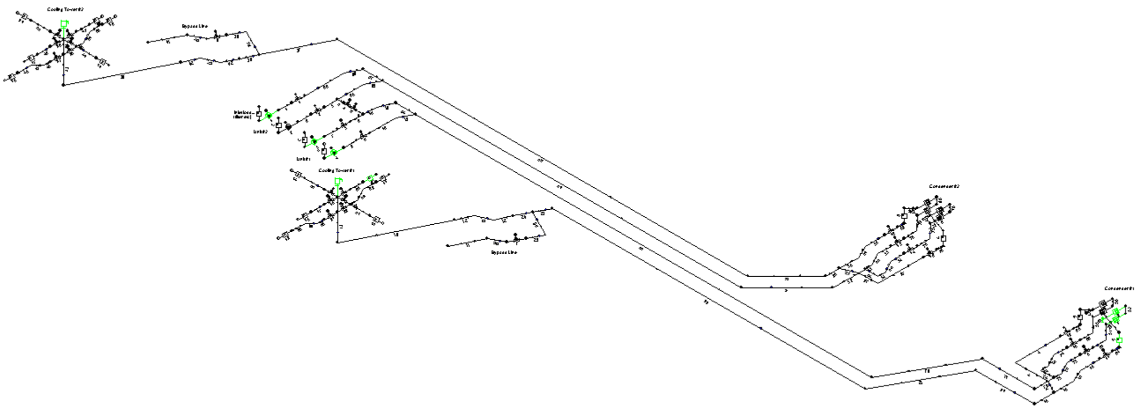
Application Bulletin – Power Industry
PIPENET® Transient Module Case Study

WATER HAMMER IN A COOLING WATER SYSTEM

BACKGROUND

In this cooling water system in China, made from steel and concrete pipes, a direct cooling system is used in a two chamber, double journey condenser in a traditional power station cooling tower, with an 18250 m^2 cross section and tubes defined by outer diameter 22 x 0.5 mm. The cooling water pump is rated at a flowrate of 5.08 m^3/s for 24.95 m of head. The pressure losses before the cooling pumps are 1.259 m of head at the rated 5.08 m^3/s, with two major pressure losses downstream, one caused by the water distributer in the cooling tower (1.428 m of head at 6 distributors x 1.69 m^3/s) and one caused by a rubber ball cleaning device (0.5 m of head at 5.08 m^3/s). The carbon steel pipes used are DN1800 and DN2400 types, and are those used most commonly, except in the cooling tower itself where concrete pipes are used.

