

Guidance for balancing of hydraulic heat and cooling systems

1 THE NEED FOR BALANCING

1.1 Without balancing, it is not likely that water will flow as the design engineer intended

Calculating head losses, water flows, pipe sizes and pressure drops is not an exact science. The design engineer can only use approximations. He will probably oversize “Just to be sure”.

The contractor with the lowest bid gets the order. He will economise and replace with lower cost items wherever possible to maximize profitability.

The system may be started up simply by checking the pump pressure and leakages.

But this is not what the designer intended or the customer will pay for.

Without balancing, all loops that are closer to the pump will get too high pressure and also too much water. They will “steal” water from the loop further away, which in turn will get too little water.

The customer wants to have evidence that design flow rates are achieved to all areas.

For this purpose it is essential to measure and adjust water flows in all parts of the building and satisfy the customer that they correspond to specification. Only then should the customer accept hand over of the system.

1.2 A well balancing system performs better in many ways

The system is optimized and can supply the correct heating or cooling capacity in all rooms, allowing the thermostats to work properly to maintain room comfort at all load conditions.

Energy is saved because temperatures are even throughout the building. When cooling no rooms are too warm and the need to compensate by lowering the water temperature is avoided. A similar argument applies for heating. The purpose of the installation is achieved. A

comfortable and efficient indoor climate is created for working or living. It is well documented that too high or too low temperature will seriously affect mental and bodily functions, apart from being just uncomfortable.

In the work place this can be translated into large cost savings. A higher productivity of only a few percent will pay for a well functioning heating or cooling system many times a year.

Finally, the designer/consultant will not get involved in excessive call back.

2 HOW TO DESIGN A SYSTEM FOR PROPORTIONAL BALANCING

2.1 System design for proportional balancing

The pipe-work should be laid out in a systematic way to enable balancing to be carried out following a rational method, see fig. 1:

- a) The chiller or boiler is the production unit together with the circulation pumps.
- b) The water is supplied from the pumps in horizontal headers.
- c) From the header vertical risers lead to the floors.
- d) On each floor water is distributed via horizontal branches.
- e) In the rooms, cooling and heating is supplied via fan coil units, baffles, cold ceilings or radiators. These units are called terminal units.

2.2 Where to install balancing valves

The balancing procedure requires measuring and adjustment of the flow at:

- 1) Each terminal unit on a branch
- 2) Each branch on a riser
- 3) Each riser on a header
- 4) Each header from the pump
- 5) The pump

The name “proportional” balancing implies that

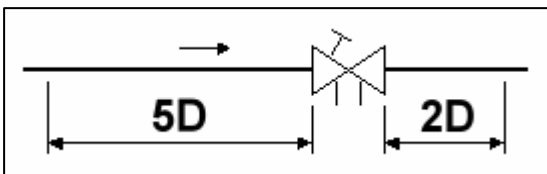
water flows are first adjusted to the same proportion of the correct value in all units, branches, etc. –After this, the total flow can be adjusted to the correct value at the pump. The flow will then automatically assume the correct value in all parts of the system (units, branches, risers and headers).

The simply reason is that the resistance has been adjusted to the correct proportion between all waterways in the system.

To enable the flow to be measured and adjusted following this method, some means of balancing must be installed at all terminal units, branches, risers, headers and the pump.

If big pressure variations are expected because of varying loads, the pump should instead be equipped with an automatic speed controller which maintain constant pressure in the system regardless of load variations.

Balancing valve should be installed with a straight length of pipe up (5D) and down (2D) stream of the valve. 10D is recommended for pumps.



3 PROPORTIONAL BALANCING

The method in outline: All units, branches, risers and headers are balanced to the same proportion, or ratio, of correct flow. Then, by adjusting the total flow at the pump, all units will get the correct flow.

Advantage: Precisously adjusted units will not need to be readjusted. No back tracking is required.

Disadvantage: Time consuming, but necessary.

