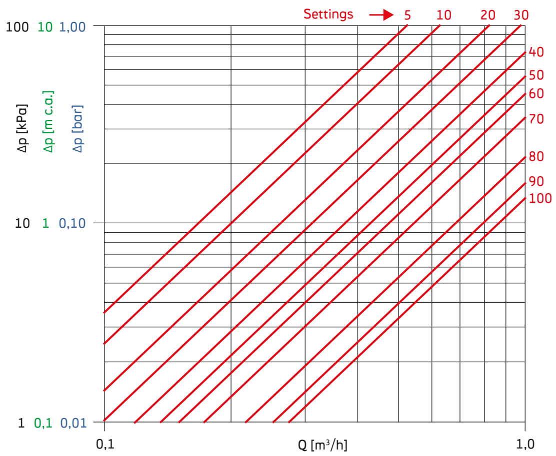


fig. 3.9
Flow-rate differential pressure diagram of the Venturi with calibrated orifice V

Flow-rate pressure drop diagrams

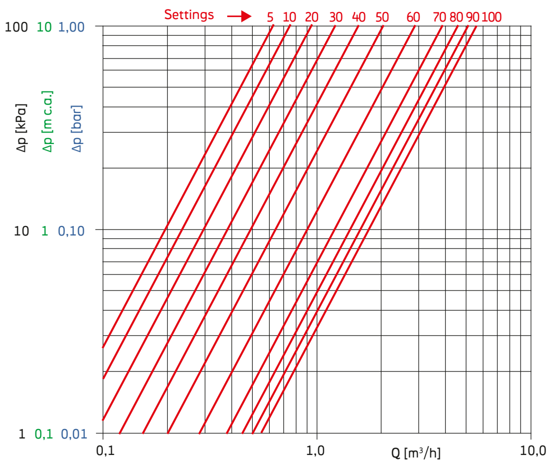
Below are listed all the flow-rate pressure drop diagrams for the complete range from 1/2" to 2", with corresponding tables showing presettings and Kv values of the complete valve:

1/2"



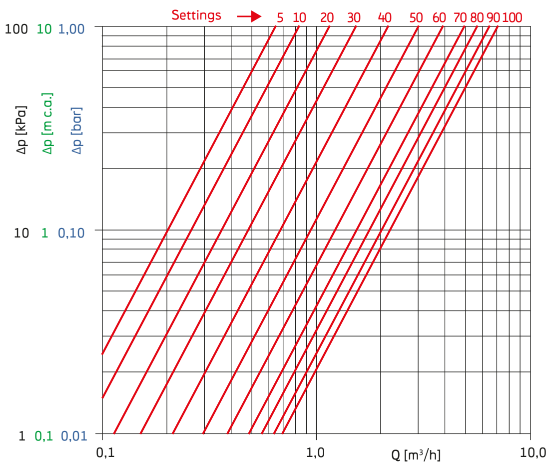
setting	Kv
100	2,70
95	2,54
90	2,48
85	2,34
80	2,18
75	1,99
70	1,71
65	1,59
60	1,48
55	1,41
50	1,33
45	1,28
40	1,19
35	1,09
30	0,98
25	0,92
20	0,83
15	0,73
10	0,63
5	0,53

3/4"



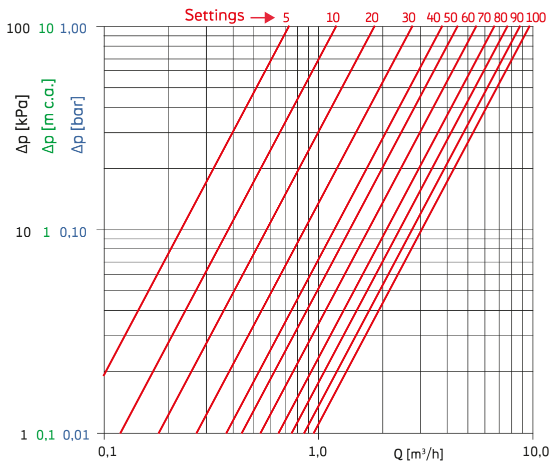
setting	Kv
100	5,50
95	5,20
90	5,00
85	4,80
80	4,57
75	4,35
70	3,95
65	3,50
60	2,88
55	2,37
50	2,00
45	1,81
40	1,58
35	1,39
30	1,24
25	1,10
20	0,96
15	0,85
10	0,75
5	0,62

1"



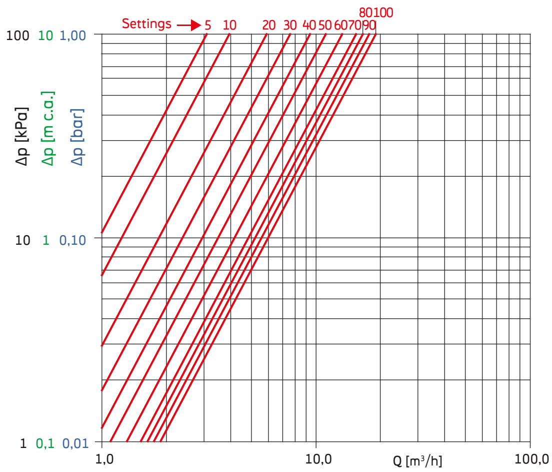
setting	Kv
100	7,00
95	6,59
90	6,25
85	5,95
80	5,49
75	5,03
70	4,86
65	4,29
60	3,89
55	3,32
50	2,92
45	2,50
40	2,14
35	1,81
30	1,47
25	1,37
20	1,14
15	0,98
10	0,83
5	0,64

1 1/4"



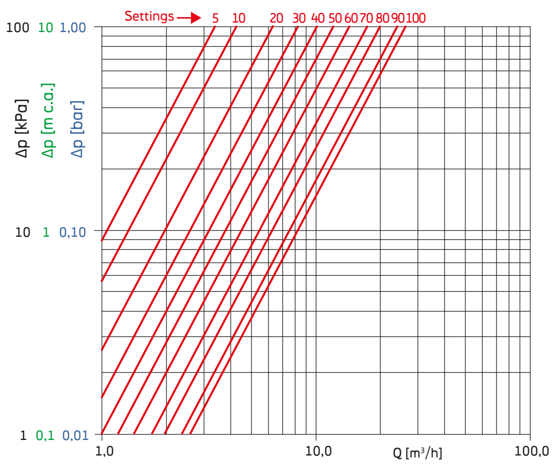
setting	Kv
100	9,50
95	8,98
90	8,55
85	7,97
80	7,60
75	7,05
70	6,46
65	5,86
60	5,50
55	4,89
50	4,39
45	4,04
40	3,69
35	3,25
30	2,66
25	2,21
20	1,79
15	1,53
10	1,21
5	0,73

1 1/2"



setting	Kv
100	18,50
95	17,80
90	17,35
85	16,98
80	16,40
75	15,84
70	15,23
65	14,29
60	13,19
55	12,28
50	11,21
45	10,13
40	9,18
35	8,41
30	7,56
25	6,74
20	5,80
15	4,67
10	3,84
5	3,02

2"



setting	Kv
100	25,50
95	24,08
90	23,21
85	21,64
80	19,98
75	18,95
70	17,64
65	16,53
60	14,72
55	13,33
50	12,06
45	11,08
40	9,98
35	8,99
30	8,02
25	7,26
20	6,24
15	5,13
10	4,18
5	3,36

Installation suggestions

Since some boundary conditions could influence and affect the commissioning and the proper functioning of the valve, the following rules should be followed:

- the valve must be installed maintaining free access to the pressure probes, the drain and the hand wheel
- the valve and the pipe on which it is installed must have the same nominal diameter
- the system needs to be washed before installing the valve
- a filter needs to be inserted upstream of the valve to protect the valve from possible impurities
- the flow direction indicated on the valve body needs to be respected
- the valve can be mounted on horizontal or vertical pipes
- if the valve is installed after a curve, the length of the straight pipe between the curve and the valve should be at least 5 times the nominal diameter Dn of the valve. After the valve, there should be a straight pipe with a length of at least 2 times the nominal diameter Dn of the valve
- if the valve is installed after a circulator, the length of the straight pipe between the circulator and the valve should be at least 10 times the nominal diameter Dn of the valve. After the valve, there should be a straight pipe with a length of at least 2 times the nominal diameter Dn of the valve

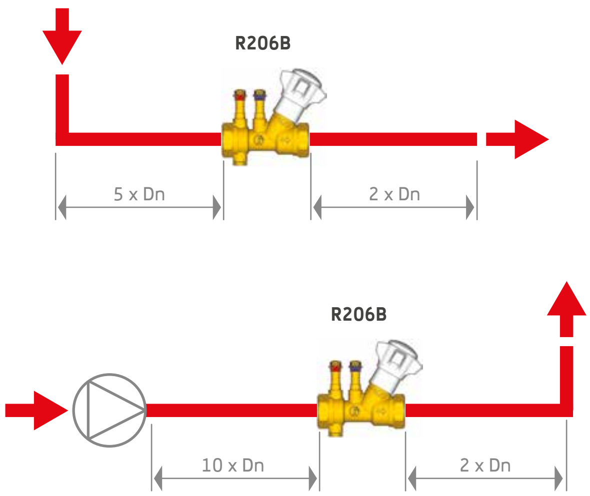


fig. 3.9
Installation suggestions

R206B-1
COMPACT STATIC BALANCING VALVE

Balancing is essential to reduce energy consumption in hydronic systems, even if space is limited. The R206B-1 is a static balancing valve for gradual and precise regulation of the flow-rate, in a compact version, with optimized dimensions.

WHY CHOOSE IT?

- extremely compact
- opening control through mechanical-memory mechanism

fig. 3.10

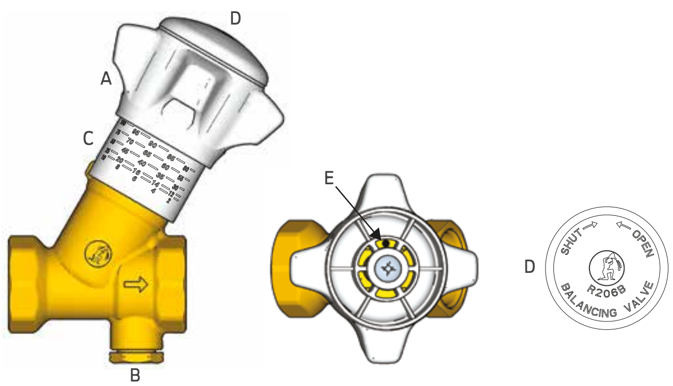
Versions

product code	connection	valve Kv
R206BY113	1/2"	2,10
R206BY114	3/4"	4,40
R206BY115	1"	6,25

fig. 3.11

The range includes sizes from 1/2" up to 1", with the respective Kv values ranging from 2,1 to 6,25.

Components



legend			
A	Handwheel	**D**	Removable cap (to carry out the limitation of the opening stroke)
B	1/4" F connection for differential pressure controller capillary	**E**	Locking screw (limits the opening stroke to the desired value)
C	Presetting scale 0÷100 % (25 position)		

fig. 3.12

Presetting and operation — mechanical memory

All R206B-1 valves are equipped with a mechanical memory mechanism for the presetting of the valve. This means that after the presetting, the positioning of the hand wheel can be limited in a way that it is still possible to shut-off the valve if maintenance has to be done, but that it is not possible to open the hand wheel further then the presetting position.

In practice, this is done as follows:

- use the diagram of fig. 3.14 to read the position of the hand wheel for the presetting, based on the desired flow Q in the circuit and the necessary pressure drop Δp for balancing
- make the regulation on the valve by means of the lower edge of the hand wheel (ref. A - fig. 3.12) and the scale (ref. C – fig. 3.12)
- disassemble the cap (ref. D - fig. 3.12) of the hand wheel and screw clockwise the presetting screw (ref. E – fig. 3.12), by using an Allen key of 1,5 mm, until the end
- reassemble the cap on the hand wheel

Dimensioning and selection procedure

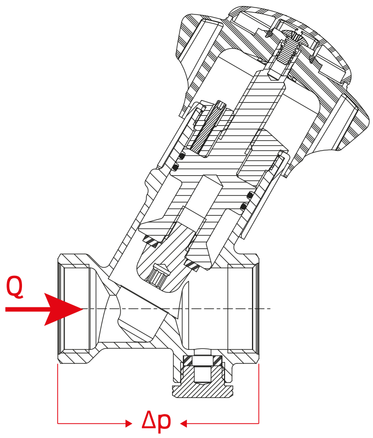


fig. 3.13

The dimensioning and the selection procedure for compact static balancing valves R206B-1 is done through the following steps, using fig. 3.14:

- calculate the desired flow-rate in the circuit that needs to be balanced
- calculate the desired differential pressure over the balancing valve R206B-1 in order to obtain a maximum regulation authority of the valve. A practical rule is to consider the same pressure drop over the balancing valve as over the complete circuit downstream, including the end user

- draw a line through both points; then, at the intersection with the vertical line which represents the Kv value, draw a horizontal line
- finally, because of the accuracy of the control, select the smallest size among the possible valves and read the presetting. In the example on fig. 3.14 within the range of 3/4" – 1", the 3/4" valve will be selected, with presetting 70

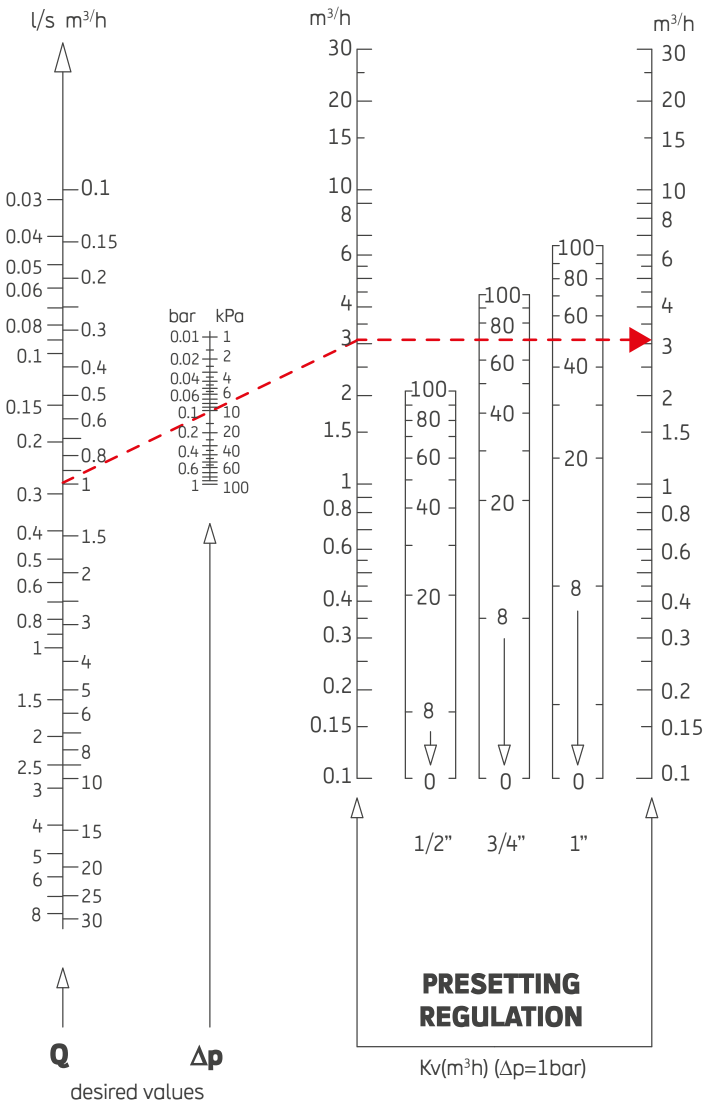
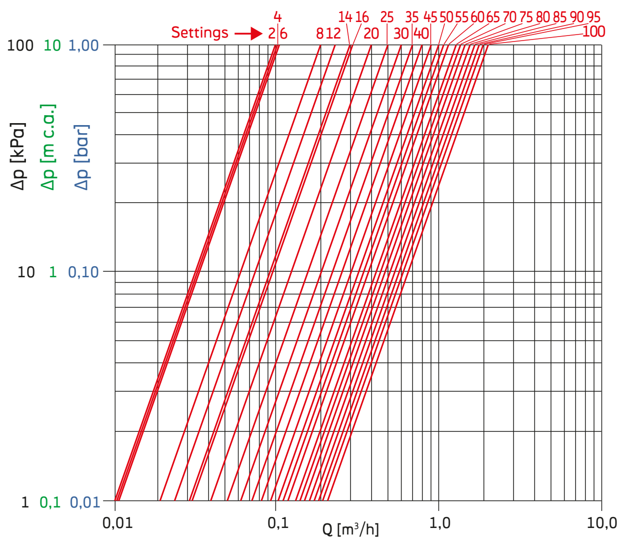


fig. 3.14

Flow-rate pressure drop diagrams

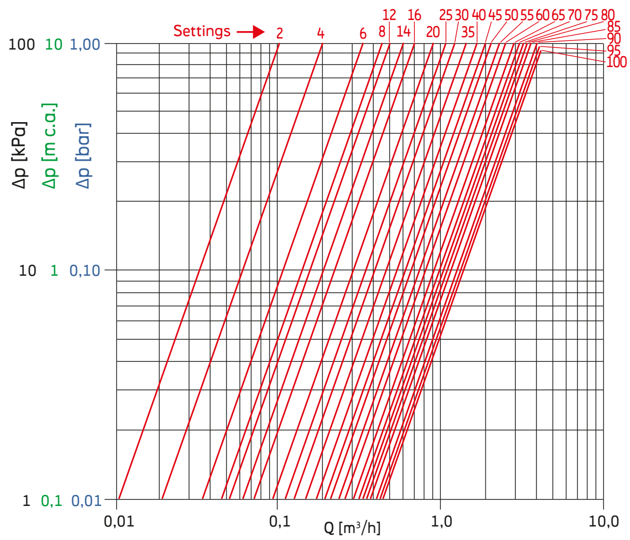
Below are listed all the flow-rate pressure drop diagrams for the complete range from 1/2” to 1”, with corresponding tables showing presettings and Kv values of the valves:

1/2”



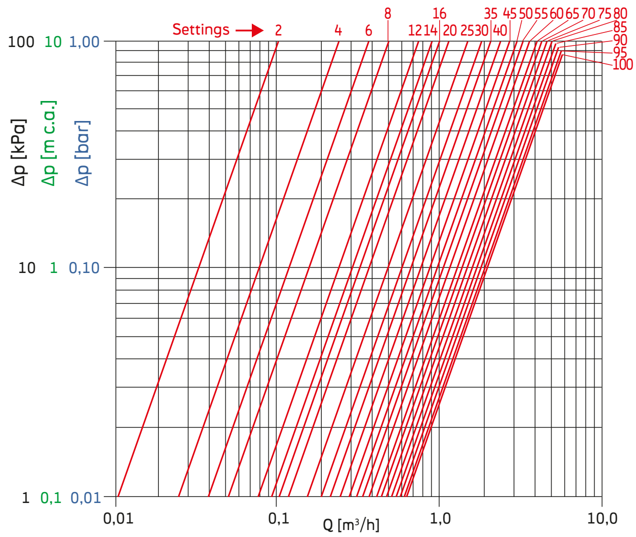
setting	Kv
100	2,10
95	2,00
90	1,85
85	1,75
80	1,65
75	1,55
70	1,45
65	1,35
60	1,25
55	1,15
50	1,05
45	0,94
40	0,83
35	0,73
30	0,62
25	0,52
20	0,42
16	0,33
14	0,29
12	0,25
8	0,17
6	0,12
4	0,08
2	0,04

3/4”



setting	Kv
100	4,40
95	4,20
90	4,00
85	3,75
80	3,55
75	3,30
70	3,10
65	2,85
60	2,65
55	2,45
50	2,20
45	1,98
40	1,76
35	1,54
30	1,32
25	1,10
20	0,88
16	0,71
14	0,62
12	0,53
8	0,35
6	0,26
4	0,18
2	0,09

1"



setting	Kv
100	6,25
95	5,95
90	5,60
85	5,30
80	5,00
75	4,70
70	4,35
65	4,05
60	3,75
55	3,45
50	3,10
45	2,81
40	2,50
35	2,18
30	1,87
25	1,56
20	1,25
16	1,00
14	0,87
12	0,75
8	0,50
6	0,37
4	0,25
2	0,12

R206B-1 Installation suggestions

Since some boundary conditions could partially influence and affect the accuracy of measurement during the installation should be followed some simple rules summarized below:

- the valve must be installed maintaining free access to the hand wheel and the drain
- the valve and the pipe on which it is installed must have the same nominal diameter
- the system needs to be washed before installing the valve
- a filter needs to be inserted upstream the valve to protect the valve from possible impurities
- the flow direction indicated on the valve body needs to be respected
- the valve can be mounted on horizontal or vertical pipes
- if the valve is installed after a curve, the length of the straight pipe between the curve and the valve should be at least 5 times the nominal diameter Dn of the valve. After the valve, there should be a straight pipe with a length of at least 2 times the nominal diameter Dn of the valve
- if the valve is installed after a circulator, the length of the straight pipe between the circulator and the valve should be at least 10 times the nominal diameter Dn of the valve. After the valve, there should be a straight pipe with a length of at least 2 times the nominal diameter Dn of the valve

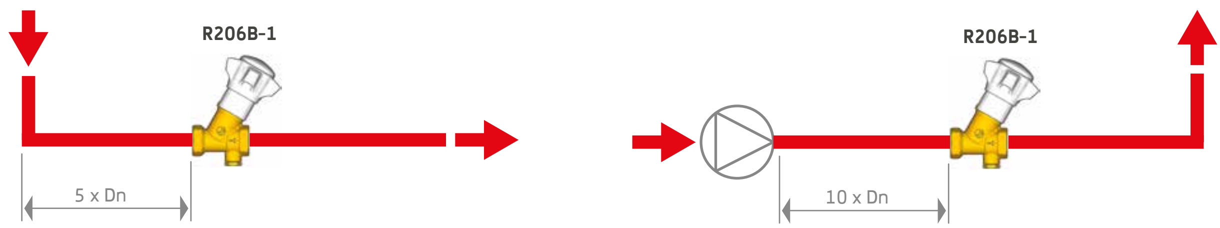


fig. 3.15
Installation suggestions

R206B
FLANGED STATIC BALANCING VALVE

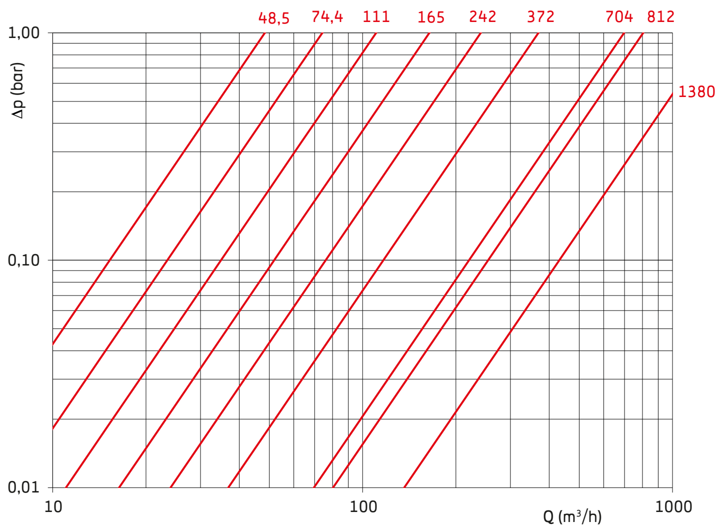
The standard range of static balancing valves covers the sizes from 1/2" to 2" using threaded female connections and brass bodies, with Venturi fixed orifice or in a compact version.

For bigger sizes, the range has been completed with cast iron bodies and flanged connections, going from DN 50 to DN 300.

WHY CHOOSE IT?

- seal stainless-steel reinforced seat

fig. 3.16



Versions

product code	size	Kv
R206BY205	DN50	48,5
R206BY206	DN65	74,4
R206BY208	DN80	111
R206BY210	DN100	165
R206BY212	DN125	242
R206BY215	DN150	372
R206BY220	DN200	704
R206BY225	DN250	812
R206BY300	DN300	1380

fig. 3.17

Dimensioning and selection procedure

The dimensioning and selection procedure for the static balancing valves with flanged connections is the same as for the valves with threated female connections and is done through the following steps, using fig. 3.18:

- calculate the desired flow-rate in the circuit that needs to be balanced
- calculate the desired differential pressure over the balancing valve R206B in order to obtain a maximum regulation authority of the valve. A practical rule is to consider the same pressure drop over the balancing valve as over the complete circuit downstream, including the end user
- choose the smallest valve where the intersection between the desired flow-rate and the desired differential pressure is located within the presetting range of the valve
- read the presetting of the valve

Pre-setting	1	2	3	4	5	6	7	8	9	10
Kv-Value	5,20	7,60	12,00	19,10	29,00	41,10	51,90	60,40	67,80	74,40
Cv-Value	6,08	8,89	14,04	22,35	33,93	48,09	60,72	70,67	79,33	87,05

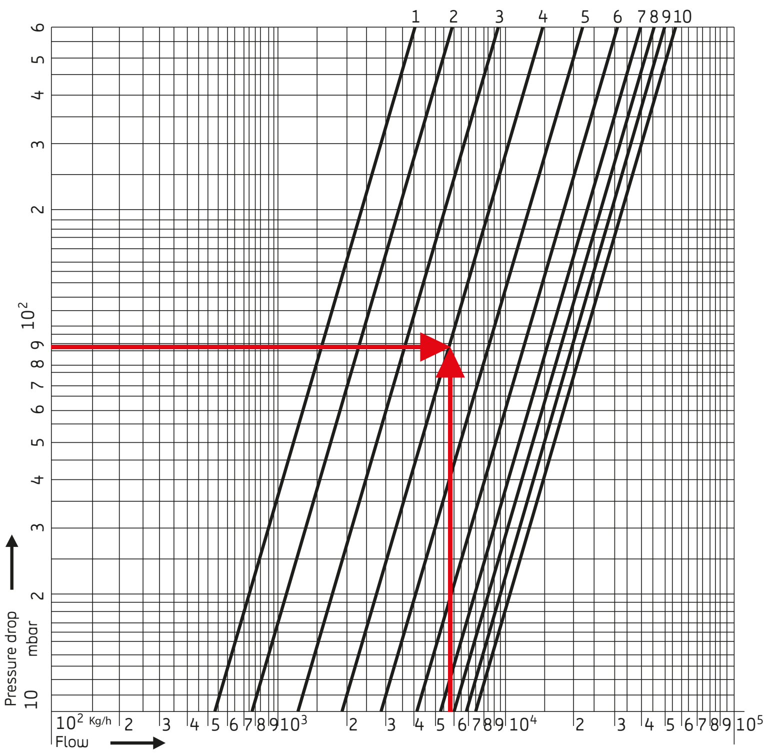


fig. 3.18
How the select the setting of the valve
(Example related to DN65 size)

Measuring procedure

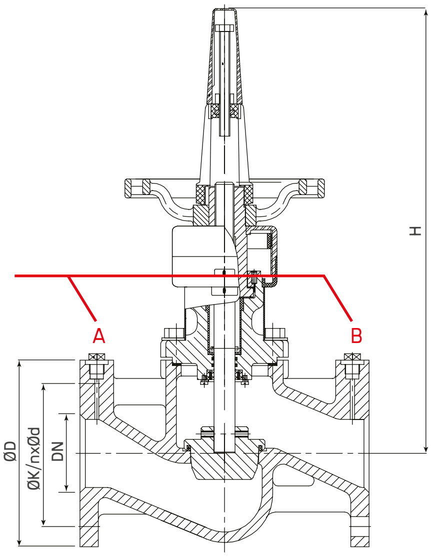


fig. 3.19

In contrast to static balancing valves with female connections, the flanged versions are not equipped with an inner flowmeter with calibrated orifice and fixed Kv value. This means that with each changing of the presetting also the hydronic shape and so the Kv value of the valve between the two pressure plugs A and B changes. Therefore, a set of Kv values is needed to calculate the circulating flow-rate Q, based on the differential pressure Δp measured through the pressure plugs A and B, using the following formula:

$$\mathbf{Q = Kv_{\text{Valve setting position}} \sqrt{\Delta p}}$$

with:

Q = flow-rate in m^3/h

$Kv_{\text{Valve setting position}}$ = Kv value, in function of the dimension and the presetting of the valve - refer to the tables in page 65

Δp = pressure drop over the valve, measured through the pressure plugs A and B, in bar

For liquids with a density ρ different from water, the circulating flow-rate Q is calculated using the following equation:

$$\mathbf{Q = Kv_{\text{Valve setting position}} \sqrt{\Delta p / \rho}}$$

with:

Q = flow-rate in m^3/h

$Kv_{\text{Valve setting position}}$ = Kv value, in function of the dimension and the presetting of the valve - refer to the tables in page 65

Δp = pressure drop over the valve, measured through the pressure plugs A and B, in bar

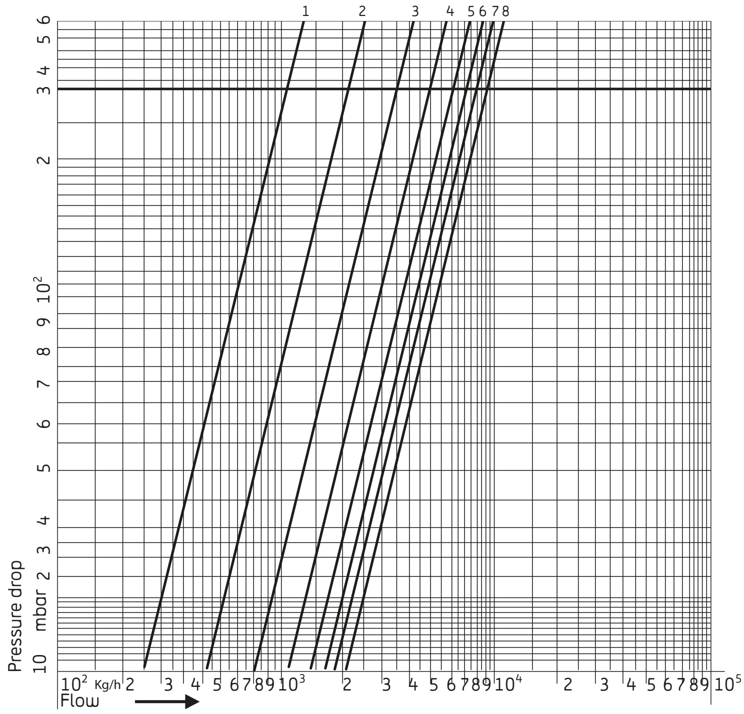
ρ = density of the liquid in Kg/m^3

R206 Flanged full range pressure losses diagrams

Below are listed all the flow-rate pressure drop diagrams for the complete range from DN50 to DN300, with corresponding tables showing presettings and Kv, respectively Cv values:

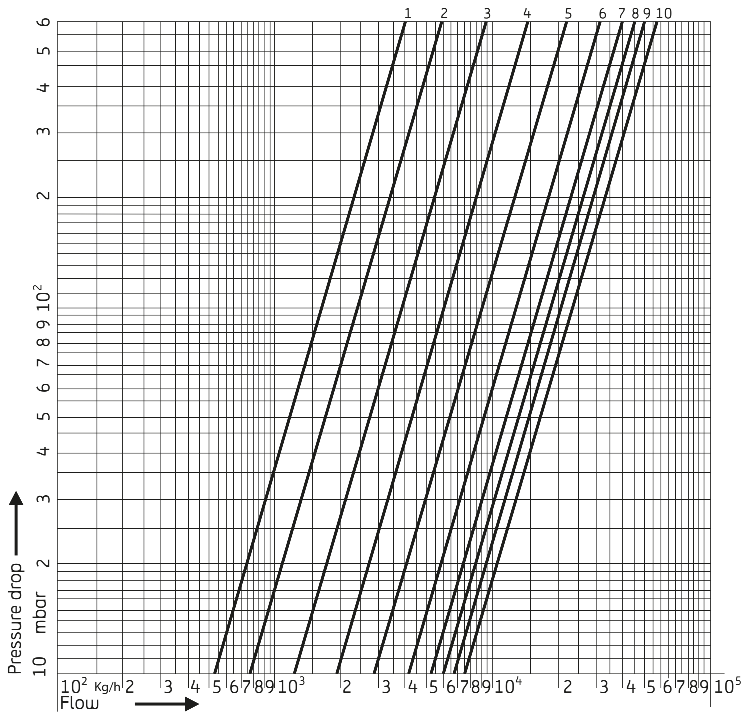
DN 50

Pre-setting	1	2	3	4	5	6	7	8
Kv-Value	7,12	16,77	24,73	30,18	34,11	37,35	40,35	42,09
Cv-Value	8,33	19,62	28,93	35,31	39,41	43,70	47,81	49,25



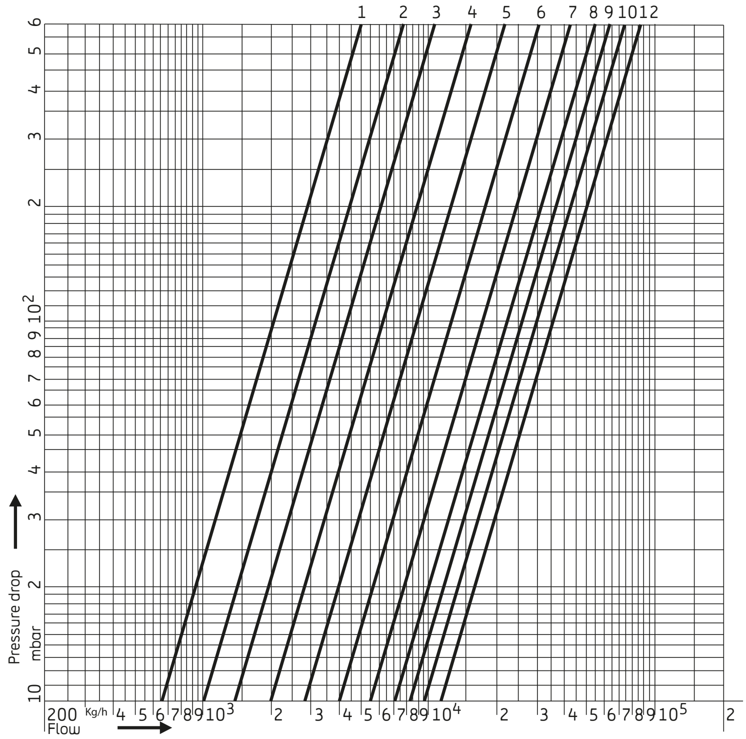
DN 65

Pre-setting	1	2	3	4	5	6	7	8	9	10
Kv-Value	5,20	7,60	12,00	19,10	29,00	41,10	51,90	60,40	67,80	74,40
Cv-Value	6,08	8,89	14,04	22,35	33,93	48,09	60,72	70,67	79,33	87,05



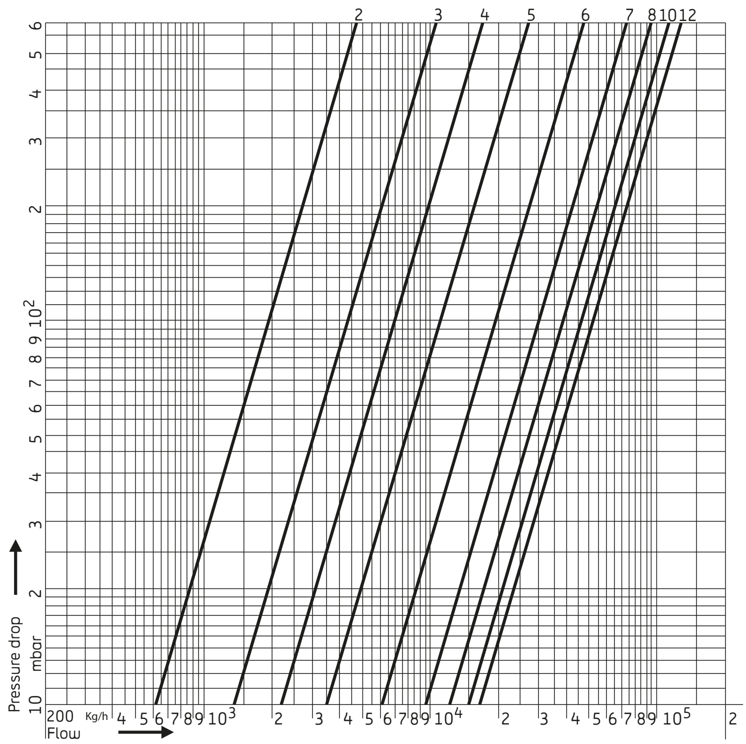
DN 80

Pre-setting	1	2	3	4	5	6	7	8	9	10	11	12
Kv-Value	6,60	10,00	13,70	19,20	28,10	40,40	55,40	70,90	81,80	96,10	104,00	111,00
Cv-Value	7,72	11,70	16,03	22,46	32,88	47,27	64,82	82,95	99,22	112,44	121,68	129,87



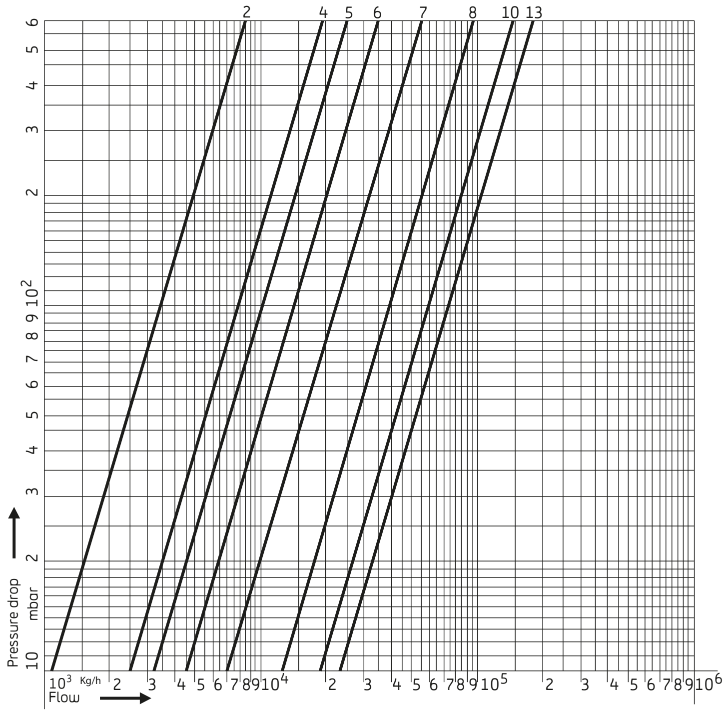
DN 100

Pre-setting	1	2	3	4	5	6	7	8	9	10	11	12
Kv-Value	2,80	6,10	13,20	21,60	35,50	62,10	96,50	121,00	137,20	148,10	159,00	165,00
Cv-Value	3,28	7,14	15,44	25,27	41,54	72,66	112,91	141,57	160,52	173,28	186,03	193,05



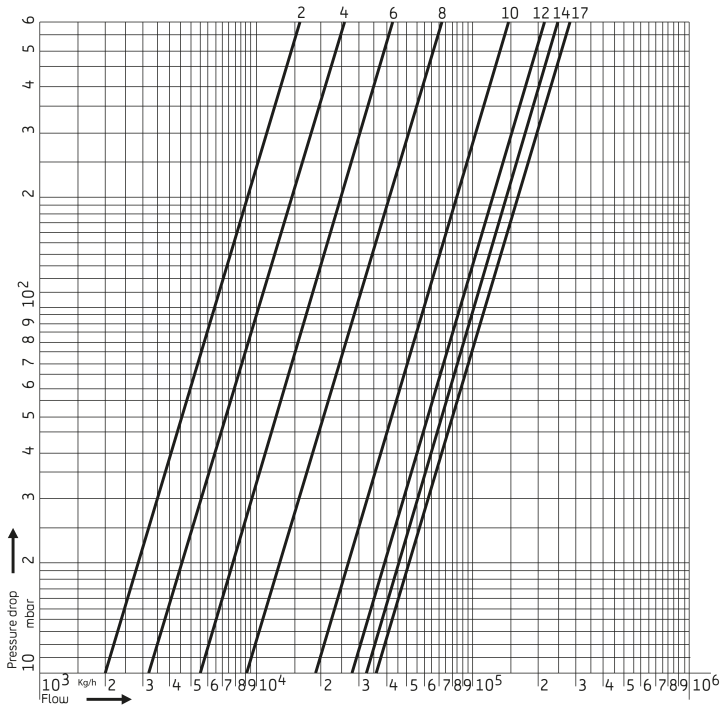
DN 125

Pre-setting	1	2	3	4	5	6	7	8	9	10	11	12	fully open
Kv-Value	5,20	11,10	17,70	24,50	32,20	44,90	72,40	120,00	163,00	191,00	210,00	237,00	242,00
Cv-Value	6,08	12,99	20,71	28,67	37,67	52,53	84,71	140,40	190,71	223,47	245,70	263,25	283,14



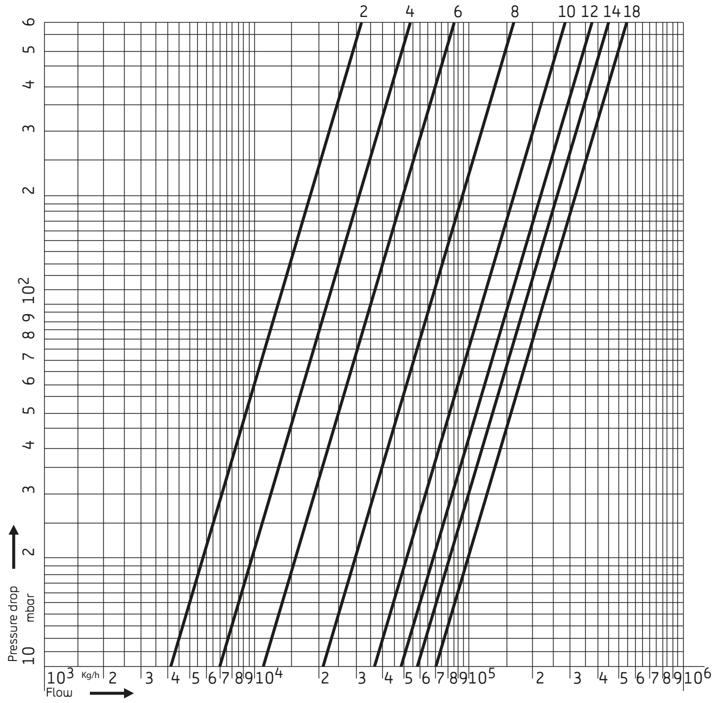
DN 150

Pre-setting	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Kv-Value	9,20	20,20	26,50	33,00	42,00	54,30	69,30	80,00	93,00	192,90	240,00	274,00	300,00	319,00	338,00	351,00	365,00
Cv-Value	10,76	23,63	31,01	38,61	49,14	63,53	81,08	93,60	108,81	225,69	280,80	320,58	351,00	373,23	395,46	410,67	427,05



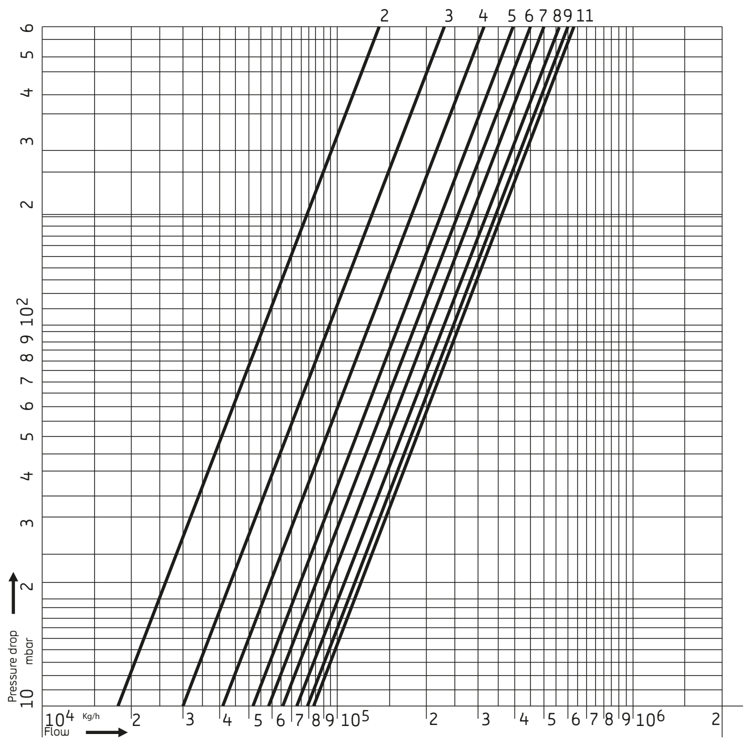
DN 200

Pre-setting	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Kv-Value	41,10	55,40	69,30	88,00	114,00	154,00	208,00	284,00	364,00	434,00	489,00	537,00	575,00	612,00	645,00	677,00	704,00
Cv-Value	48,09	64,82	81,08	102,96	133,38	180,18	243,36	332,28	425,88	807,78	572,13	628,29	672,75	716,04	754,65	792,09	823,68



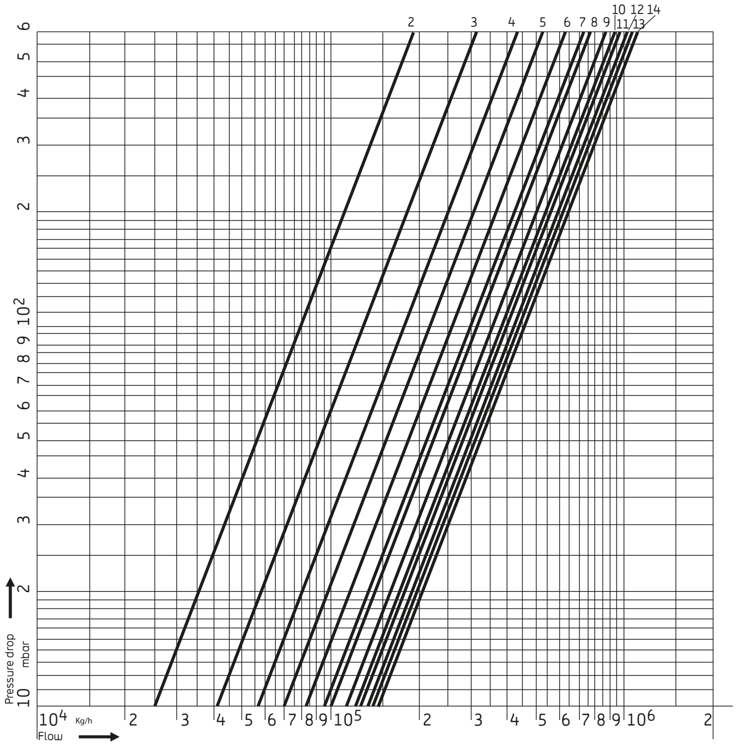
DN 250

Pre-setting	2	3	4	5	6	7	8	9	10
Kv-Value	178,00	295,00	410,00	514,00	588,00	649,00	731,00	500,00	812,00
Cv-Value	208,16	345,15	479,70	601,38	687,96	759,33	855,27	585,00	950,04



DN 300

Pre-setting	2	3	4	5	6	7	8	9	10	11	12	13	14
Kv-Value	248,00	411,00	560,00	695,00	825,00	945,00	1045,00	1138,00	1225,00	1290,00	1325,00	1345,00	1380,00
Cv-Value	290,16	480,87	655,20	813,15	965,25	1105,65	1222,65	1331,46	1433,25	1509,30	1550,25	1573,00	1614,60



R206A
DYNAMIC BALANCING VALVE

Dynamic balancing valves R206A are especially designed for regulating the flow-rate in constant flow systems (for instance air handling units, fan coils with constant water flow and variable fan speed to control room temperature) and they limit the flow-rate to the preset value when other users in the systems close and the flow-rate in the users that are still open would normally rise.

