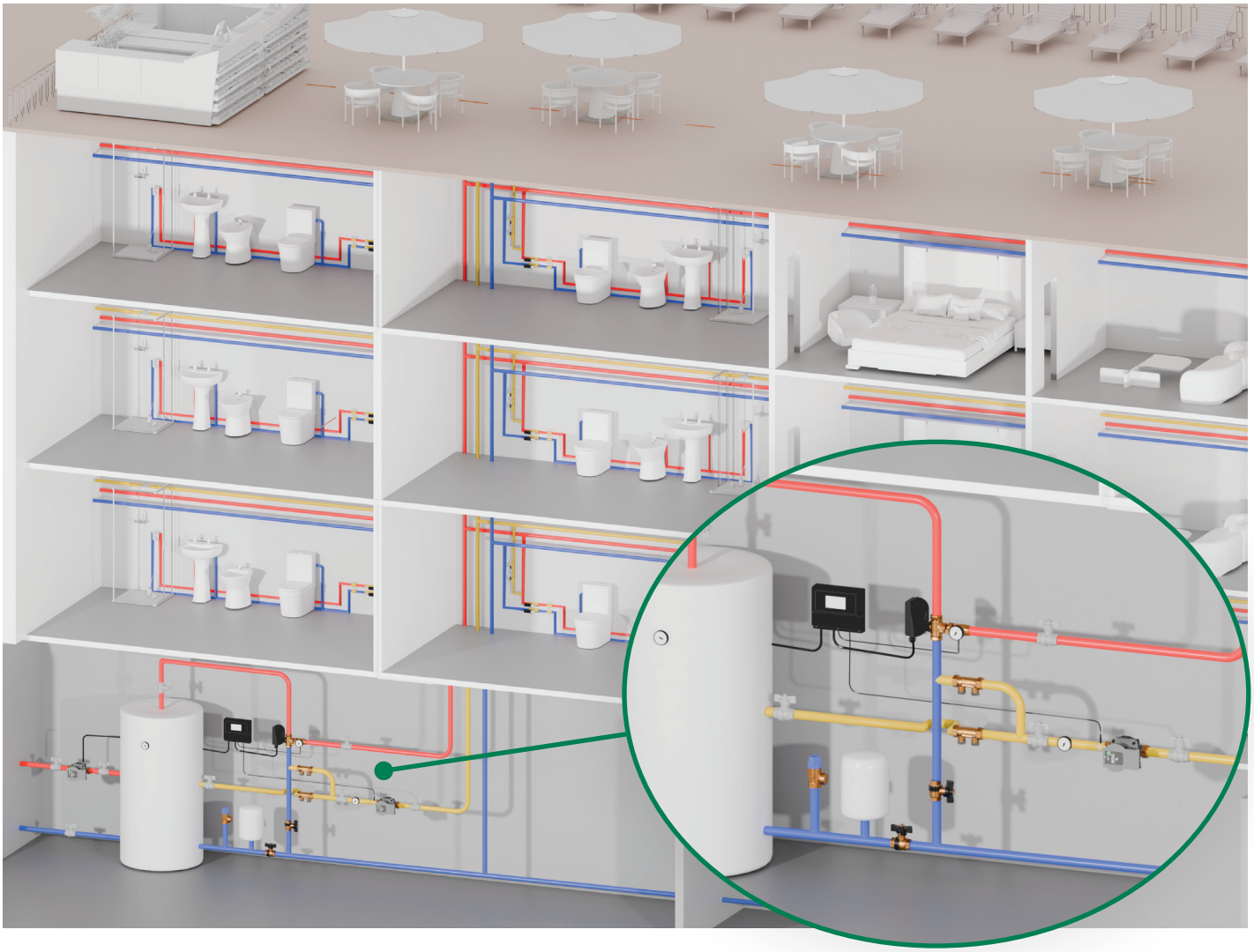
ENERGY EFFICIENCY COMPARISON BETWEEN VARIOUS DHW TEMPERATURE MANAGEMENT SYSTEMS

CALEFFI Hydronic Solutions



In international residential, commercial and hospitality buildings, the energy consumption required for the production and distribution of domestic hot water (DHW) is far from insignificant. The distribution networks are often extensive, serving several floors and complex systems (hotels, residential towers, wellness centres, gyms and hospitals) and must ensure three requirements are met simultaneously:

