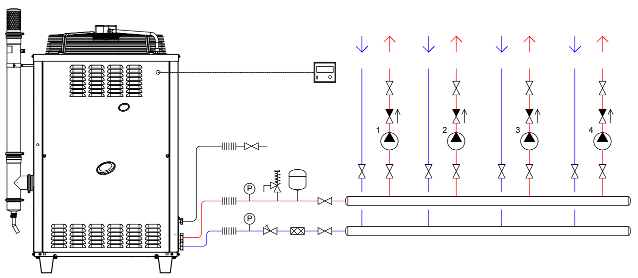
1 FLOW BALANCING

After the sizing of the generating system and the choice of distribution terminals has been completed, it should be carefully evaluated that the system currently designed does not present any interference between the plumbing circuits such as to alter the setpoint in comparison with the regulation systems, resulting in reduced comfort, efficiency and even the life of the components of the system.
Referring to the system shown in Figure 1.1 *p. 1* the following occurs:

- With the system switched off, the pressures of the delivery manifold and return manifold will be identical, so the Δp between the manifolds will be zero.
- When the first delivery is activated, a pressure difference will be created, equal to the pressure drop across the generator. Check valves are essential to prevent the risk of reverse flow on inactive deliveries.
- The activation of subsequent deliveries leads to an increase in water flow on the generator and consequently in pressure drops, with the risk of these becoming so high that the delivery pumps cannot operate properly.

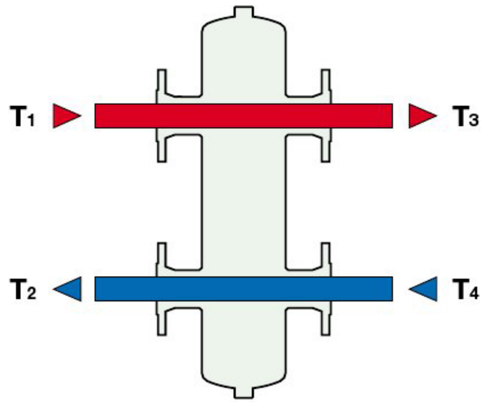
Figure 1.1 *System without an hydraulic separator*



In general these systems characterized by strong imbalances in the flow rates are unlikely to work under the design conditions and therefore to ensure efficiency and comfort.
The hydraulic separator, which was discussed in Section C01.07, is the component usually used to prevent interference between water circuits, precisely because it allows constant operation with zero Δp between manifolds.
However, careful balancing of the water flow between the primary and the secondary must be carefully considered, as inadequate balancing can trigger flow mixing phenomena, resulting in temperature changes.
In the optimal case the flow rates are perfectly balanced (see Figure 1.2 *p. 1*) and the primary and secondary temperatures are identical (T1 = T3 and T2 = T4).
Mixing becomes influential when the difference between primary and secondary flow exceeds 10%.
In this case two scenarios may occur:

- primary flow lower than secondary flow (recirculation on secondary)
- primary flow higher than secondary flow (recirculation on primary)

Figure 1.2 *Balanced separator*

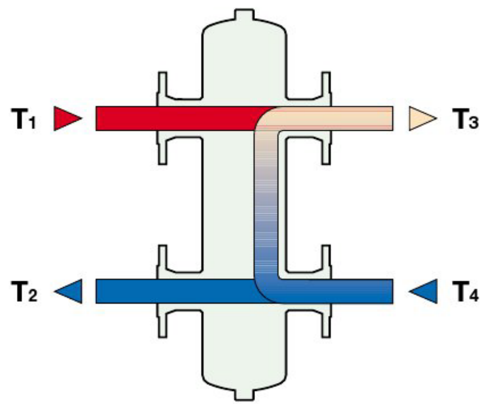


T1	Primary delivery temperature
T2	Primary return temperature
T3	Secondary delivery temperature
T3	Secondary return temperature

1.1 PRIMARY FLOW LOWER THAN SECONDARY FLOW

In this case, as shown in Figure 1.3 *p. 1*, the primary flow rate is lower than that of the secondary and there is partial recirculation of the secondary return flow, with consequent lowering of the delivery temperature T3 to the secondary as a result of mixing.

Figure 1.3 *Primary flow rate lower than secondary flow rate*



T1	Primary delivery temperature
T2	Primary return temperature
T3	Secondary delivery temperature
T3	Secondary return temperature

In this scenario, therefore:

- the secondary outlet temperature T3 is lower than the primary outlet temperature T1
- the inlet temperature of primary T2 and secondary T4 coincide

These are the possible consequences:

- Decreased generation system efficiency due to the higher temperature required to compensate for mixing.
- Potential reduction in comfort for consumers, linked to the lower supply temperature of emission devices, which therefore reduces (even significantly) heat exchange.