WHY CHOOSE IT?

- the perfect solution for constant flow-rate plants
- wide range of flow-rates

The set flow-rate is guaranteed inside the declared range of differential pressure, with an accuracy of +/- 5 % on the controlled flow-rate value or +/- 2 % on the maximum flow-rate.

They are composed of a brass body, have female-female connections and are prearranged for the installation of sensor holders to measure the differential pressure. The internal cartridge of the valve is equipped with a double indicator, having a 1 to 5 scale and a decimal decision from 1 to 9 to allow precise flow-rate regulations, and can be easily cleaned or replaced if needed. In practice, the presetting is done once, using an 8 mm wrench, even while the installation is in operation.

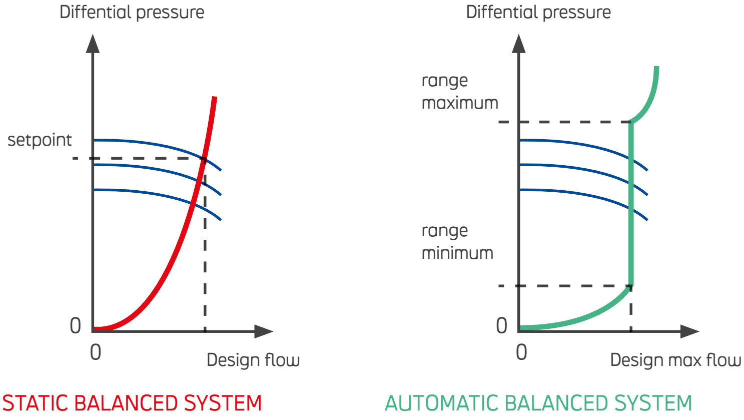


fig. 3.21 Comparison of operating diagrams of static and dynamic balancing valves

Fig. 3.21 explains the difference in operation between a static balancing valve (left graph with each red curve representing each presetting of the valve) and a dynamic balancing valve (right graph with each green curve representing each presetting of the valve). On both graphs, the blue lines represent the characteristics of the pump with changing velocity. Changing the velocity of the pump changes the position of the blue line and so the flow-rate through the static balancing valve. For the dynamic balancing valve, the flow-rate does not change as long as the differential pressure stays within the range Δp min – Δp max.

The equation below summarizes this condition:

$$Q = kA \sqrt{\Delta p} \cong \text{constant}$$

with:

Q = flow-rate in m^3/h

k = constant of the cartridge in m/(h. √ bar)

A = surface of the opening in the cartridge in m^2

Δp = pressure drop over the cartridge in bar

This means that, given a fixed k value for each cartridge, in function of the dimension, the surface A and the pressure drop Δp will always change in a way that the flow-rate Q remains the same: if the opening in the cartridge increases, the pressure drop Δp will decrease and vice versa if the opening in de cartridge decreases, the pressure drop Δp will increase so the flow-rate always stays constant.

Versions

product codes	connections	working flow-rate [m^3/h]	differential pressure working range Δp [kPa]
R206AY013	1/2"F	0,276 - 0,825	17 - 200
R206AY014	3/4"F	0,406 - 1,270	30 - 400
R206AY015	1"F	0,535 - 5,830	17 - 400
R206AY016	1 1/4"F	0,535 - 5,830	17 - 400
R206AY017	1 1/2"F	3,180 - 16,100	20 - 400
R206AY018	2"F	3,180 - 16,100	20 - 400
R206AY033	1/2"F	0,100 - 0,412	17 - 210
R206AY034	3/4"F	0,100 - 0,412	17 - 210

fig. 3.21

Accessories

- P206A: spare part cartridge for R206A valves

cartridge codes	R206A which is installed	cartridge connections	cartridge colour (1)	indicator colour (2)	plug colour (3)	legend
P206AY001	R206AY013	3/4"M	Red	White	Red	
P206AY002	R206AY014	3/4"M	Red	Grey	Red	
P206AY003	R206AY015 R206AY016	1 1/2"M	Black	White	Green	
P206AY004	R206AY017 R206AY018	2"M	White	Grey	Black	
P206AY005	R206AY033 R206AY034	3/4"M	Black	White	Black	

fig. 3.22

Installation

The R206A dynamic balancing valve should be installed on the return side of the system. It is recommended to install a filter upstream the R206A valve to prevent damage or blockage due to debris or dirt. Further, it is recommended not to exceed the maximum differential pressure control range of the cartridge.

The typical installation is represented in fig. 3.23.

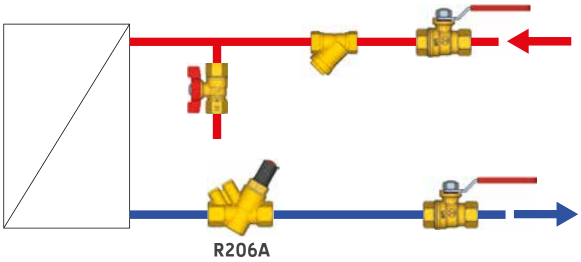


fig. 3.23
Installation downstream of a two pipe unit (for instance fan coil unit)

As mentioned before, dynamic balancing valves R206A are especially designed for constant flow systems (for instance air handling units, fan coils with constant water flow and variable fan speed to control room temperature) to limit the flow-rate to the preset value when other users in the systems close and the flow-rate in the users that are still open would normally rise.

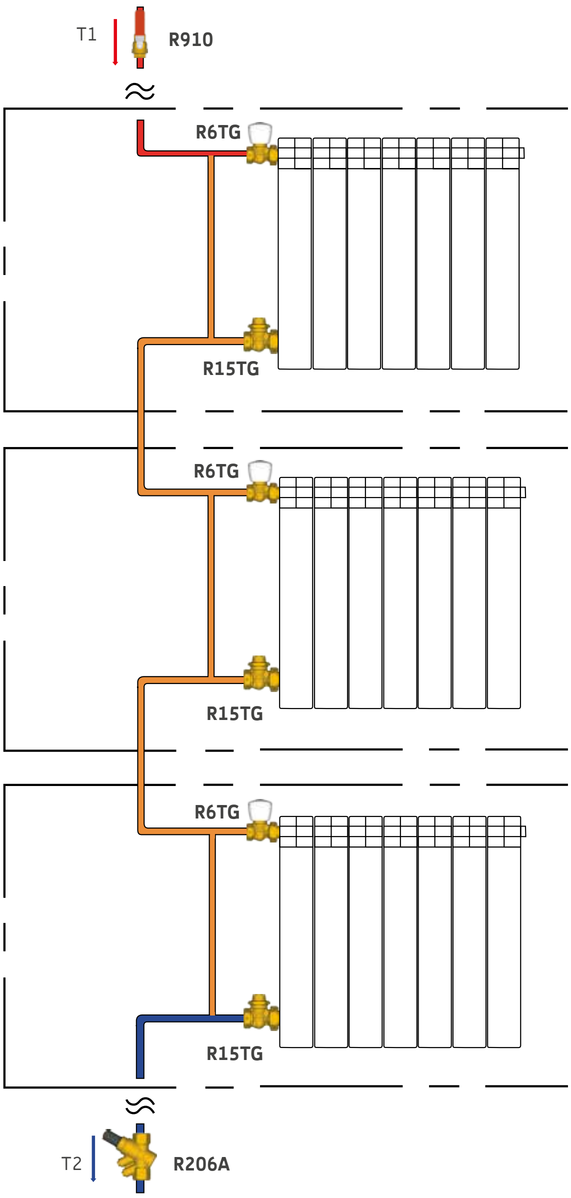


fig. 3.24
One pipe loop and R206A installation with manual radiator valves

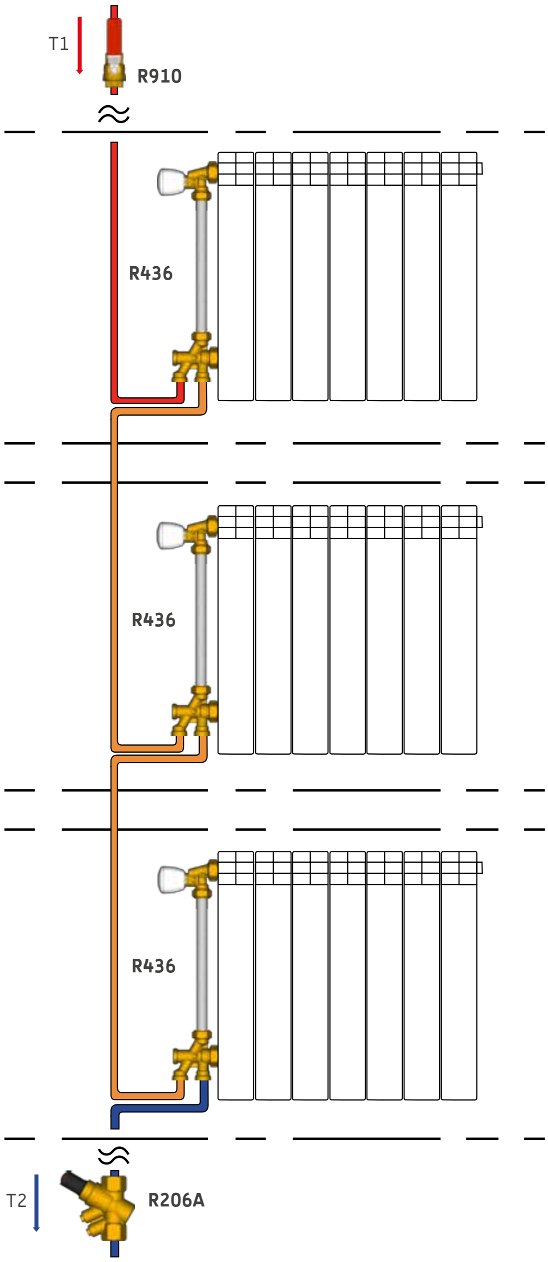


fig. 3.25
One pipe loop and R206A installation with thermostatic radiator valves

Dimensioning and selection procedure

The dimensioning and the selection procedure for the dynamic balancing valves R206A is very easy: given the desired flow-rate for the user, the pipe diameter and the dynamic balancing valve dimension are selected. Then, based on the head of the pump, the available pressure drop over the balancing valve is checked with the differential pressure working range. Finally, the presetting is read from the related flow-rate diagram.

For example, a FCU with 1/2" connections needs 520 l/h or 0,144 l sec. The dynamic balancing valve R206AY013 is selected.

product codes	connections	working flow-rate [m³/h]	differential pressure working range Δp [kPa]
R206AY013	1/2"F	0,276 - 0,825	17 - 200
R206AY014	3/4"F	0,406 - 1,270	30 - 400
R206AY015	1"F	0,535 - 5,830	17 - 400
R206AY016	1 1/4"F	0,535 - 5,830	17 - 400
R206AY017	1 1/2"F	3,180 - 16,100	20 - 400
R206AY018	2"F	3,180 - 16,100	20 - 400
R206AY033	1/2"F	0,100 - 0,412	17 - 210
R206AY034	3/4"F	0,100 - 0,412	17 - 210

fig. 3.26
Selection of R206A according to the working flow-rate range

and the available differential pressure is checked using the pipe dimensioning calculation. Finally, the corresponding presetting of 2.5 is read.

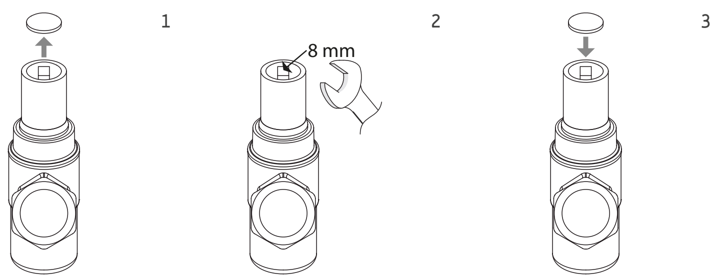
R206AY013 - Δp: 17-200 kPa		
setting	**l / sec**	**l / h**
1.0	0,0767	276
1.1	0.0813	293
1.2	0.0860	310
1.3	0.0907	326
1.4	0.0953	343
1.5	0.100	360
1.6	0.105	377
1.7	0.109	393
1.8	0.114	410
1.9	0.118	426
2.0	0.123	443
2.1	0.128	459
2.2	0.132	475
2.3	0.136	491
2.4	0.141	507
2.5	0.145	523
2.6	0.150	539

fig. 3.27
Flow-rate diagram of the 1/2" dynamic balancing valve

Cartridge presetting

To adjust the presetting of the cartridge in practice:

- first remove the cartridge plug
- then rotate the stem of the cartridge, using a 8 mm wrench, clockwise to decrease the presetting or counterclockwise to increase the presetting
- finally, replace the plug of the cartridge in position



Afterwards, no additional commissioning is required, which is one of the biggest advantages of dynamic balancing valves.

Below are listed the flow-rate diagrams for the complete range from 1/2” to 2”:

R206AY013 - Δp: 17-200 kPa

setting	l / sec	l / h
1.0	0,0767	276
1.1	0.0813	293
1.2	0.0860	310
1.3	0.0907	326
1.4	0.0953	343
1.5	0.100	360
1.6	0.105	377
1.7	0.109	393
1.8	0.114	410
1.9	0.118	426
2.0	0.123	443
2.1	0.128	459
2.2	0.132	475
2.3	0.136	491
2.4	0.141	507
2.5	0.145	523
2.6	0.150	539
2.7	0.154	554
2.8	0.158	569
2.9	0.162	584
3.0	0.166	599
3.1	0.170	614
3.2	0.174	628
3.3	0.178	642
3.4	0.182	655
3.5	0.186	669
3.6	0.189	682
3.7	0.193	695
3.8	0.196	707
3.9	0.200	719
4.0	0.203	731
4.1	0.206	742
4.2	0.209	753
4.3	0.212	764
4.4	0.215	774
4.5	0.218	784
4.6	0.220	793
4.7	0.223	802
4.8	0.225	810
4.9	0.227	818
5.0	0.229	825

R206AY014 - Δp: 30-400 kPa

setting	l / sec	l / h
1.0	0.113	406
1.1	0.119	427
1.2	0.125	449
1.3	0.131	470
1.4	0.137	492
1.5	0.143	513
1.6	0.149	535
1.7	0.155	556
1.8	0.161	578
1.9	0.167	599
2.0	0.172	621
2.1	0.178	642
2.2	0.184	664
2.3	0.190	685
2.4	0.196	707
2.5	0.202	728
2.6	0.208	750
2.7	0.214	771
2.8	0.220	793
2.9	0.226	814
3.0	0.232	836
3.1	0.238	857
3.2	0.244	879
3.3	0.250	900
3.4	0.256	922
3.5	0.262	943
3.6	0.268	965
3.7	0.274	987
3.8	0.280	1010
3.9	0.286	1030
4.0	0.292	1050
4.1	0.298	1070
4.2	0.304	1090
4.3	0.310	1120
4.4	0.316	1140
4.5	0.322	1160
4.6	0.328	1180
4.7	0.334	1200
4.8	0.340	1220
4.9	0.346	1240
5.0	0.352	1270

R206AY015-16 - Δp: 17-400 kPa

setting	l / sec	l / h
1.0	0.149	535
1.1	0.220	793
1.2	0.289	1040
1.3	0.355	1280
1.4	0.418	1510
1.5	0.479	1730
1.6	0.538	1940
1.7	0.594	2140
1.8	0.647	2330
1.9	0.699	2520
2.0	0.748	2690
2.1	0.795	2860
2.2	0.841	3030
2.3	0.884	3180
2.4	0.925	3330
2.5	0.965	3470
2.6	1.00	3610
2.7	1.04	3740
2.8	1.07	3870
2.9	1.11	3990
3.0	1.14	4100
3.1	1.17	4220
3.2	1.20	4320
3.3	1.23	4420
3.4	1.26	4520
3.5	1.28	4620
3.6	1.31	4710
3.7	1.33	4800
3.8	1.36	4890
3.9	1.38	4970
4.0	1.40	5050
4.1	1.43	5130
4.2	1.45	5210
4.3	1.47	5290
4.4	1.49	5370
4.5	1.51	5440
4.6	1.53	5520
4.7	1.55	5600
4.8	1.58	5670
4.9	1.60	5750
5.0	1.62	5830

R206AY017-18 - Δp: 20-400 kPa

setting	l / sec	l / h
1.0	0.883	3180
1.1	1.14	4100
1.2	1.37	4940
1.3	1.59	5710
1.4	1.78	6420
1.5	1.96	7070
1.6	2.13	7660
1.7	2.28	8200
1.8	2.42	8700
1.9	2.54	9150
2.0	2.66	9570
2.1	2.77	9960
2.2	2.86	10300
2.3	2.95	10600
2.4	3.04	10900
2.5	3.12	11200
2.6	3.19	11500
2.7	3.26	11700
2.8	3.32	12000
2.9	3.39	12200
3.0	3.45	12400
3.1	3.51	12600
3.2	3.56	12800
3.3	3.62	13000
3.4	3.67	13200
3.5	3.73	13400
3.6	3.78	13600
3.7	3.83	13800
3.8	3.89	14000
3.9	3.94	14200
4.0	3.99	14400
4.1	4.05	14600
4.2	4.10	14800
4.3	4.15	14900
4.4	4.20	15100
4.5	4.25	15300
4.6	4.30	15500
4.7	4.35	15700
4.8	4.39	15800
4.9	4.44	16000
5.0	4.48	16100

R206AY033-34 - Δp: 17-210 kPa

setting	l / sec	l / h
1.0	0.028	100
1.1	0.030	108
1.2	0.032	116
1.3	0.034	123
1.4	0.036	131
1.5	0.039	139
1.6	0.041	147
1.7	0.043	155
1.8	0.045	162
1.9	0.047	170
2.0	0.049	178
2.1	0.052	186
2.2	0.054	194
2.3	0.056	201
2.4	0.058	209
2.5	0.060	217
2.6	0.062	225
2.7	0.064	233
2.8	0.067	240
2.9	0.069	248
3.0	0.071	256
3.1	0.073	264
3.2	0.075	272
3.3	0.077	279
3.4	0.080	287
3.5	0.082	295
3.6	0.084	303
3.7	0.086	311
3.8	0.088	318
3.9	0.091	326
4.0	0.093	334
4.1	0.095	342
4.2	0.097	350
4.3	0.099	357
4.4	0.101	365
4.5	0.104	373
4.6	0.106	381
4.7	0.108	389
4.8	0.110	396
4.9	0.112	404
5.0	0.114	412

Flow-rate measurement

As the opening of the cartridge changes continuously to guarantee a constant flow, the Kv value of the dynamic balancing valve also changes all the time. This means that it is not possible to calculate the flow-rate through the valve, based on the Kv value and the differential pressure measured through the pressure outlets and the formula that was used for the static balancing valves.

For determing the flow-rate into the valve, it is sufficient measuring the differential pressure by mounting pressure plugs in the suitable seats and using a differential manometer. If this value is included within the differential pressure working range, then the flow-rate is equal to the value read from the flow-rate diagrams.

balancing valve R206A + sensor holder P206Y001
+ differential pressure manometer

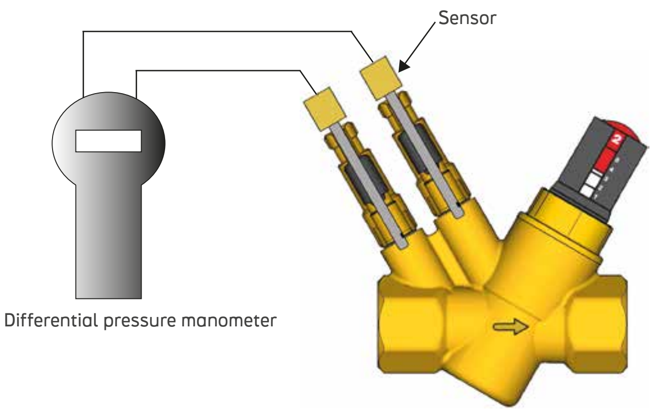


fig. 3.28
Measurement of differential pressure

R206AM
DYNAMIC BALANCING VALVE WITH ACTUATOR

Dynamic balancing valves with actuator R206AM can be integrated in heating and cooling water systems in order to provide:

> flow regulation, enabling flow-rates to be set at specific design values and limiting the flow-rate to this preset value in the presence of changing differential pressure conditions, due to changes in the pump speed or valve closures elsewhere in the system

> flow control, enabling the programmed operation of the user

For this reason, they are often called PICV (Pressure Independent Control Valves). The flow-rate can be regulated in two different ways:

> manually, through the presetting of the cartridge, like for the dynamic balancing valve R206A

> automatically, through the proportional actuator (0÷10V), in accordance with changing conditions in the system

In contrast to the standard dynamic balancing valves R206A, Pressure Independent Control Valves offer the possibility to adapt the presetting of the flow-rate through a 0-10 V input to the modular actuator. This input can come from a Building Management System that calculates the new presetting, depending on changed conditions in the installation. The value of the new presetting can change repeatedly and is limited to the manually set presetting, which corresponds with a 10 V input on the actuator. By applying a 0 V input on the actuator, the user can be shut off. The set flow-rate is guaranteed inside the declared range of differential pressure, with a maximum error of ± 10 % on the controlled flow-rate value or ± 5 % on the maximum flow-rate. R206AM feature pressure outlets connections for differential pressure measurements and verifications.

WHY CHOOSE IT?

- combines multiple functions in one single product
- automatic flow-rate control with proportional actuator
- replaceable polymer cartridge with dual indicator

fig. 3.29

Versions and product codes

product codes	connections	O-Ring colour *	working flow-rate [l/h]	working pressure Δp [kPa]	actuator (optional)
R206AY053	1/2"F	Grey	37 - 575	16 - 200	K281X012 K281X022
R206AY054	3/4"F	Black	64 - 1110	30 - 400	
R206AY055	1"F	Black	64 - 1110	30 - 400	
R206AY056	1 1/4"F	Black	865 - 4630	16 - 400	K281X032
R206AY057	1 1/2"F	Black	1900 - 13647	16 - 400	K281X042
R206AY058	2"F	Black	1900 - 13647	16 - 400	

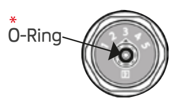


fig. 3.30

Installation

The R206AM dynamic balancing valve should be installed on the return side of the system. It is recommended to install a filter upstream the R206AM valve to prevent damage or blockage due to debris or dirt.

Further, it is recommended not to exceed the maximum differential pressure control range of the cartridge.

The typical installation is represented in fig. 3.31.

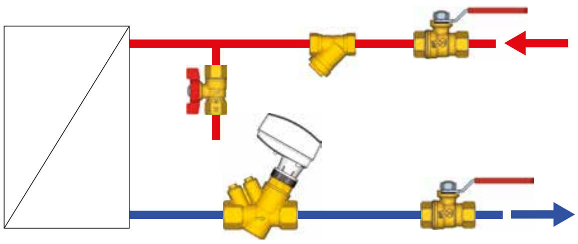


fig. 3.31
R206AM typical installation layout in a two pipe distribution system

Dimensioning and selection procedure

The dimensioning and the selection procedure for the dynamic balancing valves R206AM is identical to the R206A valves: given the desired flow-rate for the user, the pipe diameter and the dynamic balancing valve dimension are selected. Then, based on the head of the pump, the available pressure drop over the balancing valve is checked with the differential pressure working range. Finally, the presetting adjustment is read from the related flow-rate diagram.

For example, a FCU with 1/2" connections and 480 l/h, needs to be equipped with a PICV. The desired flow-rate corresponds with a presetting of 3.4. This flow-rate of 480 l/h will be the maximum reachable flow-rate in dynamic conditions.

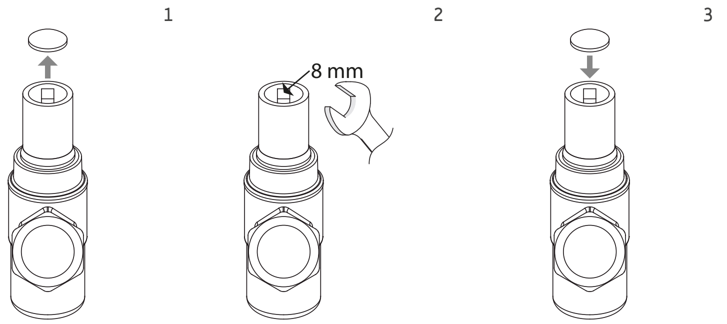
setting	l / h	GPM
1.0	-	-
1.1	37	0,163
1.2	84	0,37
1.3	116	0,51
1.4	151	0,664
1.5	180	0,792
1.6	205	0,902
1.7	234	1,03
1.8	259	1,14
1.9	281	1,24
2.0	302	1,33
2.1	320	1,41
2.2	339	1,49
2.3	353	1,55
2.4	371	1,63
2.5	381	1,68
2.6	394	1,73
2.7	406	1,79
2.8	414	1,82
2.9	428	1,88
3.0	439	1,93
3.1	449	1,98
3.2	458	2,02
3.3	468	2,06
3.4	477	2,1

fig. 3.32

Setting adjustment

To adjust the presetting of the cartridge in practice:

- first remove the cartridge plug
- then rotate the stem of the cartridge, using a 8 mm wrench, clockwise to decrease the setting or counterclockwise to increase the presetting
- finally, replace the plug of the cartridge in position



This value is the maximum design value of the presetting and can be modified proportionally throughout the 0-10 V control of the actuator, as represented in fig. 3.33:

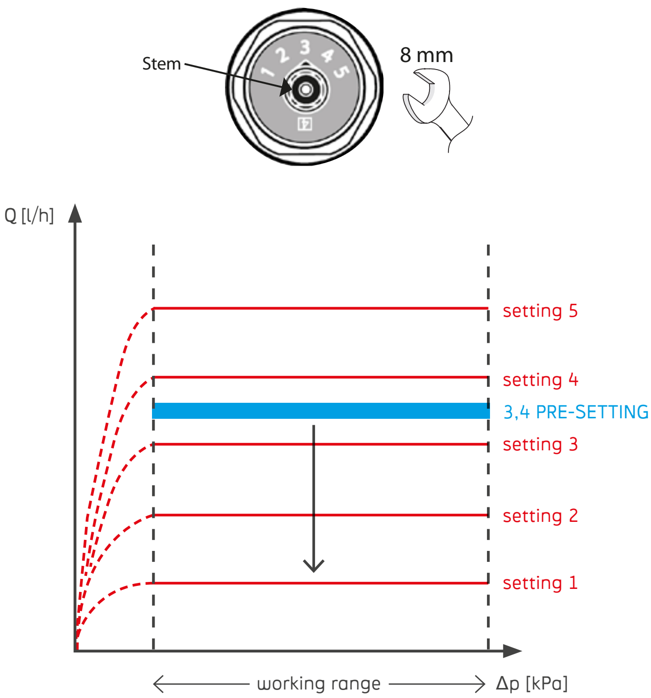


fig. 3.33

Flow-rate diagrams

Below are listed the presetting diagrams for the complete range from 1/2” to 2”:

R206AY053 - Δp: 16-200 kPa

setting	l / h	GPM
1.0	-	-
1.1	37	0,163
1.2	84	0,37
1.3	116	0,51
1.4	151	0,664
1.5	180	0,792
1.6	205	0,902
1.7	234	1,03
1.8	259	1,14
1.9	281	1,24
2.0	302	1,33
2.1	320	1,41
2.2	339	1,49
2.3	353	1,55
2.4	371	1,63
2.5	381	1,68
2.6	394	1,73
2.7	406	1,79
2.8	414	1,82
2.9	428	1,88
3.0	439	1,93
3.1	449	1,98
3.2	458	2,02
3.3	468	2,06
3.4	477	2,1
3.5	486	2,14
3.6	494	2,17
3.7	503	2,21
3.8	511	2,25
3.9	518	2,28
4.0	526	2,31
4.1	532	2,34
4.2	538	2,37
4.3	544	2,39
4.4	549	2,42
4.5	553	2,43
4.6	559	2,46
4.7	563	2,48
4.8	567	2,5
4.9	571	2,51
5.0	575	2,53

R206AY054 - Δp: 30-400 kPa

setting	l / h	GPM
1.0	64	0,282
1.1	142	0,624
1.2	209	0,92
1.3	268	1,18
1.4	319	1,41
1.5	366	1,61
1.6	408	1,8
1.7	446	1,96
1.8	482	2,12
1.9	516	2,27
2.0	549	2,42
2.1	580	2,56
2.2	611	2,69
2.3	641	2,82
2.4	671	2,95
2.5	700	3,08
2.6	728	3,21
2.7	756	3,33
2.8	783	3,45
2.9	810	3,56
3.0	835	3,68
3.1	860	3,79
3.2	883	3,89
3.3	906	3,99
3.4	927	4,08
3.5	946	4,17
3.6	965	4,25
3.7	982	4,32
3.8	998	4,39
3.9	1010	4,46
4.0	1020	4,51
4.1	1040	4,57
4.2	1050	4,61
4.3	1060	4,66
4.4	1070	4,7
4.5	1080	4,73
4.6	1080	4,77
4.7	1090	4,8
4.8	1100	4,83
4.9	1100	4,86
5.0	1110	4,89

R206AY055 - Δp: 30-400 kPa

setting	l / h	GPM
1.0	64	0,282
1.1	142	0,624
1.2	209	0,92
1.3	268	1,18
1.4	319	1,41
1.5	366	1,61
1.6	408	1,8
1.7	446	1,96
1.8	482	2,12
1.9	516	2,27
2.0	549	2,42
2.1	580	2,56
2.2	611	2,69
2.3	641	2,82
2.4	671	2,95
2.5	700	3,08
2.6	728	3,21
2.7	756	3,33
2.8	783	3,45
2.9	810	3,56
3.0	835	3,68
3.1	860	3,79
3.2	883	3,89
3.3	906	3,99
3.4	927	4,08
3.5	946	4,17
3.6	965	4,25
3.7	982	4,32
3.8	998	4,39
3.9	1010	4,46
4.0	1020	4,51
4.1	1040	4,57
4.2	1050	4,61
4.3	1060	4,66
4.4	1070	4,7
4.5	1080	4,73
4.6	1080	4,77
4.7	1090	4,8
4.8	1100	4,83
4.9	1100	4,86
5.0	1110	4,89

R206AY056 - Δp: 16-400 kPa

setting	l / h	GPM
1.0	865	3,81
1.1	1010	4,46
1.2	1160	5,10
1.3	1300	5,72
1.4	1430	6,32
1.5	1570	6,90
1.6	1700	7,47
1.7	1820	8,02
1.8	1940	8,56
1.9	2060	9,08
2.0	2180	9,59
2.1	2290	10,1
2.2	2400	10,6
2.3	2510	11,0
2.4	2610	11,5
2.5	2710	11,9
2.6	2810	12,4
2.7	2900	12,8
2.8	3000	13,2
2.9	3090	13,6
3.0	3180	14,0
3.1	3260	14,4
3.2	3350	14,7
3.3	3430	15,1
3.4	3510	15,5
3.5	3590	15,8
3.6	3670	16,1
3.7	3740	16,5
3.8	3820	16,8
3.9	3890	17,1
4.0	3960	17,4
4.1	4030	17,7
4.2	4100	18,1
4.3	4170	18,4
4.4	4240	18,7
4.5	4300	19,0
4.6	4370	19,2
4.7	4440	19,5
4.8	4500	19,8
4.9	4570	20,1
5.0	4630	20,4

R206AY057 - Δp: 16-400 kPa		
setting	l / h	GPM
1.0	1900	8,4
1.1	2278	10,0
1.2	2655	11,7
1.3	3033	13,3
1.4	3410	15,0
1.5	3787	16,7
1.6	4163	18,3
1.7	4537	20,0
1.8	4909	21,6
1.9	5279	23,2
2.0	5646	24,8
2.1	6011	26,4
2.2	6372	28,0
2.3	6730	29,6
2.4	7083	31,2
2.5	7432	32,7
2.6	7776	34,2
2.7	8115	35,7
2.8	8449	37,2
2.9	8777	38,6
3.0	9098	40,0
3.1	4913	21,6
3.2	9721	42,8
3.3	10021	44,1
3.4	10314	45,4
3.5	10599	46,6
3.6	10875	47,9
3.7	11142	49,0
3.8	11400	50,2
3.9	11649	51,3
4.0	11888	52,3
4.1	12116	53,3
4.2	12334	54,3
4.3	12540	55,2
4.4	12735	56,0
4.5	12919	56,8
4.6	13090	57,6
4.7	13249	58,3
4.8	13395	58,9
4.9	13527	59,5
5.0	13647	60,0

R206AY058 - Δp: 16-400 kPa		
setting	l / h	GPM
1.0	1900	8,4
1.1	2278	10,0
1.2	2655	11,7
1.3	3033	13,3
1.4	3410	15,0
1.5	3787	16,7
1.6	4163	18,3
1.7	4537	20,0
1.8	4909	21,6
1.9	5279	23,2
2.0	5646	24,8
2.1	6011	26,4
2.2	6372	28,0
2.3	6730	29,6
2.4	7083	31,2
2.5	7432	32,7
2.6	7776	34,2
2.7	8115	35,7
2.8	8449	37,2
2.9	8777	38,6
3.0	9098	40,0
3.1	4913	21,6
3.2	9721	42,8
3.3	10021	44,1
3.4	10314	45,4
3.5	10599	46,6
3.6	10875	47,9
3.7	11142	49,0
3.8	11400	50,2
3.9	11649	51,3
4.0	11888	52,3
4.1	12116	53,3
4.2	12334	54,3
4.3	12540	55,2
4.4	12735	56,0
4.5	12919	56,8
4.6	13090	57,6
4.7	13249	58,3
4.8	13395	58,9
4.9	13527	59,5
5.0	13647	60,0

R206C
DIFFERENTIAL PRESSURE CONTROLLER WITH DOUBLE PRESETTING RANGE

R206C balancing valves are devices controlling the differential pressure and maintaining it constant to a preset value, regardless the boundary conditions, in a range between a minimum and a maximum flow.

The nominal differential pressure of Giacomini balancing valves R206C can be controlled on a constant basis with a double presetting range from 5 to 30 kPa in "L" mode (Low) or from 25 to 60 kPa in "H" mode (High), by switching the selector in the hand wheel of the valve. This special feature guarantees great flexibility during the startup and during later changes in the plant.

WHY CHOOSE IT?

- exclusive dual control range selection: (5-30 kPa) and 25-60 kPa
- control of high flow-rates
- CR* brass body

* Dezincification resistant (DZR) or corrosion resistant (CR) brasses are used in plants with large corrosion risks, like high temperature systems with soft water or chlorides present

fig. 3.34
Differential pressure controller R206C with double presetting

Versions and product codes

product codes	DN	connections
R206CY103	15	1/2"F (Rp - EN 10226)
R206CY104	20	3/4"F (Rp - EN 10226)
R206CY105	25	1"F (Rp - EN 10226)
R206CY106	32	1 1/4"F (Rp - EN 10226)
R206CY107	40	1 1/2"F (Rp - EN 10226)
R206CY108	50	2"F (Rp - EN 10226)

fig. 3.35

In the typical installation layout, the hydronic circuit is controlled by combining two valves: the static balancing valve R206B and the differential pressure controller R206C.

The static balancing valve R206B is installed on the delivery circuit, the valve is preset at the design flow-rate and is connected to the differential pressure controller R206C, which is installed on the return circuit.

The connection between R206B and R206C is made by a copper capillary pipe included with the R206C.

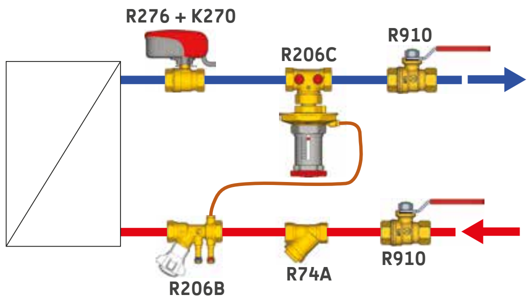


fig. 3.36
Typical installation layout of a R206C valve

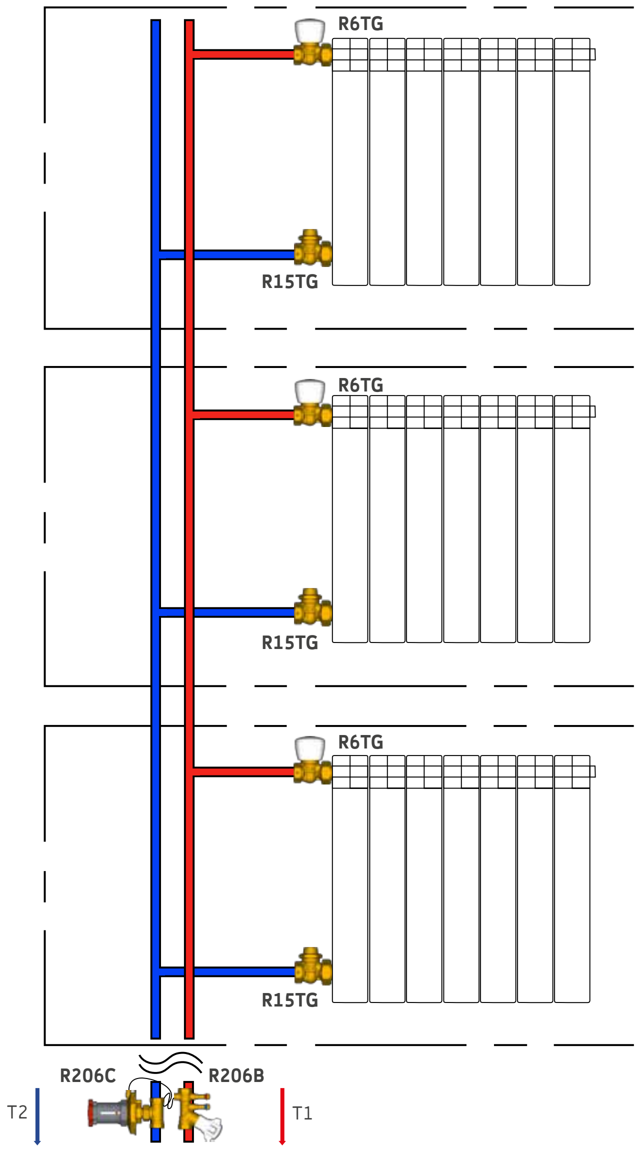
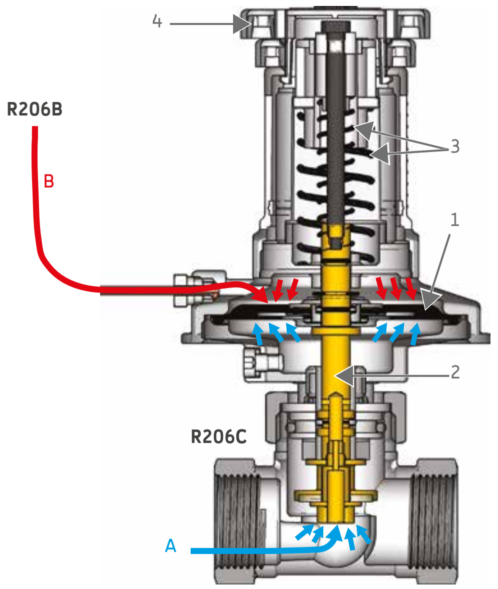


fig. 3.37
Installation layout of R206C with vertical two pipe radiators distribution

This configuration enables the differential pressure controller R206C to keep the differential pressure at the preset value (design value) within the section of the system that needs to be balanced.

Fig. 3.38 shows the operation of the valve. The interaction of two contrasting forces enables an elastic membrane (1) to activate the stopper (2): from below the water pressure inside the return piping (A) pushes to open the valve, from above the water pressure inside the delivery piping (B), carried back by the capillary pipe, tries to close the valve. The stopper opening and/or closing action is enabled by one or two springs (3) properly adjusted by the installer through an adjustment knob (4). The double spring enables to control the two presetting ranges (“L” - Low and “H” - High) in one single valve, which is the major advantage of this valve.



legend

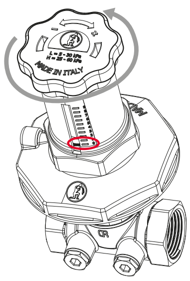
A	Return piping water pressure	**2**	Stopper
B	Delivery piping water pressure, through capillary pipe	**3**	Double spring
1	Elastic membrane	**4**	Adjustment knob

fig. 3.38
Basic components of R206C

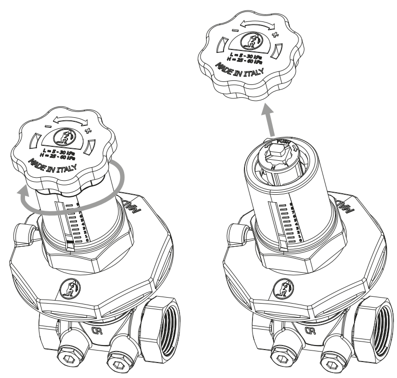
Selection of the presetting range and presetting

The R206C valves can be preset at any time. To preset the desired differential pressure, refer to the presetting diagrams in page 89. According to the diagram, select the presetting range “L” or “H” and preset the scale value (1 to 9) by rotating the red knob. The presetting is indicated on the valve indicator scale.

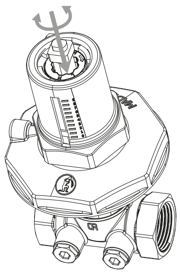
To select the presetting range “L” or “H” proceed as follows:

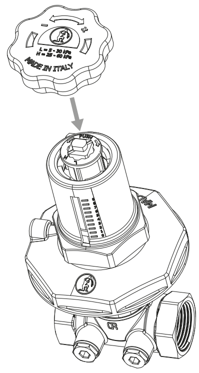


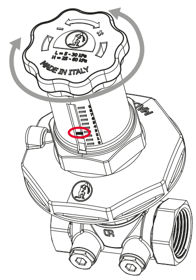
- purge the air from the membrane body
- adjust the adjustment scale to “0” by rotating the red knob until it is completely closed



- loosen the grey knob by 1/4 turn in clockwise direction and remove both knobs (red and grey) by pulling them up







• push the white ring nut down and rotate it manually to the “L” (Low) or “H” (High) presetting position	• reassemble the two knobs fitting them to the internal connections of the valve and pushing them slightly down	• preset the desired pressure value by rotating the red knob (presetting)

Dimensioning and selection procedure

The dimensioning and the selection of the differential pressure controller R206C is done in the following steps:

> define the design flow-rate for the circuit

> define the desired differential pressure, sufficiently large to guarantee the flow-rate for the farthest user with the biggest pressure drop and respecting the maximum differential pressure accepted by the combination of valves and actuators in the controlled circuits in order to avoid noise and problems with the actuators

> select the valve size and the presetting range “L” or “H”

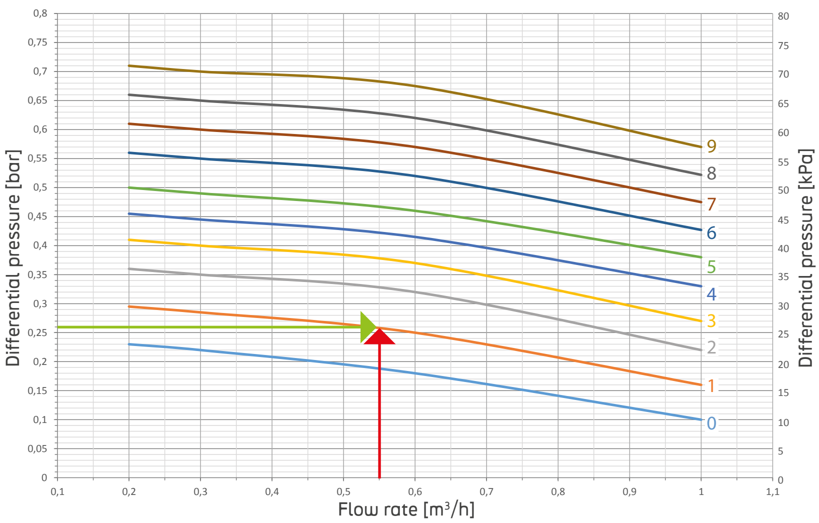


fig. 3.39
Presetting procedure of the R206C

As an example, a user with a flow-rate of 600 l/h and a desired differential pressure according to the design conditions of 25 kPa is considered. Based on both parameters, the valve size 1/2” – R206CY103 and presetting scale hige “H” are chosen.

Then, on fig. 3.39 a vertical red arrow is drawn at the desired flow-rate of 550 l/h and a green horizontal arrow is drawn at the desired differential pressure of 25 kPa. At the intersection of both lines, the presetting of the valve can be read.