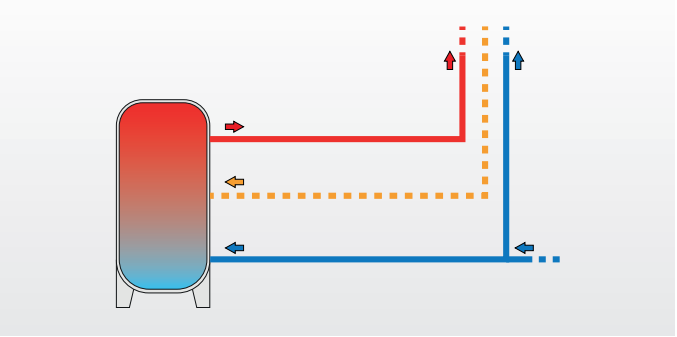
- thermal comfort, by guaranteeing water is available at the requested temperature within the desired time period, across all floors of the building;
- safety in terms of domestic water and hygiene, in particular preventing the risk of Legionella proliferating within the domestic water networks and the risk of users scalding themselves;
- energy efficiency and sustainability, with a reduction in network heat dispersion, fuel consumption and running costs.

This Technical Focus compares various alternative strategies for the thermal management of DHW distribution systems.

SYSTEMS WITH AND WITHOUT CENTRALISED WATER MIXING

Without mixing

The domestic hot water is sent to the distribution system at high temperature, directly from the storage outlet. The high temperature is necessary to guarantee safety in terms of hygiene, but this translates into low energy efficiency and a high risk of scalding for the user. An excessively high water temperature extends mixing times at the draw-off point, leading to higher water consumption.



Benefits

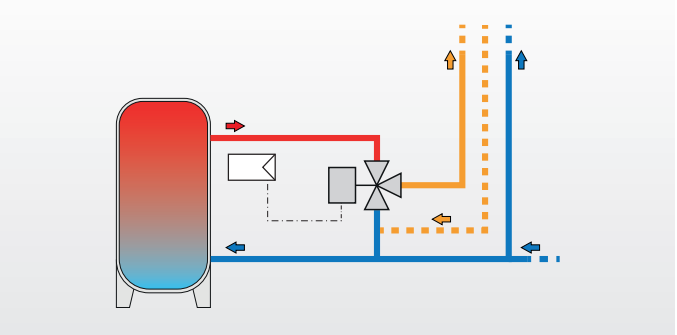
- Simple setup within the central heating system.

Disadvantages

- Low energy efficiency (high heat dispersion).
- Risk of scalding and greater wear on pipes.
- Greater water wastage associated with each user.

With mixing

The domestic hot water is mixed downstream of the storage tank so that it can be sent to the distribution system at the desired temperature. This increases the energy efficiency of the system, reduces water wastage caused by drawing off water at a temperature approaching the usage value and consequently provides greater anti-scald safety for users.
Hygiene safety can be guaranteed by periodically increasing the DHW mixing temperature.



Benefits

- Increased energy efficiency (lower heat dispersion).
- Greater anti-scald safety and less wear on pipes.
- Less water wastage associated with each user.

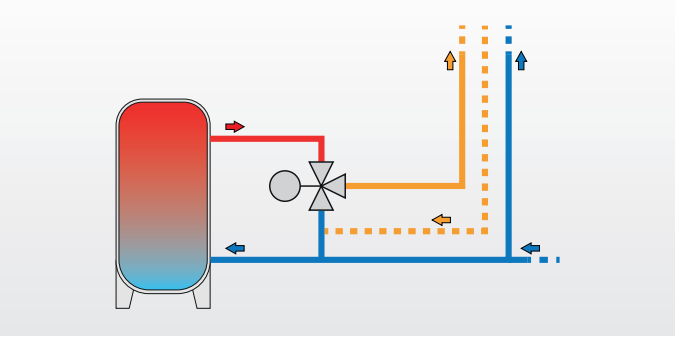
Disadvantages

- High initial cost.

TYPES OF WATER MIXING

Thermostatic water mixing

In this setup, domestic hot water is stored at a temperature that is sufficient to ensure hygiene safety. A thermostatic mixing valve downstream of the storage tank sends water to the distribution system at the desired temperature. However, network thermal disinfection treatment procedures cannot be carried out with this setup unless a by-pass line is used.