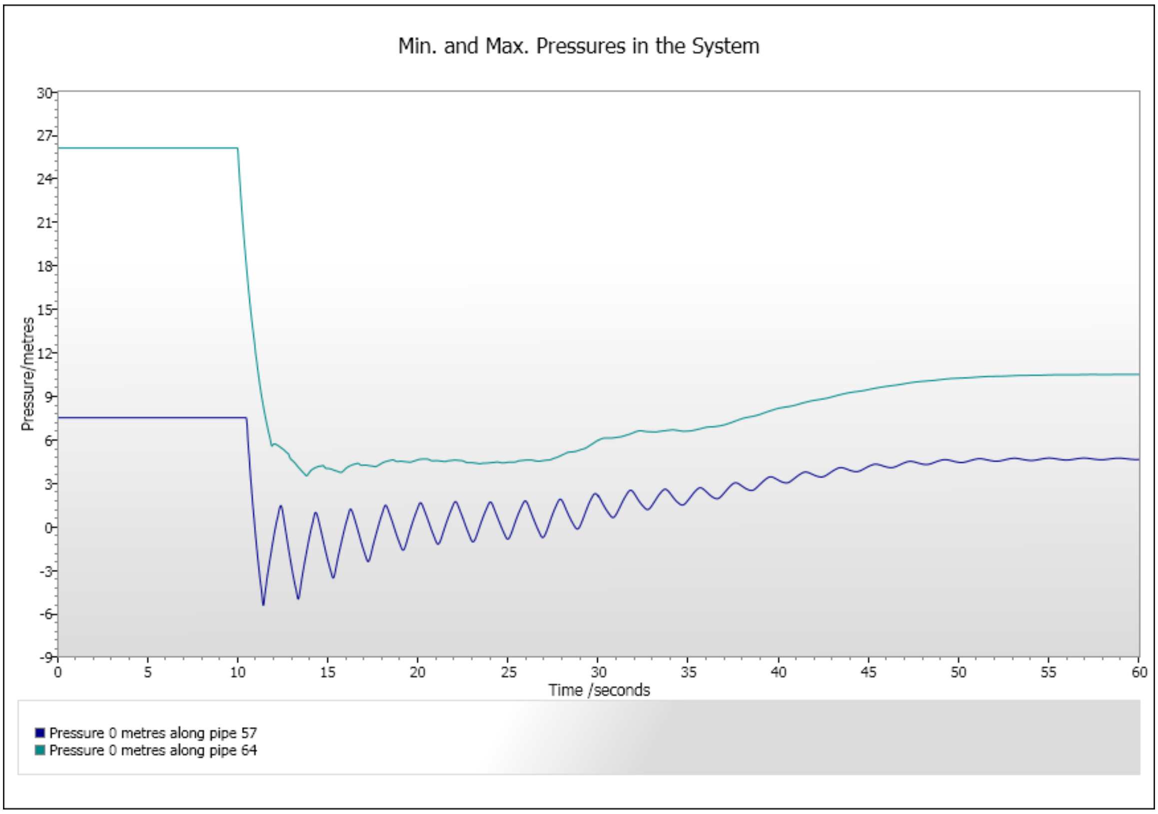
PIPENET Transient module was used to estimate the pressure surge caused by a pump trip as well as to evaluate the effect of vacuum breakers on the network in such a situation.



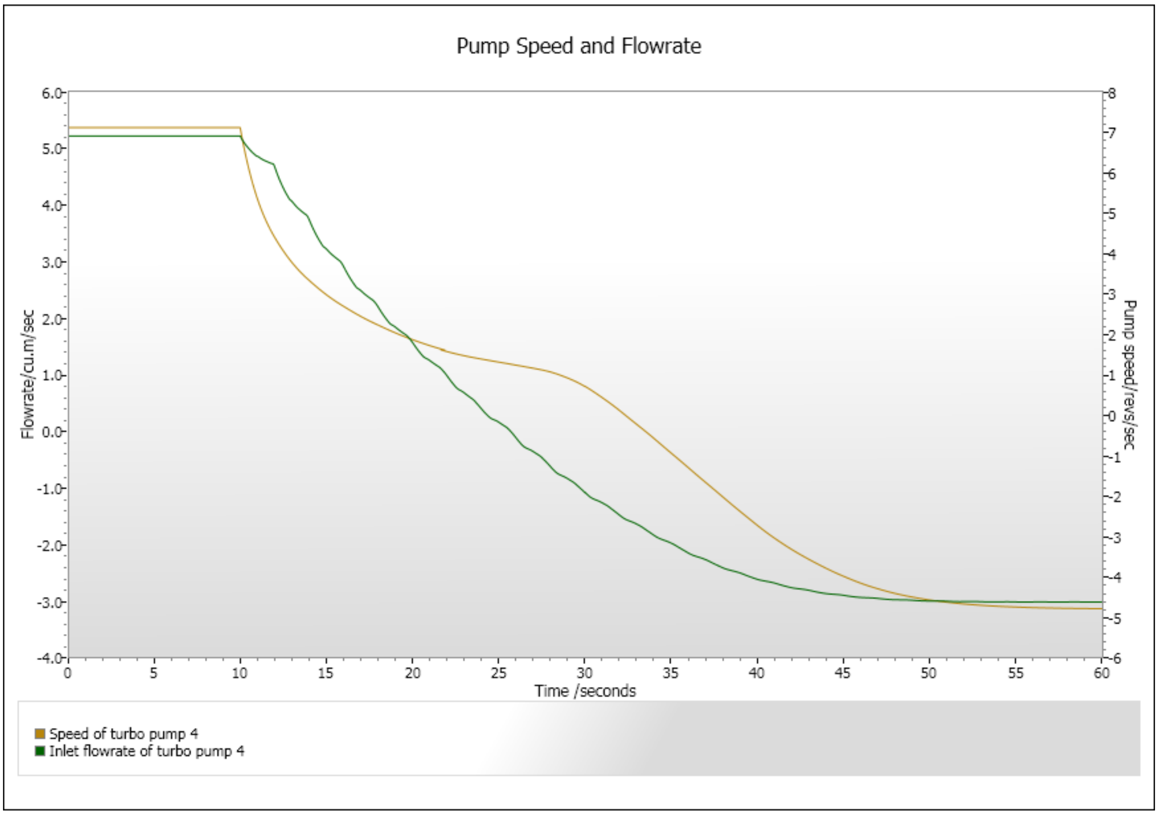
SCENARIO 1 – Main cooling pump trips without vacuum breakers