Applications

Applications of controlling dynamically the differential pressure are various and different, and can be summarized as below:

- controlling the differential pressure in circuits with proportional actuators (typically radiator valves with thermostatic heads), is a configuration in which it is intended to protect each circuit from overpressure coming from adjacent circuits
- controlling the differential pressure in circuits with “on off actuators” (typically in underfloor systems or distribution with fan coils), where the individual flow in each circuit is controlled in an indirect way. Indeed, after commissioning and presetting the differential pressure valve with all circuits open, the DPC valve R206C will keep differential pressure over the manifold constant when some circuits will close. As differential pressure and hydraulic resistance for the open circuit do not change, their flow will remain unchanged

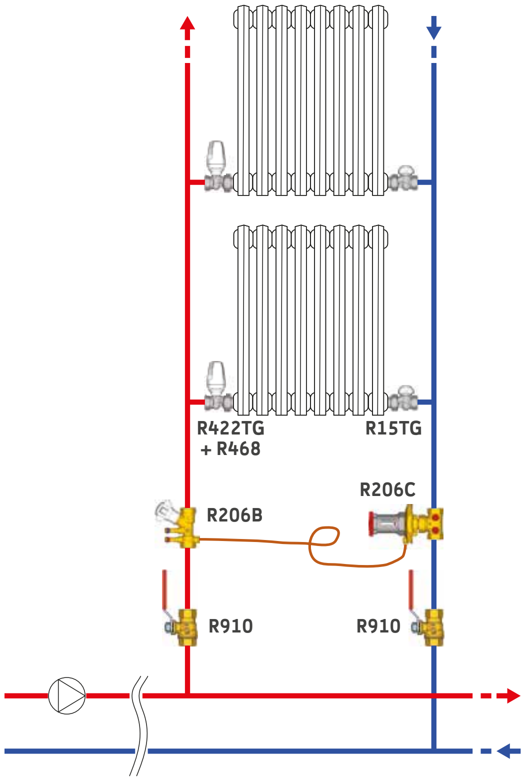


fig. 3.40
Situation 1: application with proportional actuators (thermostatic heads)

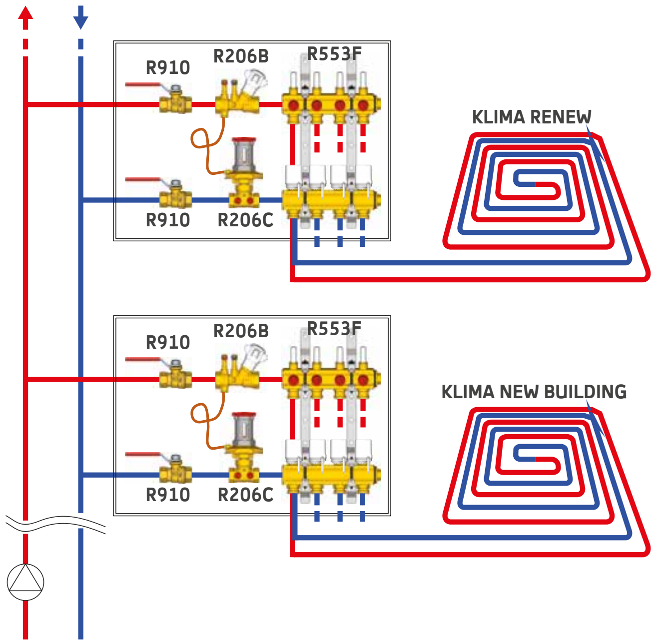


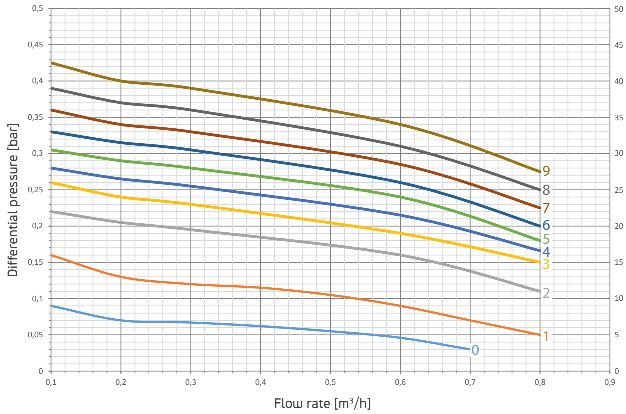
fig. 3.41
Situation 2: application with “on off” actuators (R473M electric heads)

Presetting diagrams

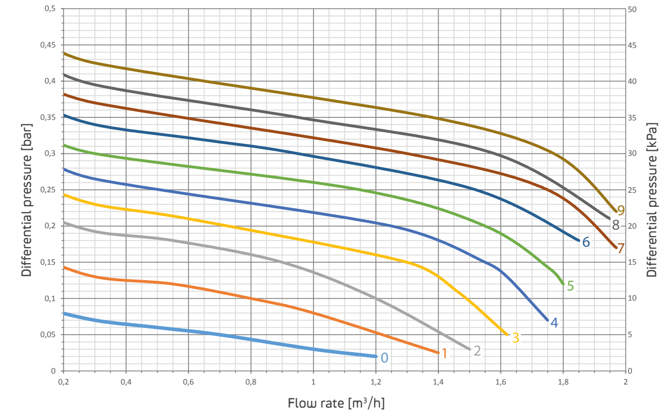
Below are listed the Low and High presetting diagrams for the complete range from 1/2" to 2":

Presetting range "L" – Low:

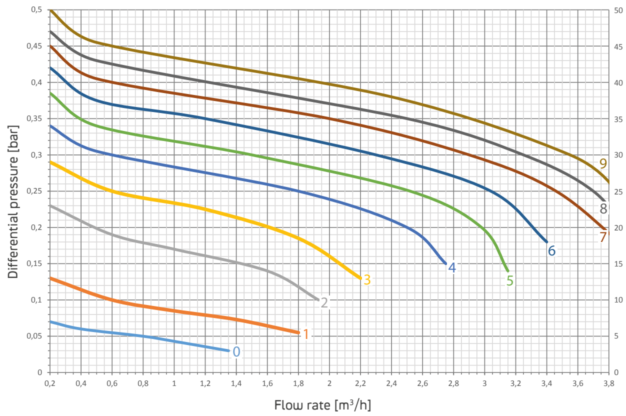
R206CY103



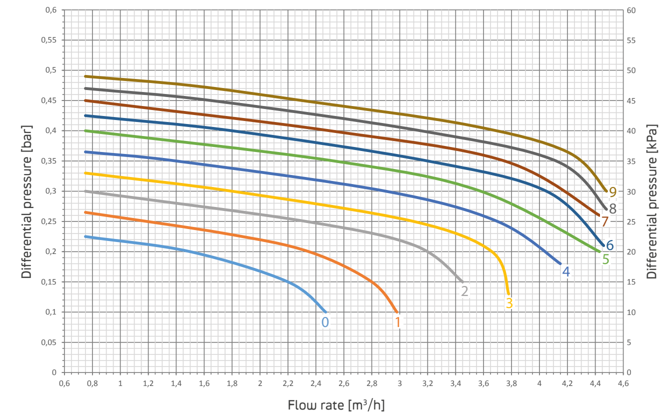
R206CY104



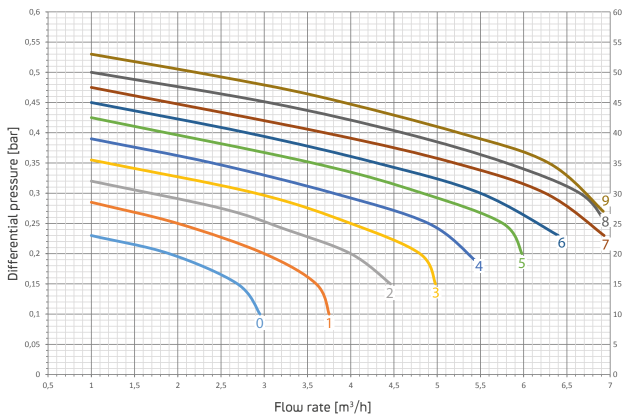
R206CY105



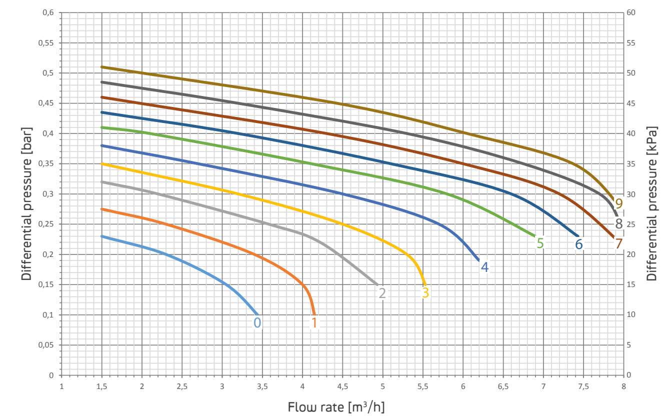
R206CY106



R206CY107

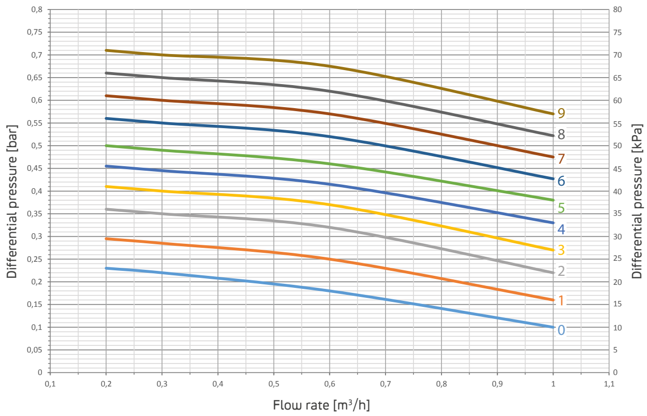


R206CY108

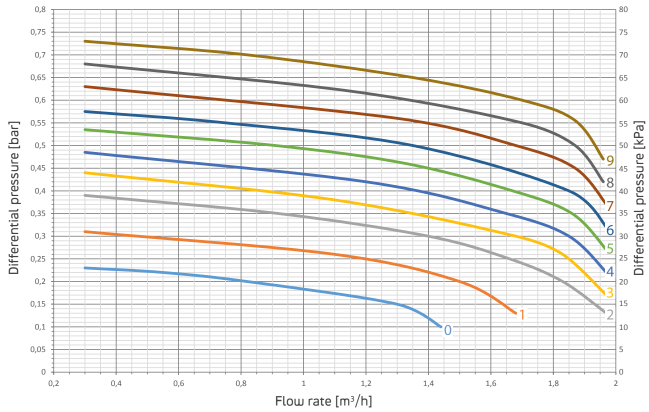


Presetting range "H" – High:

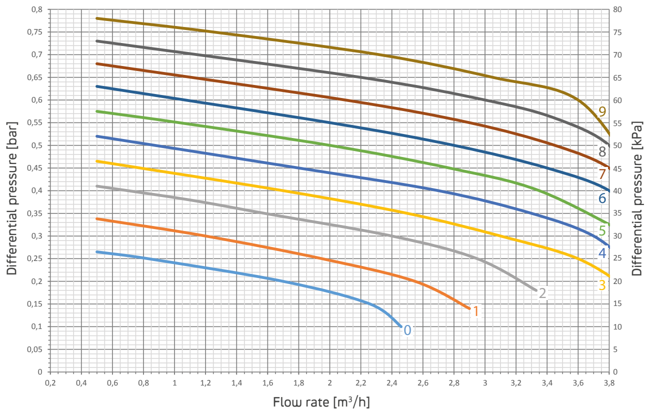
R206CY103



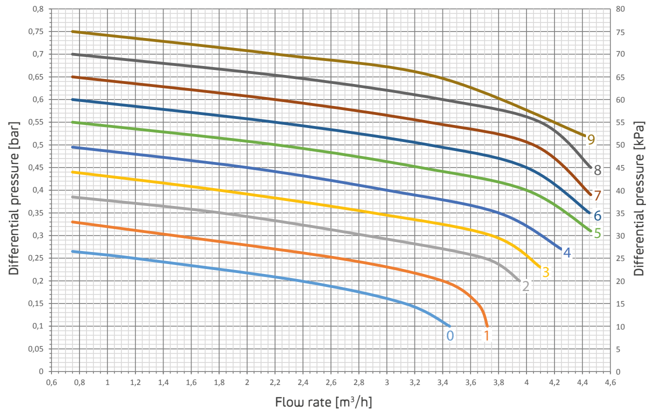
R206CY104



R206CY105



R206CY106



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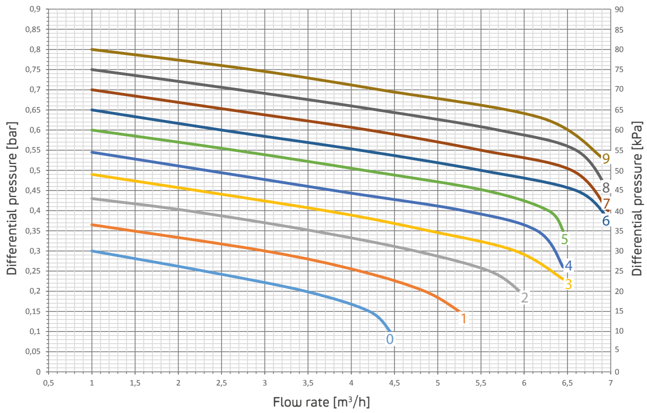

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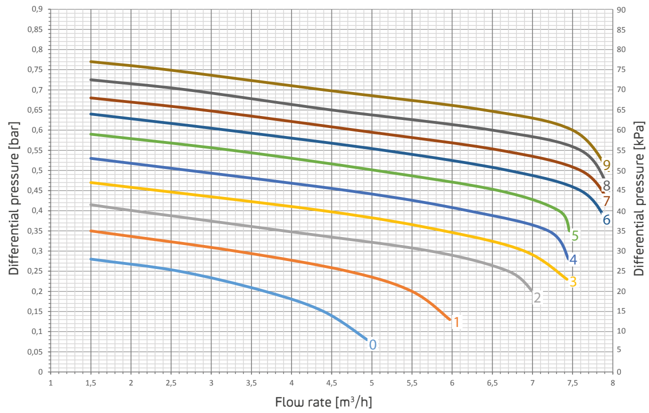


GE553

MANIFOLD UNITS AND BALANCING SOLUTIONS FOR MULTI-APARTMENT APPLICATIONS

Nowadays, most heating systems in multi-storey buildings are designed taking into account the heating distribution from the central boiler to the individual apartments on the various floors through risers that are concentrated in technical shafts.

This concept makes it possible to control the flow-rate and the differential pressure, to measure the individual energy consumption and to provide an effective regulated system for each user.

There are four solutions:

- manifold units for floor installation with general control of differential pressure
- manifold units for floor installation with individual control of differential pressure per apartment
- manifold units for installation in the apartment with general control of differential pressure
- manifold units for floor installation with control of supply pressure for sanitary systems

WHY CHOOSE IT?

- balancing and distribution combined in one single pre-assembled product
- multiple versions available for every installation need
- quick installation

GE553 Manifold units for floor installation with general control of differential pressure

Fig. 3.42 shows a manifold unit for floor installation with parallel connection of the apartments and general control of the differential pressure through the combination of a static balancing valve R206A and a differential pressure controller R206C. On the manifold, each branch/apartment can be shut off and the energy consumption can be measured individually.

This is a very rational and cost effective approach of design.

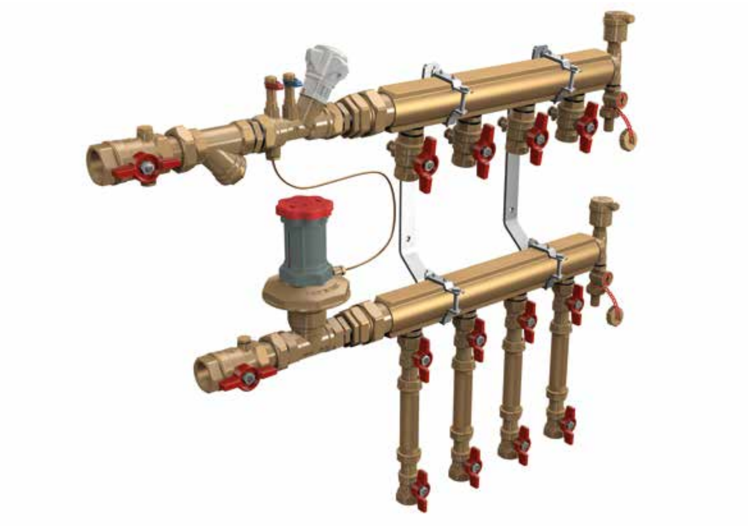


fig. 3.42
Manifold unit for floor installation with general control of differential pressure and individual energy measurement

On fig. 3.43, each apartment can be individually balanced by adding a compact static balancing valve.

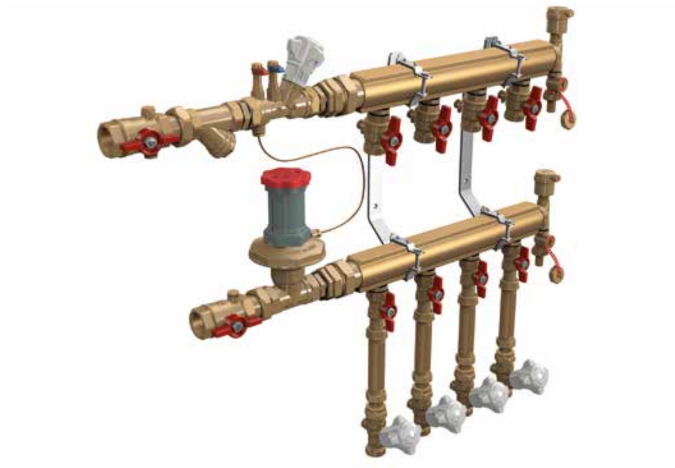


fig. 3.43
Manifold unit for floor installation with general control of differential pressure, individual static balancing and individual energy measurement per apartment

GE553 Manifold units for floor installation with individual control of differential pressure per apartment

Fig. 3.44 shows a manifold unit for floor installation with parallel connection of the apartments and individual control of the differential pressure by adding the combination of a static balancing valve R206A and a differential pressure controller R206C per apartment. On the manifold, each branch/apartment can be shut off and the energy consumption can be measured individually.

This is a very precise approach of design where it is possible to strictly control each apartment.

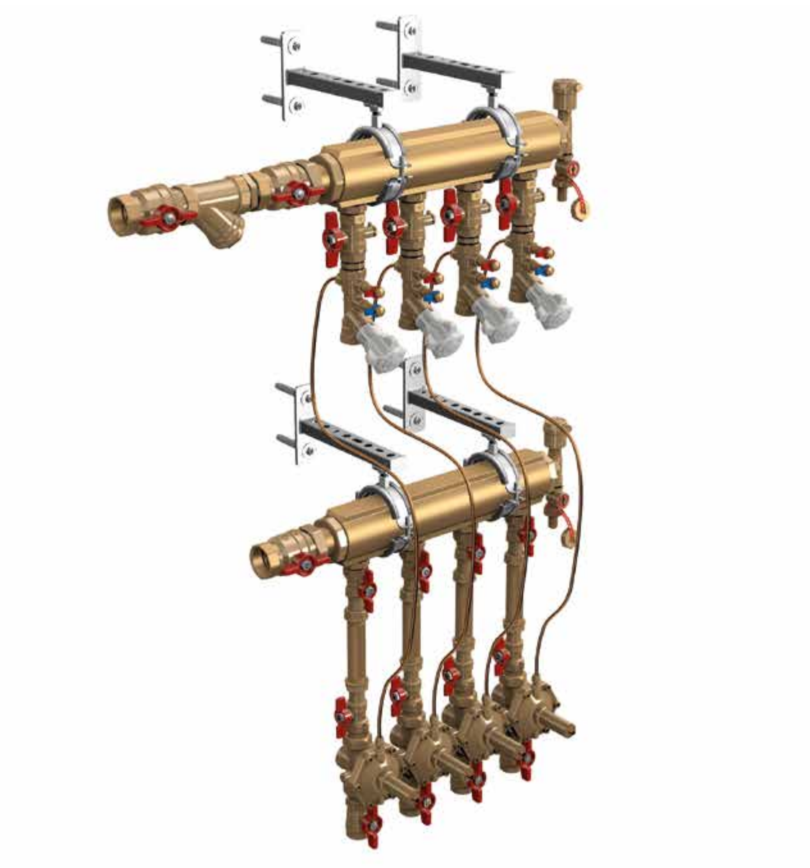


fig. 3.44
Manifold unit for floor installation with individual control of differential pressure and energy measurement per apartment

GE553 Manifold units for installation in the apartment with general control of differential pressure

Fig. 3.45 shows a manifold unit for installation in the apartment with parallel connection of the circuits in the apartment. General control of the differential pressure is done through the combination of a static balancing valve R206A and a differential pressure controller R206C; individual static balancing can be done using the individual lockshields integrated in the manifolds. Global energy consumption of the apartment can be measured.

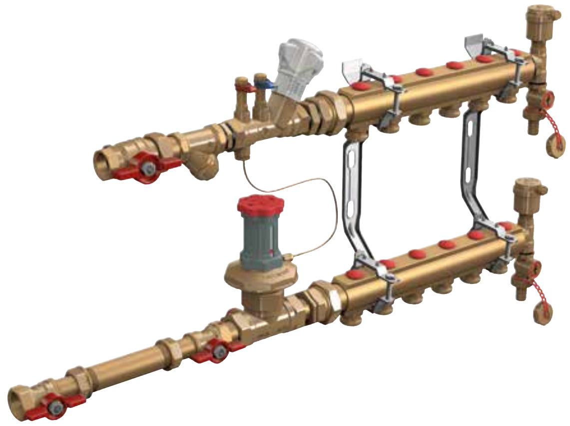


fig. 3.45
Manifold unit for installation in the apartment with general control of differential pressure and static balancing per circuit through integrated lockshields

GE553 Manifold units for floor installation with control of supply pressure for sanitary systems

The same philosophy of the previous manifold solutions can be applied to hot and cold sanitary distribution, it is necessary to protect the system from overpressures from centralized net, thus the solution can be to install pressure reducer upstream from parallel sanitary water pipelines as we see in fig. 3.46.

The same philosophy of the previous manifold solutions can be applied to hot and cold water distribution systems, when it is necessary to protect the users against overpressure from the distribution network by installing a general pressure reducer with membrane R153M, as shown on fig. 3.46.

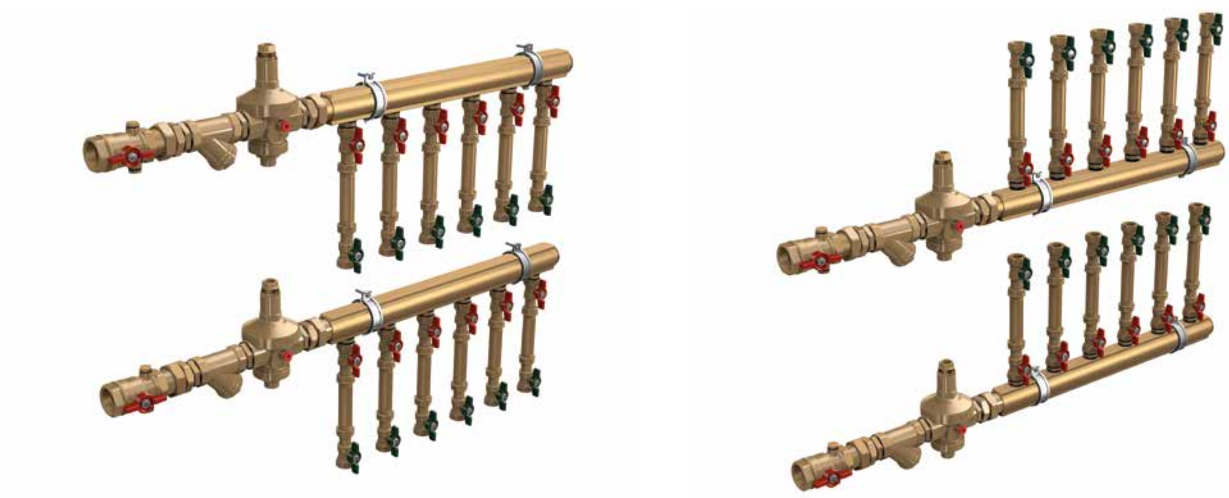


fig. 3.46
Manifold units for floor installation with general control of supply pressure and individual measurement of DHW and DCW consumption per apartment

R274
SIX-WAY VALVE: CONTROL AND STATIC BALANCING OF 4-PIPE SYSTEMS

The R274 six-way zone valves (with tail pieces) and R274N six-way zone valves (without tail pieces) allow to manage the power supply to a single user or terminal unit from two different sources of thermal energy, or to manage in an easy and rational way 4-pipe systems (typically used in heating and cooling applications).

The six-way zone valves allow the system change-over from one thermal energy source to another or from heating to cooling in 4-pipe systems (stem positions from 0° to 90°) and also the simultaneous closing of the supply from both primary sources (stem position at 45°).

In the case of systems with multiple thermal energy sources, a single valve, motorized with actuator K274-2, can substitute two motorized diverting valves, easily solving any complications with synchronization for the opening/closings of the two sources.

In the case of 4-pipe systems, six way valves are typically used in radiant ceiling systems, chilled beams and fan-coil units in particular for the offices applications, where the changeover from heating to cooling can be easily managed, even when this is required during the same day, and can be carried out individually for each zone.

In combination with fan-coil units for instance, two different batteries to manage the heating and the cooling mode are no longer needed and a single valve with actuator can substitute four two-way zone valves.

WHY CHOOSE IT?

- 4-pipe plant control with heating and cooling available simultaneously
- limited pressure drops with Kvs among the best on the market
- overpressure protection

fig. 3.47
Six-way valves R274 and R274N - bodies and configurations

The three basic positions of the six-way zone valves are shown in the figures 3.48 – 3.49 - 3.50:

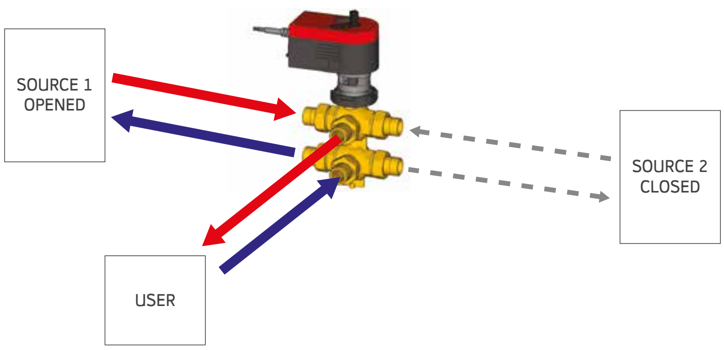


fig. 3.48
Six way valves getting flow from source 1 the user is connected with the 1st energy source

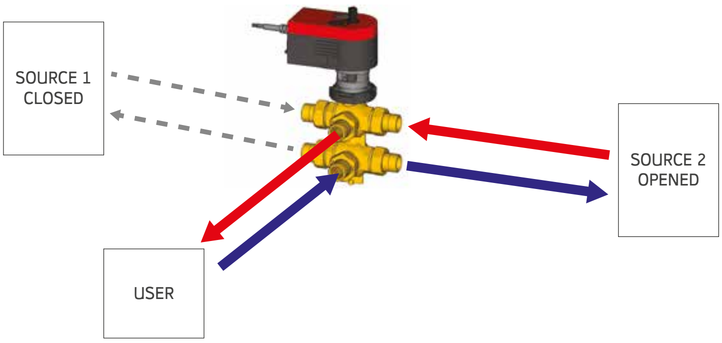


fig. 3.49
Six way valves getting flow from source 2 the user is connected with the 2nd energy source

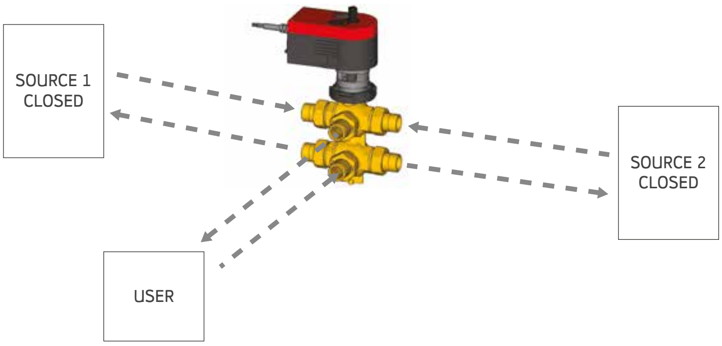


fig. 3.50
Six way valves stopping flow from both sources since the room controller set is satisfied the supply from both primary sources is closed

Typically, the control signal comes from a 0-10 V room controller, the changing of the voltage signal will change the position of the stem, the thermal energy source and the flow-rate.

In general, the advantages come from transforming a complicated multi-component system in a simple one, with just one body and one actuator.

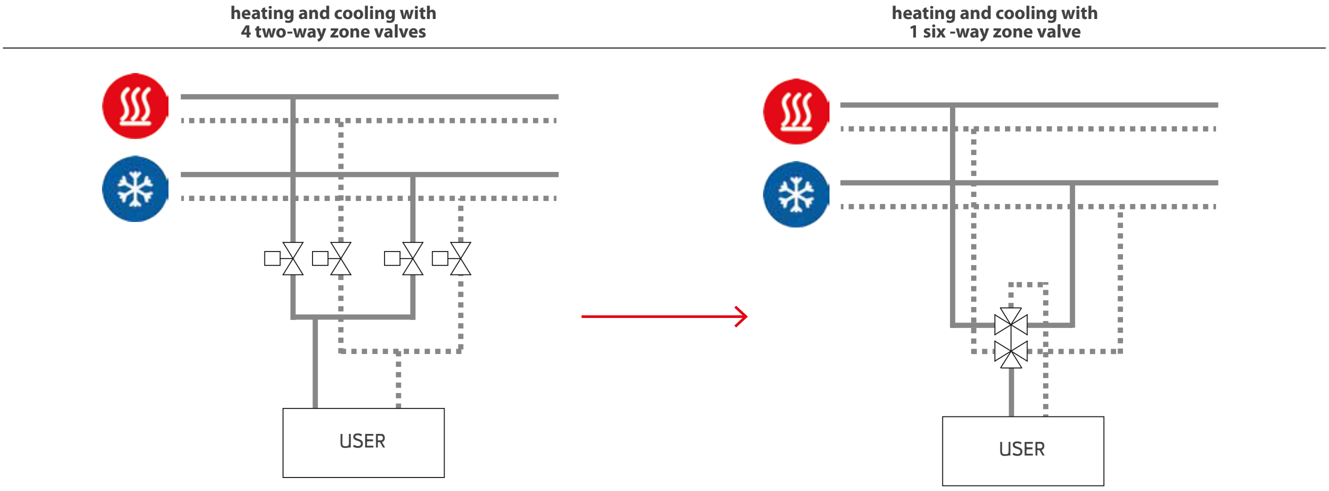


fig. 3.51
A six-way valve makes easy the management of 4-pipe systems

Dimensioning, selection and static balancing procedure

As usual, the dimensioning procedure starts with the selection of the Kv value. As six-way zone valves don't control only one circuit but both hot and cold water circuits that have different design delta T and thus different flow-rates, different calibrated washers will be selected with appropriate Kv value for the static balancing of the hot and cold water circuits. Fig. 3.52 shows all versions and possible combinations of accessories tied to R274 applications:

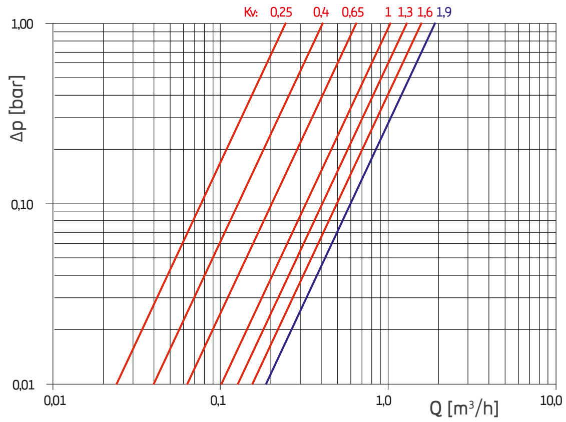
					optional extras			
series	**product code**	**valve connections**	**valve connections with flat seat tail pieces**	**valve body material**	**calibrated washers P21S** 	**actuator 24 Vac/dc (0-10 V) K274-2** 	**crosslinked polyethylene foam insulation R274W** 	**fittings**
R274 (with tail pieces)	**R274Y023**	1"M ISO 228	1/2"M ISO 228	CW617N	P21SY011 ÷ P21SY016	K274Y062	R274WY001	-
	R274Y024	1"M ISO 228	3/4"M ISO 228	CW617N	P21SY011 ÷ P21SY018	K274Y062	R274WY001	-
	R274Y025	1"M ISO 228	1"M ISO 228	CW617N	P21SY011 ÷ P21SY018	K274Y062	R274WY001	-
R274N (without tail pieces)	**R274Y033**	1/2"M ISO 228	-	CW617N	P21SY001 ÷ P21SY006	K274Y062	R274WY002	RM179Y053 (1/2"F x 16x2) RM179Y056 (1/2"F x 20x2) P15FY013 (1/2"F x 1/2"F) P15Y018 (1/2"F x 1/2"M)
	R274Y133	1/2"M ISO 228	-	CW602N (DZR)	P21SY001 ÷ P21SY006	K274Y062	R274WY002	
	R274Y045	1"M ISO 228	-	CW617N	P21SY011 ÷ P21SY018	K274Y062	R274WY001	RM179Y073 (1"F x 26x3) RM179Y074 (1"F x 32x3) RM252Y003 (1"F x RM16x2) RM252Y004 (1"F x RM20x2) R252Y023 (1"F x 1/2"M) R252Y025 (1"F x 18) P15Y015 (1"F x 1/2"M) P15Y016 (1"F x 3/4"M) P15Y017 (1"F x 1"M)
	R274Y145	1"M ISO 228	-	CW602N (DZR)	P21SY011 ÷ P21SY018	K274Y062	R274WY001	

fig. 3.52
R274 and R274N combinations and accessories

To guarantee a high range of balancing applications with a limited range of valves, it is very important to have a compact valve body with a big Kv value. This also allows in many situations to feed more terminal units in parallel, reducing the number of valves and actuators, and thus reducing the initial cost of the plant. Thanks to the large range of calibrated washers, there is still a significant flexibility in balancing.

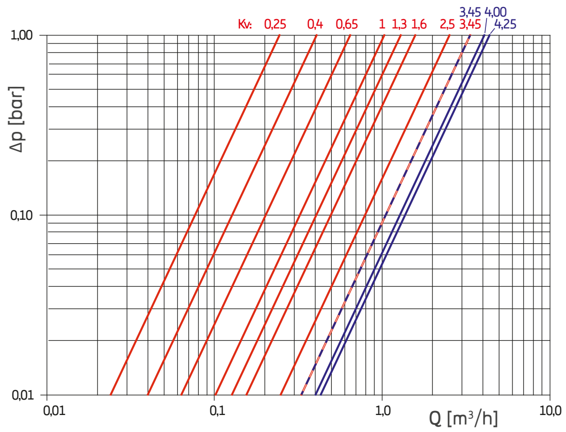
product code	**Kv total (valve delivery and return + washer)**	**installation on valves**
P21SY001	0,25 (Ø 2,7 mm)	R274Y033 - R274Y133
P21SY002	0,40 (Ø 3,5 mm)	
P21SY003	0,65 (Ø 4,5 mm)	
P21SY004	1,00 (Ø 6,0 mm)	
P21SY005	1,30 (Ø 7,0 mm)	
P21SY006	1,60 (Ø 8,0 mm)	
P21SY011	0,25 (Ø 3,0 mm)	R274Y045 - R274Y145 R274Y023 - R274Y024 R274Y025
P21SY012	0,40 (Ø 4,0 mm)	
P21SY013	0,65 (Ø 4,5 mm)	
P21SY014	1,00 (Ø 5,8 mm)	
P21SY015	1,30 (Ø 6,7 mm)	
P21SY016	1,60 (Ø 7,5 mm)	
P21SY017	2,50 (Ø 9,0 mm)	R274Y045 - R274Y145 R274Y024 - R274Y025
P21SY018	3,45 (Ø 12,7 mm)	

fig. 3.53
Calibrated washers range



product code	Kv total (valve delivery and return + washer)
valve + P21SY001	0,25
valve + P21SY002	0,40
valve + P21SY003	0,65
valve + P21SY004	1,00
valve + P21SY005	1,30
valve + P21SY006	1,60
valve without P21S	1,90

fig. 3.54
Loss of pressure diagram and Kv values for valves R274Y033 and R274Y133, inclusive of delivery and return, with or without calibrated washers



product code	Kv total (valve delivery and return + washer)
valve + P21SY011	0,25
valve + P21SY012	0,40
valve + P21SY013	0,65
valve + P21SY014	1,00
valve + P21SY015	1,30
valve + P21SY016	1,60
valve + P21SY017	2,50
valve + P21SY018	3,45
R274Y023 without P21S	3,45
R274Y024 without P21S	4,00
R274Y025/045/145 without P21S	4,25

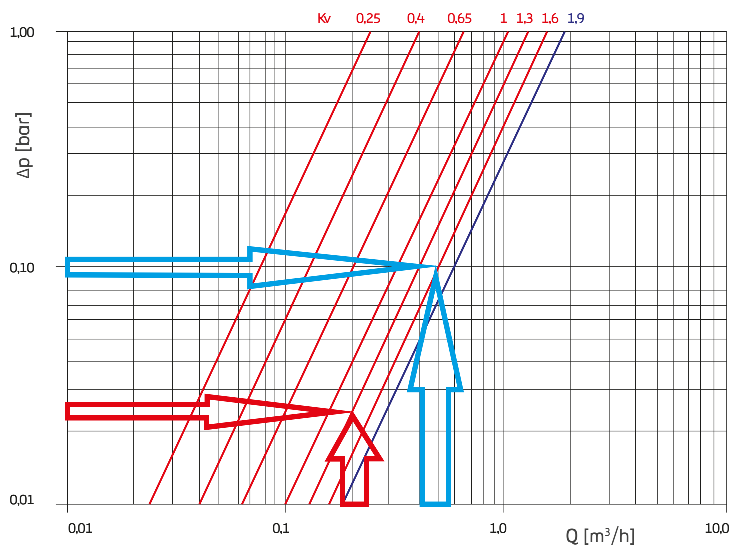
fig. 3.55
Loss of pressure diagram and Kv values for valves R274Y045, R274Y145, R274Y023, R274Y024 and R274Y025 inclusive of delivery and return, with or without calibrated washers

Based on the fig. 3.54 and 3.55, the following example explains the selection procedure of the washers.

A terminal unit is used for heating/cooling an office and needs 500 l/h for cooling and 200 l/h for heating. Because of the compact dimensions, the six-way valve R274Y033 with 1/2" connections is chosen.

For cooling, a flow-rate of 500 l/h through the terminal unit will create a pressure drop of 0,1 bar. Because of the authority, as explained in chapter 1 and 2, the calibrated washer needs to be selected in order to have the same pressure drop in the six-way valve. Finally, the intersection of the blue lines in fig. 3.56 points on the Kv value 1,6 and so P21SY006 will be the appropriate washer.

For heating, the pressure drop with 200 l/h through the terminal unit will be 0,025 bar and again, the pressure drop in the six-way valve should be the same. Finally, the intersection of the red lines in fig. 3.56 points on the Kv value 1,3 and the washer P21SY005 needs to be selected.



product code	Kv total (valve delivery and return + washer)
valve + P21SY001	0,25
valve + P21SY002	0,40
valve + P21SY003	0,65
valve + P21SY004	1,00
valve + P21SY005	1,30
valve + P21SY006	1,60
valve without P21S	1,90

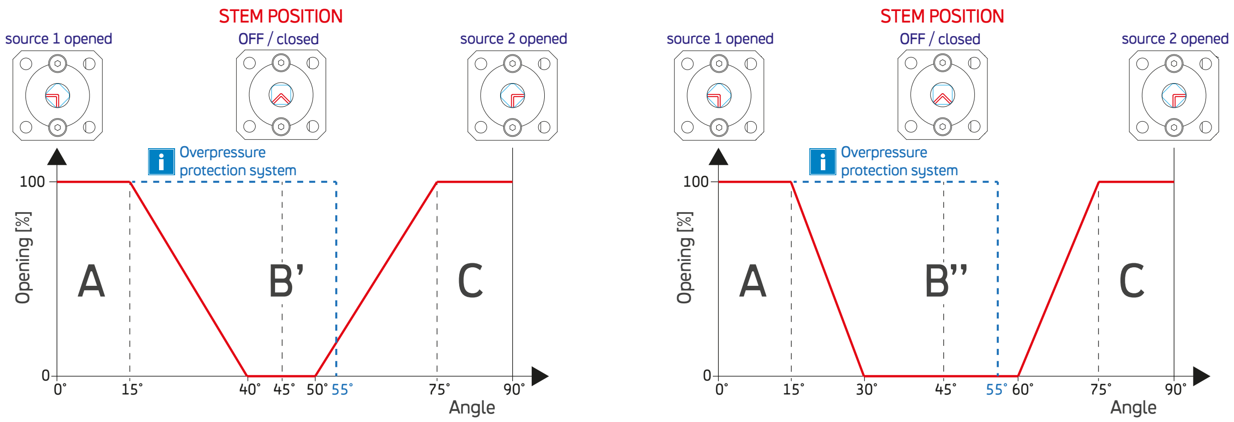
fig. 3.56
Example of selection procedure

Operating diagrams, overpressure protection, applications

The operating diagram is very important to explain the behavior of the valve according to the stem position and the combination with the actuator.

Fig. 3.57 shows the valve opening diagram and fig. 3.58 shows the characteristic curves of the valve in combination with the 0-10 V actuator K274Y062.

R274Y045, R274Y145, R274Y023, R274Y024, R274Y025 (1") | **R274Y033, R274Y133 (1/2")**



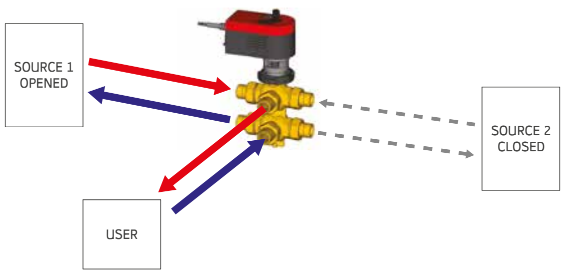
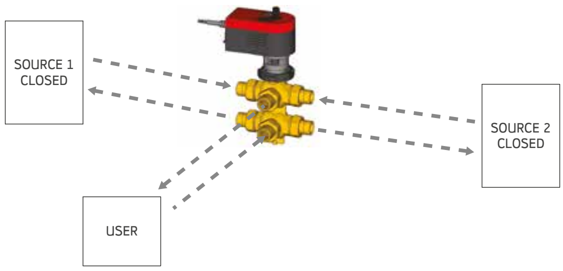
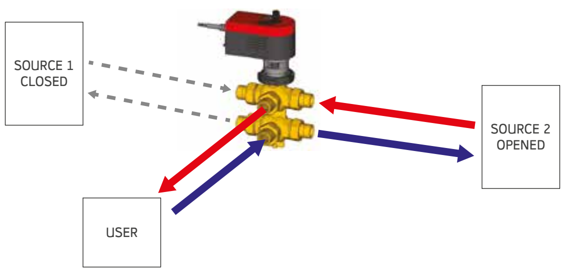
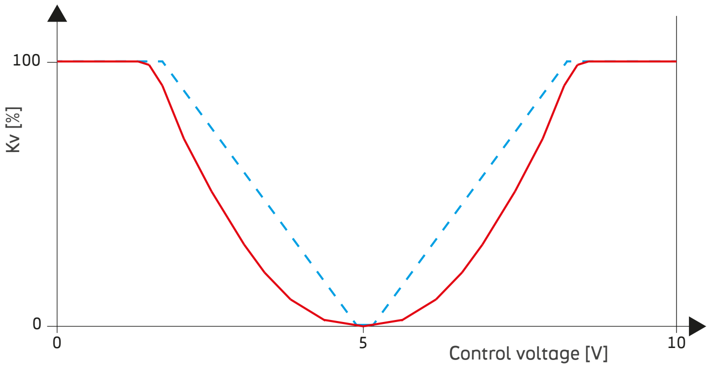
graphical reference	stem angle	opening percentage	action
A	0°÷15°	100 %	
B′	40°÷50°	0 %	
B″	30°÷60°		
C	75°÷90°	100 %	

fig. 3.57
Valve opening diagram



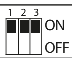
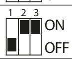
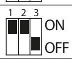
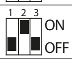
DIP SWITCH settings	characteristic curve of valve	speed
	1)	120 s ± 4 (factory setting)
	1)	60 s ± 2
	2)	120 s ± 4
	2)	60 s ± 2

fig. 3.58
Valve operation with actuator K274Y062

Fig. 3.59 shows the example of an operating diagram with radiant ceiling system and with fan-coil.

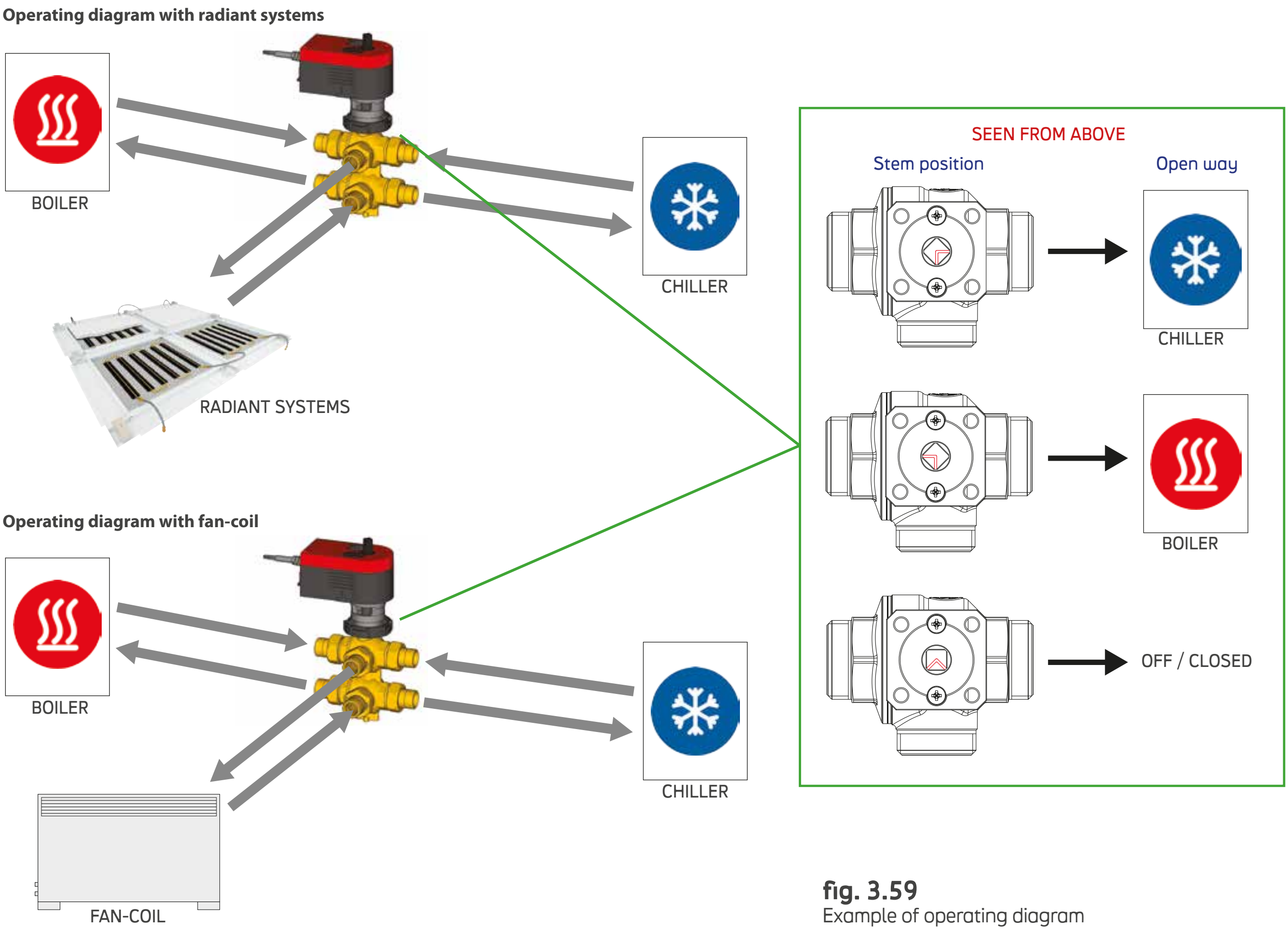


fig. 3.59
Example of operating diagram

However, throughout all the different operating conditions a feature that is really important is the possibility to protect the valve from overpressures.

In fact, as fig. 3.60 shows, when using the six-way valve for combined heating/cooling applications (radiant ceilings, fan-coil), the fluid inside the user circuit becomes completely isolated when the valve is in the closed position (not heating or cooling). The pressure of the trapped fluid inside the user circuit might then increase or decrease due to changes in the temperature of the fluid, caused by variations of the room temperature.

The six-way valve is equipped with an integrated protection against overpressure, and is designed to compensate as such pressure variations may occur. The upper ball of the valve has a small hole in its interior which maintains the connection of the “user” with the “source 1” on the left side, even when the valve is closed (stem position 45°). This means that the fluid inside the user circuit can expand and shrink freely without changing the pressure. As the lower ball is closed and does not have this special connection, there will be no circulation in the user circuit and the hydraulic separation between the two primary circuits remains respected.

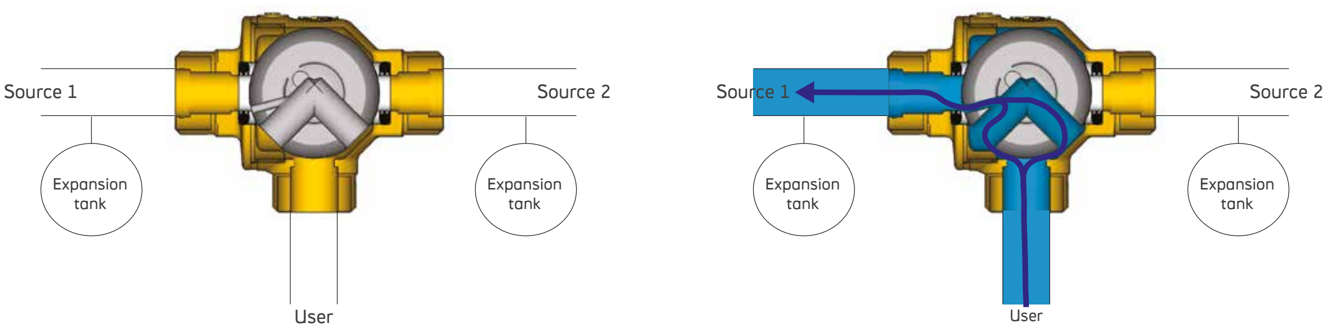


fig. 3.60
Prevent from the overpressure and at the same time avoid cross contamination and energy losses

DX274

SIX-WAY VALVE WITH DYNAMIC BALANCING: ACTIVE CONTROL OF 4-PIPE SYSTEMS FLOW

The evolution of the standard six-way valve is the DX274 with dynamic balancing, to guarantee a variable flow control as boundary conditions may vary in the plant application.

fig. 3.61
Six-way valve with dynamic balancing

WHY CHOOSE IT?