Benefits

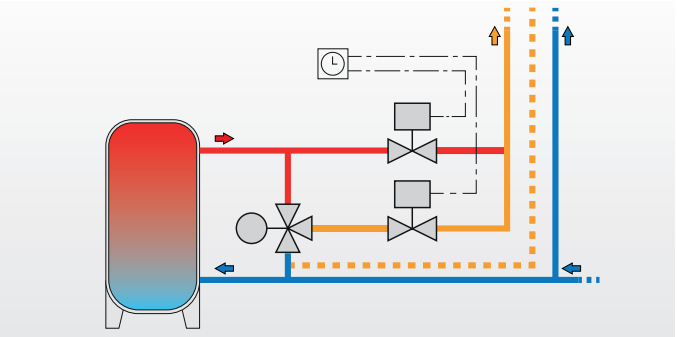
- Distribution at the desired temperature.
- Simple system (does not require electronics).

Disadvantages

- Fixed mixing temperature.
- Thermal disinfection treatment procedures cannot be performed.

Thermostatic water mixing with by-pass

This setup keeps the water in the network at the desired temperature, thanks to a thermostatic mixing valve downstream of the storage tank. Compared with standard systems, it includes a by-pass line which means the mixing valve can be temporarily isolated so that high-temperature water coming directly from the storage tank can be sent to the distribution system, allowing thermal disinfection treatments to be carried out.



Benefits

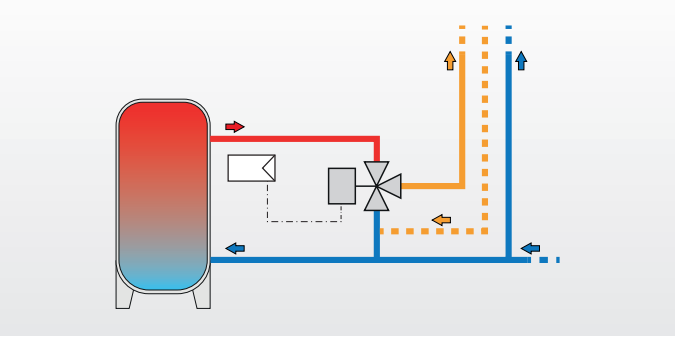
- Distribution at the desired temperature.
- Allows regular thermal disinfection treatments.

Disadvantages

- Disinfection treatment activation requires a dedicated external control system.
- Non-native thermostatic mixing valve disinfection function.

Water mixing with an electronic valve

Using an electronic mixing valve (LEGIOMIX) allows water to be distributed at the desired temperature in the network during routine system operating phases. The system guarantees hygiene safety via the option of setting regular thermal disinfection treatments on the electronic mixing valve.



Benefits

- Distribution at the desired temperature.
- Programmable regular thermal disinfection treatments.
- Parameters recorded and data available remotely.

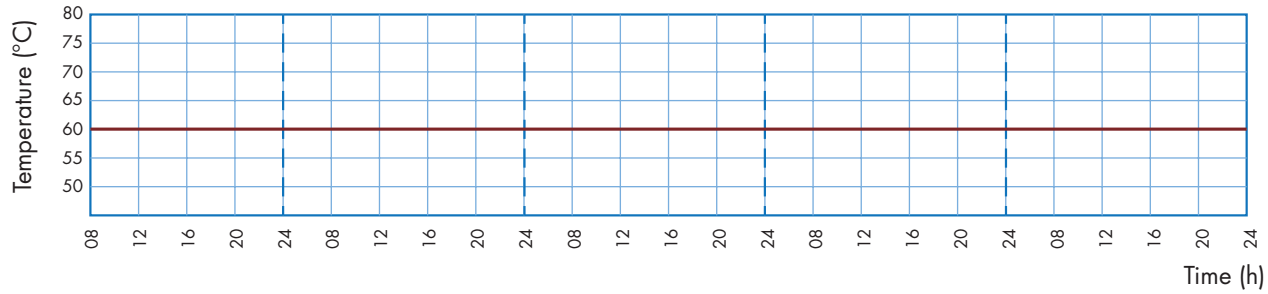
Disadvantages

- High initial cost.

