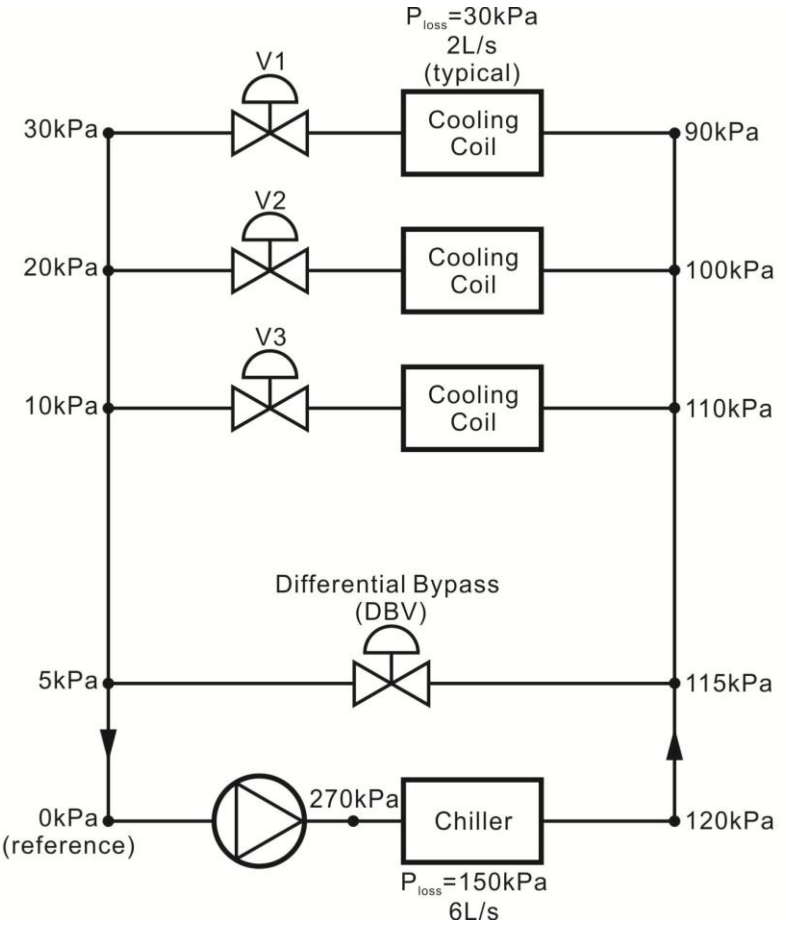
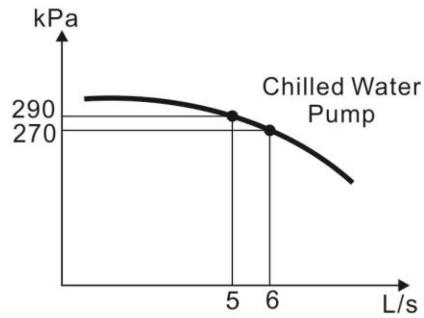
MECH3023 Building Energy Management and Control Systems
Sizing of Valves and Dampers
Worked Example

1.
A chilled water circuit is designed as shown below. Chilled water is served by a chiller to 3 air handling equipment each comprising a cooling coil with a specified flow rate of 2L/s at design cooling loading. A differential bypass valve DBV is modulated to maintain the chilled water flow at 6L/s across the chiller during part load conditions. The anticipated pressure of the pump, chiller, cooling coils and pipe work at design flow rate are indicated (based on a reference pressure of 0 Pa at the suction of the pump). The selected pump curve is shown.





Based on the available information, properly size the modulating valves V1, V2 and V3 of the air handling equipment, and the differential bypass valve DBV of the system. It should be noted that in order for the chiller to operate properly, the minimum chilled water flow rate should be 5L/s.

Suggested Solution
a)
The modulating valve V1 is firstly considered.
The available pressure drop between chilled water supply and return at design flow
= (90 – 30) kPa = 60 kPa.
Cooling coil pressure loss = 30 kPa, thus the available pressure across valve V1
= (60 – 30) kPa = 30 kPa.
Comparing the valve pressure against the pressure between supply and return,
30kPa / 60kPa = 50%, it is still acceptable for proper control (range 50% - 70%).