In this scenario, the main pump in unit 1 trips after 10 seconds of operation, whilst the outlet butterfly valves continue to remain open. At this point, there are no vacuum breakers installed on the system. The cooling tower silo is modelled by several pipes in which the water level is unchanged while the pump trips. This increases the safety margin in the event of pressure surge and reverse rotation of the pumps.

The maximum calculated pressure is 26.36 m of head (gauge) with the minimum pressure at -5.52 m of head (gauge), which suggests no cavitation occurred after the pump tripped. The figures below show what happened:



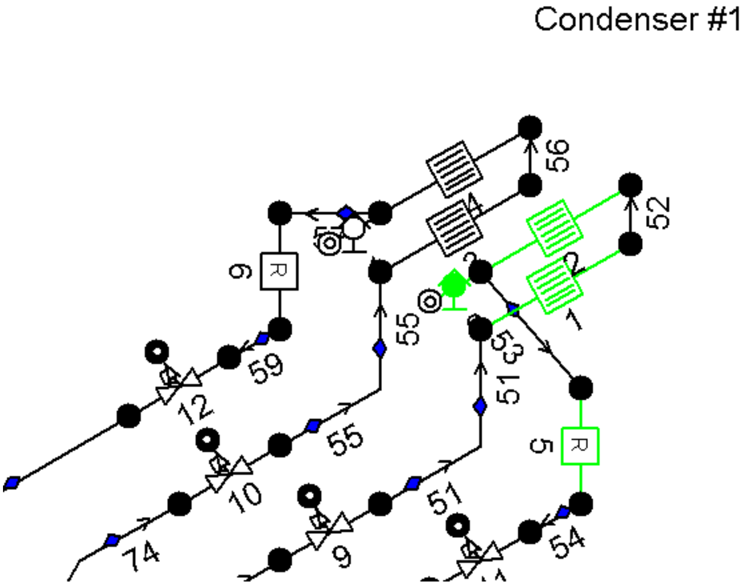
The figure below shows that the maximum reverse rotation of the pump was -4.787 revs/s (approximately 67.6% of rated speed):