TYPES OF OPERATION

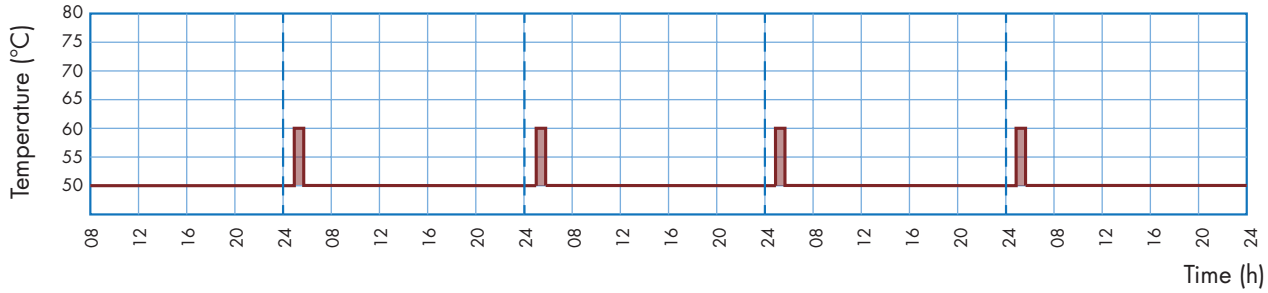
Continuous operation at high temperature

The system maintains a constant temperature 24 hours a day, sending high-temperature DHW to the distribution system. This type of operation leads to high heat dispersion in the pipes, which translates into low energy efficiency of the system.



Operation with programmed thermal disinfection cycles

The system is able to modulate the temperature according to requirements, maintaining a lower value during normal operating phases and increasing it only during programmed thermal disinfection periods. This type of operation guarantees lower heat dispersion in the pipes and therefore greater energy efficiency of the system.



Heat dispersion in pipes

The formula governing linear heat dispersion in pipes is as follows:

$$q = \frac{\Pi\,(T_1 - T_2)}{\frac{1}{\alpha_1 \cdot d_1} + \frac{1}{2 \cdot \lambda_1} \cdot \ln\frac{d_2}{d_1} + \frac{1}{2 \cdot \lambda_2} \cdot \ln\frac{d_3}{d_2} + \frac{1}{\alpha_2 \cdot d_3}} \quad [W/m]$$

where:

α_1 = internal surf. unitary inductance [W/(m² · °C)]
α_2 = external surf. unitary inductance [W/(m² · °C)]
λ_1 = pipe material conductivity [W/(m · °C)]
λ_2 = insulating material conductivity [W/(m · °C)]
T_1 = water temperature [°C]
T_2 = room temperature [°C]
d_1 = internal diameter of the pipe [m]
d_2 = external diameter of the pipe [m]
d_3 = external diameter of the insulated pipe [m]

The heat dispersion of a building can be worked out by multiplying the linear heat dispersion q [W/m] and the total length of the pipes l [m].

$$Q = q \cdot l \quad [W]$$

PRACTICAL CASES

To quantify the energy benefit of operation with thermal disinfection cycles in relation to continuous operation at high temperature, three practical cases have been analysed: a shopping centre, a hospitality venue and a hospital. Each case lists the dimension-related details of the DHW distribution system, the size of the LEGIOMIX electronic mixing valve selected and the calculation data used to simulate each case.

TYPE	SHOPPING CENTRE	HOTELS	HOSPITAL
Number of users	500 shops	300 rooms	400 rooms
Length of pipes	5.000 m	8.000 m	16.000 m
Design flow rate	25 m^3/h	30 m^3/h	70 m^3/h
LEGIOMIX size	DN 40	DN 50	DN 65
Minimum recirculation flow rate	1,5 m^3/h	2,0 m^3/h	4,0 m^3/h

CALCULATION DATA				
T_1 (continuous operation at high temperature)		55 °C	60 °C	65 °C
T_1 (operation with disinfection cycles)	**normal phase**	50 °C	50 °C	55 °C
	disinfection phase	60 °C	70 °C	70 °C
Thermal disinfection		1 h/day	1 h/day	2 h/day

The calculations were performed assuming a temperature T_2 of 25 °C and using well-insulated pipes.

RESULTS			
Heat dispersion (continuous operation at high temperature)	320.043 kWh/year	597.414 kWh/year	1.365.518 kWh/year
Heat dispersion (operation with disinfection cycles)	271.148 kWh/year	440.948 kWh/year	1.066.810 kWh/year
Energy saving	48.895 kWh/year	156.466 kWh/year	298.708 kWh/year
Percentage saving	**15 %**	**26 %**	**22 %**

The results highlight how operation with disinfection cycles allows a 15 % to 26 % reduction in heat loss in comparison with continuous operation at high temperature, with energy savings that grow in terms of absolute value as the network increases in size: from around 50.000 kWh/year for the shopping centre example to around 300.000 kWh/year in the case of the hospital with 16.000 m of pipes.
The percentage saving largely remains constant as the size of the system changes: the advantage of electronic mixing is significant even in smaller-scale applications. These energy-related benefits are joined by the advantages of lower water consumption.