- electronic flow-rate control
- perfect to control heating and cooling systems simultaneously (4-pipe plants)
- BUS protocol control
- shut-off function also included

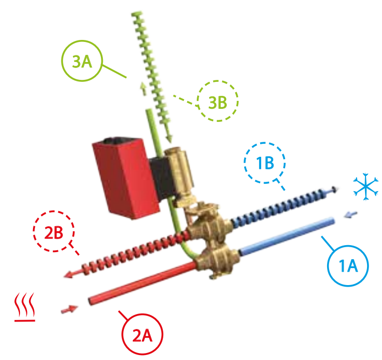
The product is a combination of a six-way valve, an electronic flowmeter and a controller in order to guarantee a complete and precise regulation in every system condition.

Basically the main advantage related to this product is the possibility to combine five valves in one:

- flow control valve
- pressure independent control valve
- shut off valve
- change-over valve
- integrated room temperature controller (optional)

All these features can be managed and put under control through Modbus, connecting every single device to the building management system.

Moreover, this allows remote commissioning and troubleshooting, making maintenance easier and cheaper.



	supply	return
cooling	1A	1B
heating	2A	2B
end unit	3A	3B

fig. 3.62
Typical application of a six-way valve with dynamic balancing

Operating diagrams, control loop, applications

Six-way valves with dynamic balancing are used in HVAC systems for heating and cooling, so called 4-pipe systems like radiant ceiling systems, with variable flow.

They control the flow-rate towards a setpoint, independently from potential pressure fluctuations in the system (see figures 3.63 and 3.64).

As they can perform the automatic, dynamic hydronic balancing as well as the real-time flow-control, they can replace both balancing and control valves.

The setpoint of the flow-rate is defined by an external analog 0-10 Vdc control signal, coming from a room controller or set via Modbus. This control signal is converted into a “split-range” signal that will be used to control heating (0,5-4,5 Vdc) and cooling (5,5-9,5 Vdc).

The integrated ultrasonic flowmeter, which has no moving parts, measures continuously the real flow-rate, compares it with the setpoint and adjusts the position of the six-way valve if necessary. To monitor the real flow-rate, a 0-10 Vdc output signal is available.

This kind of dynamic balancing works at full load as well as in part load situations and guarantees a maximum comfort for the user with a minimal energy consumption.

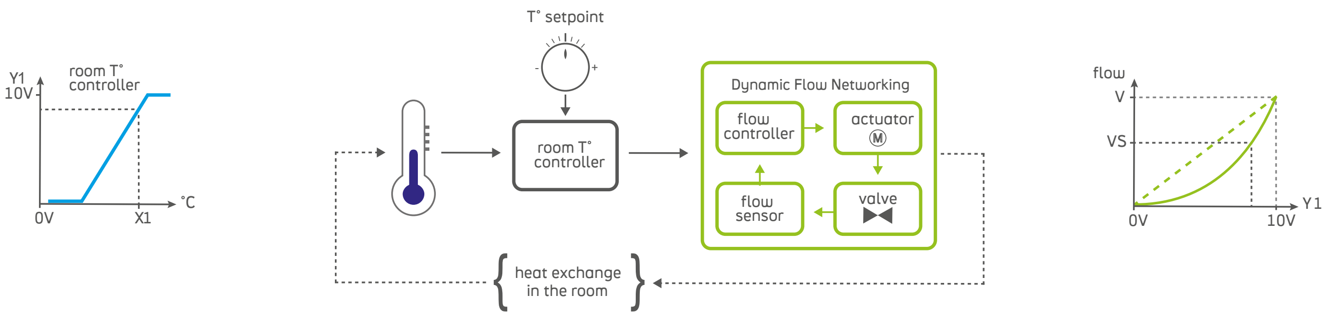


fig. 3.63
Control loop of a six-way valve with dynamic balancing

As shown in the control signal diagram fig. 3.64, the maximum flow-rate for heating and cooling are set separately:

- Vs maxc : maximum flow-rate for cooling (l/h)
- Vs maxh : maximum flow-rate for heating (l/h)

This way, no specific programming of the building management system is required and all parameters can be set locally, directly onto the device itself.

Between the heating and the cooling there is a «dead zone» (DZ) where both heating and cooling are deactivated.

When applying 0 Vdc (heating) or 10 Vdc (cooling) the six-way valve will be opened completely, for example when flushing the installation.

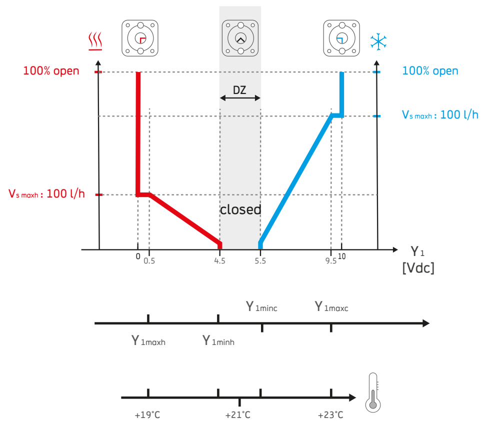


fig. 3.64
Control signal diagram of a six-way valve with dynamic balancing

SERIES DB
THERMOSTATIC RADIATOR VALVES WITH DYNAMIC FLOW CONTROL

Thermostatic radiator valves series DB have an integrated cartridge that regulates and limits the flow-rate so that overflow is eliminated. The preset flow-rate will not be exceeded, even if there are load changes in the system due to other valves closing or during start up. Within a range of minimum and maximum differential pressure, this operation is completely independent of differential pressure.

As the required flow-rate can be preset directly on the cartridge using a regulation key, complicated calculations of pressure drop and balancing are not necessary anymore and moreover commissioning time is clearly reduced.

These features are very important in new plants and even more significant in renovations where often many parameters are not known by the designer or the installer.

Another important topic is the maximum differential pressure this kind of valve can resist. Giacomini thermostatic radiator valves series DB are engineered to work up to 150 kPa, which allows its application in a wide range of situations.

WHY CHOOSE IT?

- efficient balancing with energy saving
- constant precision control
- bonnet replacement when plants are ON

Function

fig. 3.65
Thermostatic radiator valve DB series with dynamic flow control

The presetting of the calculated flow-rate is done with a special regulation key, as explained in page 106 “Cartridge presetting”.

If for instance the flow-rate is tending to rise because other thermostatic radiator valves are closing, the membrane of the cartridge will reduce the opening surface so the flow-rate is automatically limited to the preset value. The preset flow-rate is therefore never exceeded. On the contrary, if the flow-rate tends to descend below the preset value, the membrane of the cartridge enlarges the opening surface and the flow-rate rises again to the preset value.

Fig. 3.66 shows the typical flow-rate pressure drop diagram of a thermostatic radiator valve with dynamic flow control. Decreasing the preset flow-rate will shift the curve to the left; increasing the preset flow-rate will shift the curve to the right. The radiator valve can only be used in the linear part of the graph, so within the range of minimum and maximum delta P.

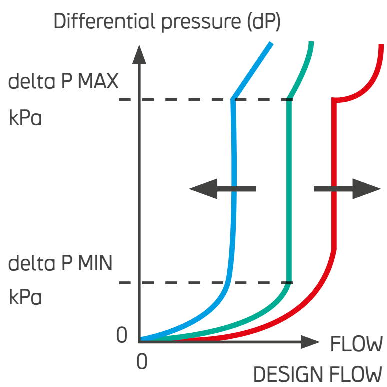


fig. 3.66
Setting and working principle of thermostatic radiator valve DB series with dynamic flow control

Application

The thermostatic radiator valve with dynamic flow control series DB is applied in two-pipe heating systems with normal to high temperature spread delta T.

The desired design flow-rate is calculated using the heating capacity and the delta T of the radiator. This means that the time consuming calculation of pressure losses and pipe dimensioning in renovation projects is no longer necessary.

The valve controls the flow-rate through the radiator, in an interval of minimum and maximum differential pressure, independently from differential pressure changes.

The minimum differential pressure has to be checked with the most disadvantaged valve while the maximum differential pressure needs to be checked with the most advantaged valve. The thermostatic radiator valves series DB are characterized by a high maximum differential pressure of 150 kPa, which allows its application in a wide range of situations.

The desired design flow-rate is directly preset on the radiator valve using a special regulation key. Thanks to the dynamic flow control, the preset flow-rate will never be exceeded, even if there is an oversupply of pressure due to load changes in the system for example when other valves are closing.

This makes this kind of thermostatic valves a time and cost-saving solution, especially for system commissioning, and later on for the effective functioning of the installation and the maximum comfort of the user.

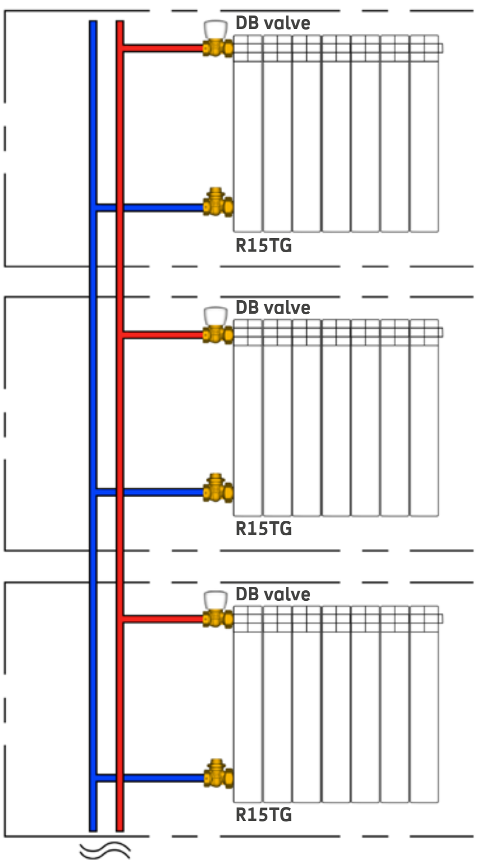


fig. 3.67
Typical two pipes application for radiator valve DB series

Cartridge presetting

The presetting of the valve is done, using a special regulation key, between the position 1 and 6 that are indicated on the cartridge.

To adjust the presetting of the cartridge:

- read the position of the cartridge that corresponds with the desired flow-rate from fig. 3.69
- remove the hand wheel or the thermostatic head from the valve
- place the regulation key on the cartridge and turn the key until the desired position points at the index on the valve body, as shown of fig. 3.68
- remove the regulation key and replace the hand wheel or the thermostatic head

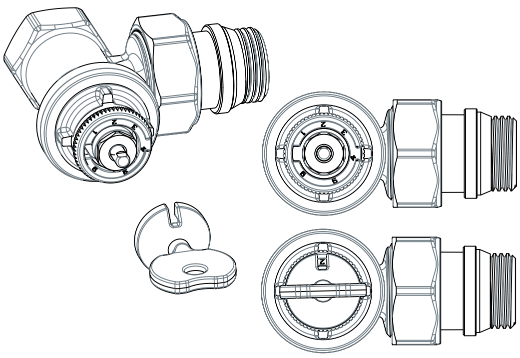


fig. 3.68
Flow presetting operation through the regulation key

Diagram

differential pressure kPa	flow-rate l/h							
	15	**50**	**100**	**125**	**175**	**210**	**250**	**coefficient**
0	0	0	0	0	0	0	0	0
10	8	25	50	63	88	105	125	0,5
20	12	40	80	100	140	168	200	0,8
30	14	48	96	120	168	202	240	0,96
40	15	49	98	123	172	206	245	0,98
50	15	50	99	124	173	208	248	0,99
60	15	50	100	124	174	209	249	0,995
70	15	50	100	125	175	210	250	1
80	15	50	100	125	175	210	250	1
90	15	50	100	125	175	210	250	1
100	15	50	100	125	175	210	250	1
110	15	50	100	125	175	210	250	1
120	15	50	100	125	175	210	250	1
130	15	50	100	125	175	210	250	1
140	15	50	100	125	175	210	250	1
150	15	50	100	125	175	210	250	1

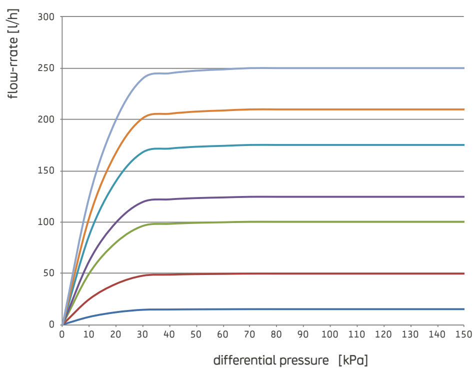


fig. 3.69
Diagram for presetting of thermostatic radiator valves - series DB

Distribution manifolds with dynamic flow control

Distribution manifolds with dynamic flow control regulate and limit the individual flow-rate in the connected circuits throughout a special cartridge that is installed in each outlet of the return manifold. It suffices to do the presetting of the desired flow-rate and the cartridge ensures the flow-rate, within a range of differential pressure, when other circuits on the manifold or elsewhere in the plant are opening or closing. Moreover, the flow-rate can be checked on the flowmeters that are installed in each circuit of the delivery manifold.

This makes this kind of distribution manifold a time and cost saving solution for system commissioning and later on for effective functioning of the installation and the maximum comfort of the user.

Moreover, these distribution manifolds are characterized by a high maximum differential pressure of 150 kPa, which allows its application in a wide range of situations.

Fig. 3.71 shows the typical flow-rate pressure drop diagram of a manifold with dynamic flow control. The manifold can only be used in the linear part of the graph, so within the range of minimum and maximum delta P. Decreasing the preset flow-rate will shift the curve to the left; increasing the preset flow-rate will shift the curve to the right.

Function

In operation, the opening and closing of outlets on the manifold or elsewhere in the plant can cause changes of the pressure and so of the flow-rate in the working circuits. By adapting automatically the internal shape of the membrane, the cartridge changes the opening surface and thus the flow-rate trough the cartridge so that the flow-rate is limited to the preset value.

If for instance circuits are closing and the flow-rate in a circuit that remains open is tending to rise, the membrane of the cartridge of that circuit will reduce the opening surface so the flow-rate is automatically limited to the preset value. On the contrary, if the flow-rate tends to descend below the preset value, the membrane of the cartridge enlarges the opening surface and the flow-rate rises again to the preset value.

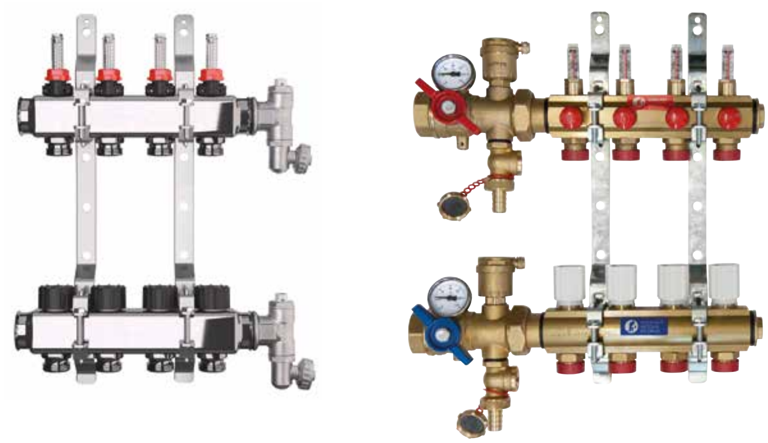


fig. 3.70
Distribution manifolds with dynamic flow control

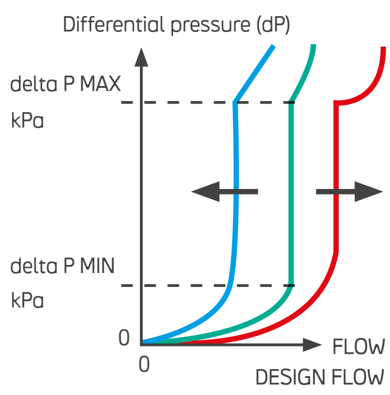


fig. 3.71
Presetting and working range of the manifolds series with dynamic flow control

Application

Distribution manifolds with dynamic flow control are typically used in radiant floor systems where the individual desired flow-rate can be easily preset per circuit on the return manifold and checked on the corresponding flowmeter on the delivery manifold.

As the boundary conditions change because other circuits may open or close, the preset flow-rates are dynamically controlled and limited thanks to the control cartridge, so hydraulic balancing is achieved in one simple operation when presetting the flow-rates.

This makes this kind of distribution manifolds a time and cost-saving solution, especially for system commissioning, and later on for the effective functioning of the installation and the maximum comfort of the user.

Presetting the desired flow-rates on conventional manifolds with static lockshields is time-consuming, unless a study of balancing and presetting has been done in advance. However to calculate the presetting of the different lockshields, all information of the plant is needed before starting. Using the flow-rate indicators on the manifold as an alternative to do the presetting also requires significant time as changing the position of the lockshield of one circuit will change the flow-rate in the other circuits. Anyway, the water quantities distributed in this way correspond to design conditions, so maximum requirements, and balancing is static.

This means when individual circuits are turned off, the quantity of water in the adjacent circuits will change, resulting in an oversupply in these circuits. The automatic hydraulic balancing with manifolds with dynamic flow control avoids this oversupply and ensures optimum temperature distribution, saves energy and increases comfort.

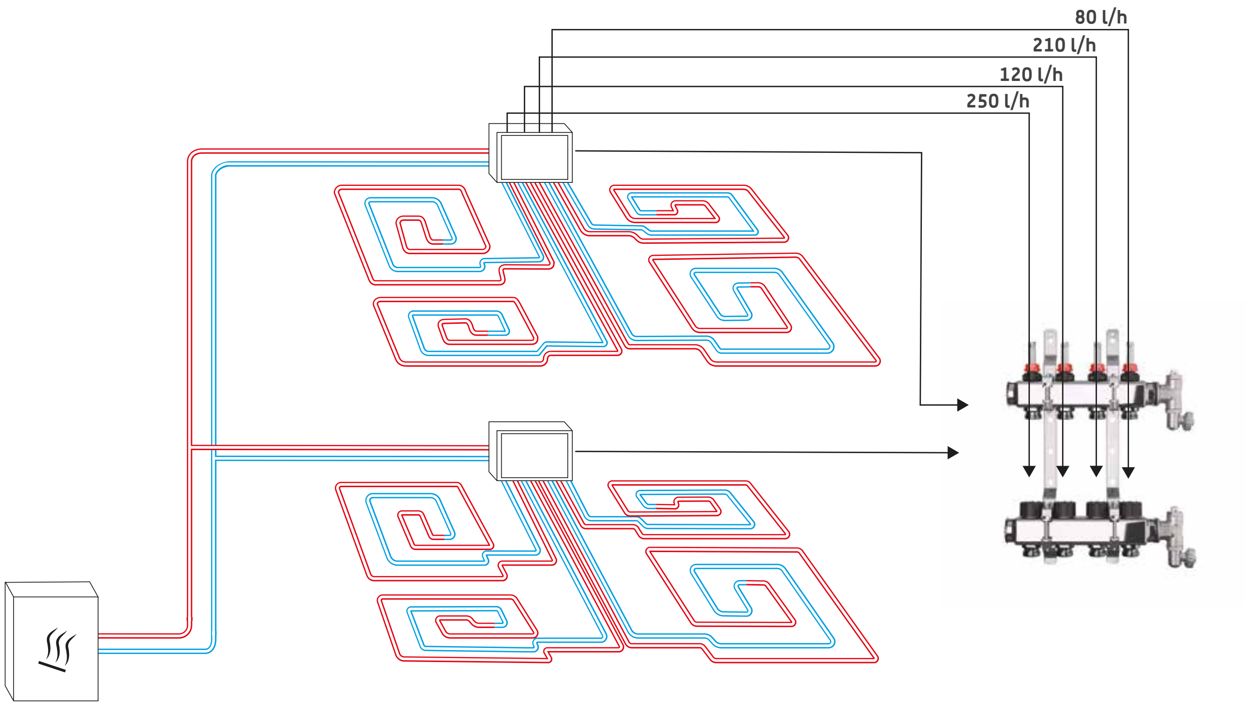


fig. 3.72
Typical application of manifold with dynamic flow control in a radiant floor system

Cartridge presetting

The presetting of the cartridge in the manifold is done, using a special regulation key, between the position 1 and 6 that are indicated on the cartridge.

To adjust the presetting of the cartridge:

- read the position of the cartridge that corresponds with the desired flow-rate from fig. 3.74
- remove the hand wheel or the thermo-electric actuator from the manifold
- place the regulation key on the cartridge and turn the key until the desired position points at the index
- remove the regulation key and replace the hand wheel or the thermo-electric actuator

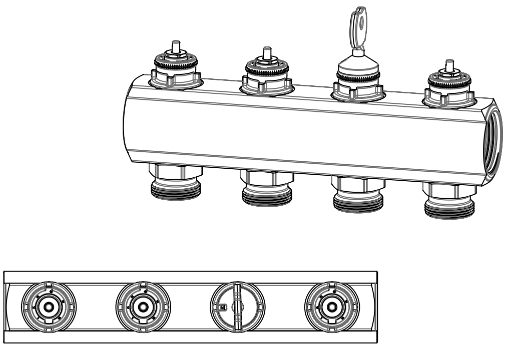


fig. 3.73
Flow presetting operation through the regulation key

Diagram

differential pressure kPa \ flow-rate l/h	15	50	100	125	175	210	250	coefficient
0	0	0	0	0	0	0	0	0
10	8	25	50	63	88	105	125	0,5
20	12	40	80	100	140	168	200	0,8
30	14	48	96	120	168	202	240	0,96
40	15	49	98	123	172	206	245	0,98
50	15	50	99	124	173	208	248	0,99
60	15	50	100	124	174	209	249	0,995
70	15	50	100	125	175	210	250	1
80	15	50	100	125	175	210	250	1
90	15	50	100	125	175	210	250	1
100	15	50	100	125	175	210	250	1
110	15	50	100	125	175	210	250	1
120	15	50	100	125	175	210	250	1
130	15	50	100	125	175	210	250	1
140	15	50	100	125	175	210	250	1
150	15	50	100	125	175	210	250	1

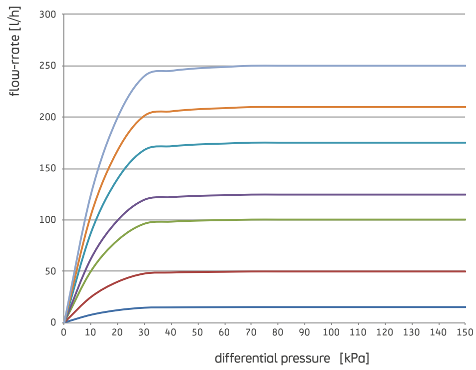


fig. 3.74
Diagram for presetting of distribution manifolds with dynamic flow control

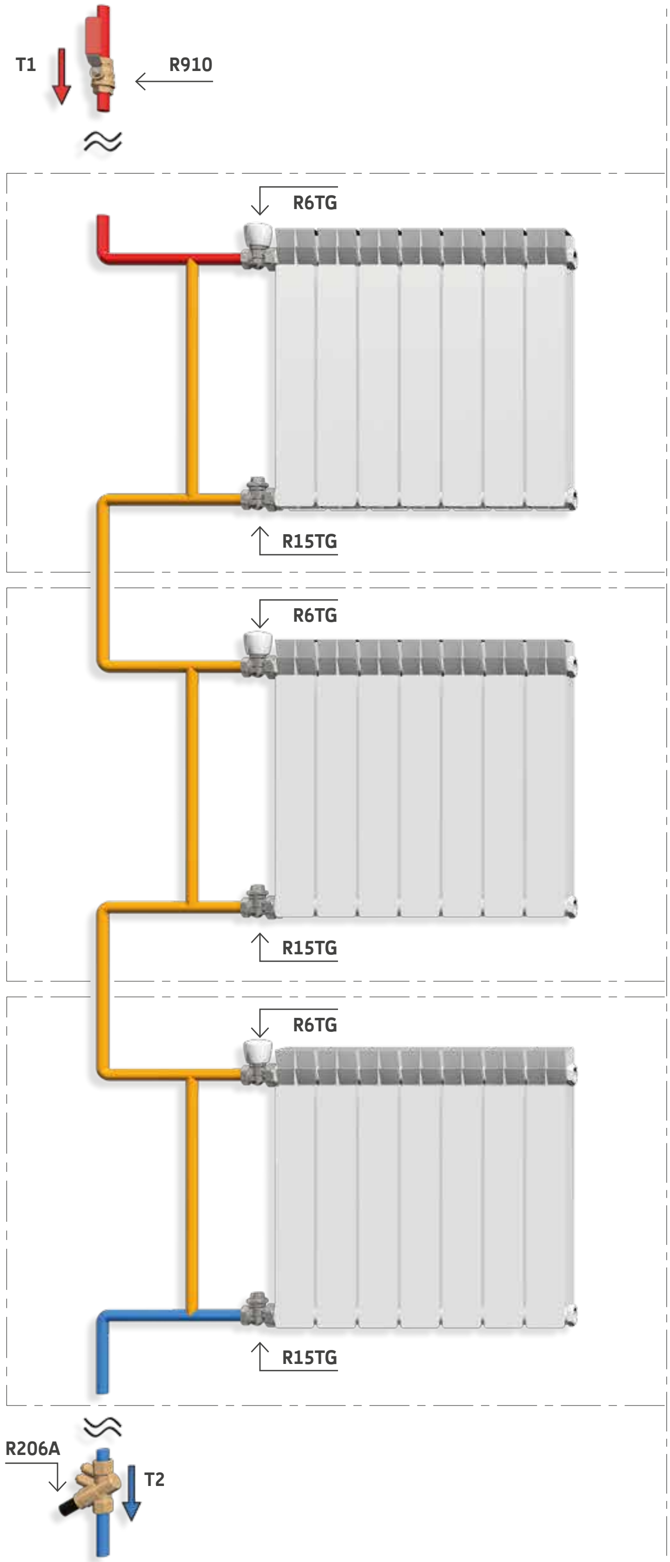
GIACOMINI
WATER E-MOTION

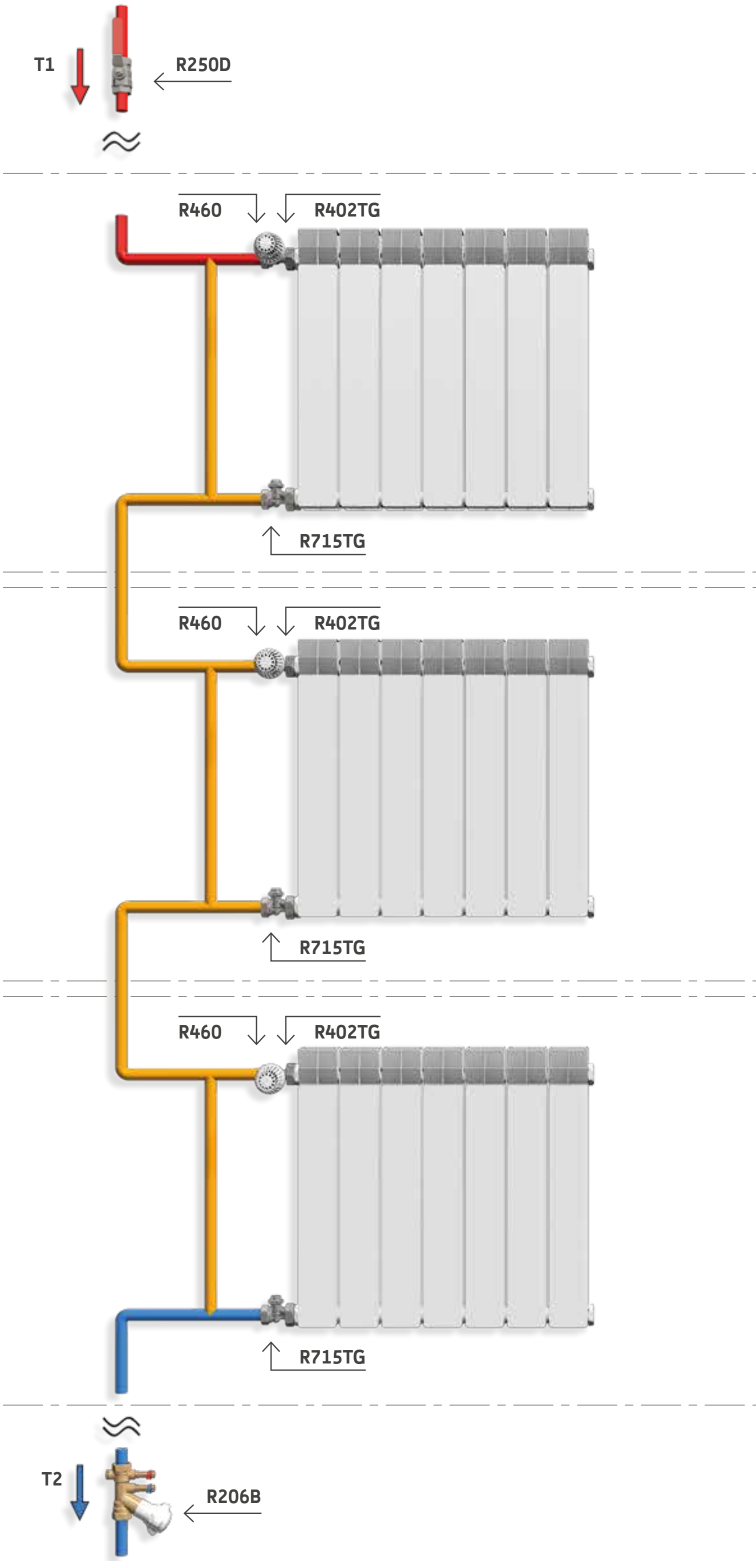
Chapter 4

Applications and schemes in balancing systems

VERTICAL LAYOUT HEATING SYSTEM

VERTICAL LAYOUT OF SINGLE-PIPE HEATING SYSTEM



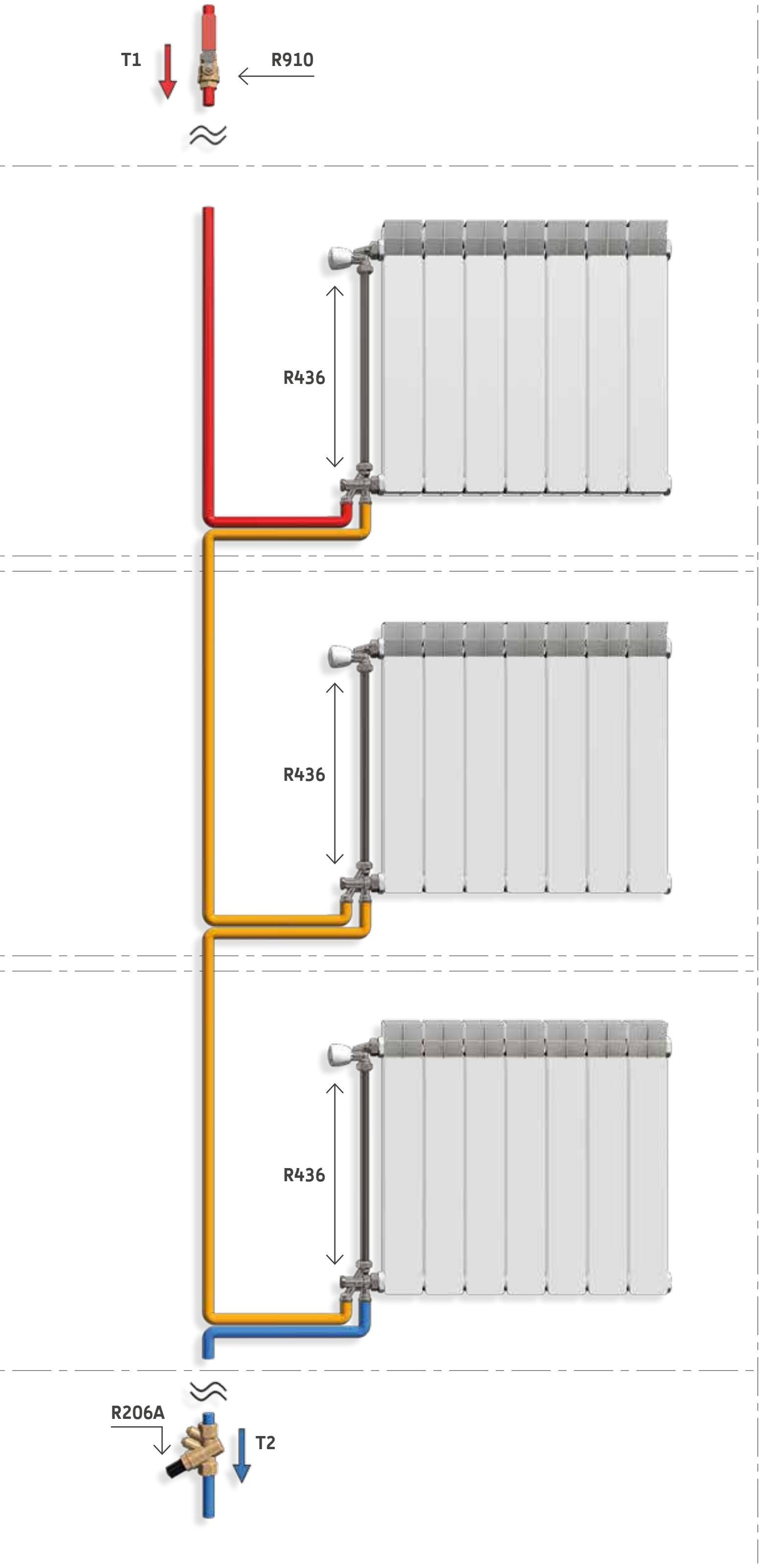


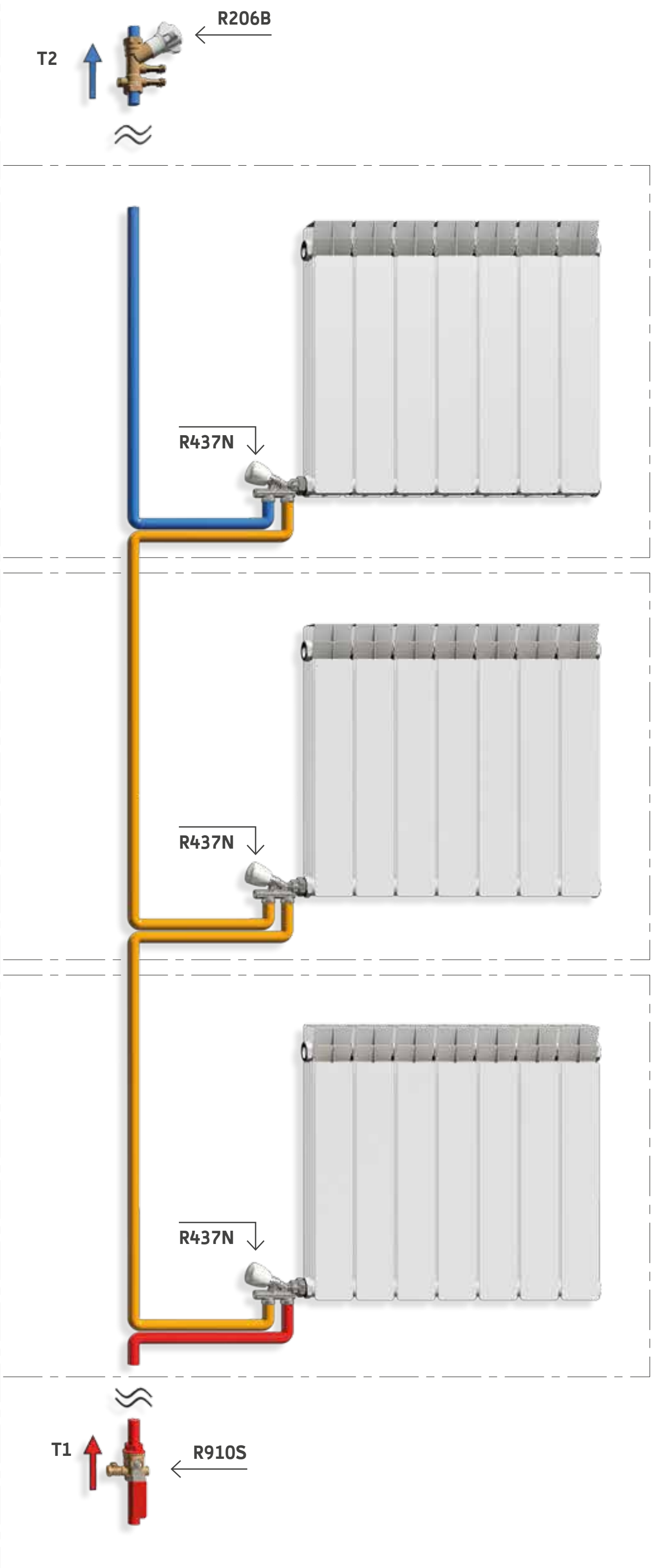
Automatic control of the flow by the dynamic balancing valve R206A and the shut-off of the flow by the ball valve.

Side connection of radiators. Straight manual valve R6TG and straight shut-off valve R15TG.

Manual flow control with a static balancing valve R206B and shut off the flow of the fluid by ball valve.

Side connection of radiators. Straight thermostatic valve R402TG with thermostatic head R460 and straight shut-off valve R715TG.





Automatic control of the flow by the dynamic balancing valve R206A and the shut-off of the flow of the fluid by the ball valve.

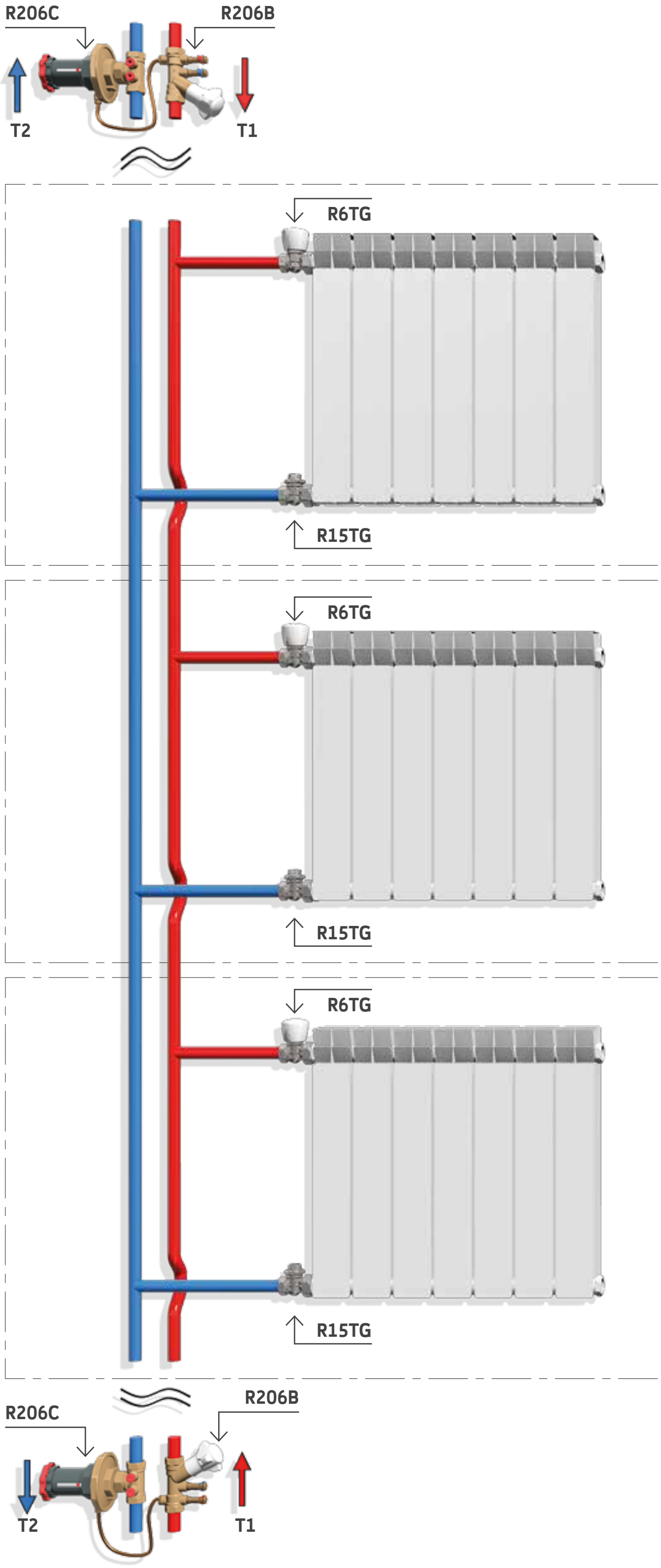
Lower connection of radiators. Micrometric thermostatic compact unit for single-pipe systems with integrated shut-off valve R436.

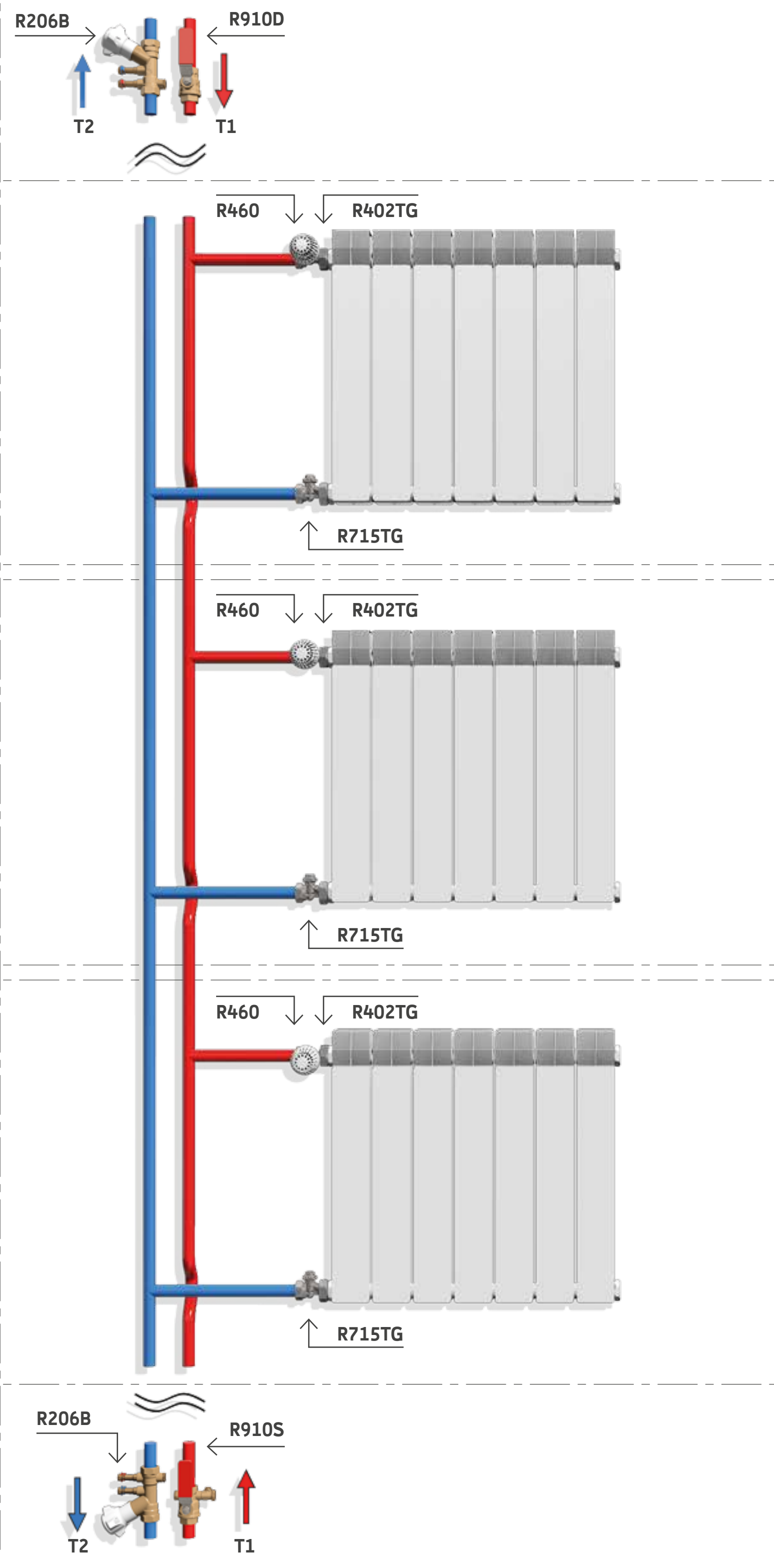
Manual flow control with a static balancing valve R206B and shut off the flow of the fluid with ball valve.

Lower connection of radiators. Micrometric thermostatic compact unit for single-pipe systems with integrated shut-off valve R437N.