K_v of valve V1 is considered based on the equation:

$K_v = Q\sqrt{\frac{\rho}{\Delta P \times 10}} = 7.2\sqrt{\frac{1000}{30\times 10}} = 13.1$ (Q = 2L/s = 7.2m^3/h, take ρ = 1000kg/m^3)

The modulated valve V2 is considered.
The available pressure drop between chilled water supply and return at design flow
= (100 – 20) kPa = 80 kPa (a higher pressure drop is available since this branch circuit is closer to the pump hydraulically)
Cooling coil pressure loss = 30 kPa, thus the available pressure across valve V2
= (80 – 30) kPa = 50 kPa.
Comparing the valve pressure against the pressure between supply and return,
50kPa / 80kPa = 62.5%, it is acceptable for proper control (range 50% - 70%).
K_v of valve V2 is considered based on the equation:

$K_v = Q\sqrt{\frac{\rho}{\Delta P \times 10}} = 7.2\sqrt{\frac{1000}{50\times 10}} = 10.2$

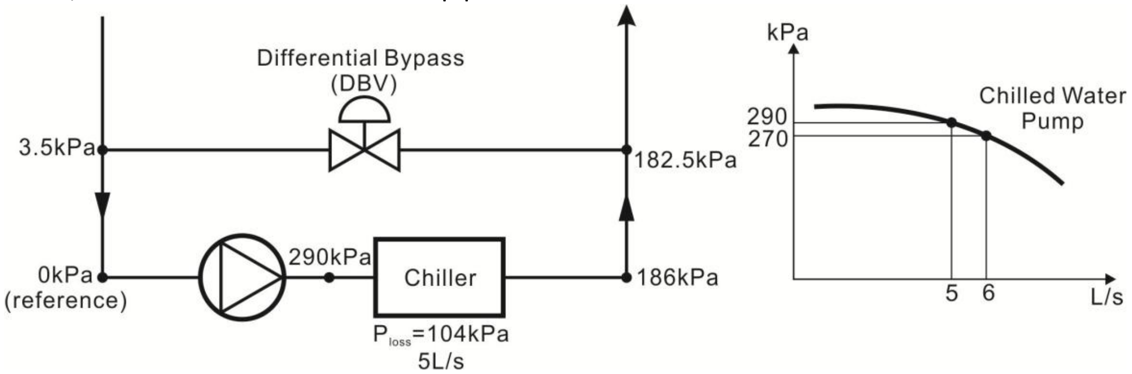
The modulated valve V3 is considered.
The available pressure drop between chilled water supply and return at design flow
= (110 – 10) kPa = 100 kPa (a higher pressure drop is available since this branch circuit is closer to the pump hydraulically)
Cooling coil pressure loss = 30 kPa, thus the available pressure across valve V2
= (100 – 30) kPa = 70 kPa.
Comparing the valve pressure against the pressure between supply and return,
70kPa / 100kPa = 70%, it is acceptable for proper control (range 50% - 70%).
K_v of valve V3 is considered based on the equation:

$K_v = Q\sqrt{\frac{\rho}{\Delta P \times 10}} = 7.2\sqrt{\frac{1000}{70\times 10}} = 8.6$

b)
The differential bypass valve DBV is considered.
Consider the differential bypass valve has to be fully opened to allow for 100% chilled water flow (6L/s).
The pressure loss across the DBV = (115 – 5) kPa = 110kPa
K_v of DBV is calculated:

$K_v = Q\sqrt{\frac{\rho}{\Delta P \times 10}} = 21.6\sqrt{\frac{1000}{110\times 10}} = 20.6$ (Q = 6L/s = 21.6m^3/h)

Since the minimum flow for the system is 5L/s to prevent freezing of the chiller, the case should also be evaluated.
At 5L/s, the chiller pump has a higher pressure = 290kPa
However, the chiller and the associated pipework have a lower frictional loss due to lower flow rate.



Consider the pressure loss by the chiller and pipe work follow the relationship: $\Delta P \propto Q^2$, the pressure at the chiller outlet and the associated pipe work are calculated.
The pressure at this lower flow rate is shown in the figure.
Pressure across the DBV = (182.5 – 3.5) kPa = 179 kPa

$$K_v = Q\sqrt{\frac{\rho}{\Delta P \times 10}} = 18\sqrt{\frac{1000}{179 \times 10}} = 13.5$$

Comparing the two valve indices: 20.6 and 13.5, the lower one should be selected to ensure sufficient chiller protection. Thus, the valve with index 13.5 is chosen.