CONCLUDING REMARKS

Financial and energy-related benefits

The three practical cases confirm that system operation with disinfection cycles plus water mixing using a LEGIOMIX electronic valve leads to a consistent energy saving in terms of heat dispersion, which then translates into a financial saving.

Advantages in terms of safety

The thermal disinfection treatments carried out using the LEGIOMIX electronic valve can be tracked and documented: the digital regulator records every implementation along with the date, time, temperature values reached and duration. This is objective evidence for the Legionnaire's disease self-checking register and makes it easier to comply with international guidelines.

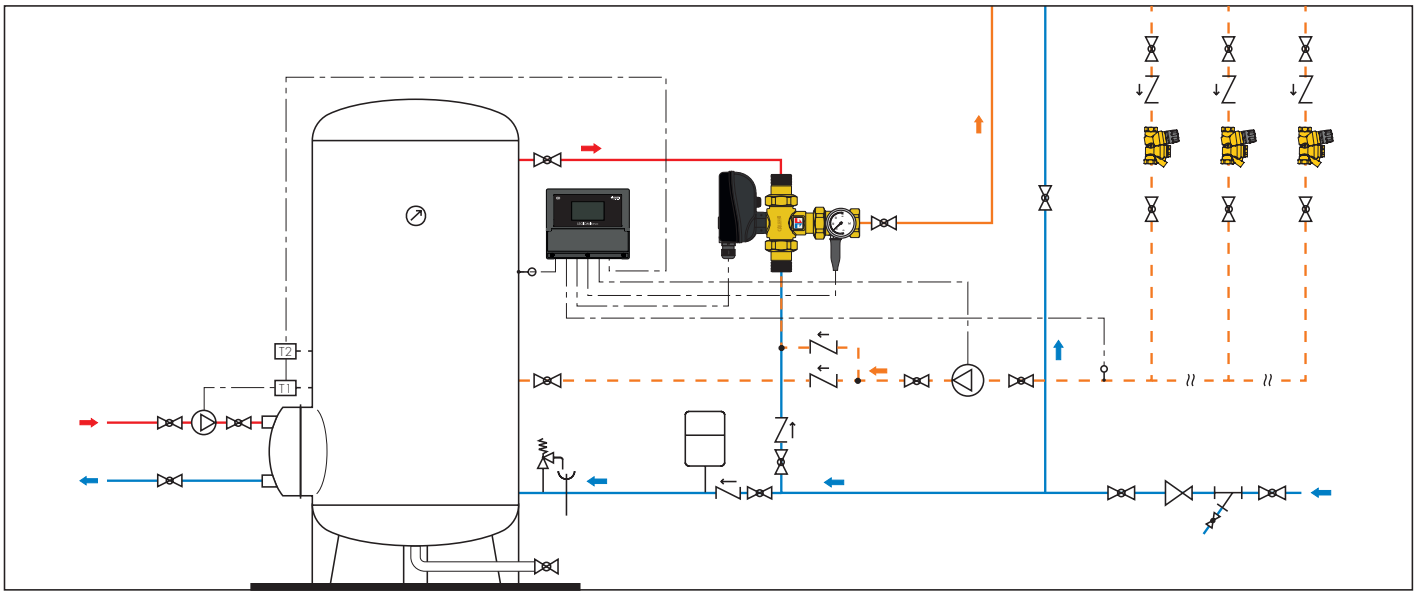
Plumbing and comfort benefit

Through water mixing in the central heating system, the water gets to the end user at a stable, controlled temperature value close to the usage temperature. As a result, the user quickly achieves the desired temperature without having to spend too long adjusting the tap, thereby significantly reducing water wastage.

Recirculation circuit balancing

In large systems with centralised water mixing, it is essential to balance the recirculation circuits. Series 116 thermostatic regulators automatically adjust the flow rate according to temperature, ensuring that each section is kept at the correct temperature value. This happens both during routine operating phases and during the thermal disinfection cycles programmed by the electronic mixing valve.
In systems with several recirculation branches, hydraulic balancing is the essential finishing touch in the design: without it, temperature stability at the user points and thermal disinfection efficiency cannot be guaranteed.

Application diagram



REFERENCE DOCUMENTATION:
TECH. BROCH. 01428
TECH. BROCH. 01086
TECH. BROCH. 01325

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