VERTICAL LAYOUT HEATING SYSTEM

VERTICAL LAYOUT OF TWO-PIPE HEATING SYSTEM



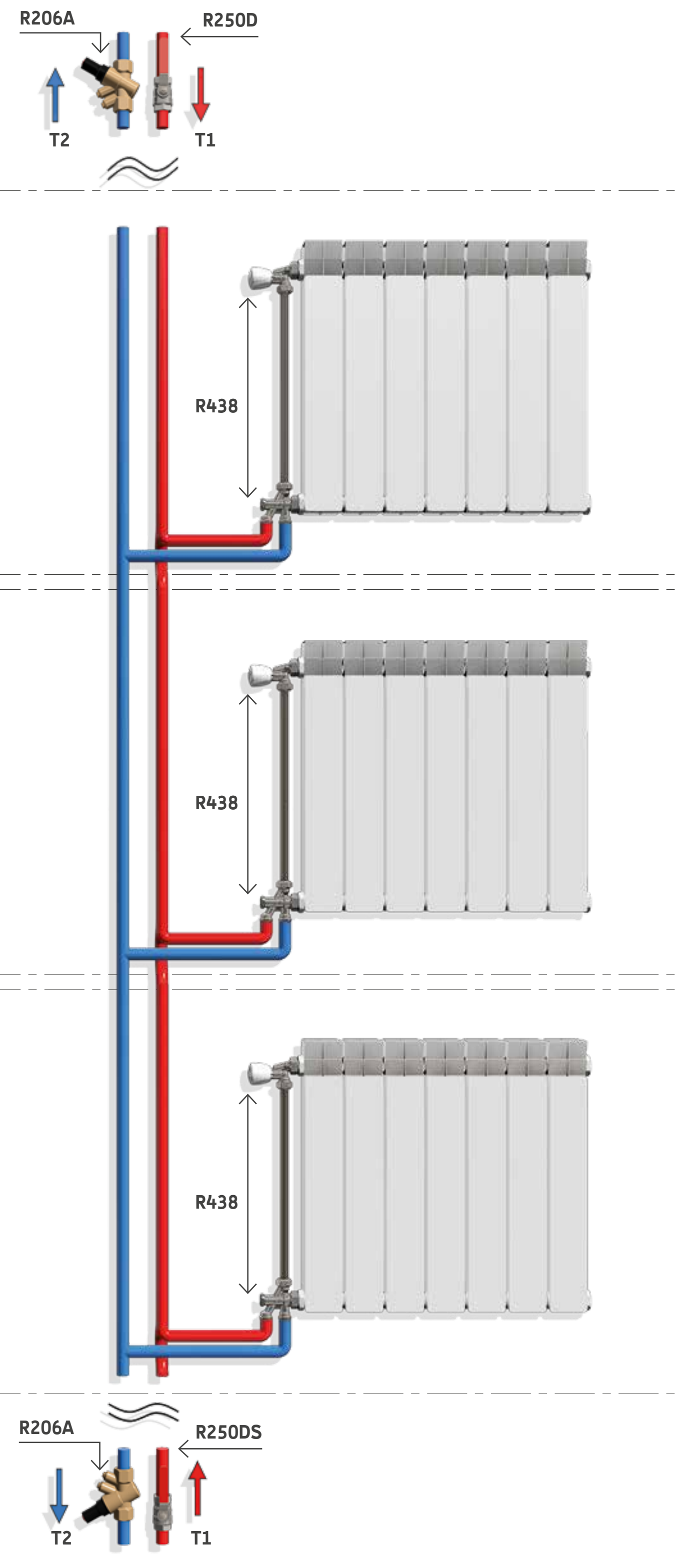


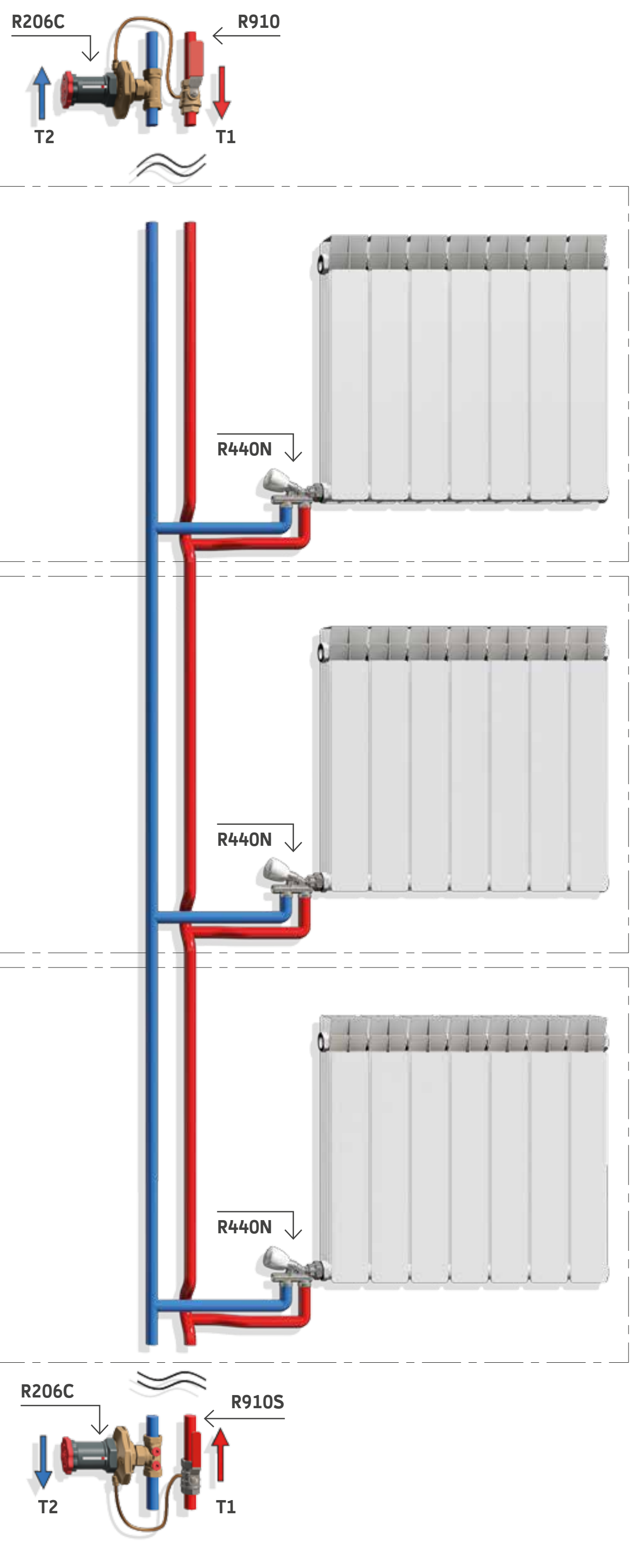
Manual flow control with static balancing valve R206B and automatic differential pressure control with R206C differential pressure regulator.

Side connection of radiators. Straight manual valve R6TG and straight lockshield R15TG.

Manual flow control with a static balancing valve R206B and shut off the flow of the fluid with ball valve.

Side connection of radiators. Straight thermostatic valve R402TG with thermostatic head R460 and straight lockshield R715TG.





Automatic control of the flow by the dynamic balancing valve R206A and the shut-off of the flow by ball valve.

Side connection of radiators. Micrometric thermostatic compact unit for two-pipe systems with integrated shut-off valve R438.

Automatic control of differential pressure by the differential pressure regulator R206C and shut off the flow of the fluid by ball valve.

Lower connection of radiators. Micrometric thermostatic compact unit for two-pipe systems with integrated shut-off valve R440N.

HORIZONTAL DISTRIBUTION HEATING SYSTEM

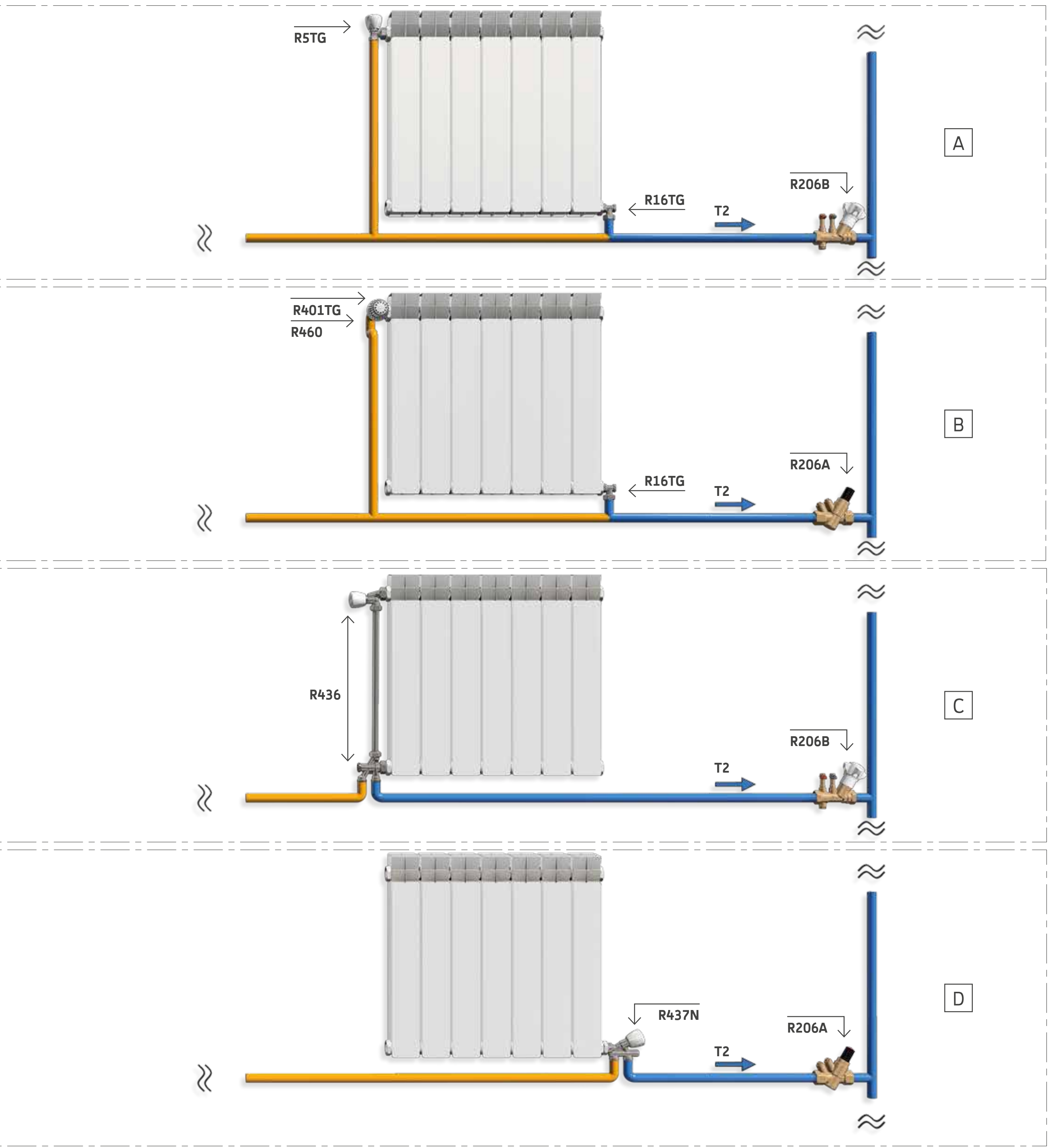
HORIZONTAL LAYOUT OF A SINGLE-PIPE HEATING SYSTEM

Manual flow control with a static balancing valve R206B and shut off the flow with a ball valve.

Side connection of radiators. Angle hand valve R5TG and angle shut-off valve R16TG.

Flow is kept automatically to constant value by the dynamic balancing valve R206A and the shut-off of the flow of the fluid is made by the ball valve.

Side connection of the radiators from the wall. Angle thermostatic valve R401TG with thermostatic head R460 and angle shut-off valve R16TG.



C

Manual flow control with a static balancing valve R206B and shut off the fluid with a ball valve.

Lower connection of radiators. Micrometric thermostatic compact unit for single-pipe systems with integrated shut-off valve R436.

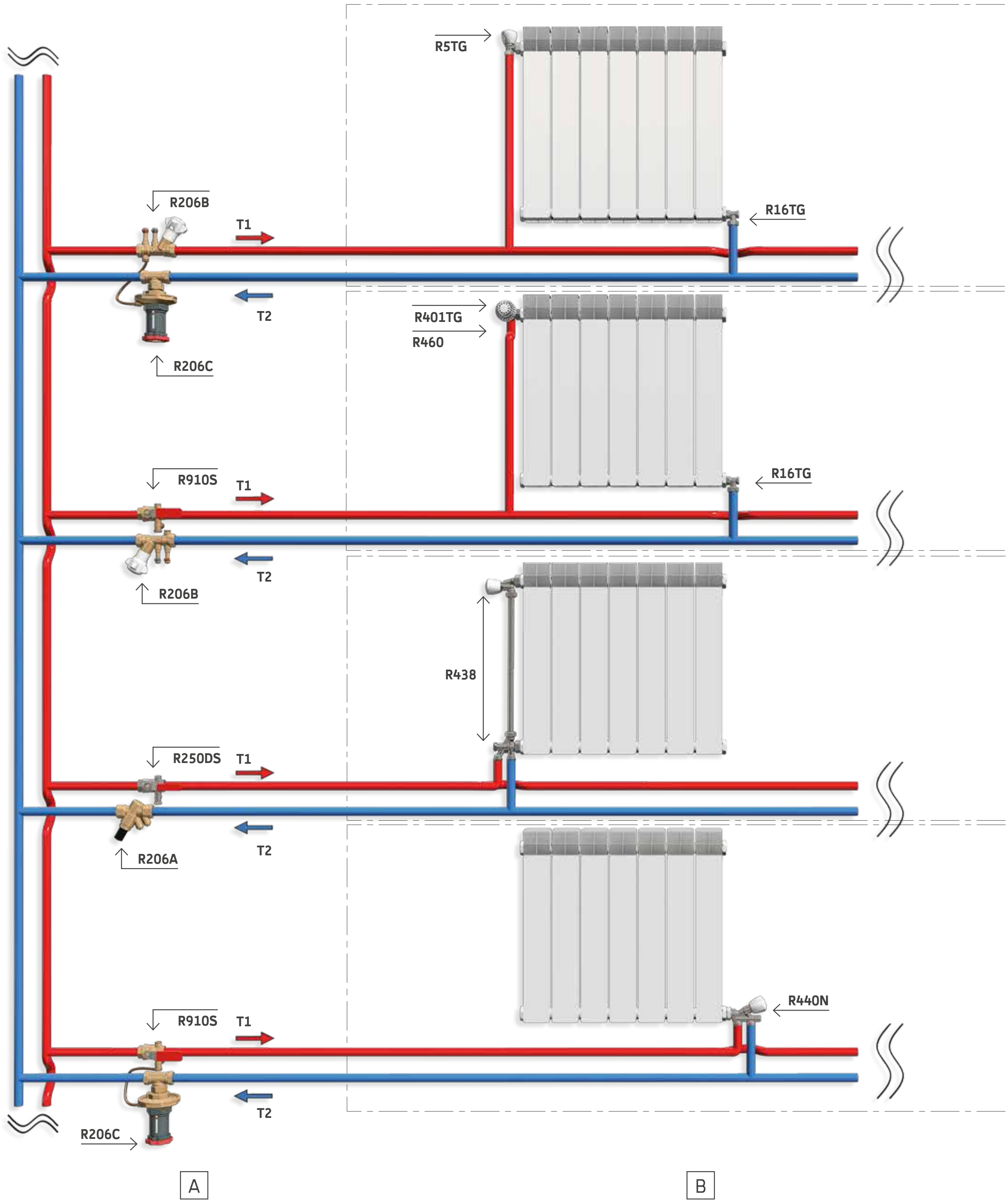
D

Flow is kept constant by the dynamic balancing valve R206A and the shut-off of the fluid is made by the ball valve.

Lower connection of radiators. Micrometric thermostatic group for two-pipe systems with angle valve R437N.

HORIZONTAL DISTRIBUTION HEATING SYSTEM

HORIZONTAL DISTRIBUTION OF TWO-PIPE HEATING SYSTEM

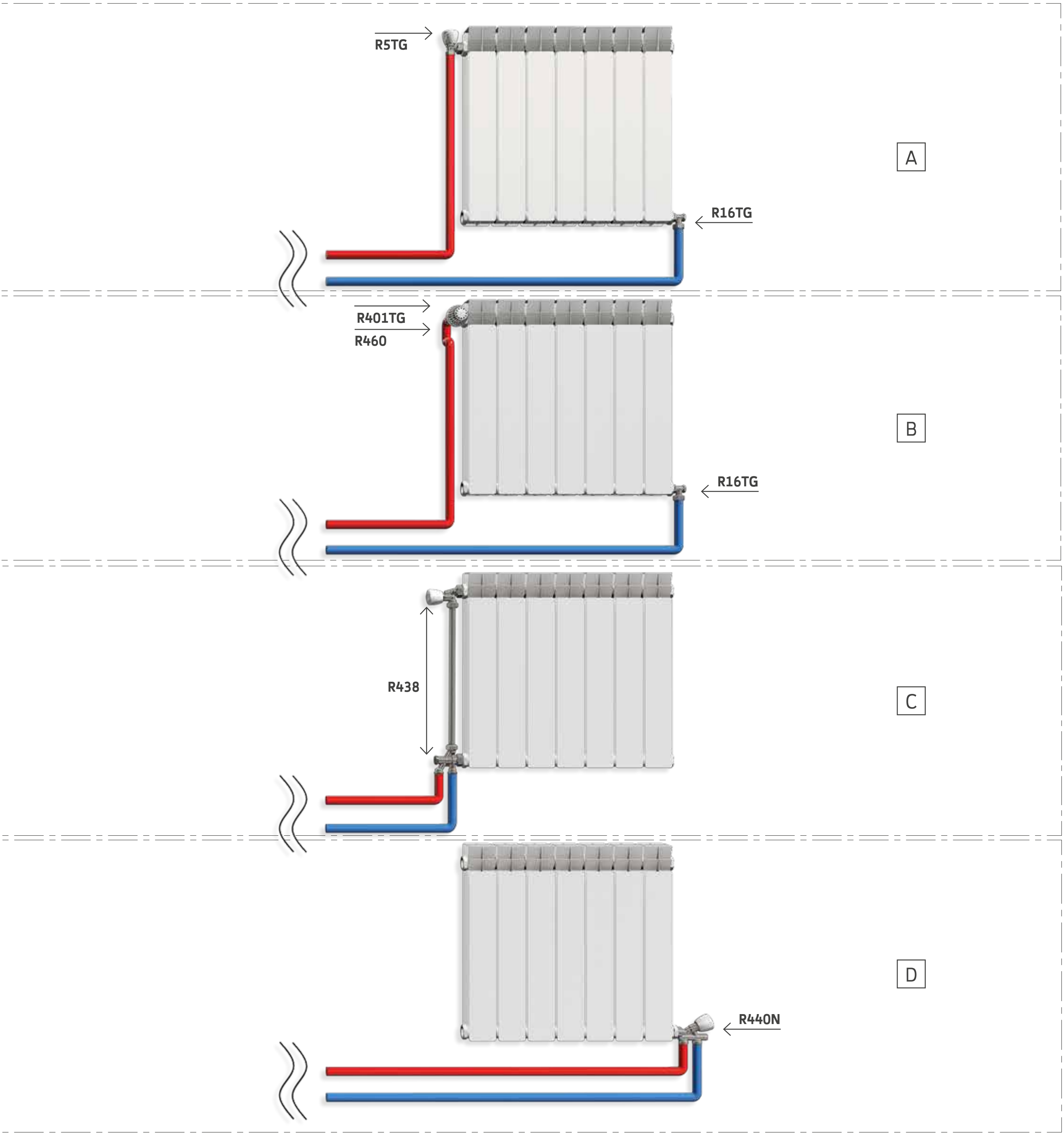


Manual flow control with static balancing valve R206B and automatic differential pressure control with R206C differential pressure regulator.

Side connection of radiators. Angle hand valve R5TG and angle shut-off valve R16TG.

Manual flow control with a static balancing valve R206B and shut off the the flow of the fluid with a ball valve.

Side connection of the radiators from the wall. Angle thermostatic valve R401TG with thermostatic head R460 and angle shut-off valve R16TG.



C

Automatic control of the flow by the dynamic balancing valve R206A and the shut-off of the flow of the fluid by the ball valve.

Lower connection of radiators. Micrometric thermostatic compact unit for two-pipe systems with integrated shut-off valve R438.

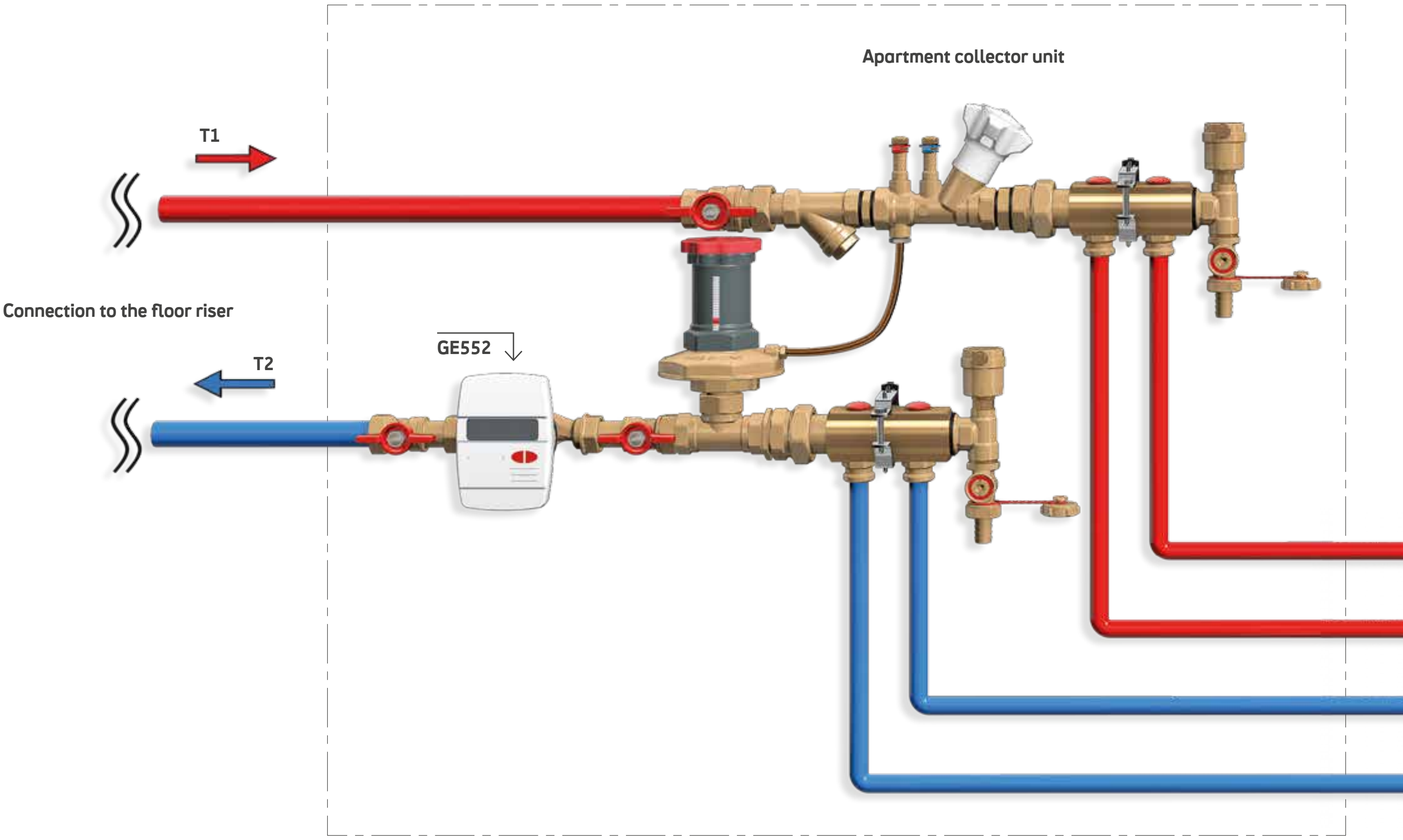
D

Automatic control of differential pressure by the differential pressure regulator R206C and shut off the flow of the fluid by a ball valve.

Lower connection of radiators. Micrometric thermostatic group for two-pipe systems with angle valve R440N.

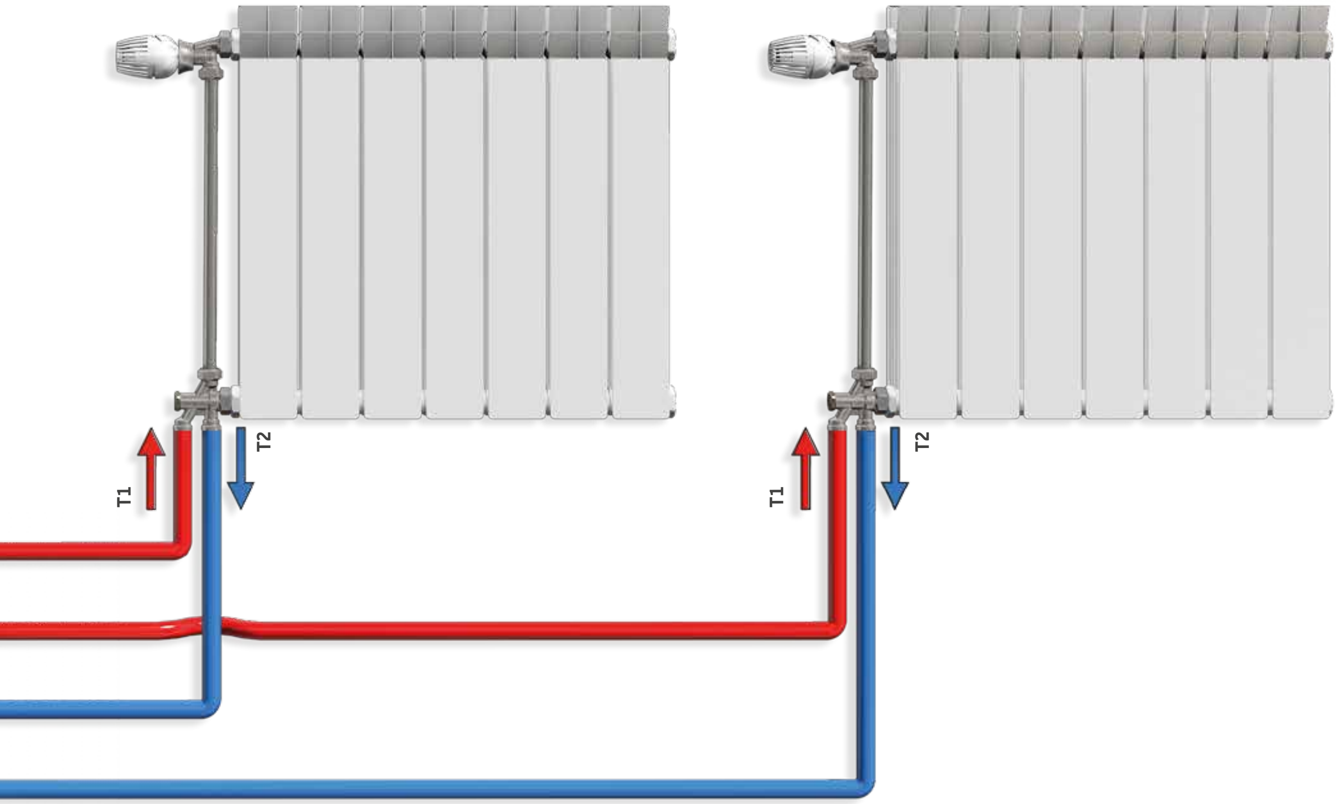
INDIVIDUAL MANIFOLD UNITS GE550

APPLICATION WITH R206C + R206B AND THERMOSTATIC HEADS



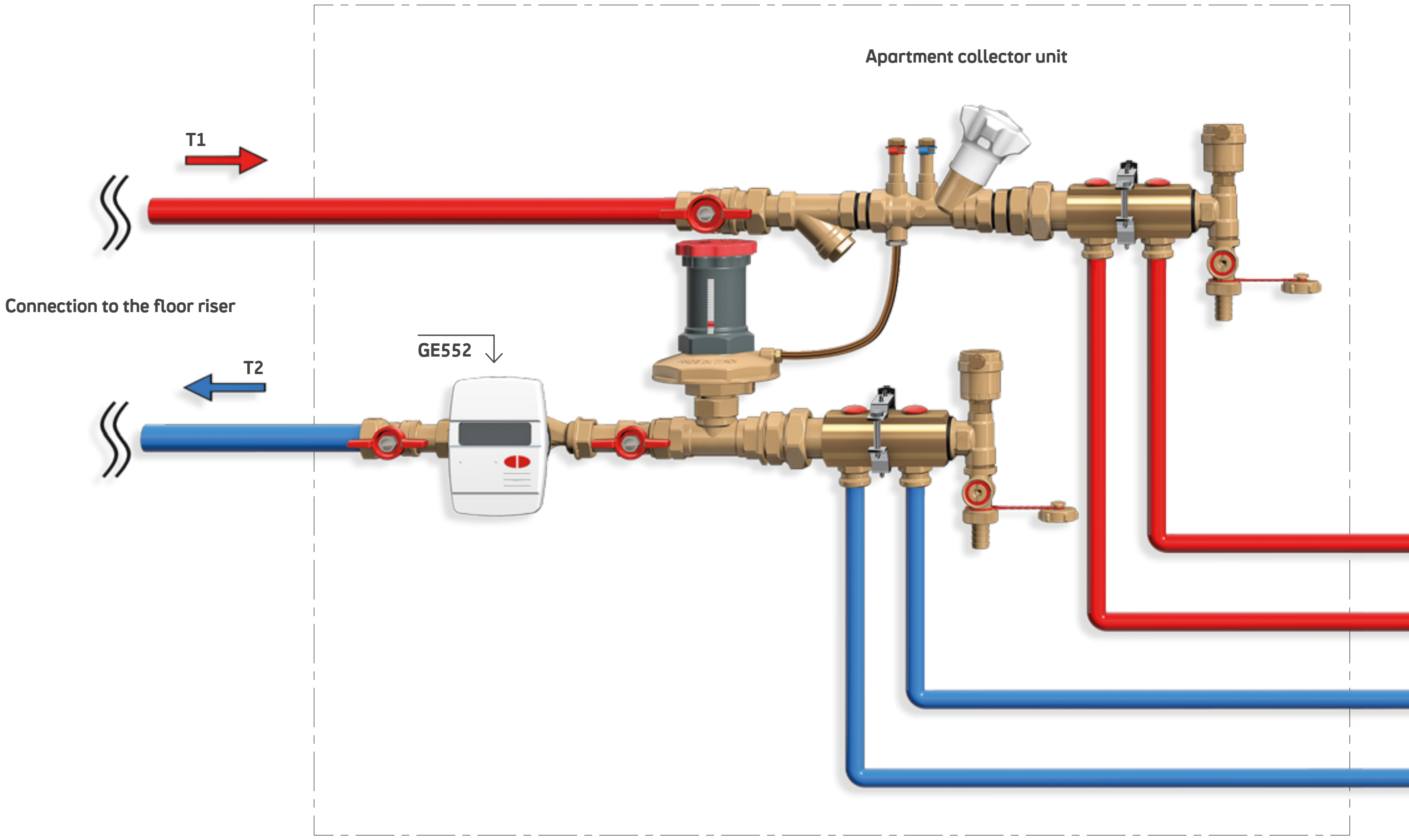
WORKING FEATURES:

In this application the combination of R206C and R206B allow to get dynamic control of differential pressure across radiator valves. The differential pressure for each branch will be constantly at the set value avoiding noise and overflows.


T1
T2
T1
T2

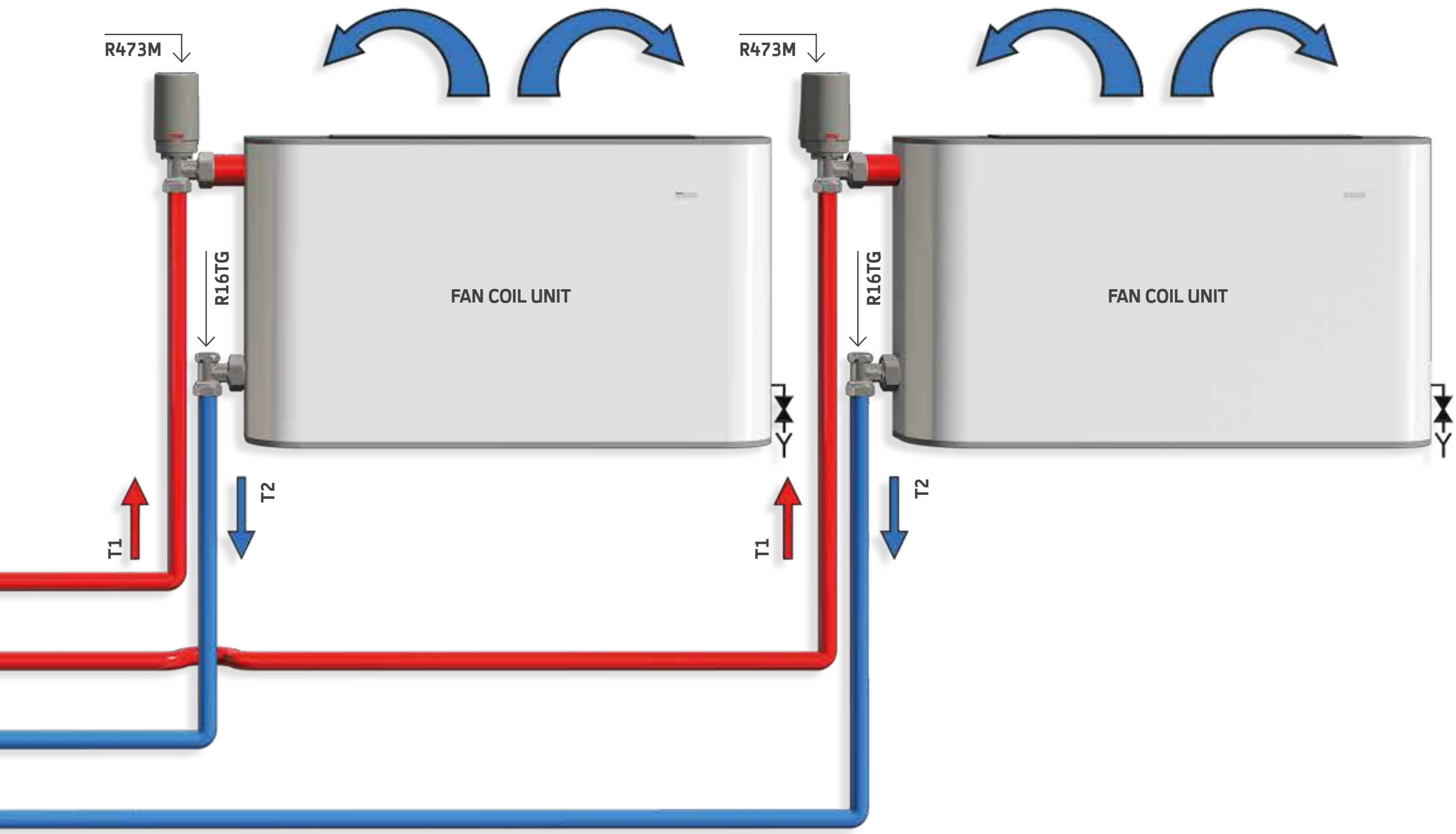
INDIVIDUAL MANIFOLD UNITS GE550

APPLICATION WITH R206C+R206B AND THERMOELECTRIC ACTUATORS



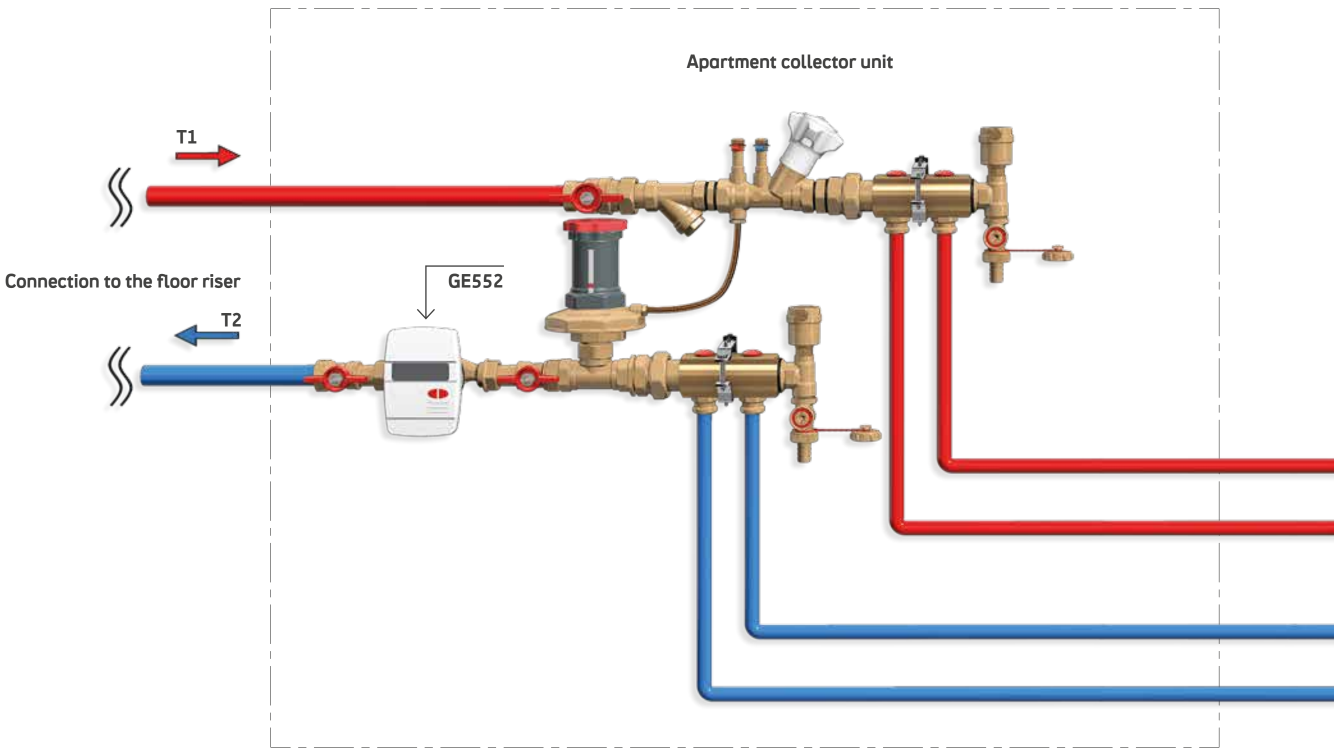
WORKING FEATURES:

In this application the combination of R206C and R206B allow to get dynamic control of differential pressure across manifold and dynamic control of each circuit flow. Downstream are on-off actuators. Thus the flow-rate for each branch will be constantly at the set value, regardless the branches nearby are open or closed.


R473M
R473M
FAN COIL UNIT
FAN COIL UNIT
R16TG
R16TG
T1
T2
T1
T2

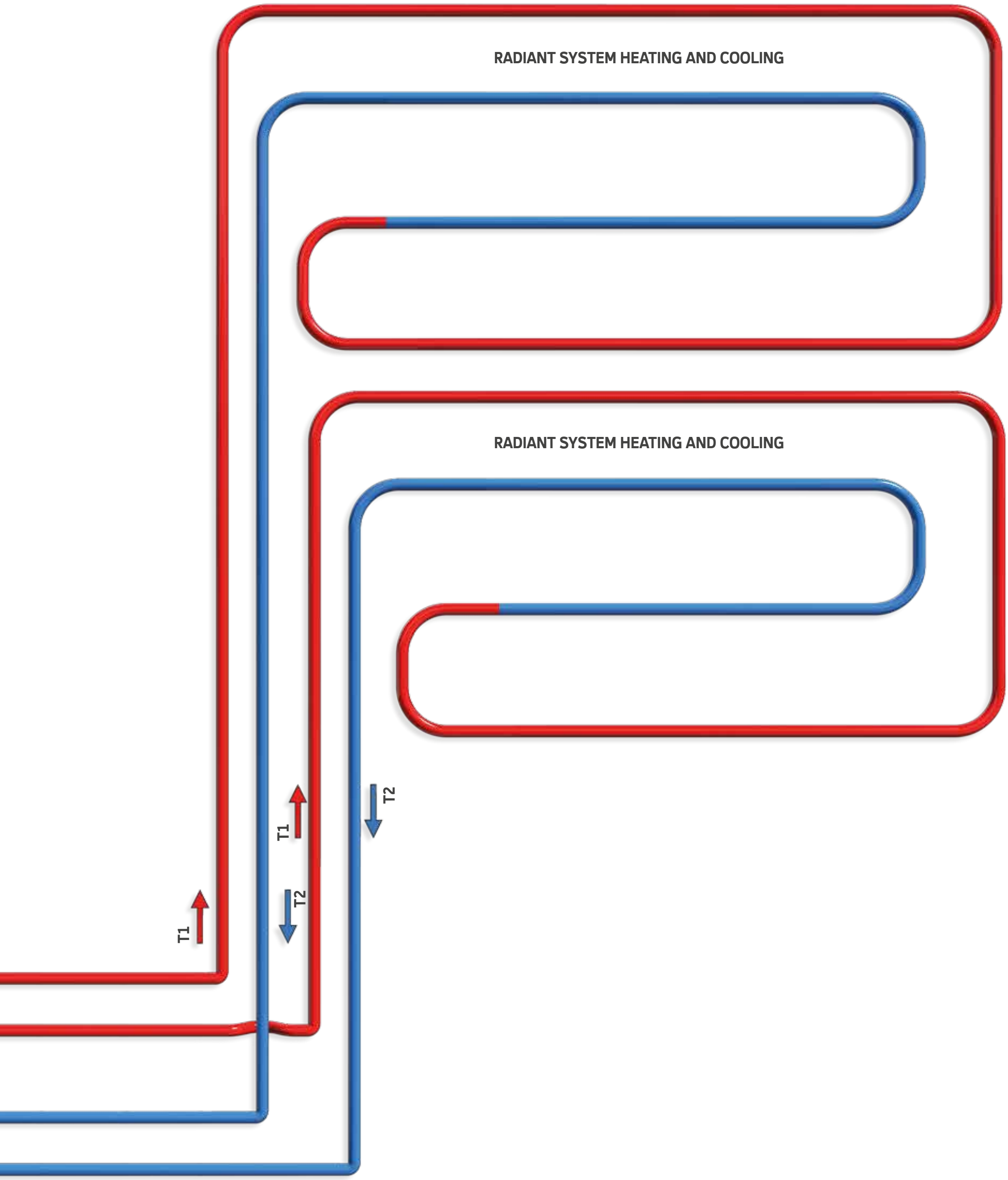
INDIVIDUAL MANIFOLD UNITS GE550

APPLICATION WITH R206C + R206B AND RADIANT HEATING/COOLING SYSTEM



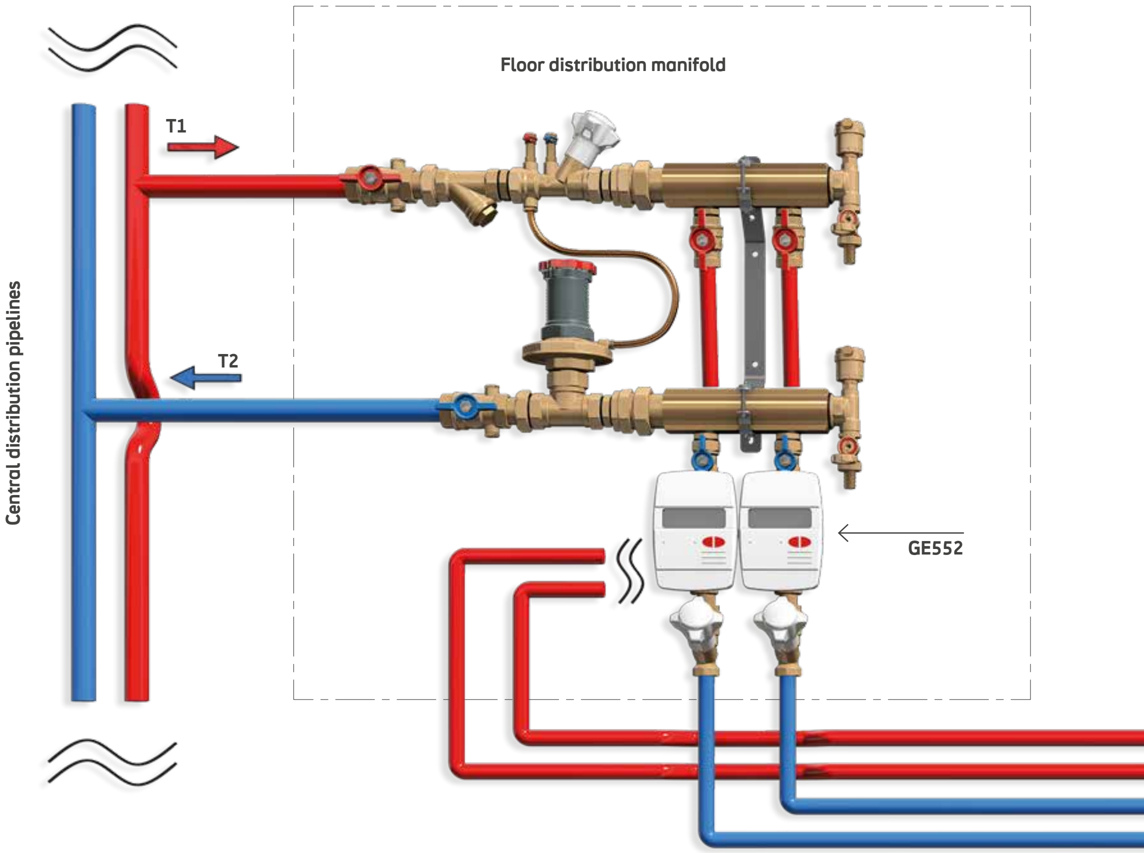
WORKING FEATURES:

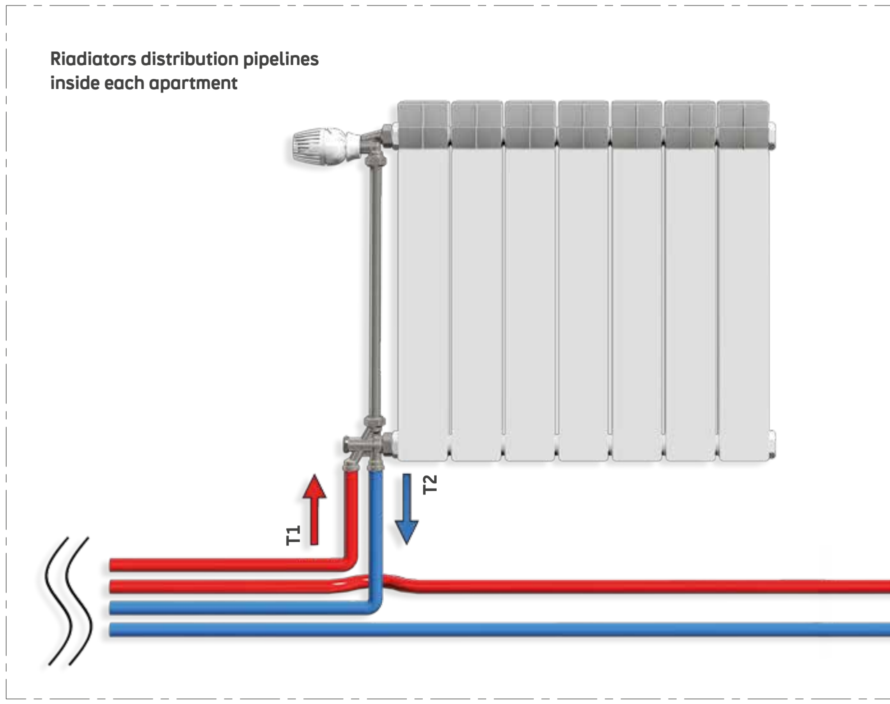
In this application the combination of R206C and R206B allow to get dynamic control of differential pressure across radiant system manifold. The differential pressure for each circuit will be constantly at the set value avoiding noise and overflows. Also the flow-rate through radiant circuits will be constant, regardless into the pipeline upstream the manifold the boundary conditions may change.