This case typically occurs when the secondary circuit works with

a thermal leap lower than the primary circuit.
In the worst case, there could be a case where the GAHP appliances operate at maximum temperature but the served consumers still feel cold because of inefficient heat exchange due to the drop in temperature.
Reduced heat exchange could easily also lead to a reduction in the thermal leap on the secondary side, thus raising the temperature on the return side, and ultimately to the shutdown of the appliances due to exceeded inlet operational limit.
Table 1.1 *p. 2* shows the maximum temperatures that can be reached by the Robur appliances.

Table 1.1 *Heating temperature limits*

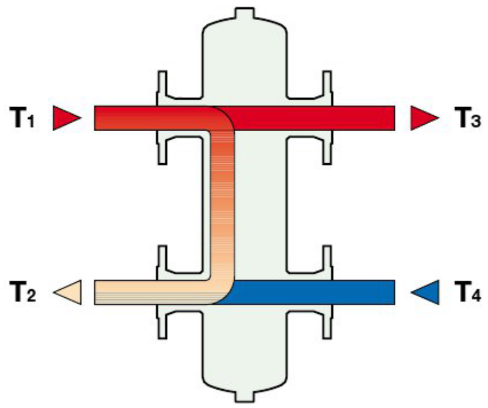
			GAHP A	GAHP-AR	GAHP GS/WS	AY
Heating operation						
Hot water outlet temperature	maximum for heating	°C	65	-	65	-
	maximum	°C	-	60	-	88
Hot water inlet temperature	maximum for heating	°C	55	-	55	-
	maximum	°C	-	50	-	-

To calculate the magnitude of the drop in outlet temperature to the secondary, it is sufficient to determine the thermal leap Δt on the secondary, based on the flow rate of the secondary and the heat output generated on the primary, according to the formula:
$Q = m \cdot cp \cdot \Delta t$
where Q is the primary heat output in [kW], m is the secondary water flow in [kg/s], cp is the specific heat of water in [kJ/kg ·°C] and Δt is the secondary thermal leap in [°C].
This thermal leap is added to the return temperature T4 of the secondary to determine the delivery temperature T3 of the secondary.
An absolutely similar but specular discussion can be made for operation in cooling mode, where the room for manoeuvre on temperatures is further restricted on the one hand by the need to have temperatures low enough to carry out dehumidification, and on the other hand by the minimum outlet temperature of the Robur appliances, which, except for specific versions for process cooling, cannot fall below 3 °C.

1.2 PRIMARY FLOW HIGHER THAN SECONDARY FLOW

In this case, as shown in Figure 1.4 *p. 2*, the primary flow rate is higher than that of the secondary and there is partial recirculation of the primary return flow, with a consequent increase in the return temperature T2 of primary due to mixing.

Figure 1.4 *Primary flow rate higher than secondary flow rate*



T1	Primary delivery temperature
T2	Primary return temperature
T3	Secondary delivery temperature
T3	Secondary return temperature

In this scenario, therefore:
- the secondary outlet temperature T3 is equal to the primary outlet temperature T1
- the primary inlet temperature T2 is higher than the secondary inlet temperature T4

These are the possible consequences:
- Significant decrease in efficiency of the generation system due to the increase in the primary return temperature.
- Potential blocking of Robur appliances by exceeded operational limit on inlet.
- Severe repercussions on comfort should the units exceeded operational limits.

This case typically occurs when the secondary circuit works with a thermal leap higher than the primary circuit.
This entails the risk of very quickly reaching the limit temperature condition on the inlet (Table 1.1 *p. 2*) and thus leading to the switching off of the appliances, despite the fact that there is still a service request from the system, with serious repercussions on the comfort of the consumers.
To calculate the magnitude of the increase in the primary return temperature, it is sufficient to determine the thermal leap Δt on the primary, based on the primary flow rate and the heat demand of the secondary, according to the formula:
$Q = m \cdot cp \cdot \Delta t$
Where Q is the power demand by the secondary in [kW], m is the water flow of the primary in [kg/s], cp is the specific heat of water in [kJ/kg ·°C] and Δt is the primary thermal leap in [°C].
This thermal leap is subtracted from the primary delivery temperature T1 to determine the primary return temperature T2.
An absolutely similar but specular discussion can be made for operation in cooling mode.

2 HOW TO MAKE BALANCING

The guidelines to ensure that the system is properly balanced can be summarized as follows:
- Check the nominal water flow of the Robur appliances on the technical data tables (Section B for the specific appliance).

- Please note that in the case of Link equipped with independent water pumps, the water flow on the primary varies substantially in relation to the number of actually active modules.
- Please note that the nominal thermal leap for heating service is approximately twice that for cooling service.
- Check that balancing is carried out for each of the services required by the system (heating, cooling, DHW).
- Co-ordinate the operation between the distribution circuits and the generation system.