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- 3.4 Balancing risers and headers
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- 3.6 Checking, report and approval

3.1 Preparation

- A. Refer to the drawings of the plant and check that water flows are given for all units, branches, risers and the pump. Refer also to any calculated presetting. Two balancing instruments will be needed together with the flow charts for all valves.
- B. Check that balancing valves are installed where necessary and locate them in the actual installation. If preset values have been calculated, set them on all valves. If not, leave them fully open. Also ensure that the system has been adequately vented.
- C. Open all control and isolating valves. Check that strainers are cleaned after start-up. Check that the pump is installed as specified and running properly.
- D. Make rough flow tests in headers and risers. Adjust provisionally any serious imbalances and eliminate obvious problems.

3.2 Balancing units on a branch

Start with a branch on a riser with strong circulation near the pump and continue with branches further away from the pump. This will gradually push water into risers and branches with weak circulation further away from the pump.

On the selected first branch, balance the terminal units as follows:

- 1) Find the unit with the lowest %DFR (Design Flow Rate).

$$\%DFR = 100 \sqrt{P1/P2}$$

Where P1= Actual Pressure Drop
P2= Design Pressure Drop

If all units on the branch are of similar size and flow, it will most likely be the unit at the end of the branch.

If one or two units are bigger and require more flow than all the others, they should be checked first.

If in doubt, the %DFR of all units on the branch should be checked.

Calculate the lowest %DFR.

Example: Assuming BV-B in fig. 1. is the lowest unit with a 82%DFR then adjust the last unit on the branch, BV5 in the example, to the same %DFR as the lowest. If the last unit was the lowest, then just leave it fully open.

This valve is now the reference valve for the next BV to be balanced.

- 2) Leave the first instrument connected to the reference valve and connect the second instrument to the next valve upstream on the branch, BV4. adjust this BV to the same %DFR as the reference valve, BV5.

As BV4 is turned down, the flow through BV5 will increase slightly. BV4 only needs

to be turned down until the %DFR become the same in both. Both valves are now finally adjusted. Lock the settings.

- 3) Take the first instrument from BV5 and connect to BV3. Leave the second instrument BV4 which is now the reference valve. Adjust BV3 to the same %DFR as BV4 by turning down the valve. Again it will be noted that the flow in the reference valve BV4 will increase slightly. Turn down BV3 until the %DFR of BV3 and BV4 become the same. BV5 will follow BV4 as they are proportionally balanced. So there is no need to check back on BV5 again.
- 4) Continue to balance BV2 by taking the instrument from BV4 and using BV3 as reference. Follow the same procedure for BV1.

The branch is now ready and balanced to the same %DFR.

If required, the main BV for the branch can now be adjusted to the correct total flow, and all units on the branch will assume correct flows. This may be needed if the rooms on this floor are occupied, but the rest of the building is not yet ready. If not, do not touch this valve at this stage.

- 5) Now balance the units on all other branches on the riser following the same procedure as above.(steps 1-4 above).

3.3 Balancing branches on a riser

Now balance the branches on the riser following the same procedure. Find the branch with the lowest %DFR. Turn down the BV on the last branch to get the same %DFR as the lowest. This is now the reference BV for the next branch to be balanced.

Continue to balance the branches toward the pump using the previous branch as reference, until all branches on the riser have the same %DFR.

If the customer wants to use this part of the building, this riser can now be adjusted to the correct total flow using the main BV for the riser. If not, leave the balancing of the riser to a later stage.

3.4 Balancing risers and headers

Repeat the above procedures for all risers. Finally balance the risers on the header following the same procedure. The whole system now has the same %DFR. Some checking and fine tuning may be required to insure a perfect result.

3.5 Adjusting total flow at the pump

Finally check the BV in the pump main and adjust to 100-105%DFR.

3.6 Checking, report and approval

After the balancing procedure has been completed, including fine tuning, sample testing can be made in the presence of the customer or commissioning engineer.

All balancing units should now be locked and the settings documented in the commissioning schedule.

4 Commissioning Requirements

The requirements are as followings:

- 1) A schematic diagram of the system with design flow rates.
- 2) Flow charts for balancing valves.
- 3) Flow chart for pumps.
- 4) Two manometers scaled 1 to 5 Kpa are required for balancing. One is used for the valve being balanced and the other for the index valve. For commissioning signals in excess of 5 kPa and for direct read out of flow rates one universal balancing instrument containing Progressive data may be used.