RADIANT SYSTEM HEATING AND COOLING
RADIANT SYSTEM HEATING AND COOLING
T1
T2
T1
T2

FLOOR DISTRIBUTION MANIFOLD UNITS GE553 WITH DIFFERENTIAL

APPLICATION WITH R206C + R206B AND RADIATOR SYSTEM

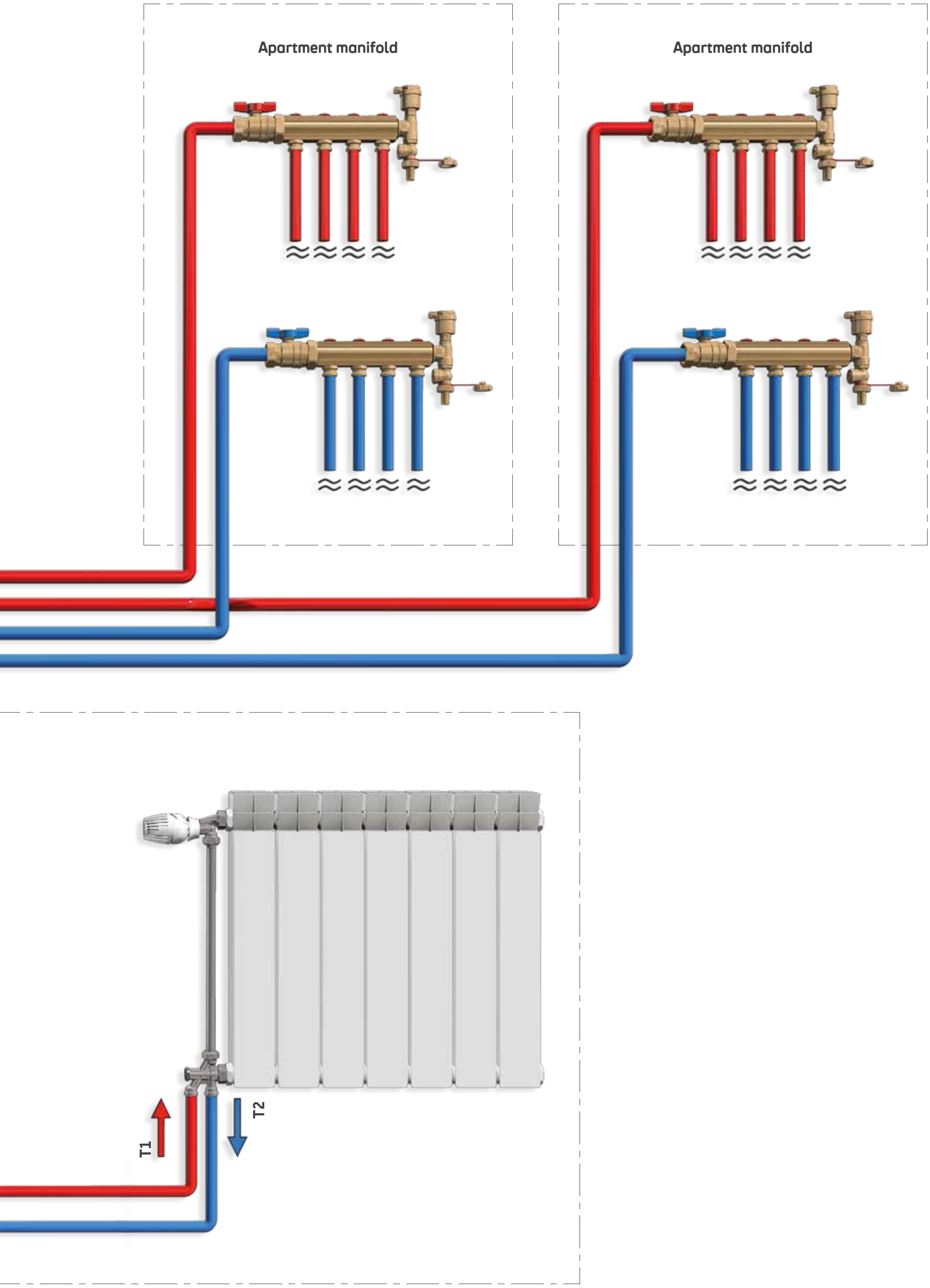




WORKING FEATURES:

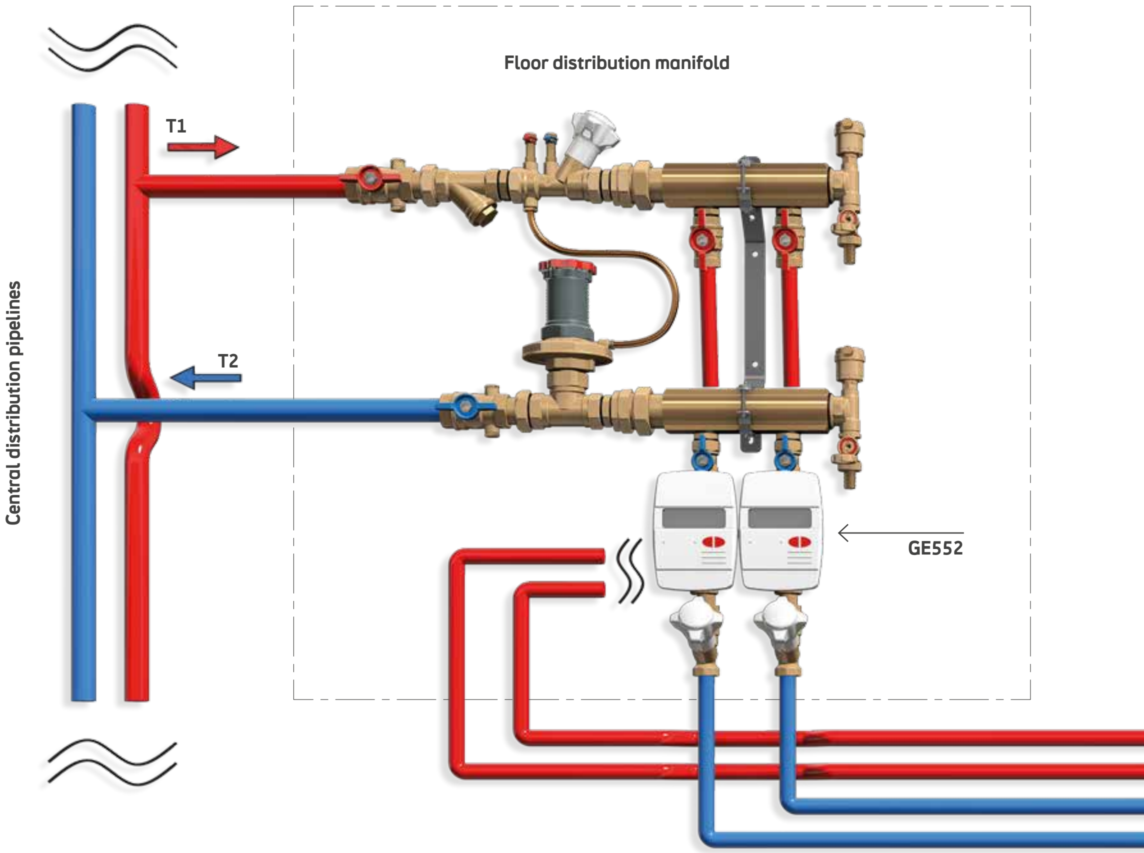
In this application the combination of R206C and R206B allow to get dynamic control of differential pressure upstream from each single apartment. The differential pressure for each circuit will be constantly at the set value avoiding noise and overflows.

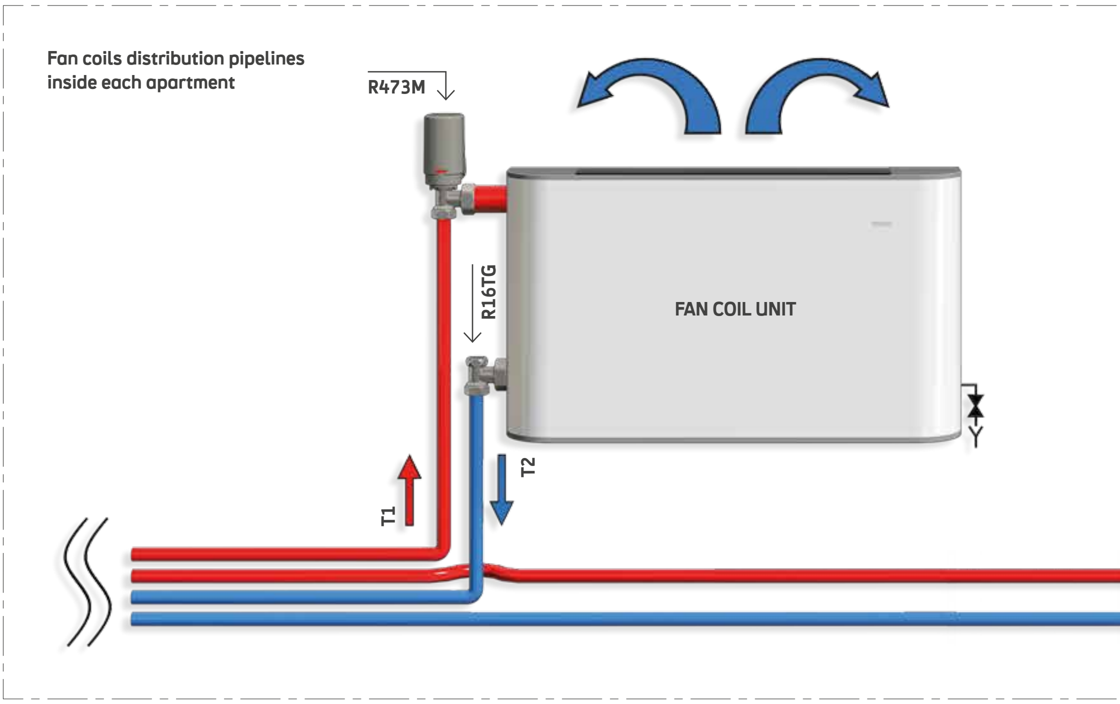
PRESSURE CONTROL UPSTREAM FROM APARTMENTS



FLOOR DISTRIBUTION MANIFOLD UNITS GE553 WITH DIFFERENTIAL

APPLICATION WITH R206C + R206B AND FAN COIL SYSTEM

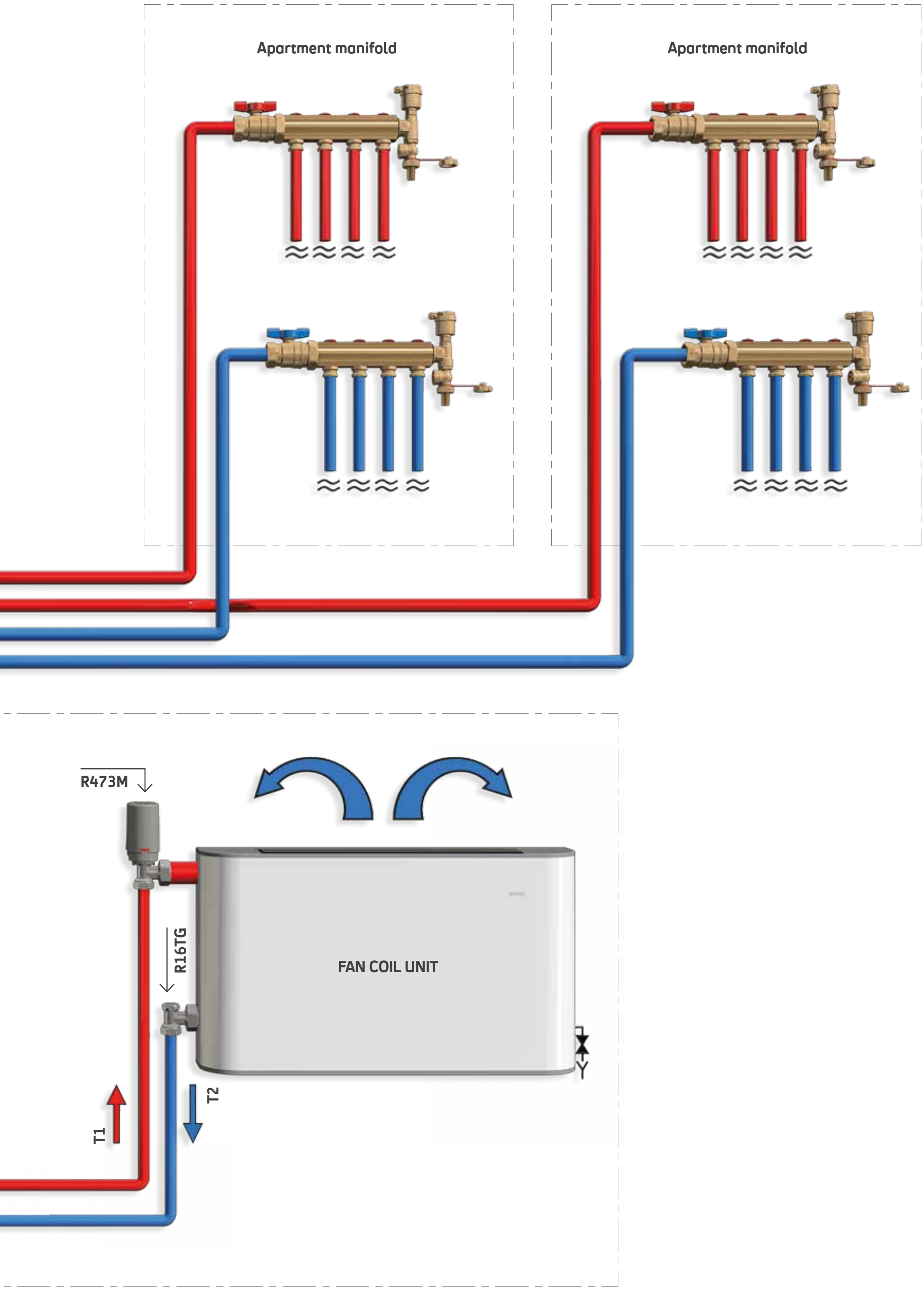




WORKING FEATURES:

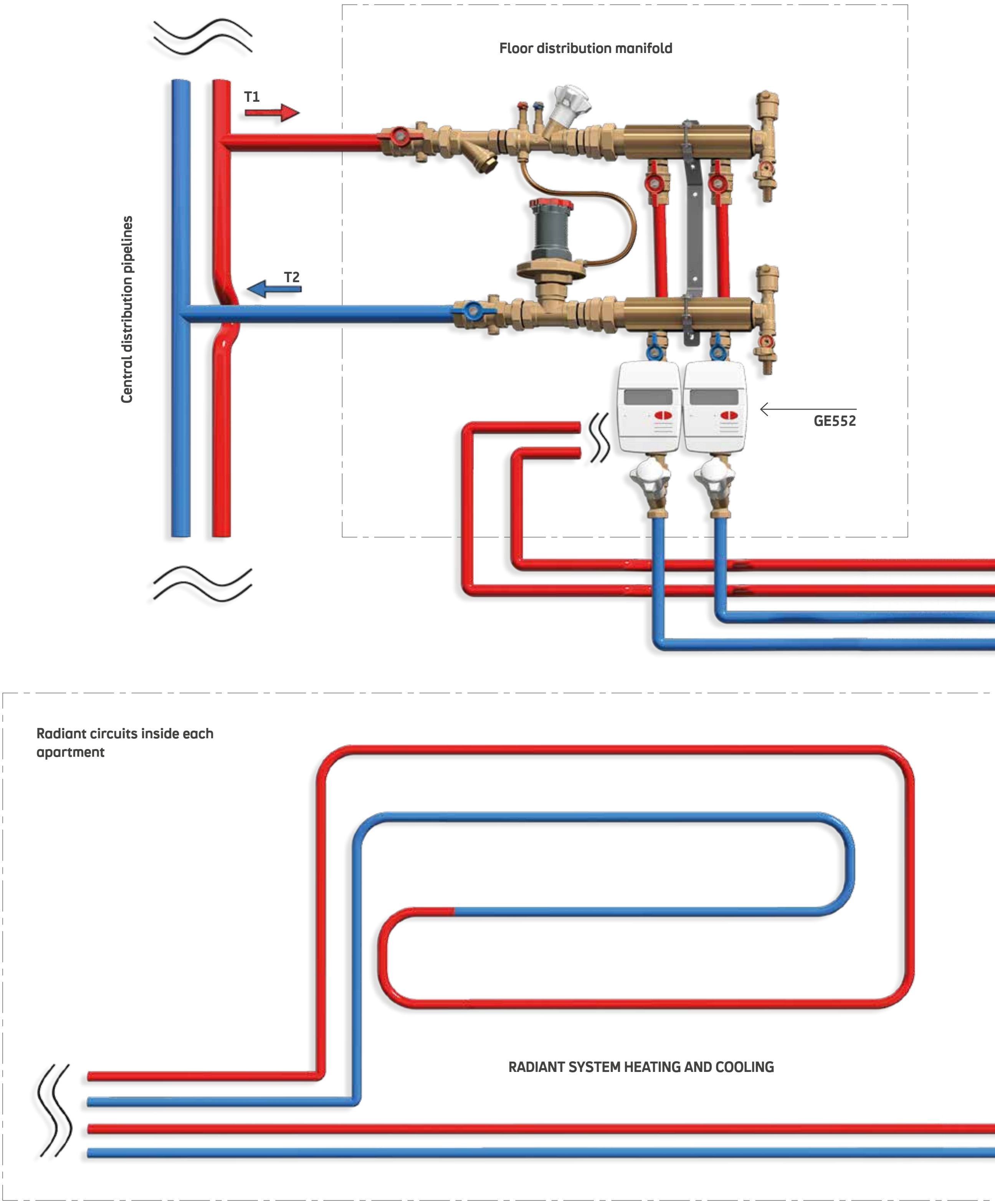
In this application the combination of R206C and R206B allow to get dynamic control of differential pressure across manifold and dynamic control of each circuit flow. Downstream are on-off actuators. Thus the flow-rate for each branch will be constantly at the set value, regardless the branches nearby are open or closed.

PRESSURE CONTROL UPSTREAM FROM APARTMENTS



FLOOR DISTRIBUTION MANIFOLD UNITS GE553 WITH DIFFERENTIAL

APPLICATION WITH R206C + R206B AND RADIANT SYSTEM HEATING/COOLING



WORKING FEATURES:

In this application the combination of R206C and R206B allow to get dynamic control of differential pressure across manifold and dynamic control of each circuit flow. Downstream are on-off actuators. Thus the flow-rate for each branch will be constantly at the set value, regardless the branches nearby are open or closed.

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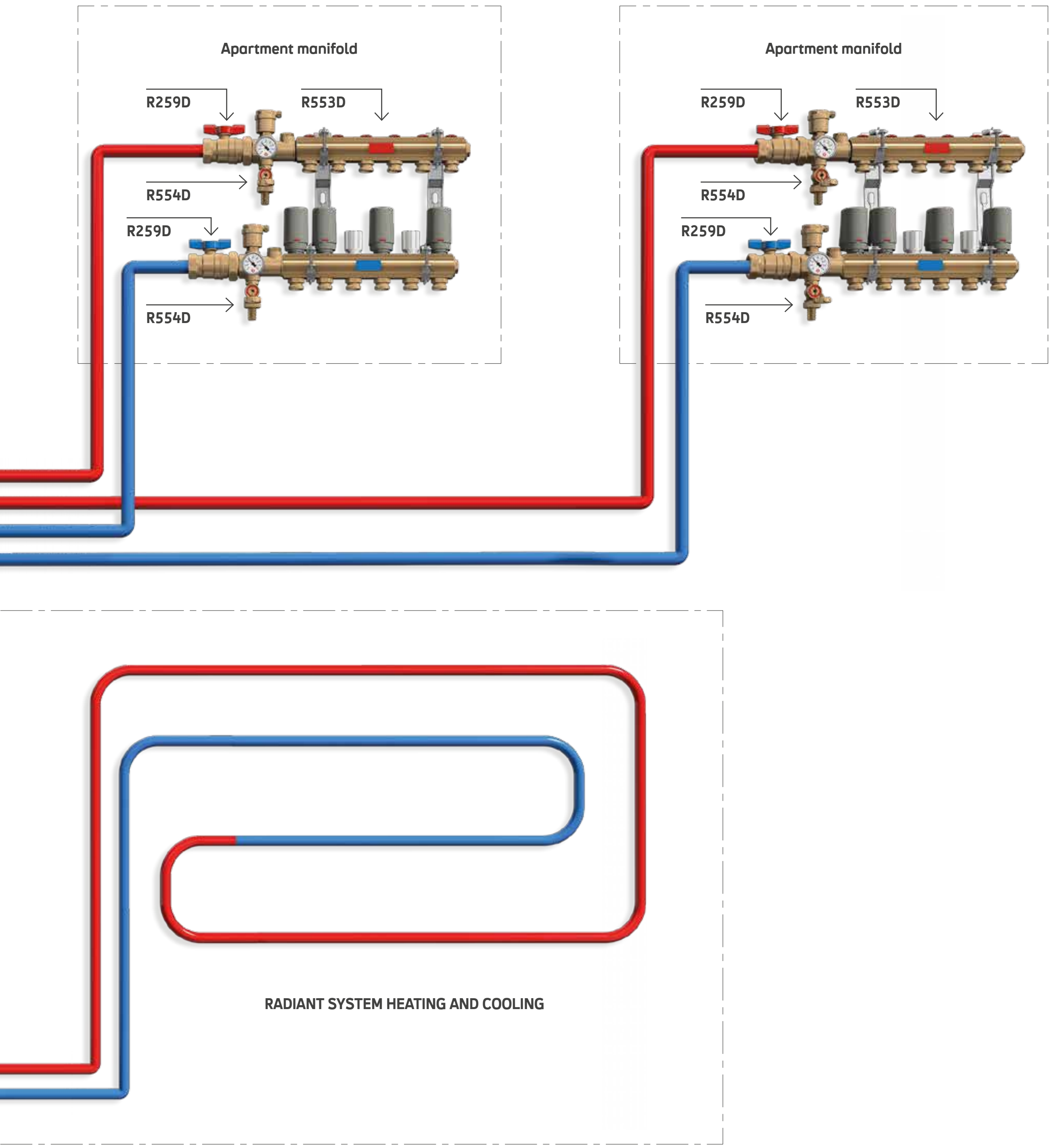
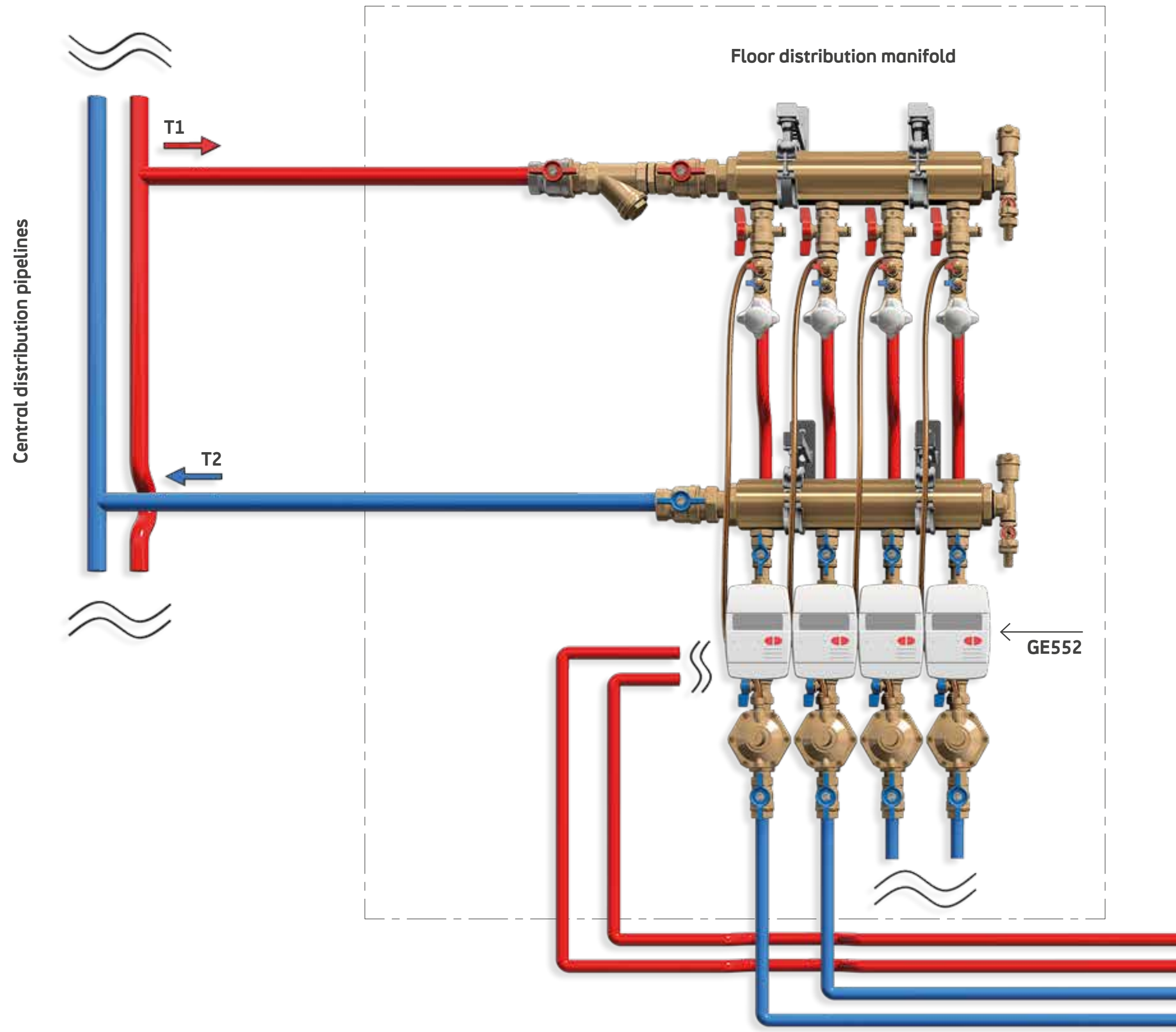
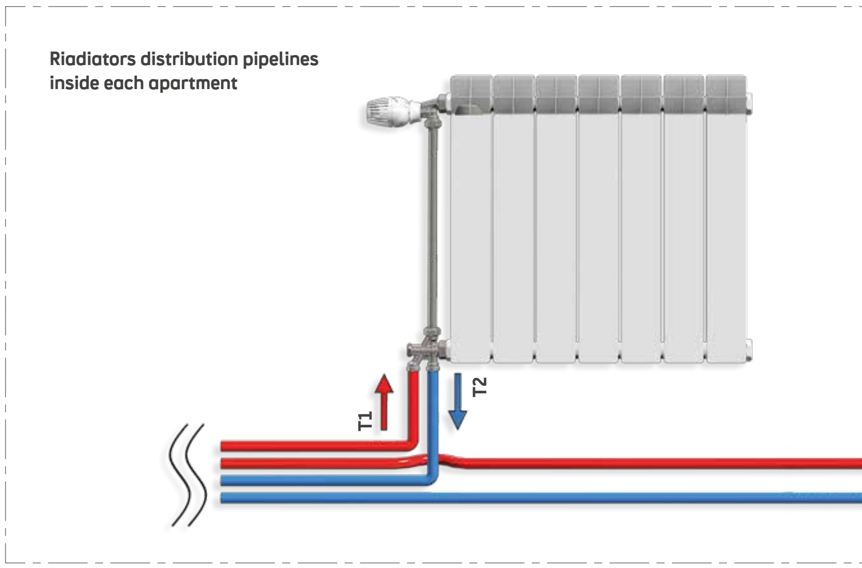


FLOOR DISTRIBUTION MANIFOLD UNITS GE553 WITH DIFFERENTIAL

APPLICATION WITH R206C + R206B AND RADIATOR SYSTEM

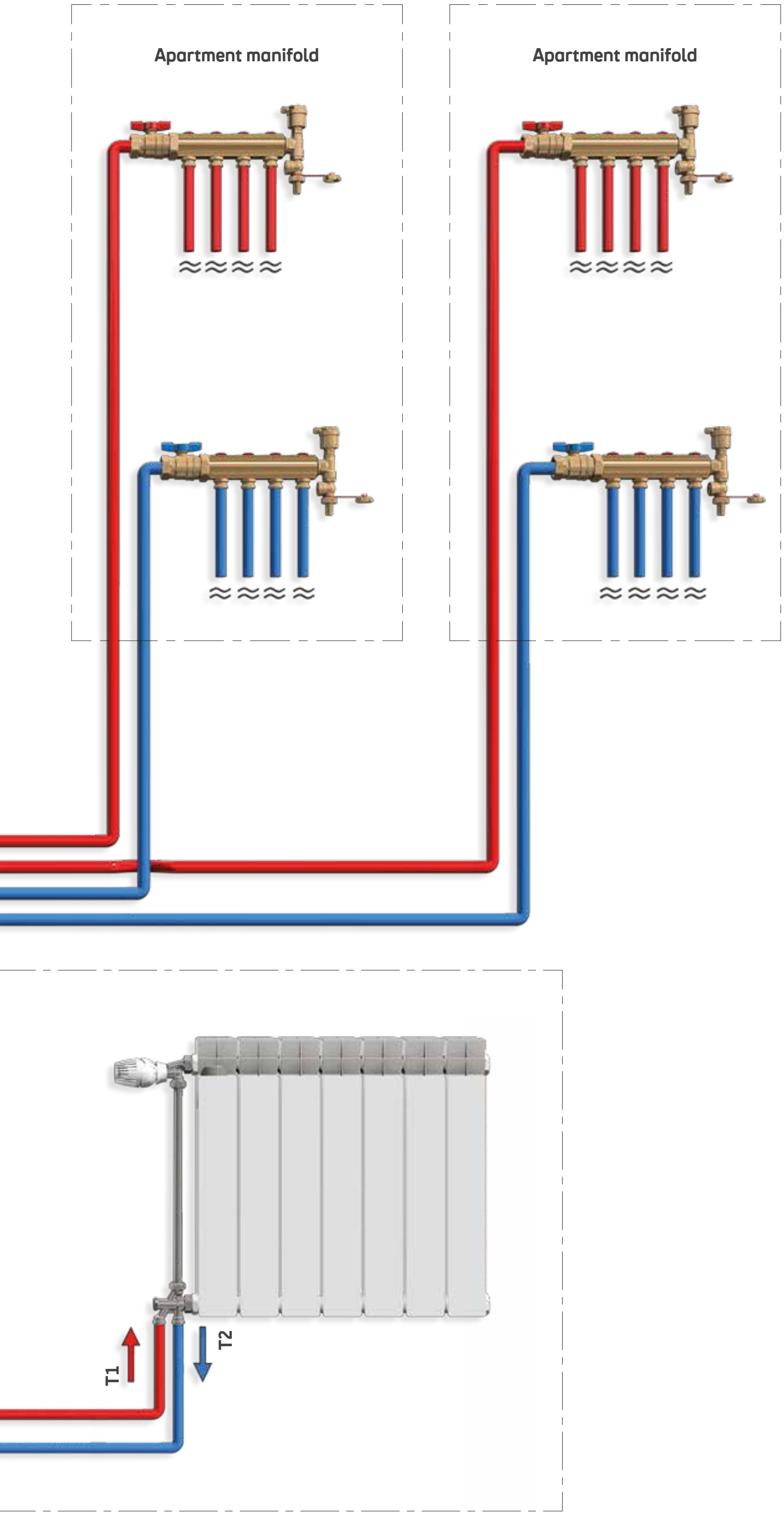




WORKING FEATURES:

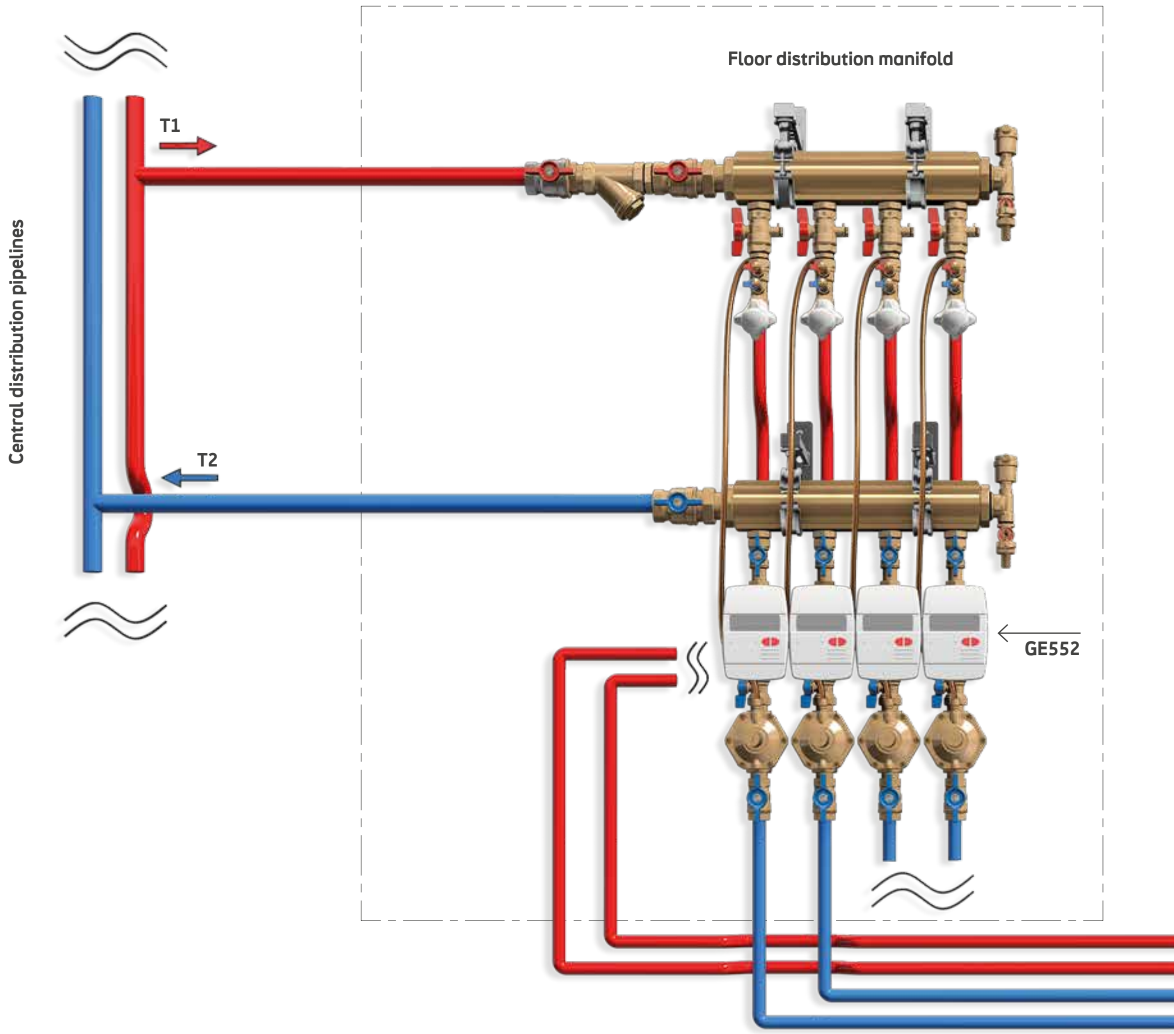
In this application the combination of R206C and R206B allow to get dynamic control of differential pressure upstream from each single apartment (with possible different settings). The differential pressure for each circuit will be constantly at the set value avoiding noise and overflows.

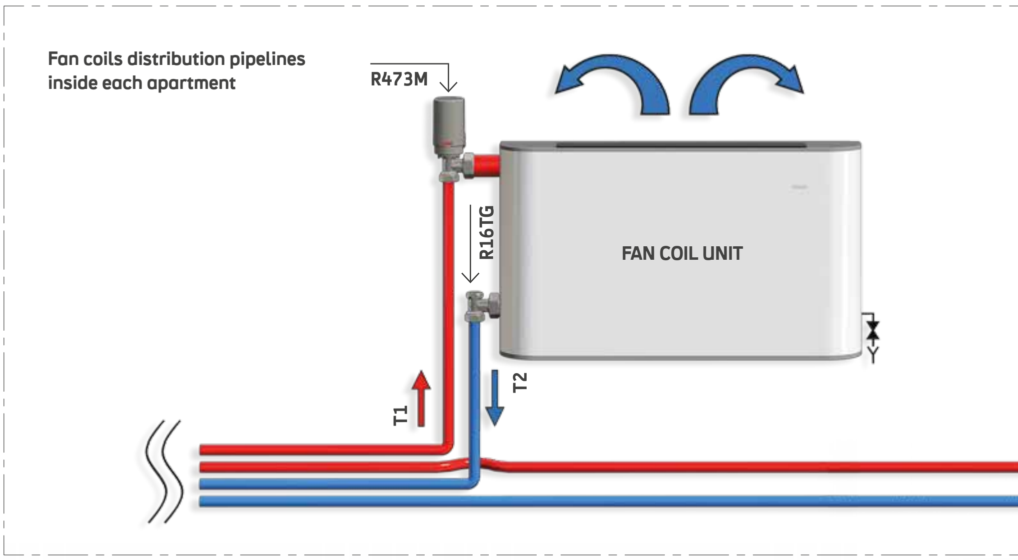
PRESSURE CONTROL UPSTREAM FROM EACH APARTMENT



FLOOR DISTRIBUTION MANIFOLD UNITS GE553 WITH DIFFERENTIAL

APPLICATION WITH R206C + R206B AND FAN COIL SYSTEM

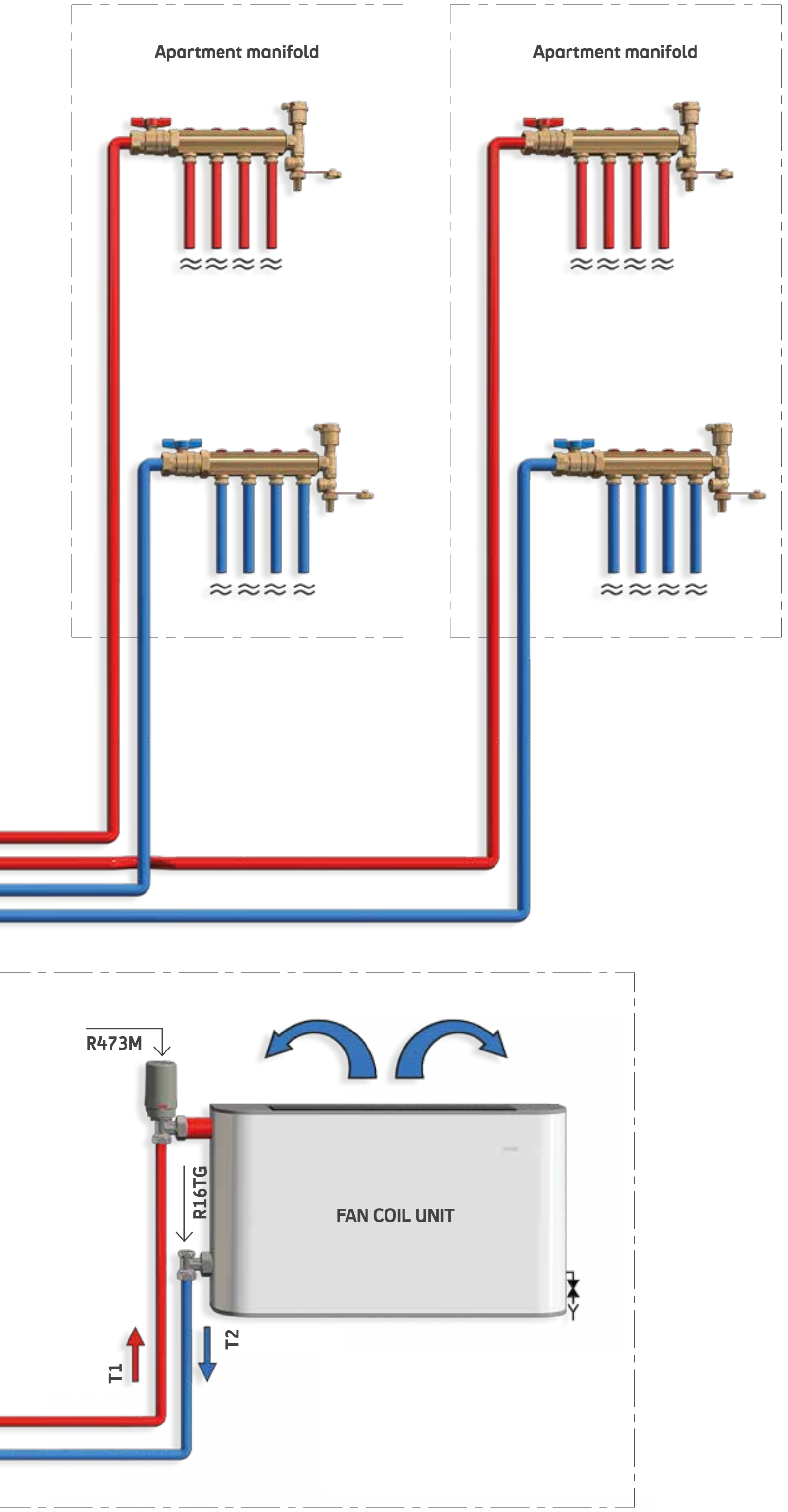




WORKING FEATURES:

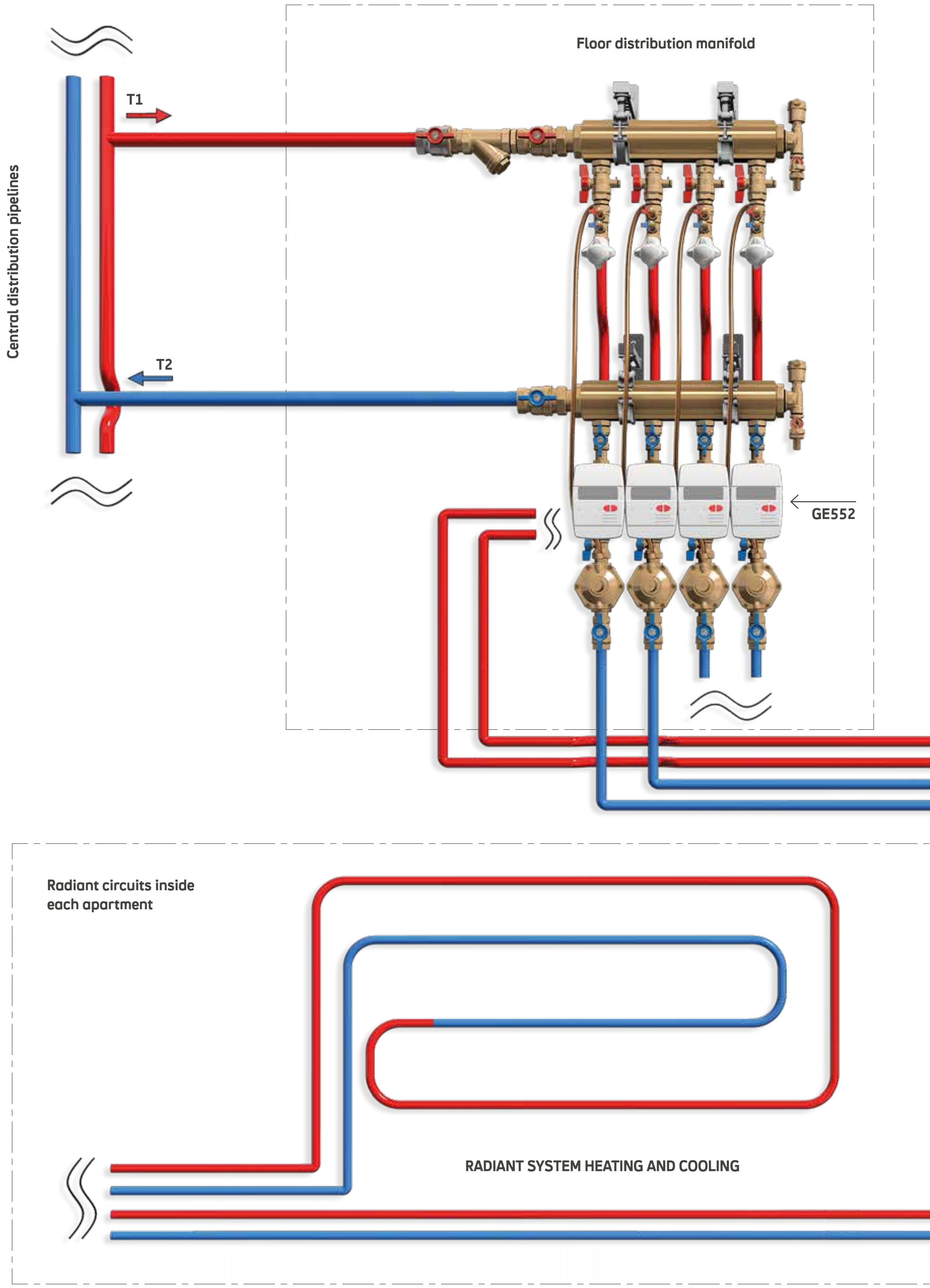
In this application the combination of R206C and R206B allow to get dynamic control of differential pressure across manifold and dynamic control of each circuit flow. Downstream are on-off actuators. Thus the flow-rate for each branch will be constantly at the set value, regardless the branches nearby are open or closed.