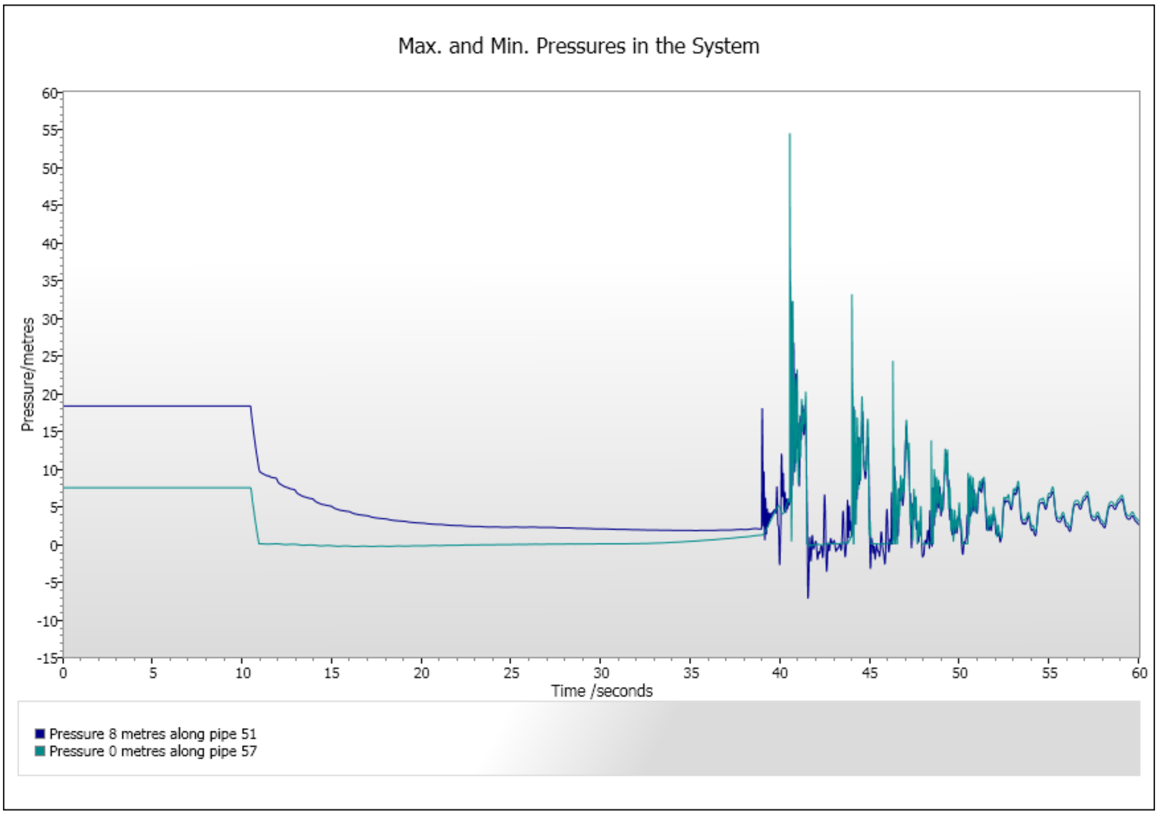


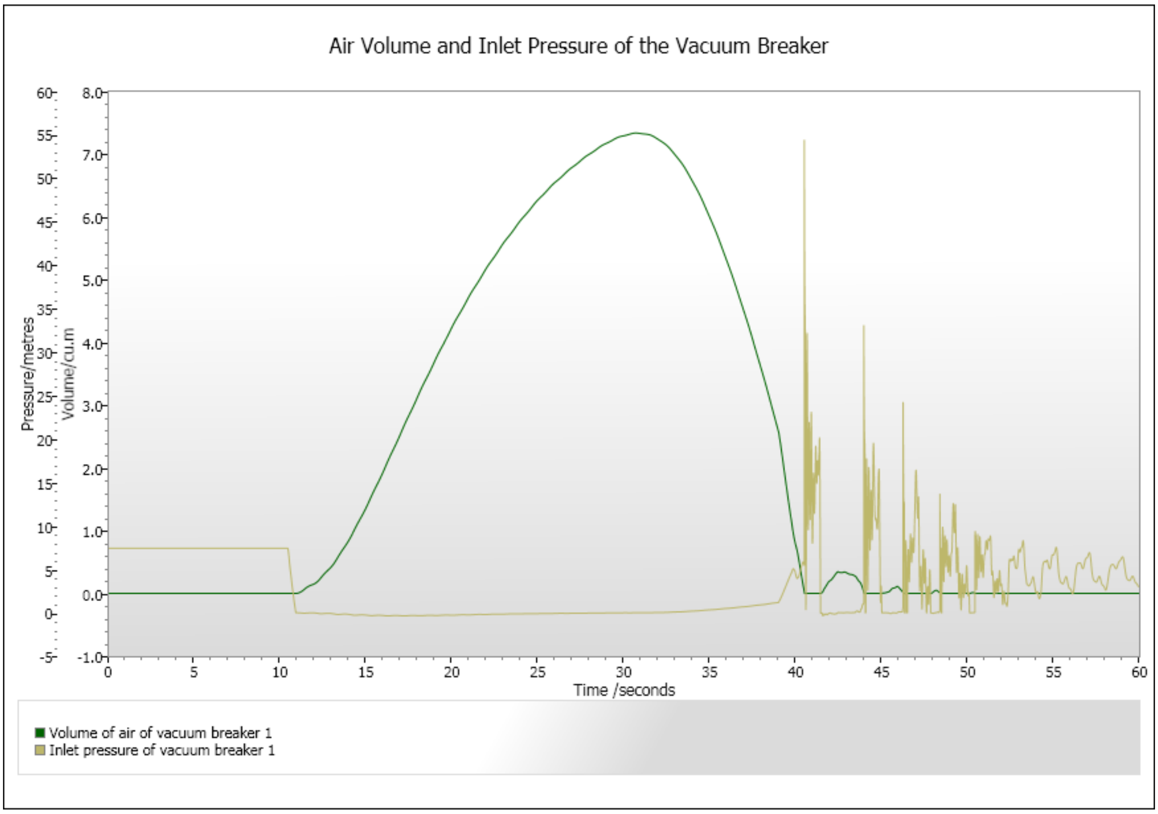
SCENARIO 2 – Main cooling pump trips with vacuum breakers