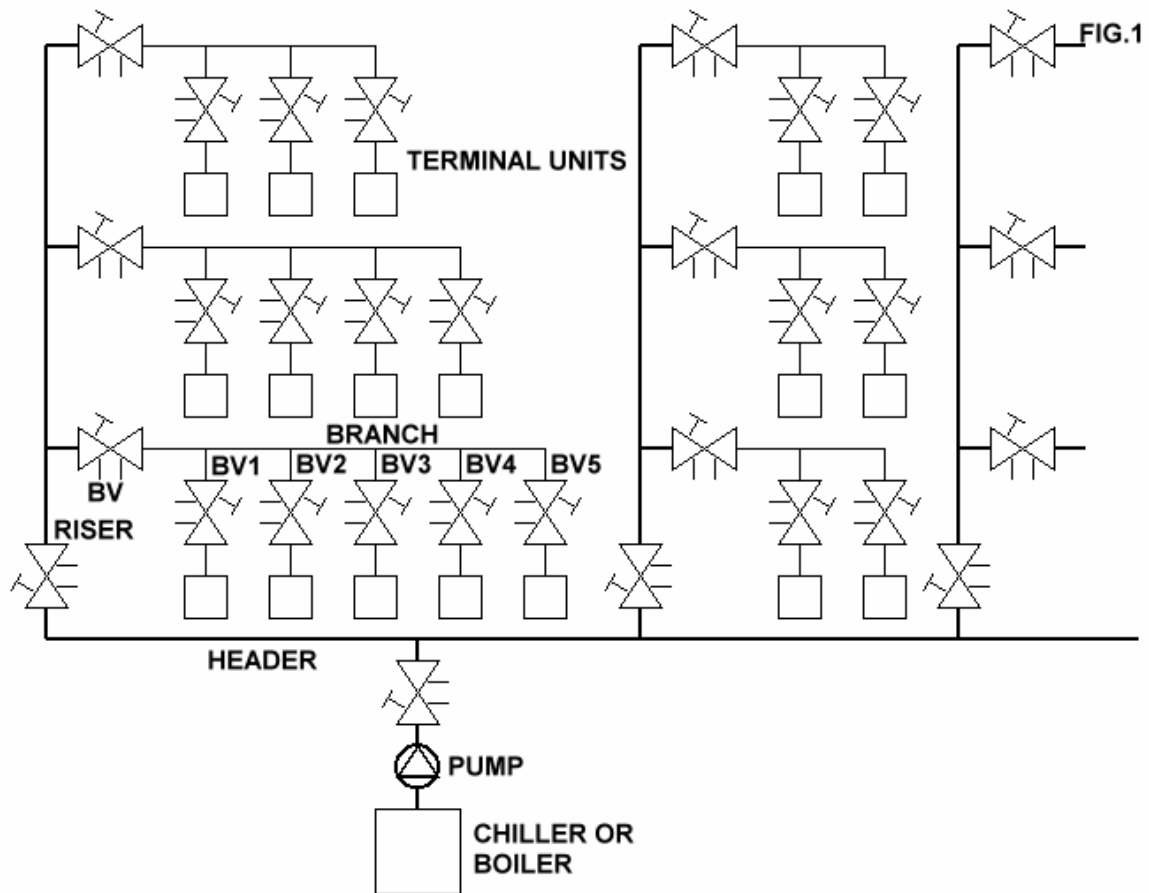


FIGURE 1 SYSTEM DESIGN AND PROPORTIONAL BALANCING

- 1 Divide the system into headers, risers, branches and terminal units
- 2 Install balancing valves in all terminal units, branches, risers, headers
- 3 The pump can be controlled with a balancing valve or automatic pressure controller
- 4 The balancing procedure:
 - A Balance all terminal units on each branch proportionally to the same %DFR
 - B Balance all branches on a riser to the same %DFR
 - C Balance all risers on a header to the same %DFR
 - D Finally adjust the total flow at the pump to the specified total flow
- 5 Chiller or boiler circuit
 - Follow the manufacturer's recommendations for connection to the system