Balancing methods
What is the purpose of balancing?

Adjusting the *design flows* in all terminal units in *design conditions* (when all control valves are fully open), while creating *minimum additional pressure drops*.

1) Call Santa Claus!

2) Have a method.
Infinity of possible balancing solutions

1.  
   2 psi 3 psi 3 psi 2 psi 3 psi
   100 100 100 100 100
   4 psi 3 psi 2 psi 1 psi 0.5 psi
   1 psi 1 psi 1 psi 0.5 psi 0.5 psi
   = 7.5 psi
   = 17.3 ft

2.  
   100 100 100 100 100
   6 psi 5 psi 4 psi 3 psi 2.5 psi
   = 9.5 psi
   = 21.9 ft

3.  
   100 100 100 100 100
   13 psi 12 psi 11 psi 10 psi 9.5 psi
   = 16.5 psi
   = 38 ft

...
Building brick: the hydronic module

1. Direct return piping

2. 1 balancing valve per circuit

3. Main balancing valve
Splitting into modules
Splitting into modules

Simplifying the drawing is essential
Splitting into modules

Solution for the main module
Splitting into modules

Another solution for the main module
Turning direction criteria for splitting into modules

At any bifurcation between many and many units, turn in the direction of the main flow.

At any bifurcation between one and many units, turn in the direction of the many units regardless of the flow.

Remark: bifurcations can be

or
Splitting into modules

Find out the sub-modules (1)
Splitting into modules

Find out the sub-modules (2)
Splitting into modules

Find out the sub-modules (3)
Splitting into modules
Where to install balancing valves?

Where would you install balancing valves?
Exercise: Split the plant into modules and place valves

All black numbers is $q$ in gpm
All red numbers is $\Delta p$ in psi

Mark with $\bigcirc$ where STAD/F is needed, use the smallest amount!
Size all STAD/F regardless of pipe $\Delta p$
Exercise: Split the plant into modules, place and calculate valves

All black numbers is $q$ in gpm
All red numbers is $\Delta p$ in psi
All blue numbers in feet
All circuit length is 10 feet

Mark with ○ where STAD/F is needed, use the smallest amount!
Size all pipes and STAD/F in TA Select
Compare the valve size from the previous exercise
Balancing a module

The iterative method (trial and error) quickly becomes a nightmare because of hydraulic interactivity.
Balancing a module

Exploit the proportion rule

100

30
20
10
20
20

45
30
15
30
30

150
Balancing a module

The proportion rule applies itself downstream from a perturbation
Balancing methods

Proportional method
- adapted from air system balancing methodologies
- **not optimal** in pressure drops

Compensated method (Pr. Robert Petitjean)
- designed for application with balancing valves
- **optimal** in pressure drops

TA Balance method (Pr. Robert Petitjean)
- fully computerized: automatic determination of the index valve
- **optimal** in pressure drops
Preset the reference valve for a pressure drop of at least 1 ft at design flow. (use calculation disk or TA SCOPE)
The compensated method

Partner valve

Reference valve

Obtain the design flow in the reference valve by adjusting the partner valve.
The compensated method

Maintain the flow in the reference valve, by adjusting the Partner valve, while adjusting valve no 4. (by using the computer method in TA SCOPE on no 4)
Continue the procedure with valve no 3. The flow is maintained in the reference valve and in valve no 4 by virtue of the proportion rule. Continue until all valves is balanced in this module.
The compensated method

- Reliable
- Each valve is adjusted only once
- Minimum pressure drops

- 3 people needed
- 2 instruments needed
- Difficult if the index is not the reference
The structure of hydronic modules can be seen as a hierarchical tree.

By virtue of the proportion rule, before a valve can be adjusted, all its children valves must themselves be adjusted.

Before a module can be balanced, the whole descent of this module must be balanced.

Balancing order:
Order for balancing modules

Correct

Incorrect!

Correct
Setting of balancing valves by step 1

- Fully open
- 50% open
- Balanced
- Module @ work
Setting of balancing valves by step 2

- Fully open
- 50% open
- Balanced
- Module @ work
Setting of balancing valves by step 3

- Fully open
- 50% open
- Balanced
- Module @ work
Setting of balancing valves by step 4

- Fully open
- 50% open
- Balanced
- Module @ work
Setting of balancing valves by step 5

- Fully open
- 50% open
- Balanced
- Module @ work
Setting of balancing valves by step 6

- Fully open
- 50% open
- Balanced
- Module @ work
Setting of balancing valves by step 7

- Fully open
- 50% open
- Balanced
- Module @ work
Setting of balancing valves by step 8

- Fully open
- 50% open
- Balanced
- Module @ work
**TA Balance** is a computerized balancing method incorporated in the TA SCOPE:

1. Two measurements are performed on each valve
2. It calculates the best settings for the balancing valves of the module

**Preliminary operations:**
- Partner valve is fully open
- Balancing valves of all circuits are set at 50% opening
TA Balance method

For each valve:
1) Enter the design flow
2) Enter valve and setting
3) Measure the current flow
4) Shut the valve
5) Measure the pressure drop
6) Re-open the valve

Repeat on all module valves

For the partner valve:
1) Shut the valve
2) Measure the differential pressure
3) Re-open the valve

TA SCOPE calculates and displays the required valve openings.
The settings displayed by the TA SCOPE are adopted:

- Circuits of the module are then proportionally balanced.
- With the lowest pressure drops in the valves. (starting with selected min $\Delta p$ in the index valve)

Setting the partner valve to the design flow, now or in a later stage

Gives the correct flows in every balancing valves of the module.
TA Balance method

- Reliable
- Minimum pressure drops

- Only one person needed
- Only one instrument needed

- The index valve is automatically detected

- Overall gain of 25% on the balancing time
Balancing methods

Proportional method
- adapted from air system balancing methodologies
- not optimal in pressure drops
- minimum 2 to 3 access to each valve
- 1 man; 1 instrument

Compensated method (Pr. Robert Petitjean) 
- designed for application with balancing valves
- optimal in pressure drops
- only 1 access to each valve (if index valve at the end)
- 3(2) men; 2 instruments needed

TA Balance method (Pr. Robert Petitjean) 
- fully computerized: automatic determination of the index valve
- optimal in pressure drops
- 1 man; 1 instrument
- 3 to 4 access to each valve
Balancing reveals the optimal set-point

1. Minimum pressure drops in the balancing valves

2. All the pump head in excess is located in the main valve

3. Re-open the main valve and adjust the pump speed
All above 1 ft (0.5 psi) in $\Delta p$ in the index valve and main valve is energy waste….

….no balancing is completed before the pump is optimized
Pfizer pharmaceutical production unit nearby Tours (France)

- Installed cooling capacity of 184,256 MBTUH (3 chillers in cascade)
- Total design flow: 3400 GPM
- Problem: production alarms!
- 80 TA balancing valves from STAD ½” to STAF 8”

Audit of plant with TA Select based on a first measurement campaign
- Presettings calculated with TA Select
- Viscosity corrections checked with TA Select
- Full balancing performed using TA-Balance on one TA-CBI
Savings are real

Before balancing

Industrial plant
184,256 MBTUH
cooling capacity

3900 GPM
49 psi pump head

After balancing

3400 GPM (-13%)
No production alarms!

39 psi pump head (-20%)
Pumping power reduction: 52 HP
Savings: 17200 €/year
24000 $/year