PRESSURE CONTROL UPSTREAM FROM EACH APARTMENT



FLOOR DISTRIBUTION MANIFOLD UNITS GE553 WITH DIFFERENTIAL

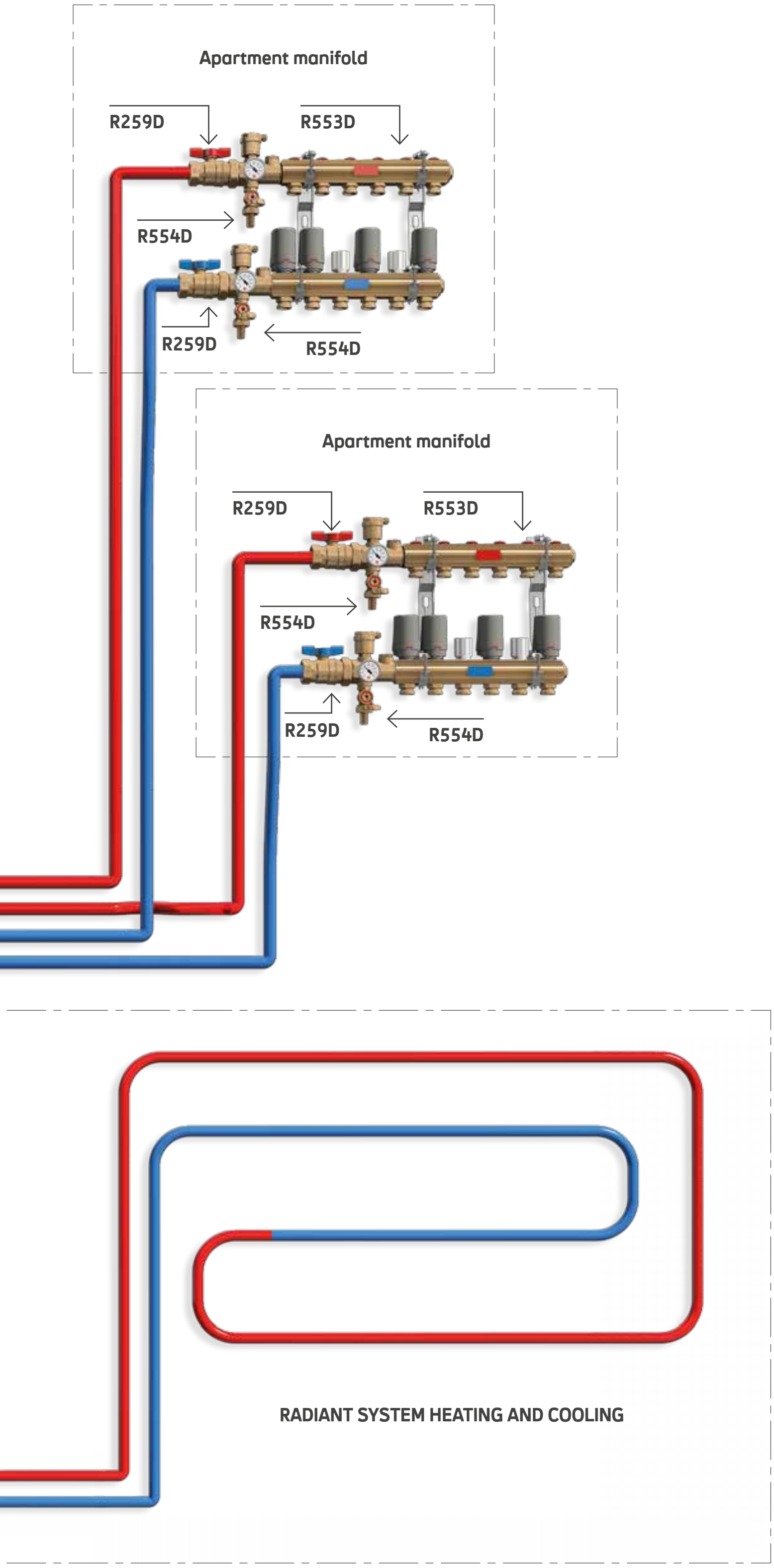
APPLICATION WITH R206C + R206B AND RADIANT SYSTEM HEATING/COOLING



WORKING FEATURES:

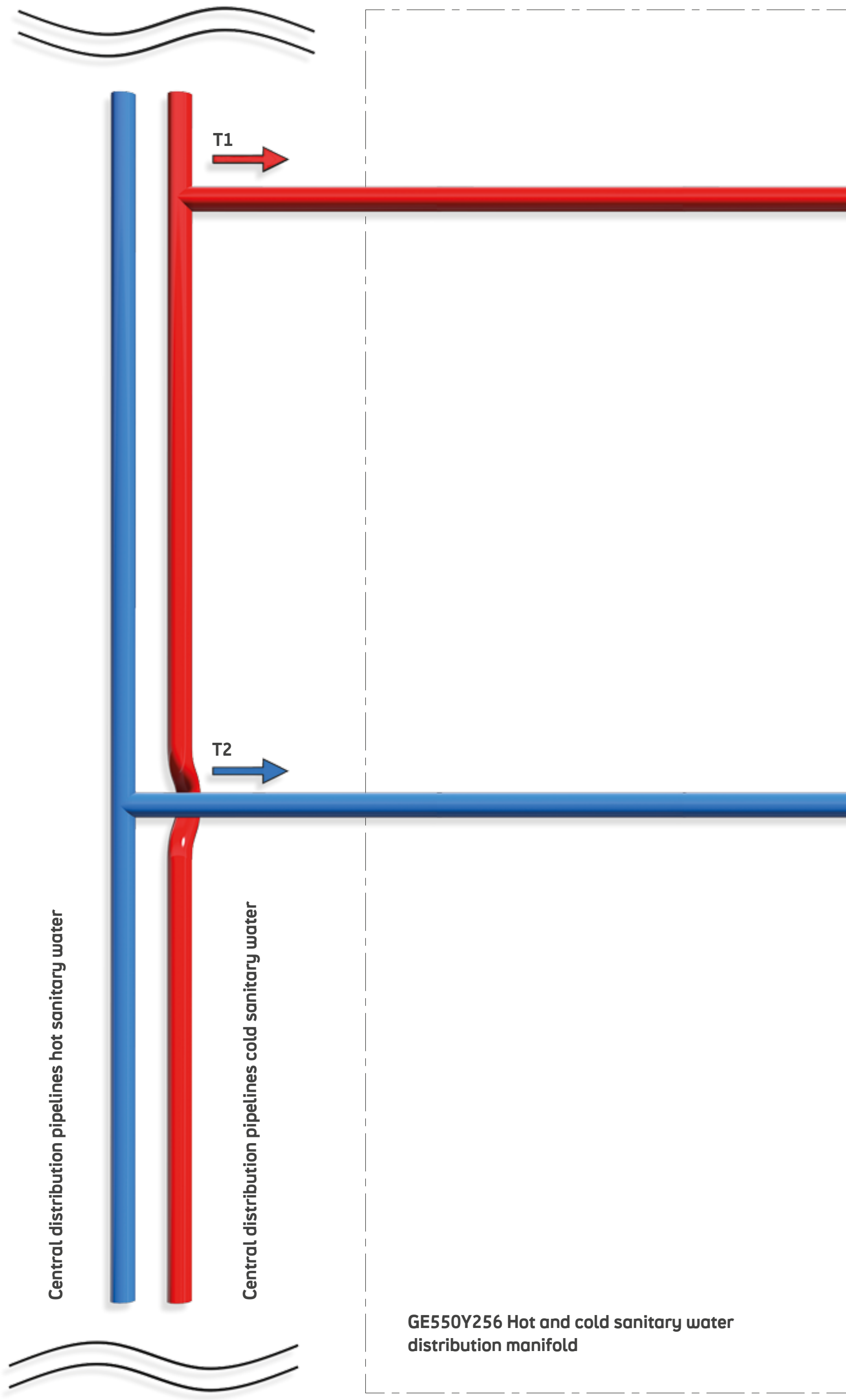
In this application the combination of R206C and R206B allow to get dynamic control of differential pressure across manifold and dynamic control of each circuit flow. Downstream are on-off actuators. Thus the flow-rate for each branch will be constantly at the set value, regardless the branches nearby are open or closed.

PRESSURE CONTROL UPSTREAM FROM EACH APARTMENT



FLOOR MANIFOLD FOR DISTRIBUTION OF SANITARY WATER WITH

APPLICATION FLOOR MANIFOLDS WITH R153 PRESSURE REDUCER AND WATER

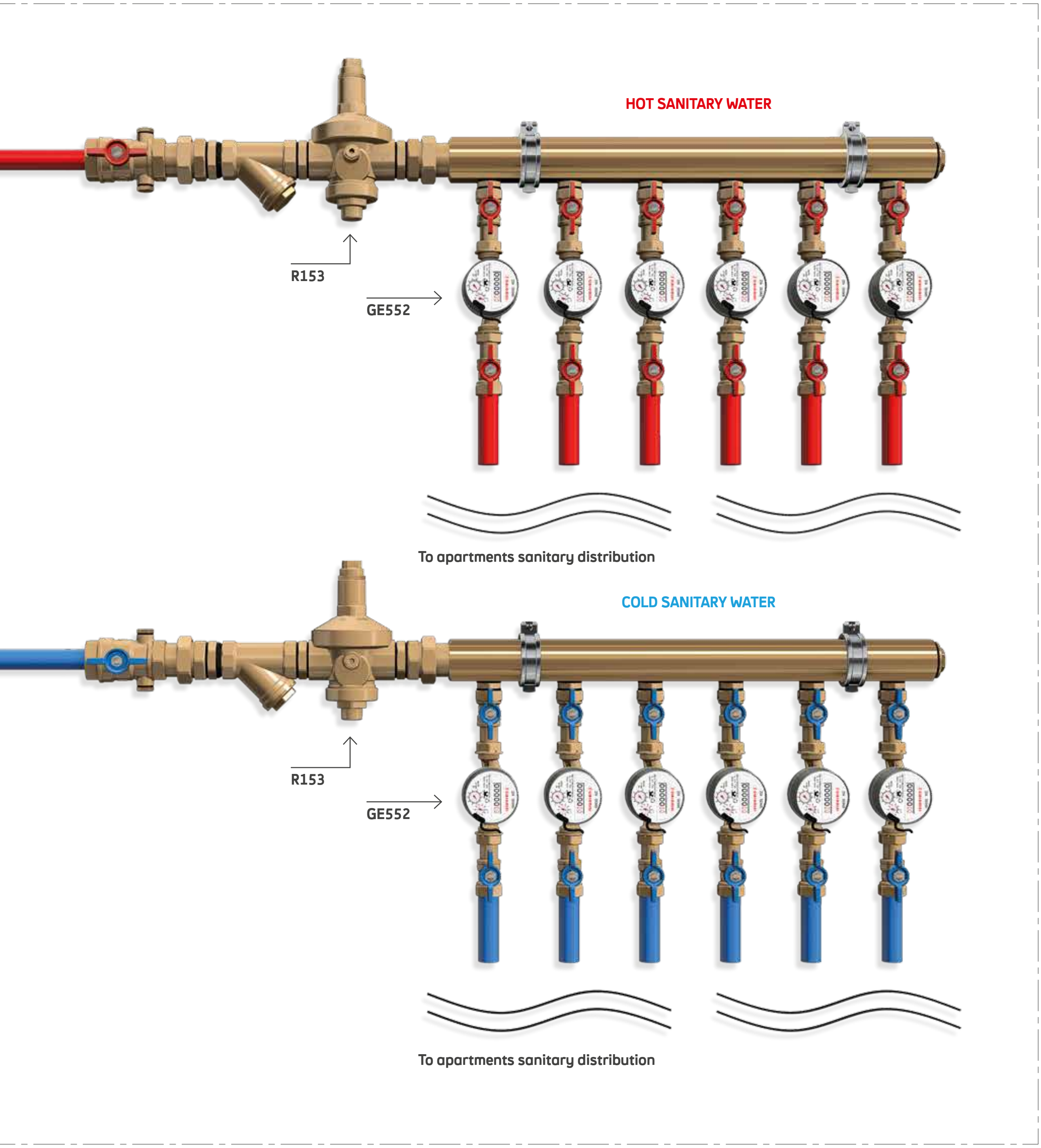


WORKING FEATURES:

In this application R153 pressure reducer allow to get control of pressure upstream from both hot and cold sanitary water distribution. In the meanwhile GE552 water meters allow to measure consumption of each apartment.

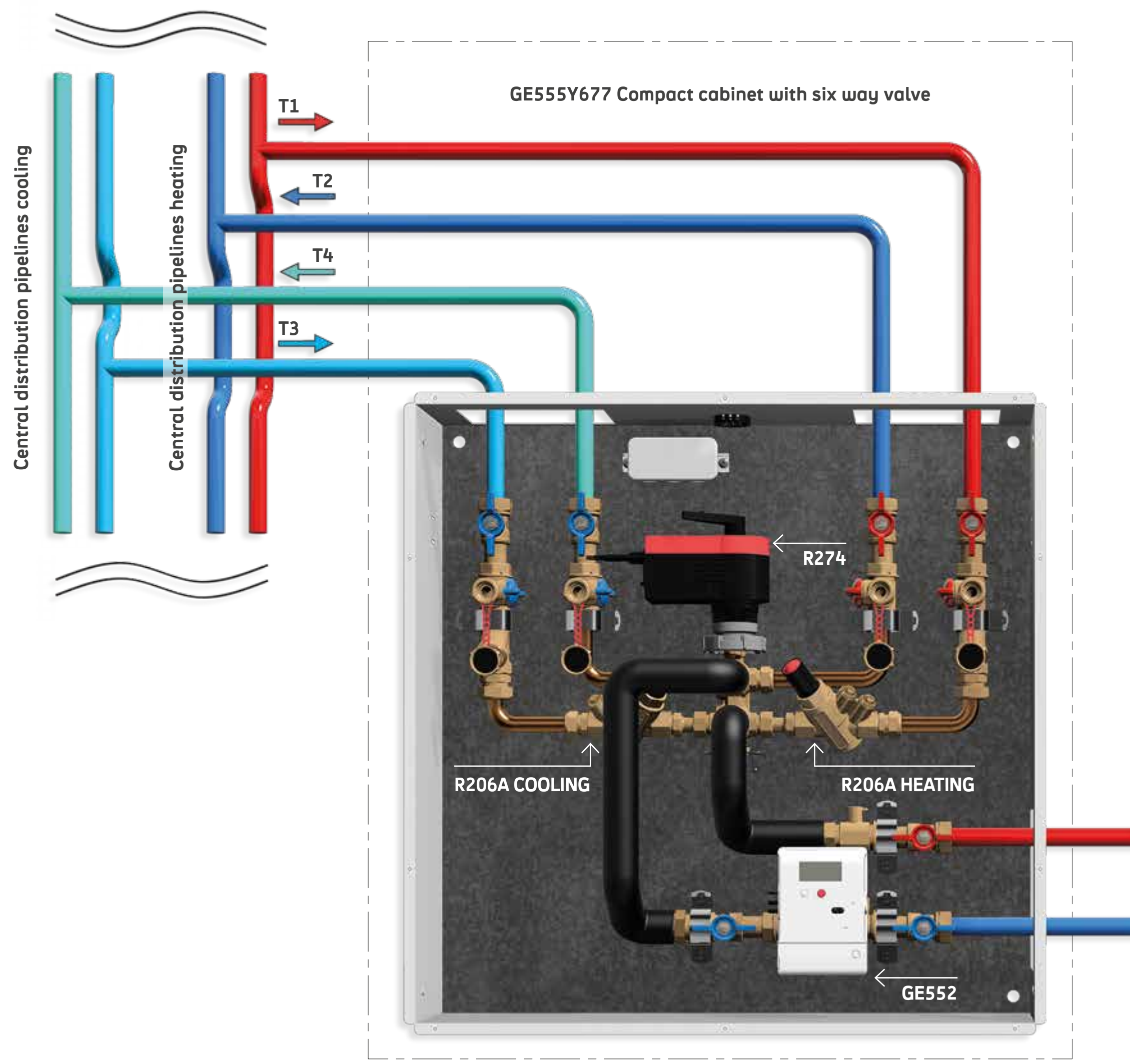
PRESSURE REDUCER AND WATER METERS

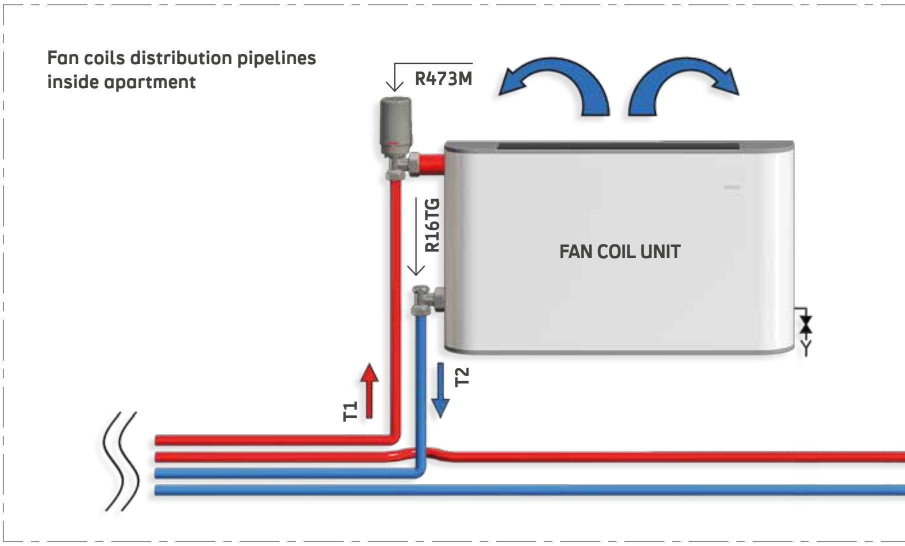
METER



FOUR PIPES DISTRIBUTION COMPACT CABINET WITH SIX WAY VALVE

APPLICATION WITH R274 + R206A AND FAN COIL SYSTEM

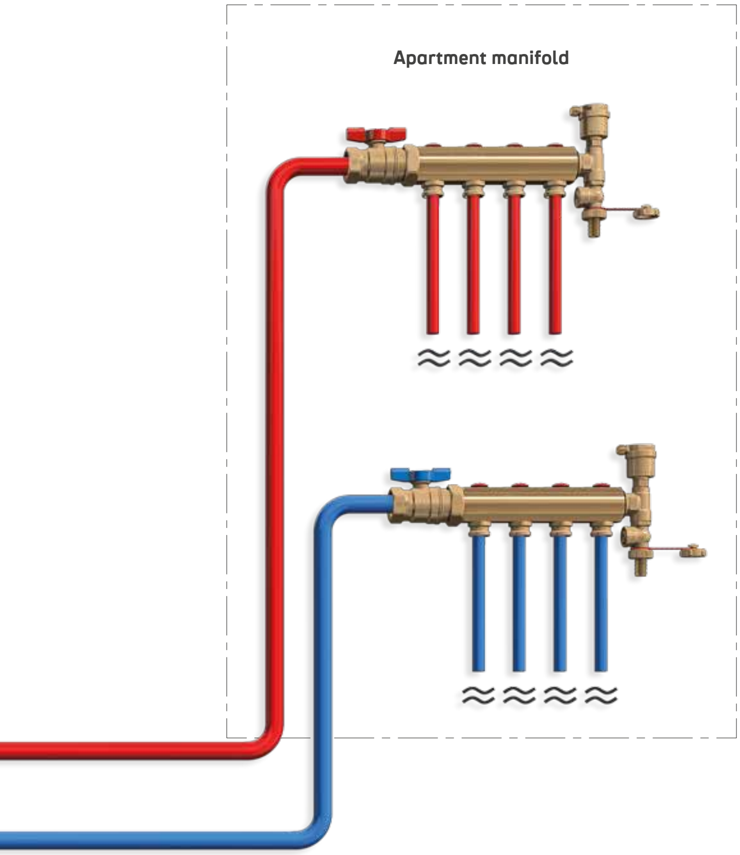


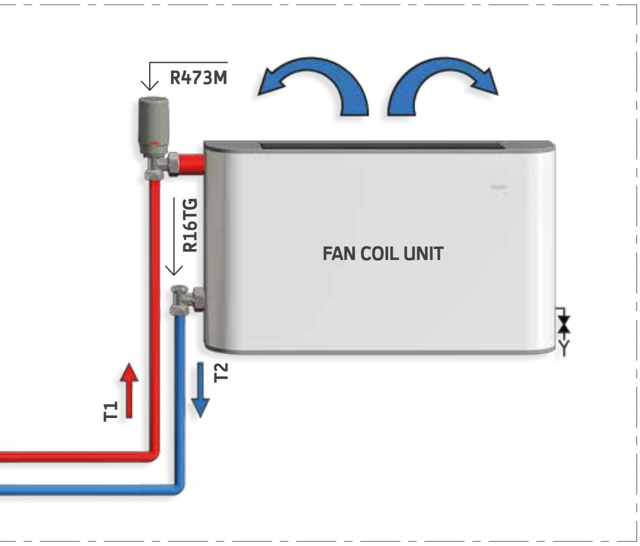


WORKING FEATURES:

In this application R274 six ways valve manages changes between heating and cooling mode.The presence of R206A on both heating and cooling side keeps the flow-rate constantly at the set value regardless the pressure variation.

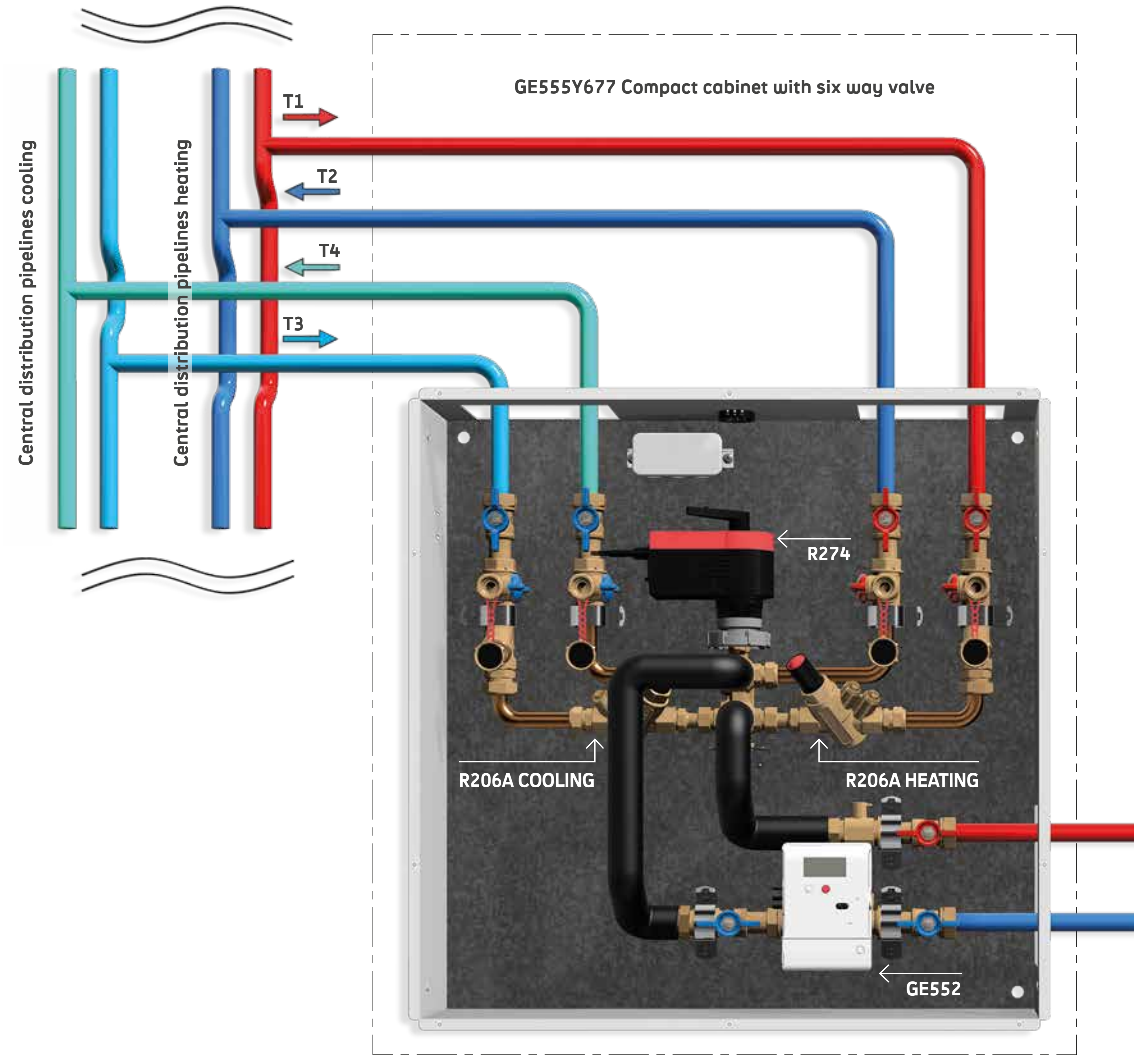
AND DYNAMIC BALANCING

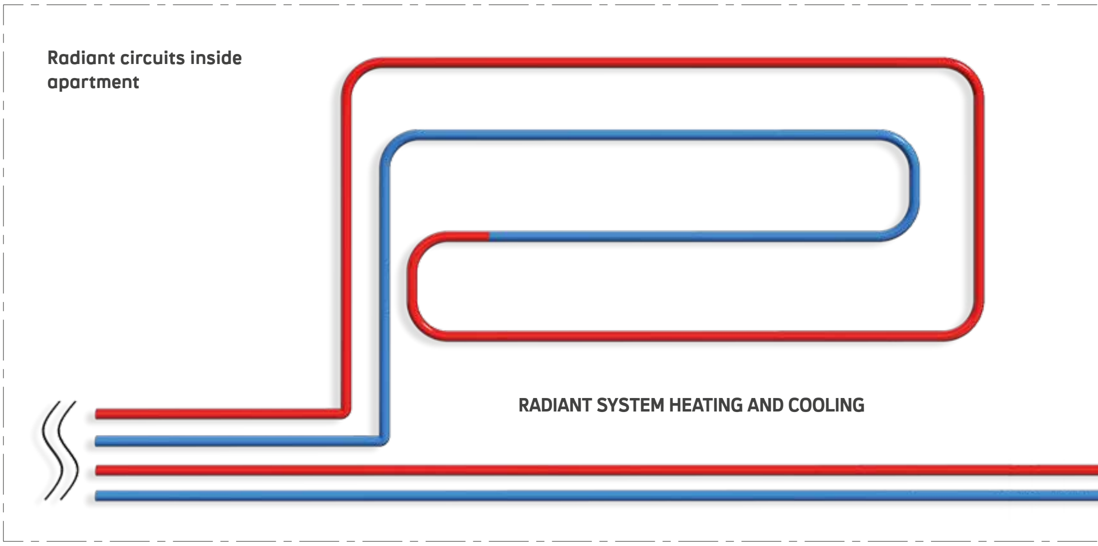




FOUR PIPES DISTRIBUTION COMPACT CABINET WITH SIX WAY VALVE

APPLICATION WITH R274 + R206A AND RADIANT SYSTEM

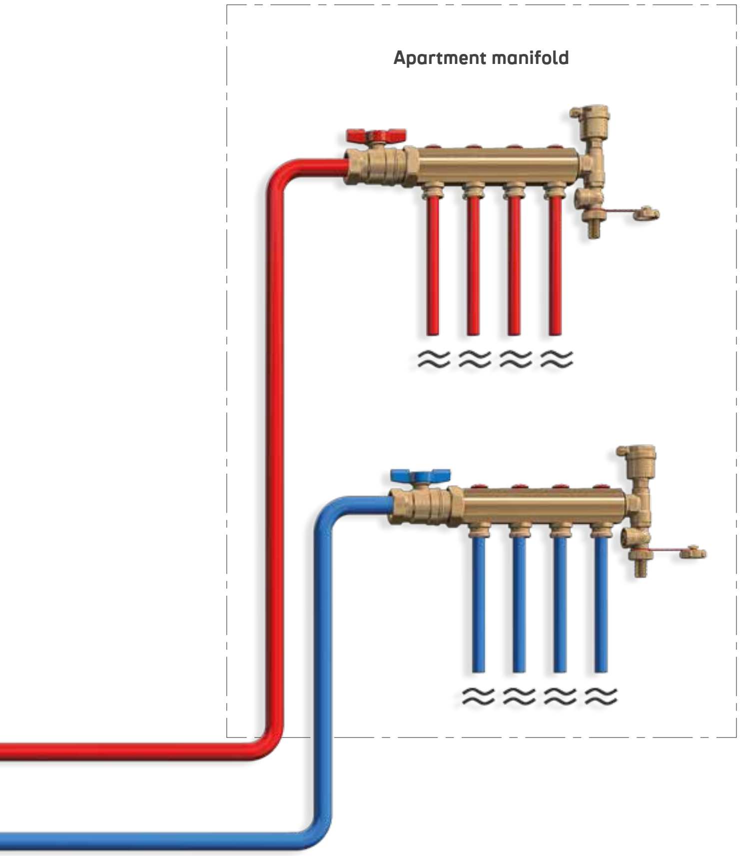


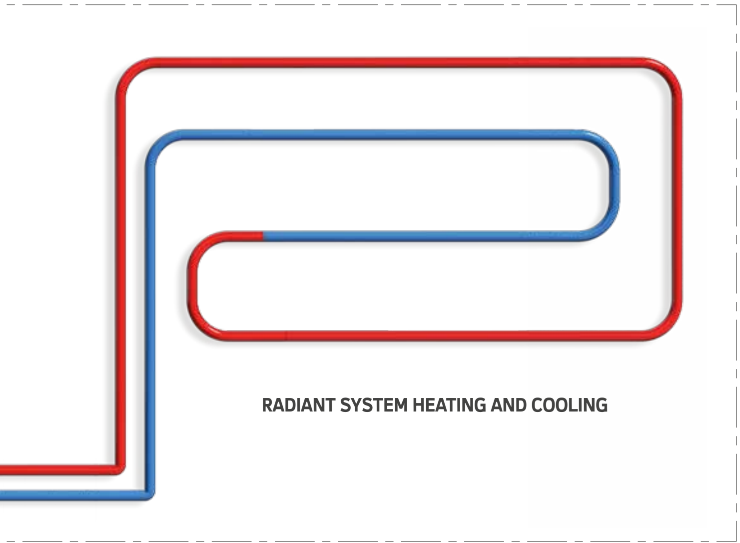


WORKING FEATURES:

In this application R274 six ways valve manages changes between heating and cooling mode.The presence of R206A on both heating and cooling side keeps the flow-rate constantly at the set value regardless the pressure variation.

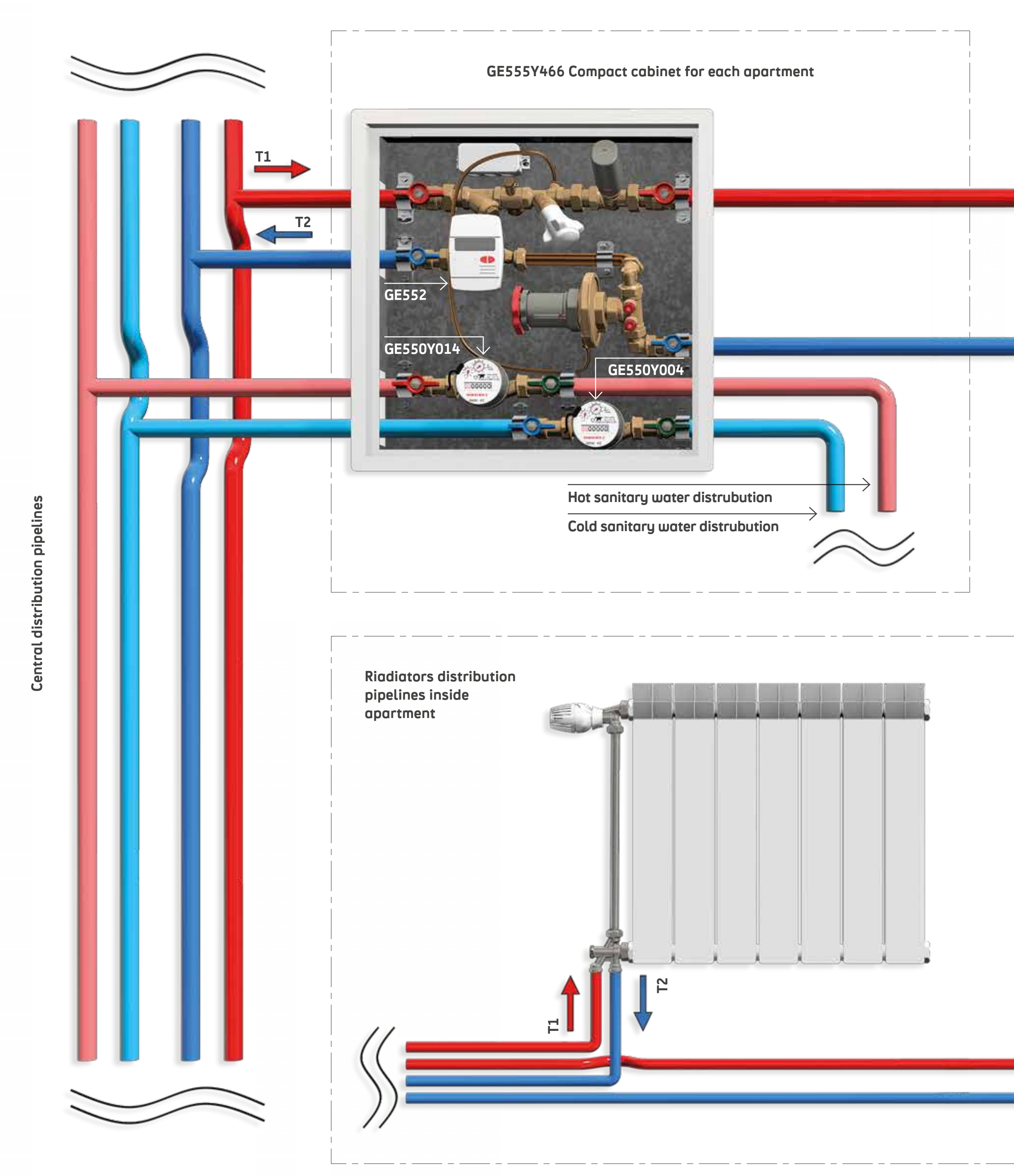
AND DYNAMIC BALANCING





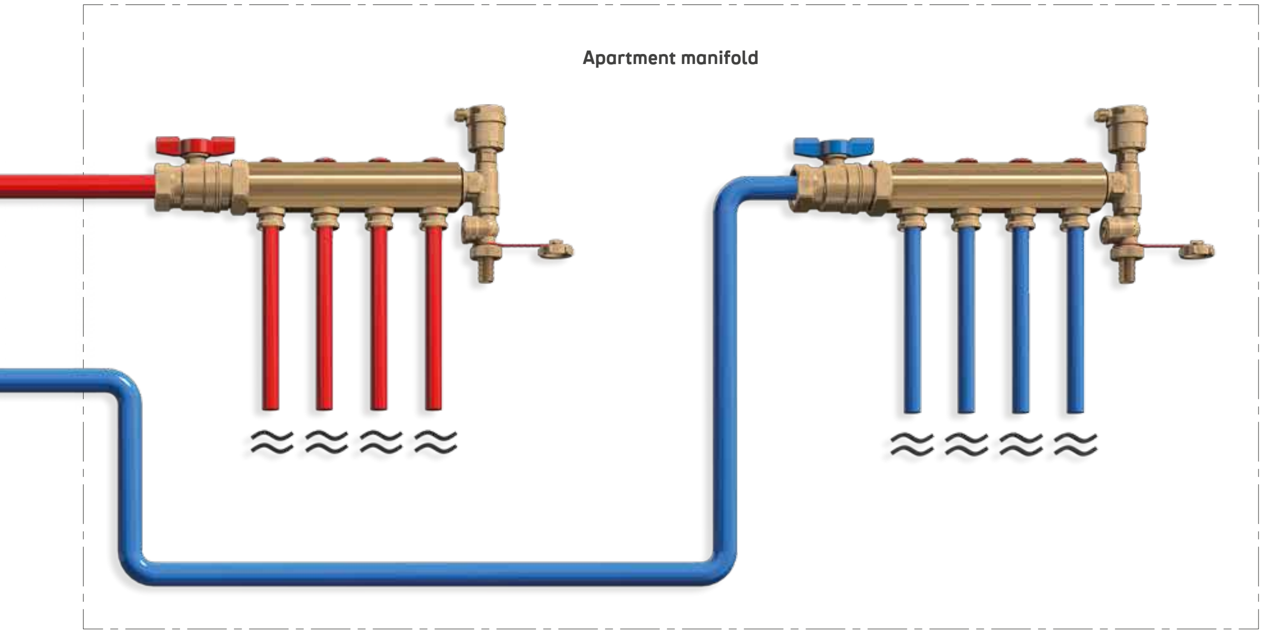
COMPACT CABINETS WITH ENERGY METERING, R206C AND R206B

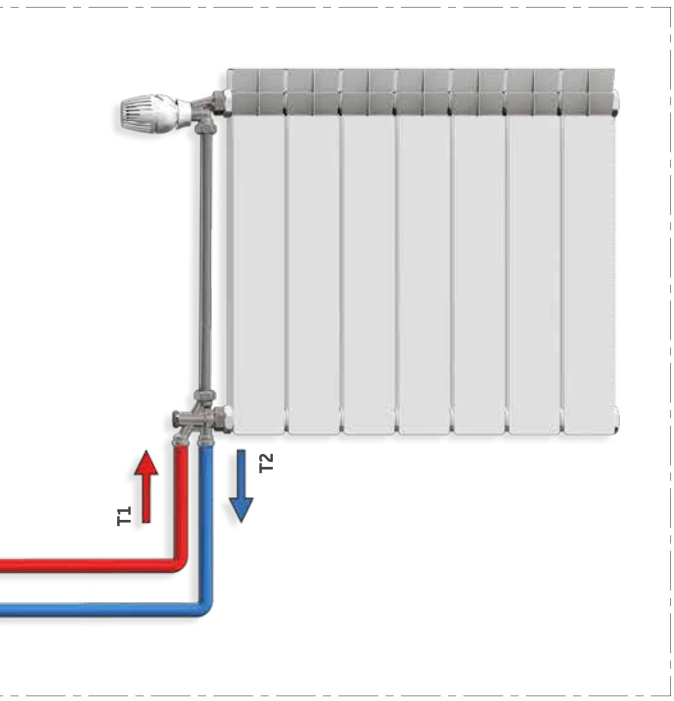
APPLICATION WITH RADIATOR SYSTEM



WORKING FEATURES:

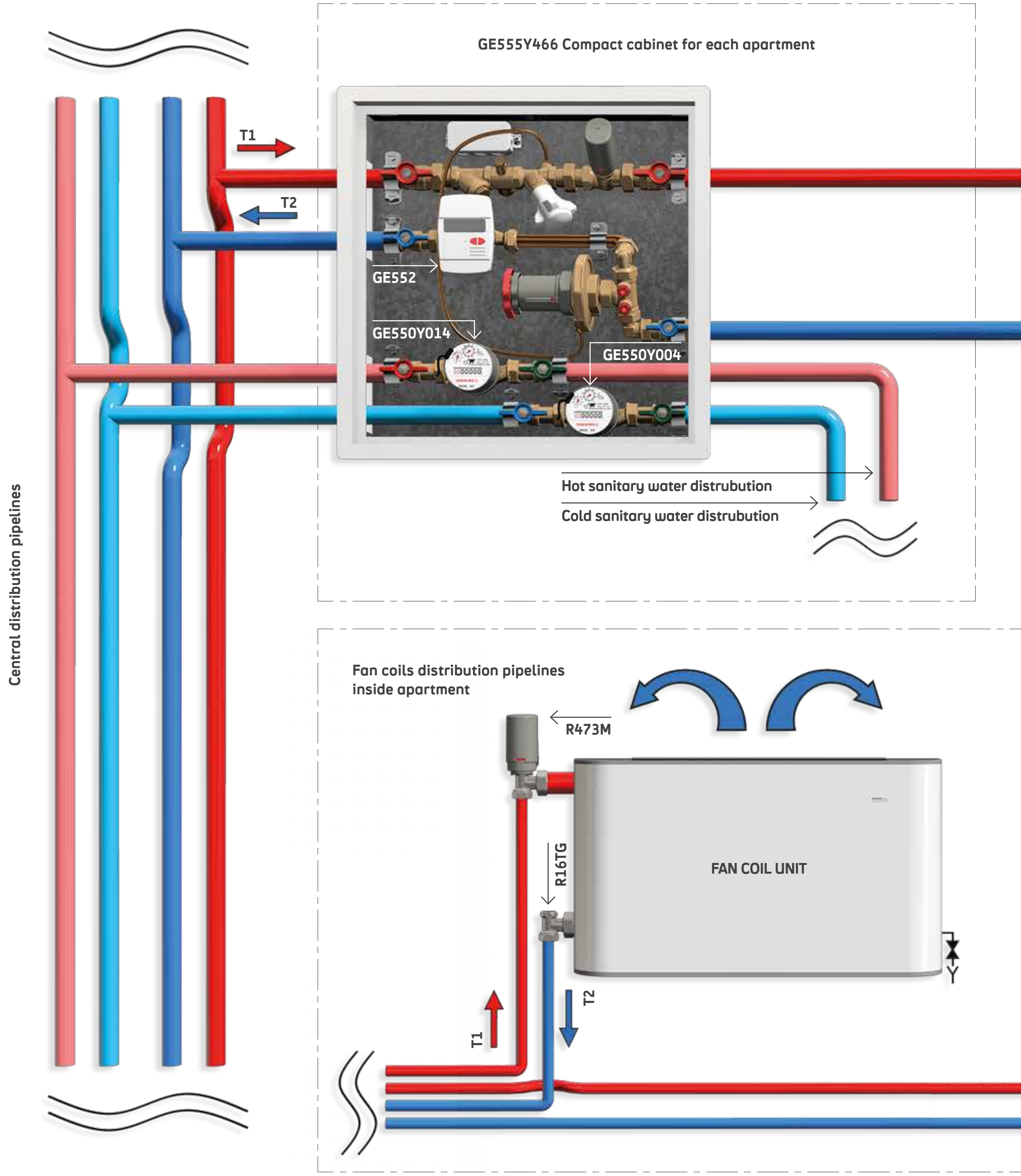
In this application the combination of R206C and R206B allow to get dynamic control of differential pressure upstream from each single apartment (with possible different settings). The differential pressure for each circuit will be constantly at the set value avoiding noise and overflows.


Apartment manifold


T1
T2

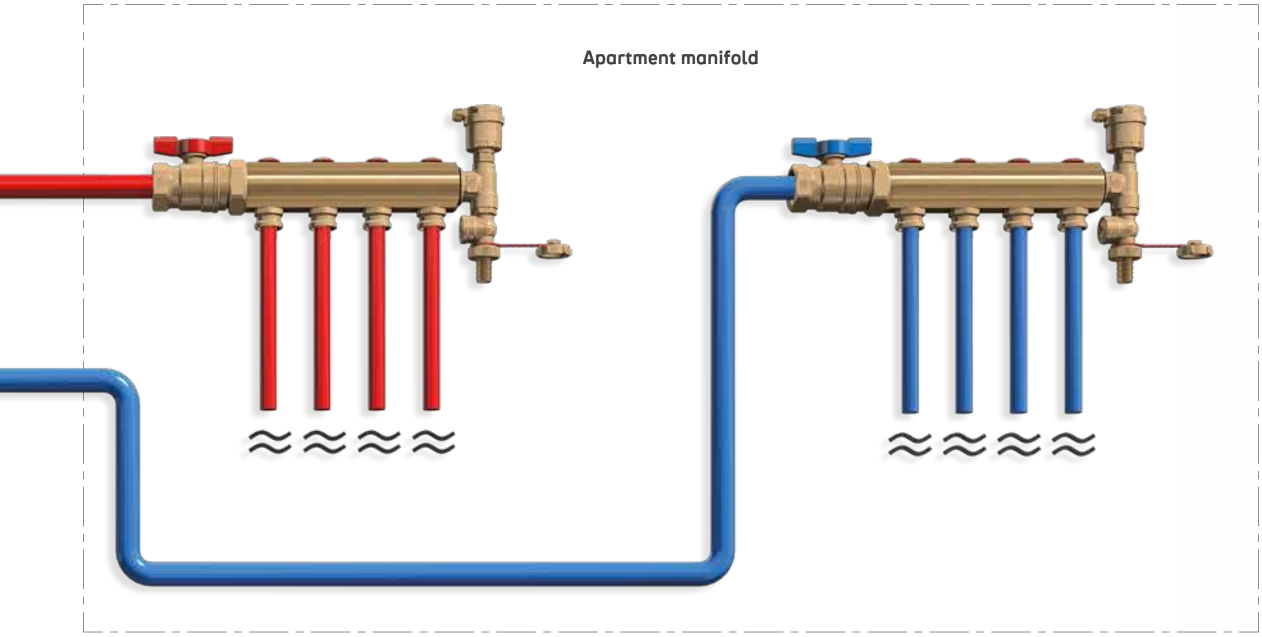
COMPACT CABINETS WITH ENERGY METERING, R206C AND R206B

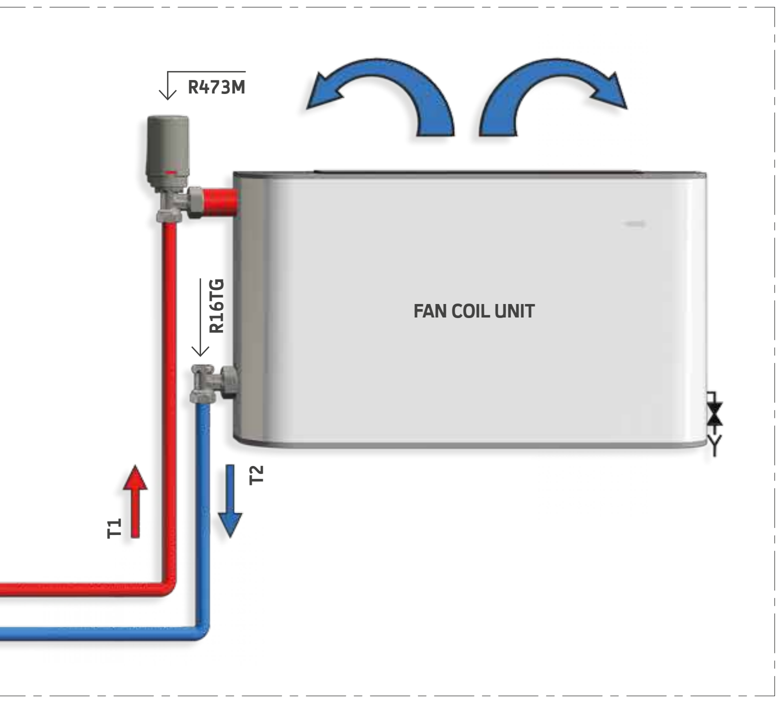
APPLICATION WITH R206C + R206B AND FAN COIL SYSTEM



WORKING FEATURES:

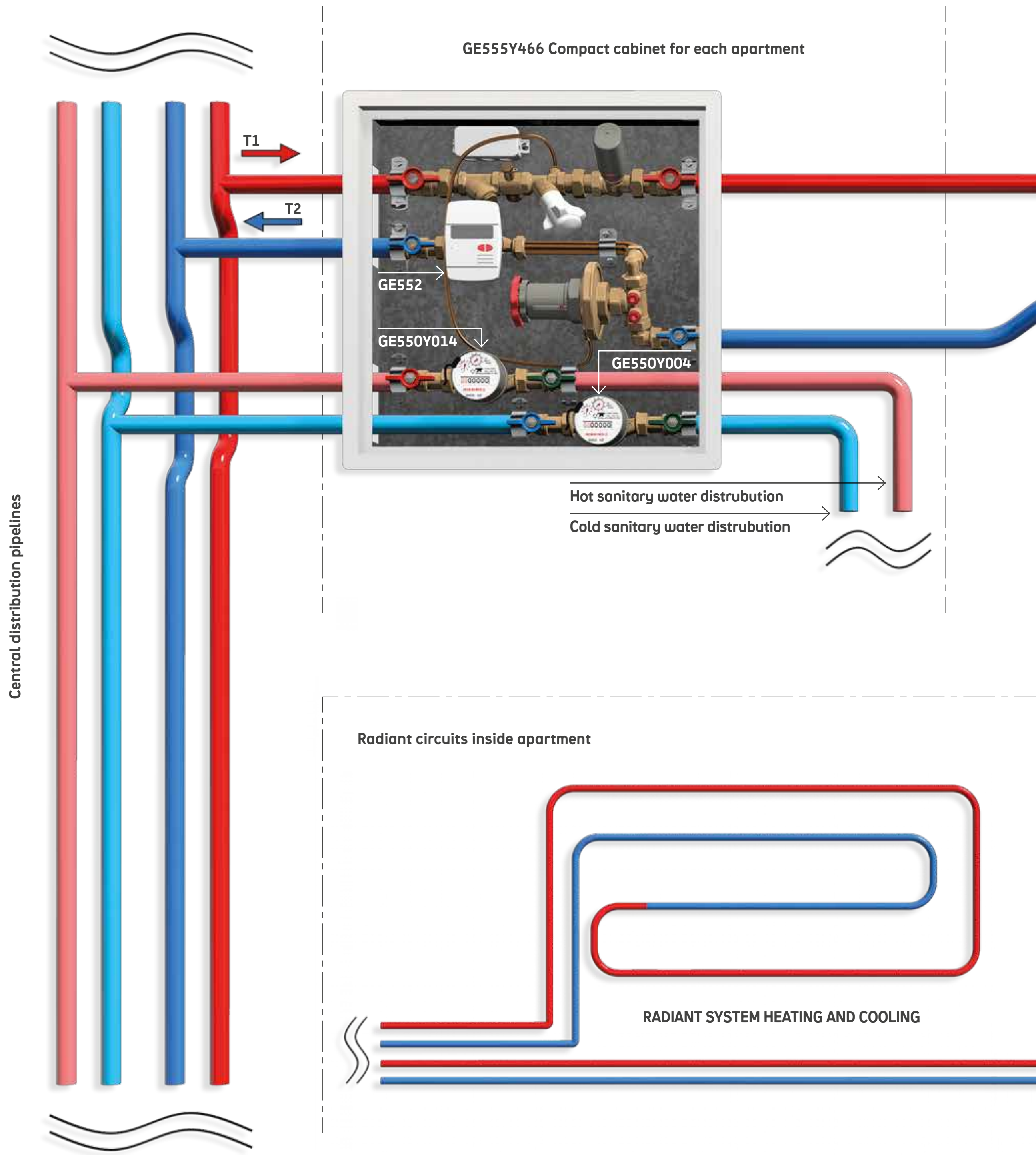
In this application the combination of R206C and R206B allow to get dynamic control of differential pressure across manifold and dynamic control of each circuit flow. Downstream are on-off actuators. Thus the flow-rate for each branch will be constantly at the set value, regardless the branches nearby are open or closed.


Apartment manifold


R473M
R16TG
FAN COIL UNIT
T1
T2

COMPACT CABINETS WITH ENERGY METERING, R206C AND R206B

APPLICATION WITH R206C + R206B AND RADIANT SYSTEM HEATING/COOLING



WORKING FEATURES:

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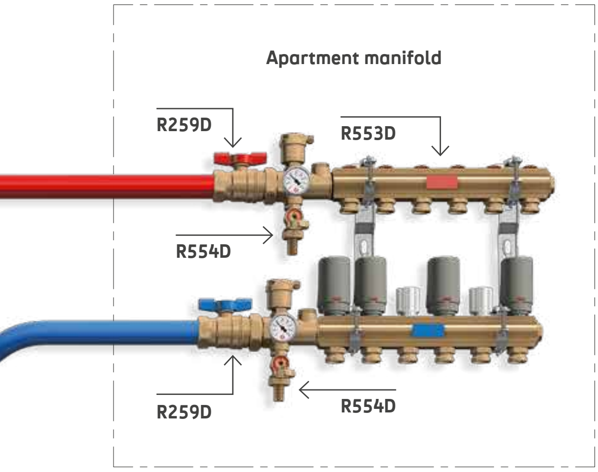
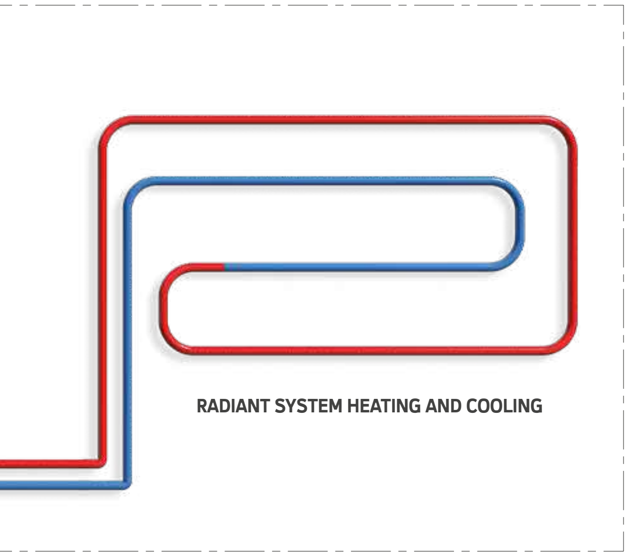

Apartment manifold
R259D
R553D
R554D
R259D
R554D


RADIANT SYSTEM HEATING AND COOLING

GIACOMINI
WATER E-MOTION

Operation principles of mixing, injection and diverted basic circuits.
Selection and dimensioning of the related components.

ENERGY MANAGEMENT

Chapter 5

Control loops: operation principles, sizing and selection

CONTROL LOOPS: OPERATION PRINCIPLES, SIZING AND SELECTION

BASIC CIRCUITS

In this chapter, we will describe circuits to be considered as basic elements for temperature distribution and control, energy/power exchange in pipes of comfort and industrial systems.

We will analyze in detail the selection and sizing procedure for the components of diverted circuits with three-way mixing valves, mixing circuits and finally injection circuits.

Diverted circuits with three-way mixing valves

Fig. 5.1 shows the installation of a three-way mixing valve in a diverted circuit. It separates the flows in **"primary circuit"** and **"secondary circuit"**.

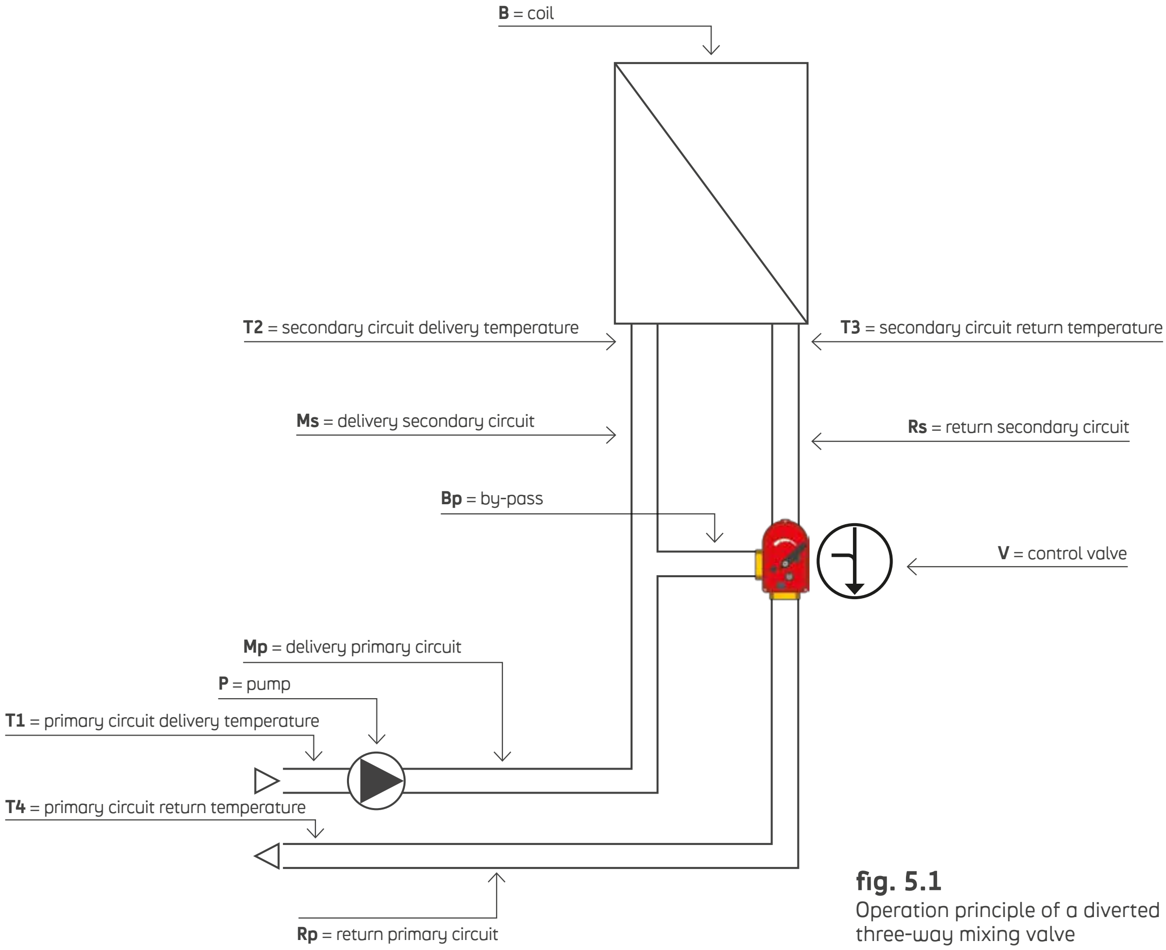


fig. 5.1
Operation principle of a diverted circuit with three-way mixing valve

When the (control) valve is closed, the total flow-rate generated by pump P in delivery of the primary circuit is diverted to the return of the latter. For each intermediate position, a certain quantity with temperature T = 1 will flow through the secondary circuit (downstream of the mixing valve).

Power Q (kW), transferred to the secondary fluid through the heat exchanger, varies based on the flow.

This is basically a flow control. In this application, power transfer throughout the entire heat exchanger is non-linear.

Furthermore, in case of partial loads of the secondary fluid (water or air), there will be sudden and fluctuating temperature changes, even if this application is typical in comfort systems.

Valve sizing is essential for proper operation of a proportional control system.

A valve is sized correctly when the maximum flow-rate is provided to the system circuits when the valve is fully open.

The greater the valve Δp versus the total Δp (ΔpLs + ΔpA + ΔpV), the better the system is controlled.

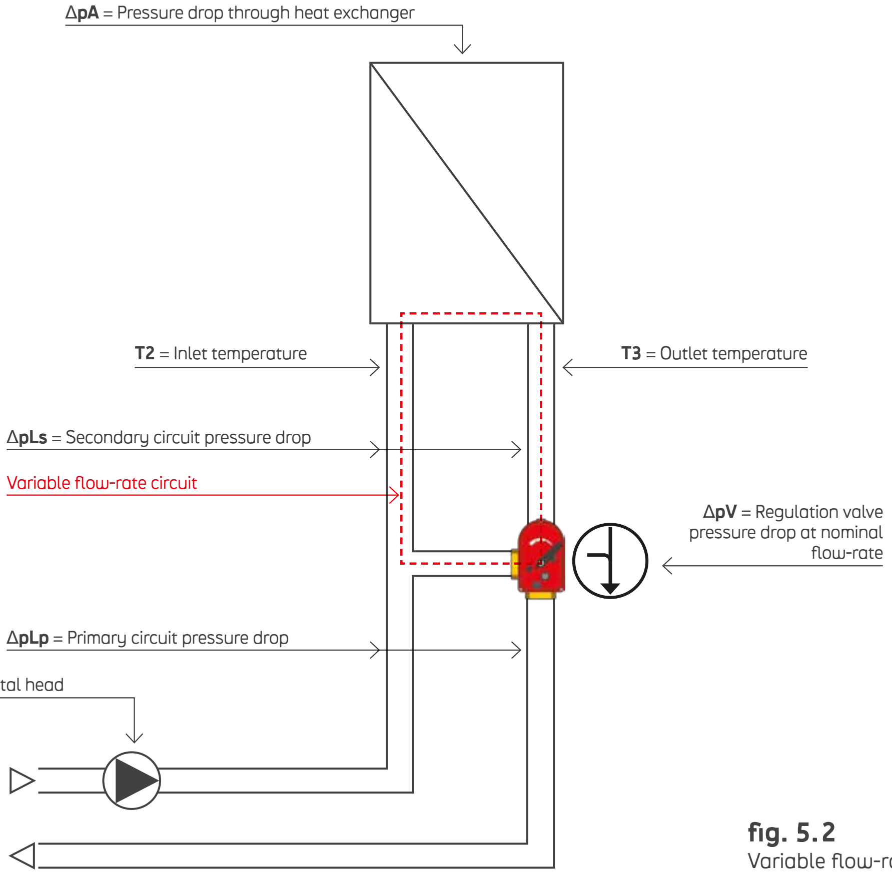


fig. 5.2
Variable flow-rate circuit in a diverted circuit

$$\frac{\Delta pV}{\Delta pLs + \Delta pA + \Delta pV}$$ **must be equal at least 0.5**

In other words, as described in chapters 1 and 2, the pressure drop through the regulation valve with nominal flow-rate must be equal to the pressure drop in the variable flow-rate section of the system.

So the dimension of the regulation valve must be selected based on:

$$\textbf{Water nominal flow-rate } V\left[\frac{l}{s}\right] = \frac{Q[kW]}{4.19\,(t_2 - t_3)}$$

- Minimum pressure drop of regulation valve
  ΔpVmin > (ΔpLs+ ΔpA)
- Pressure drop available for regulation valve
  ΔpzV = p1- (ΔpLp + ΔpLs + ΔpA)

Through this equation we will have:

$$Kv = \frac{V\left[\frac{l}{s}\right] 3.6}{\sqrt{\Delta pv}\ [bar]}$$

Where **Δpv** is the available pressure drop, while Kv is the water flow-rate through the valve with a pressure drop equal to 1 bar.

Each valve has a value Kvs representing the water flow-rate through the valve with a pressure drop of 1 bar when the valve is fully open.

Once selected Kv, it would be ideal to select a valve of the closest smaller dimension.

The actual pressure drop in the valve will be calculated through the equation below:

$$\Delta pv\ [bar] = \left(\frac{V\ 3.6}{Kvs}\right)^2$$

Available is a wide range of pumps and control valves with different Kv values.

This makes it virtually impossible to limit the flow-rate and the calculated value by simply choosing a pump and then a regulation valve.

One must also remember that an excessive flow-rate sensibly reduces the control valve regulation *range*.

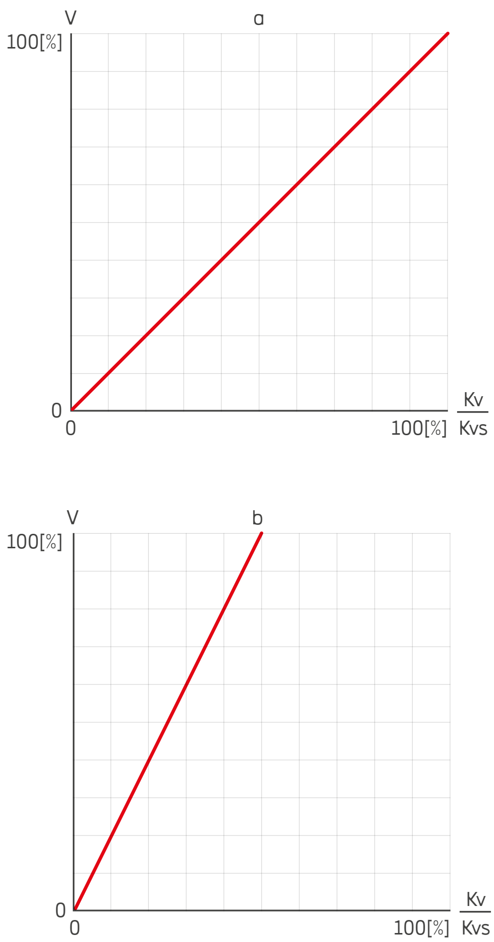


fig. 5.3
Flow-rate / valve opening ratio:
a= with correct flow-rate
b= with incorrect flow-rate

The diagram in fig. 5.3 is based on a curve with linear characteristics.

A reduced regulation *range* means that a small change in the valve stroke increases excessively the power supplied to the heat exchanger; this will cause fluctuations around the system set-point.

The only way to solve this kind of problem in an effective way is to adjust the total pressure drops (ΔpD + ΔpLs + ΔpA + ΔpV) to the available pressure drop by installing balancing valves (e.g. R206B) as shown in fig. 5.4.

It must be pointed out that as the flow-rate can be limited only in constant-flow pipes, balancing valves must be installed only in the sections of the system featuring this type of characteristic.

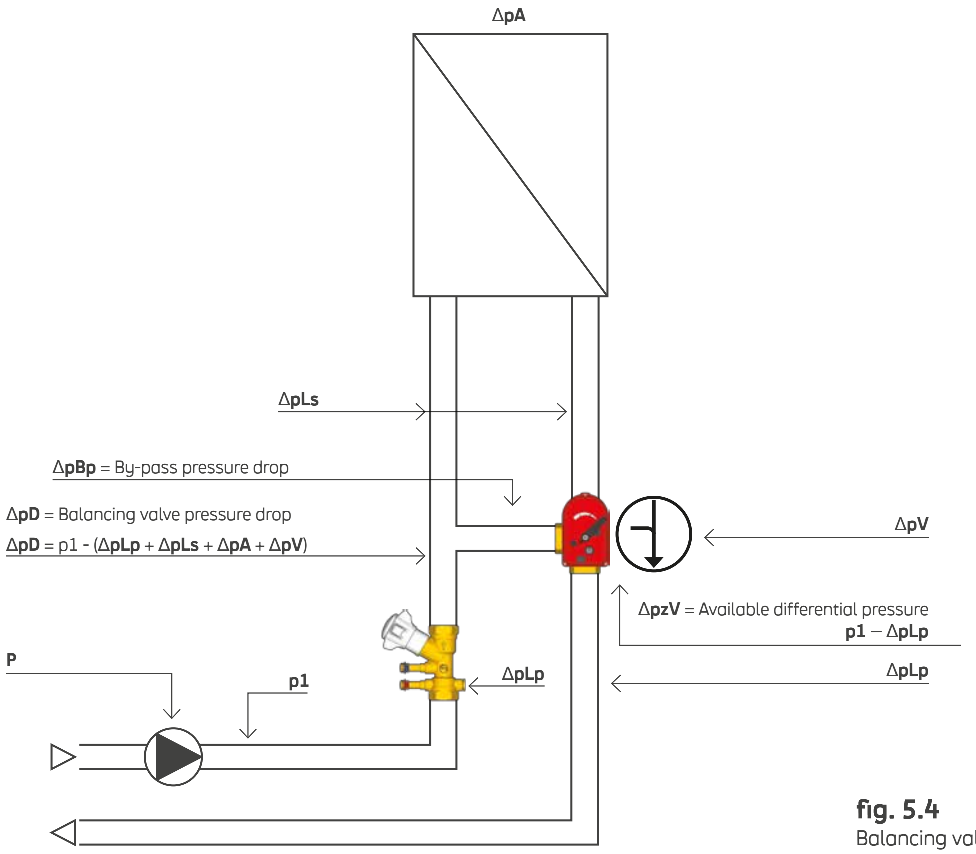


fig. 5.4
Balancing valves installed in diverted circuits

For example:

Presuming that in fig. 5.4 we have

ΔpzV = 0.4 bar

ΔpA = 0.05 bar

ΔpLs = 0.02 bar

ΔpV = 0.11 bar

ΔpD will be equal to 0.22 bar (0.4-0.05-0.02-011)

A 0.22 bar pressure must be artificially overcome through balancing valve D1.

For this reason, one must select the valve with the closest smaller diameter, as long as its pressure drop allows for it.

When it comes to air conditioning applications, diverted circuits are generally used in cooling coils of air treatment units working in dehumidification mode.

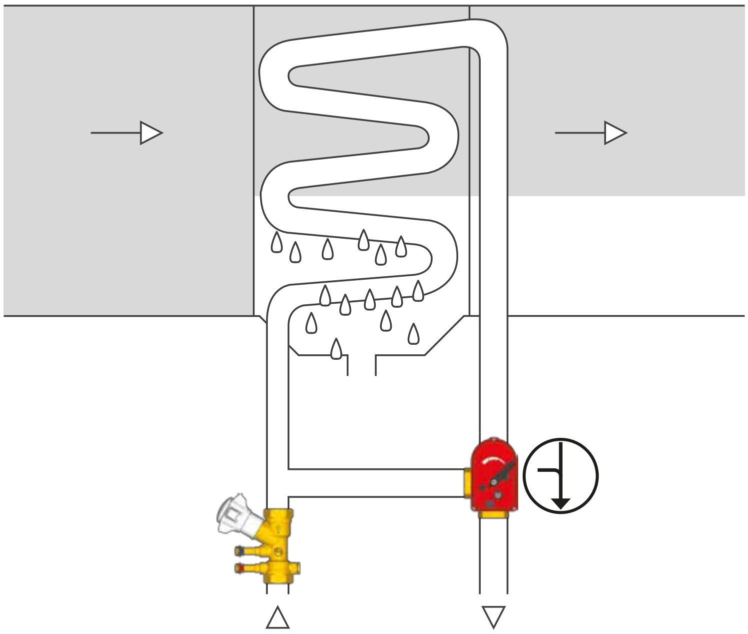


fig. 5.5
Application of a diverted circuit in a dehumidification cooling coil

Based on the valve position, part of the cooling coil goes below dew point, thus dehumidifying the corresponding part of air flowing through the coil.

This type of circuit features temperature variations and is thus recommended for air coils only when the delivery temperature is not controlled downstream of the coils, for example in zone heating or recirculated air heating.

This type of circuit is not recommended for pre-heating coils.

Mixed circuits

The total flow in this type of application goes through the thermal energy exchange coil in a constant way. Therefore, the water temperature must be controlled to modulate the quantity of transferred heat.

When the control valve is closed, the pump makes the water flow through the delivery pipes, the circuit, the return pipes and the by-pass before flowing back to the valve.

When the latter is open, part of the water flow continues circulating, based on the position of the by-pass, while the remaining part flows through the primary return pipes (riser), the boiler and the primary delivery pipes (riser) towards the control valve.

Then the valve mixes two partial water flows. This is defined as temperature control through mixing.

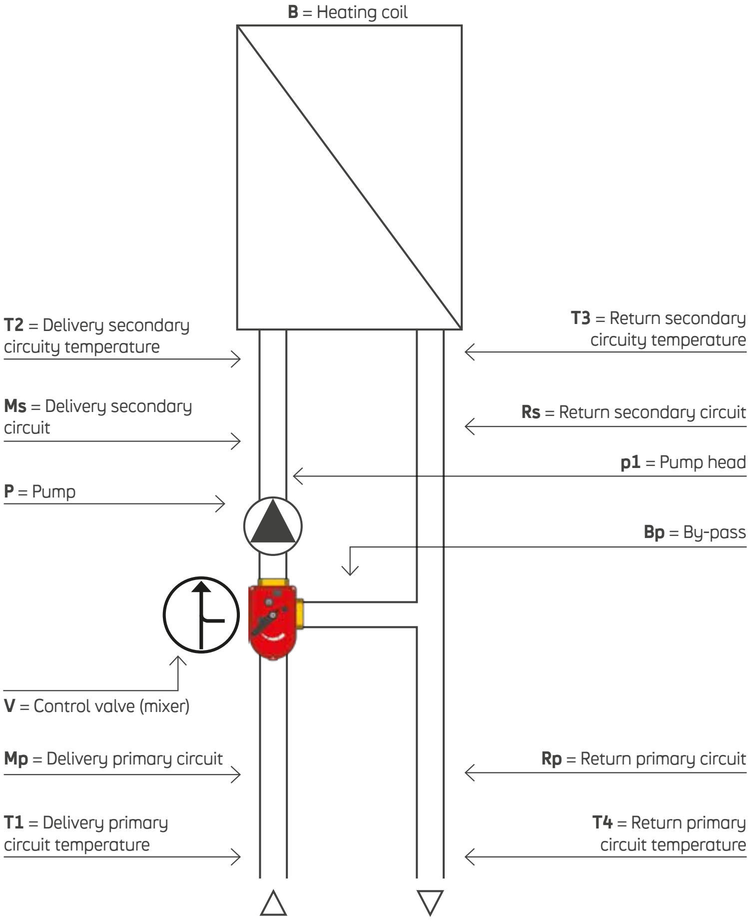


fig. 5.6
Typical diagram of a mixing circuit

Therefore, the control valve dimension must be selected based on:

- Water nominal flow $V\left[\frac{l}{s}\right] = \frac{Q[kW]}{4.19\,(t_2 - t_3)}$
- Minimum pressure drop for control valve
  ΔpVmin > (ΔpLp+ ΔpE)
- Pressure drop available for control valve
  ΔpzV = p1- (ΔpLs + ΔpA + ΔpLp + ΔpE)

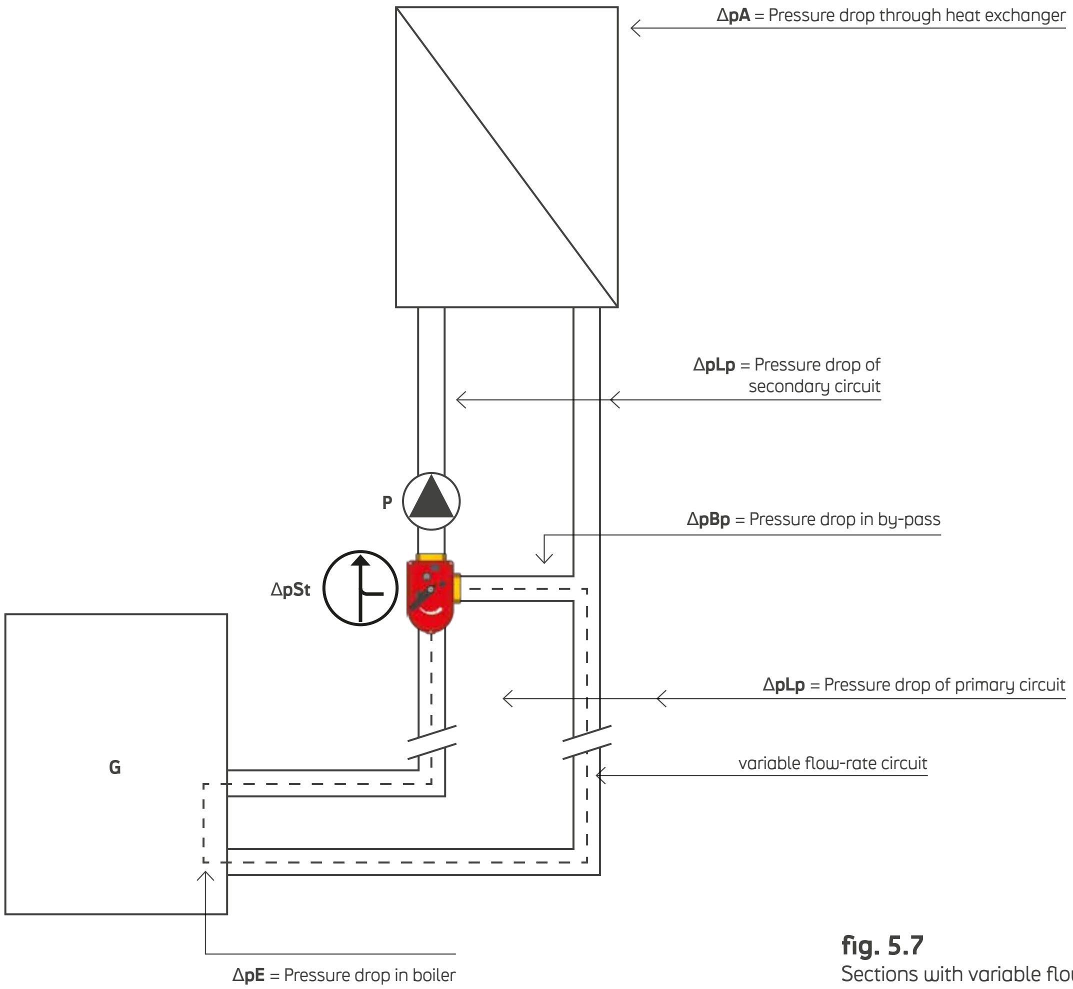


fig. 5.7
Sections with variable flow-rate

As shown in fig. 5.7, when the control valve is fully open, the pump pushes the water through the coil, the return pipe, the boiler, the delivery pipes and the valve itself. The variable flow-rate section is situated in the primary circuit.

Therefore, the minimum pressure drop through the valve must be equal at least to the pressure drop in the primary circuit ($\Delta pLp + \Delta pE$).

In the same way, the by-pass pressure drop must be equal to the pressure drop in the primary circuit. For this circuit, also the total pressure drop must be adjusted to the pump head.

If the latter can't be adjusted, a balancing valve D must be installed in the circuit section with constant flow-rate.

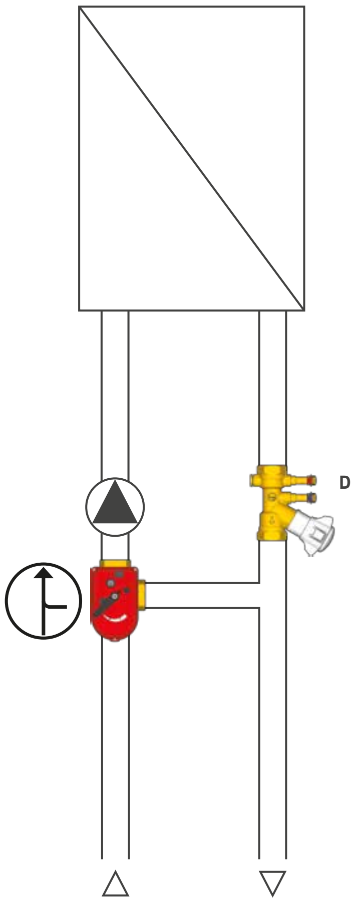


fig. 5.8
Balancing valve in a mixed circuit

In air conditioning systems, the mixing circuit is used in any situation requiring a variable temperature of the coil water and when there is no pressure in the primary pipes.

This is also the type of circuit generally used for both floor and ceiling radiant systems.

The main benefit of the mixing circuit compared to a diverted one is the constant pressure on the entire coil surface, connected to the constant flow V; it thus receives water approximately at the same temperature in all its parts.

In this way, there are only slight temperature variations.

As the freezing point of water decreases when the water pressure and movement increase, the freezing risk is reduced when the pump is on.

When heating, the diverted circuit is used only for small installations with no main pump or to connect multiple coils with no differential pressure.

If the maximum delivery temperature in a heating circuit must be different from the boiler's, for example in radiant systems, the proper delivery temperature must not be exceeded by monitoring it through proper measurements. This can be achieved through the circuit shown in fig. 5.9.

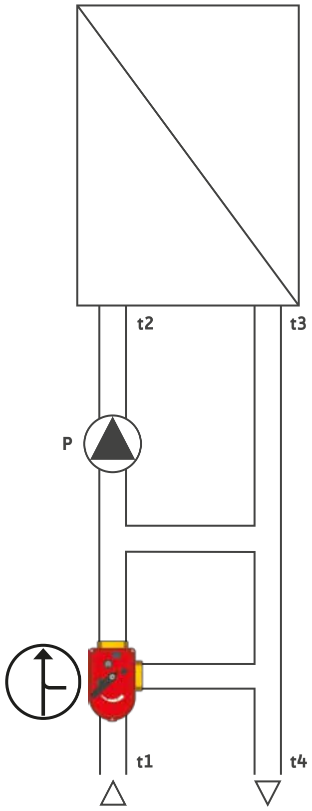


fig. 5.9
Operation principle of a mixed circuit with temperature difference $T_{primary\ delivery} - T_{secondary\ delivery}$

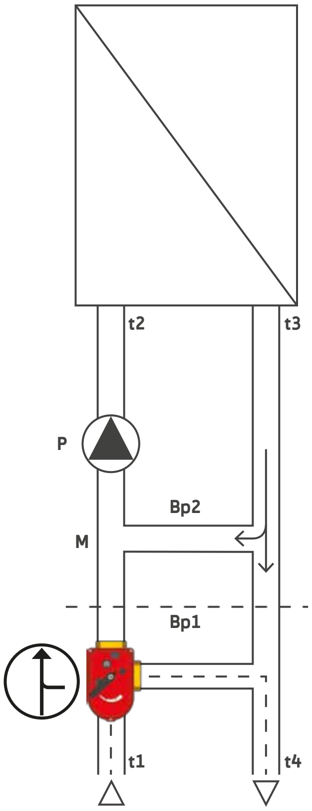


fig. 5.10
Variable flow-rate zones in a mixing circuit with temperature difference $T_{primary\ delivery} - T_{secondary\ delivery}$
Upper section: mixing circuit with constant flow and fix mixing ratio
Lower section: normal mixing with variable ratio
M = Mixing point

This circuit can be considered as a combination of two mixing circuits, as shown in fig. 5.10.

The nominal flow-rate of the secondary circuit is made by a constant portion flowing through by-pass 2 towards mixing point "**m**" and a variable portion which flows through by-pass 1 or the primary circuit based on the mixing device position.

As for the dimension of the control valve, the nominal flow-rate is the result of the following equation:

$$\textbf{Water nominal flow-rate: } V\left[\frac{l}{s}\right] = \frac{Q[kW]}{4.19\ (t_2 - t_3)}$$

Two balancing valves must be installed as shown in fig. 5.11 to balance the water flow.

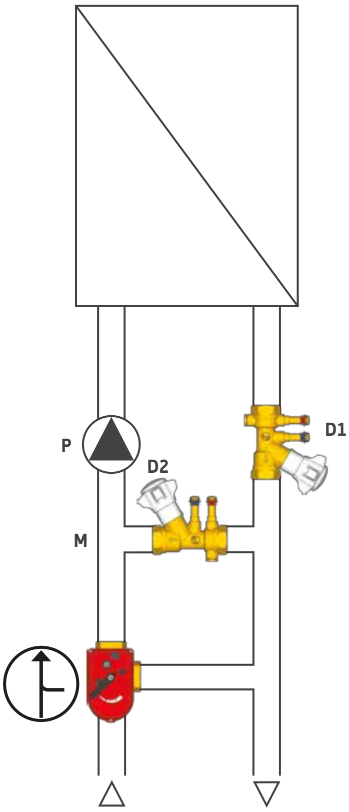


fig. 5.11
Balancing valve in a mixed circuit with temperature difference
$T_{\text{delivery primary}} - T_{\text{delivery secondary}}$
D_1 = Balancing valve for total flow
D_2 = Balancing valve for constant mixing part

D_1 limits the total flow while D2 controls the constant mixing volume. D_2 is first opened and then closed slightly to prevent the temperature from exceeding the maximum value in mixing point M.

Injection circuit

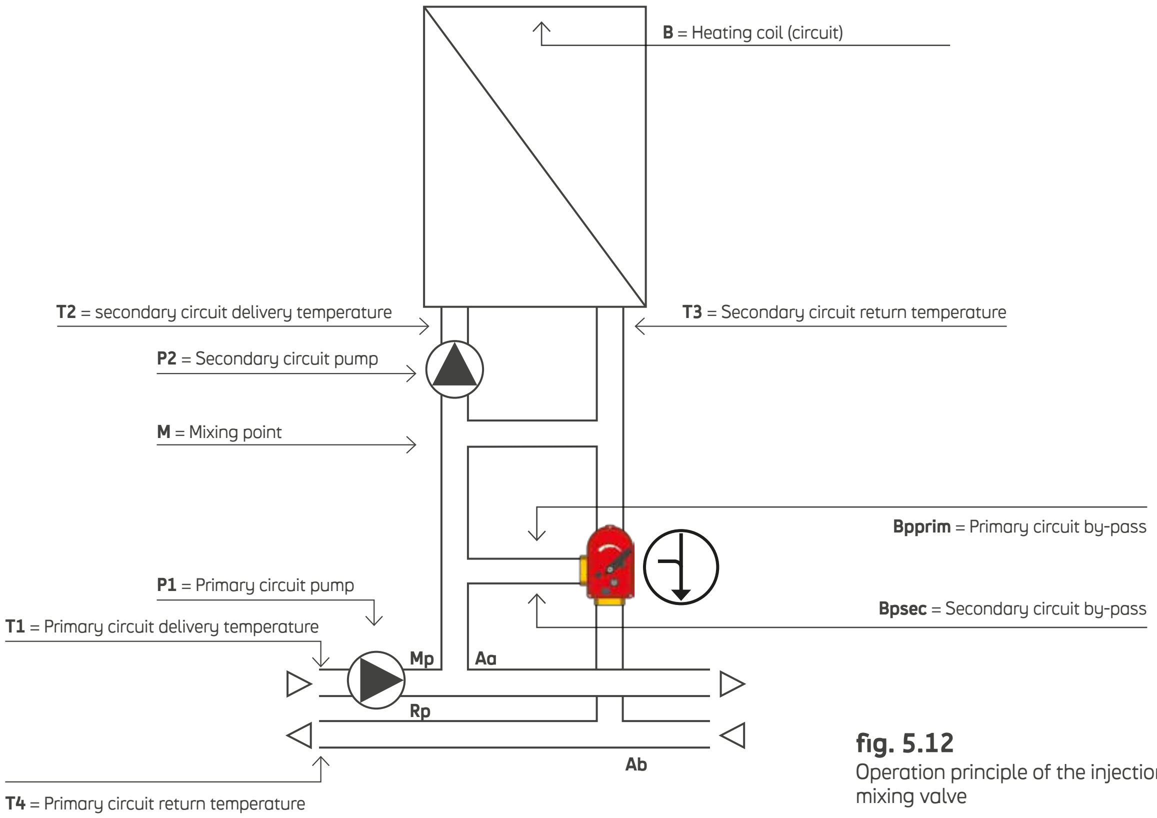


fig. 5.12
Operation principle of the injection circuit with mixing valve

If, based on the construction of the distribution manifold or primary distribution pipes, there is a differential pressure between point AA and point AB at the derivation point towards the coil, it is possible to exploit this situation to overcome the control valve resistance, as shown in fig. 5.12.

When the valve is closed, secondary pump P_2 pushes the water flow from point M through the secondary circuit delivery, the coil, the secondary circuit return, the secondary by-pass and then towards mixing point M.

Pump P_1 pushes the primary flow required for this unit from point AA towards connection point AB through the main by-pass and the control valve. If the control valve opens, part of the flow, based on the position, is injected at point M in the secondary circuit, while the same quantity will flow out of the secondary circuit from the return and the control valve.

The valve resistance is thus overcome by the primary pump in the injection circuit.

As the secondary circuit is always closed on itself, it is possible to have different water flows circulate inside two different circuits independently from the control valve, and to work with different delivery temperatures, for example 110 ° C / 70 ° C in the primary circuit and 90 ° C / 70 ° C in the secondary.

As for the control valve dimension, the nominal flow-rate is calculated based on the equation below:

$$\textbf{Water nominal flow-rate: } V\left[\frac{l}{s}\right] = \frac{Q[kW]}{4.19\ (t_2 - t_3)}$$

The differential pressure available between point AA and point AB must also be considered.

The flow circulating from point AA towards the primary by-pass and the one circulating from the control valve towards point AB are constant.

Pump 2 guarantees a constant flow in the secondary circuit.

Variable flow circuits required to size the regulation valve are thus always the ones between the primary and secondary by-pass (fig. 5.13).

In short, the resistance in these circuits is so little that it can be ignored when sizing the control valve.

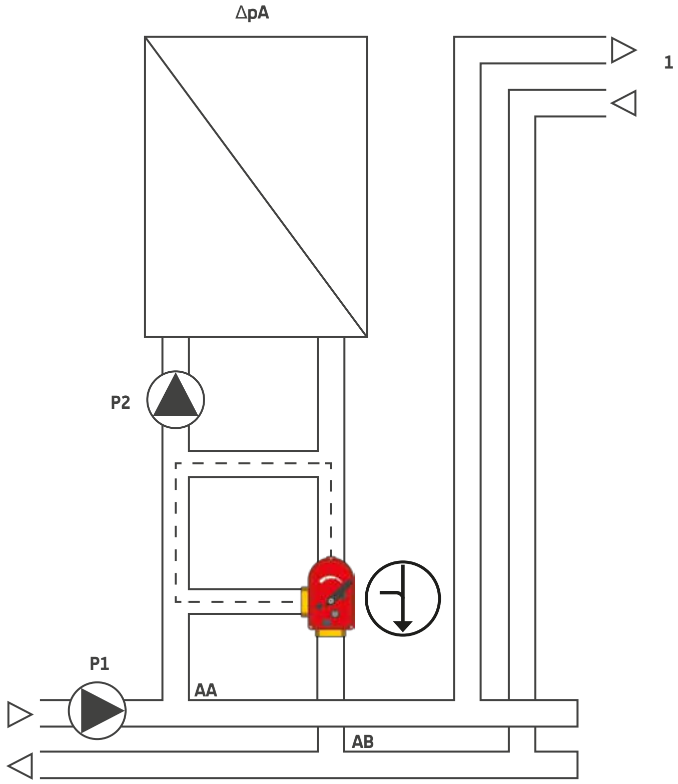


fig. 5.13
Variable flow sections of an injection circuit
1 = Pipes towards other terminal units
AA = Delivery connection
AB = Return connection

As for the mixing circuit, the pressure drop on the secondary circuit must be compatible with the pump head.

For this reason, a balancing valve D2 must be installed in the constant flow pipes.

The pressure drop of the primary circuit from point AA towards point M and from point N towards point AB, passing through the control valve, must be equal to the differential pressure available between point AA and point AB for pipes connected to other terminal units.

If this is not achieved, the water flow in one of the pipes would be greater than expected and the other circuits would not receive a sufficient flow.

Balancing valve D1 balances such pressure drop (fig. 5.14).

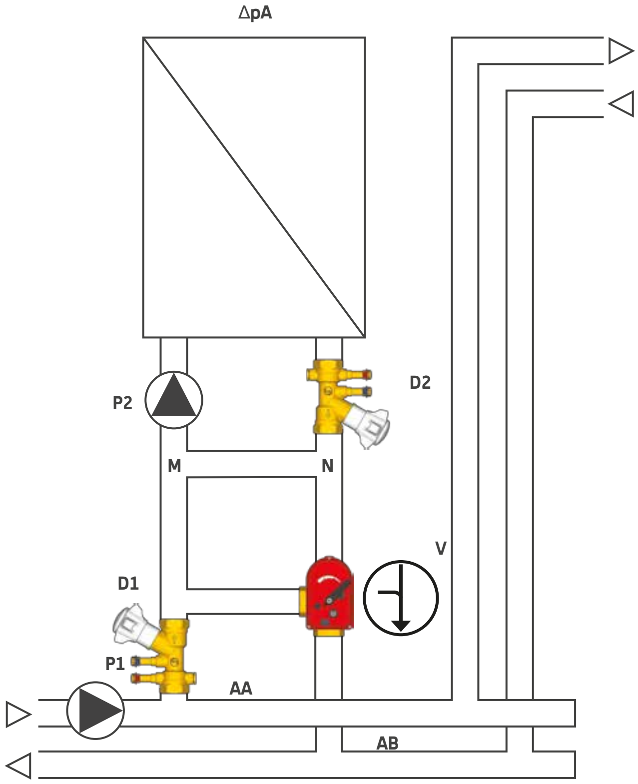


fig. 5.14
Balancing valves in an injection circuit
D_1 = Primary balancing valve
D_2 = Secondary balancing valve

The injection circuit is used when the coil is installed on the circuit parallel to the supply pipes, providing that the differential pressure available at connection point is sufficient to overcome the valve resistance.

From a general standpoint, great care must be paid to the distance between the two by-pass pipes when planning injection circuits.

The minimum distance between the primary and secondary by-pass must be 10 diameters, with a minimum of 50 cm (see fig. 5.15).

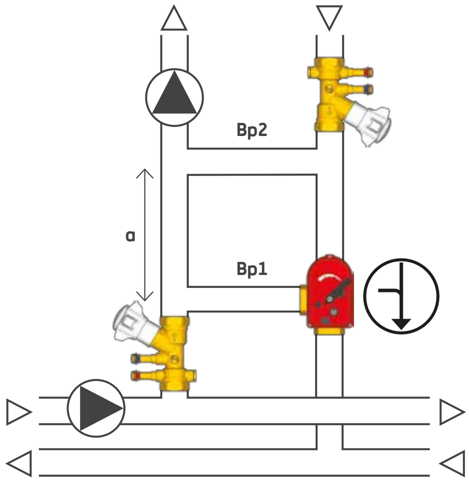


fig. 5.15
Distance between two by-pass of an injection circuit
a=Min. distance
Bp=By-pass

As the differential pressure between the primary delivery and return is relatively high, the valve can be selected with a diameter smaller than the secondary pipe. Undesired circulation may occur when the heating circuit is off, if we use pipes of the same size to connect the primary and secondary circuits, and for the secondary circuit.

This special condition may occur especially if the valve by-pass has the same nominal diameter of these ones.

Water starts to flow slowly from point D1 towards the upper part. However, the speed is higher inside the by-pass because of the smaller section, so the circulation will be the one shown in fig. 5.16.

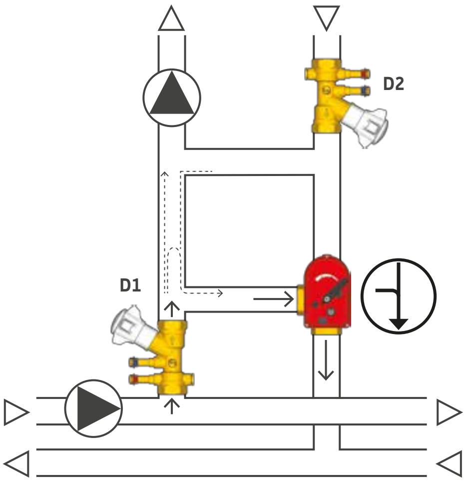


fig. 5.16
Undesired circulation

This may cause such an inductive effect that the connection water is sucked towards the secondary by-pass and then replaced by hot water from the primary circuit.

This problem must be solved by sizing accurately the connection between the primary and secondary circuits, as shown in fig. 5.17.

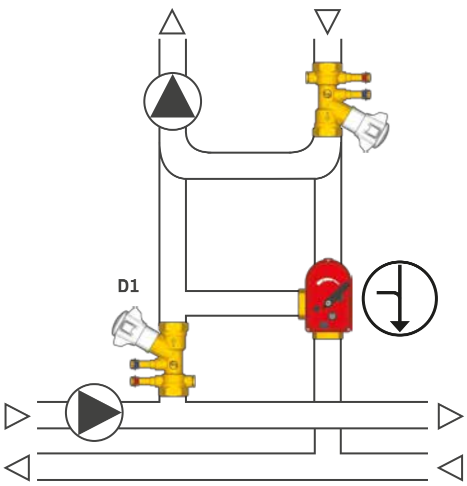


fig. 5.17
How to prevent undesired circulation in pipes with a smaller diameter

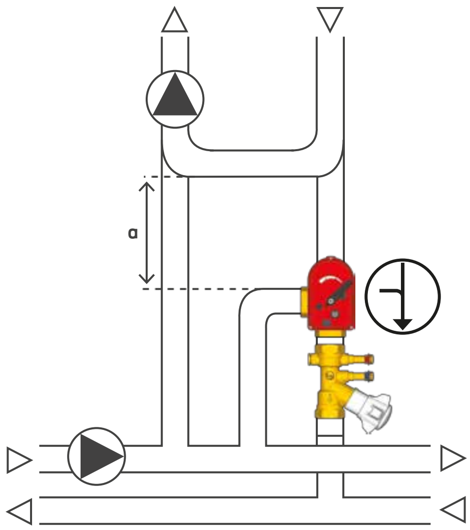


fig. 5.18
Installation example of an injection circuit in limited space.
A = Any distance

Fig. 5.18 shows an example that enables to reduce dimensions. This is very useful when only a limited space is available.

In the same way, injection circuits can be achieved using a two-way control valve, as shown in fig. 5.19.

This creates variable flows in the primary circuits that may generate pressure fluctuations in the primary circuit itself, in addition to unstable temperatures in the correlated controllers.

It is thus necessary to install a differential pressure controller on the primary circuit.

Control valves must be sized with great care.

The pressure drop must be suitable as strictly possible to the available pressure drop as balancing valves cannot be installed in the primary circuit.

In fact, these may not be effective in the pipe section with variable flow, thus making the typical diagram of the control device worse.

This circuit requires a device highly performing in terms of accuracy and controllable minimum flow.

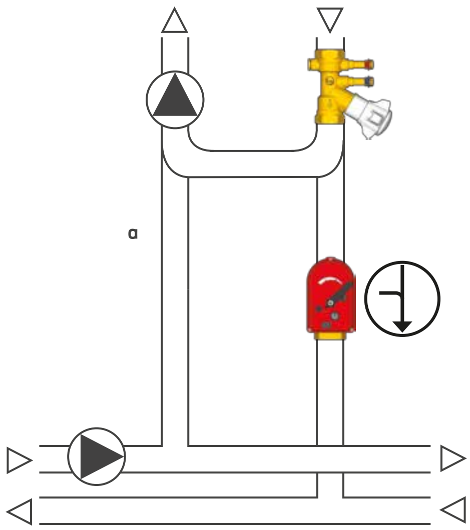


fig. 5.19

NOTE

HEATING - COOLING HOT WATER

Heating systems

TWO PIPE systems

Systems with thermostatic heads

Systems without thermostatic heads

Without presetting

Recommended:
R401+R470
R206C+R206B

With presetting

Recommended:
R401PTG+R470
R206C+R206B

DB series with dynamic balancing

Recommended:
R401 DB SERIES
R470

ONE PIPE systems

Systems with thermostatic heads

Systems without thermostatic heads

Possible upgrade to thermostatic heads

Recommended:
R470+R206C+R206B

Not possible upgrade to thermostatic heads

Acceptable:
R206B

Recommended:
R206A

Acceptable:
R206B

Recommended:
R206A

Acceptable:
R206B

HEATING - COOLING HOT WATER

Cooling systems

VARIABLE FLOW

Differential pressure control

Terminals without on off actuator

Just differential pressure control:

Recommended: R206C+R206B

Terminals without on off actuator

Differential pressure control + flow control on single branches:

Recommended: R206C+R206B

Dynamic flow control with actuator

Control of the flow and automatic adjusting

Recommended: R206AM +Actuator

Hot sanitary water systems

CONSTANT FLOW

Dynamic balancing

Recommended:
R206A

Recommended:
R206AM +Actuator

Static balancing

Recommended:
R206B

Domestic hot water recirculation

Recommended:
R158C

Acceptable:
Clock managing
recirculation pump

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