In this scenario, a set of vacuum breaker valves (DN100) have been installed at the outlet of the condenser.

The maximum calculated pressure increases to 54.26 m of head (gauge) and the minimum pressure drops to -7.22 m of head (gauge). This is clearly worse than Scenario 1, showing that vacuum breakers cannot protect the cooling water system when the pumps have tripped. The figures below show the full results.



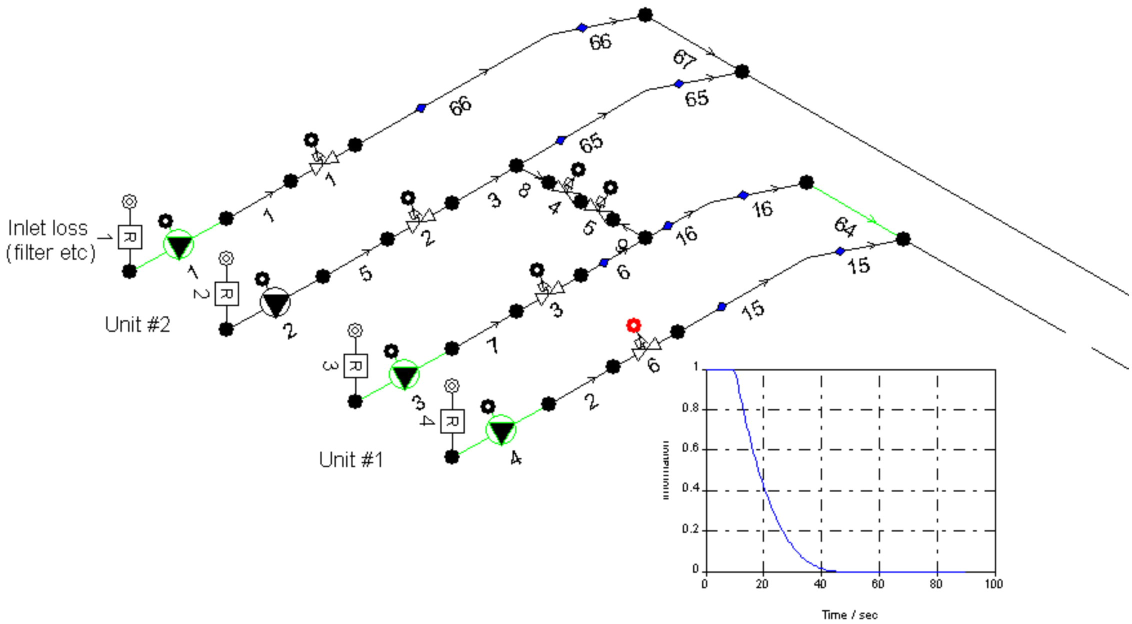


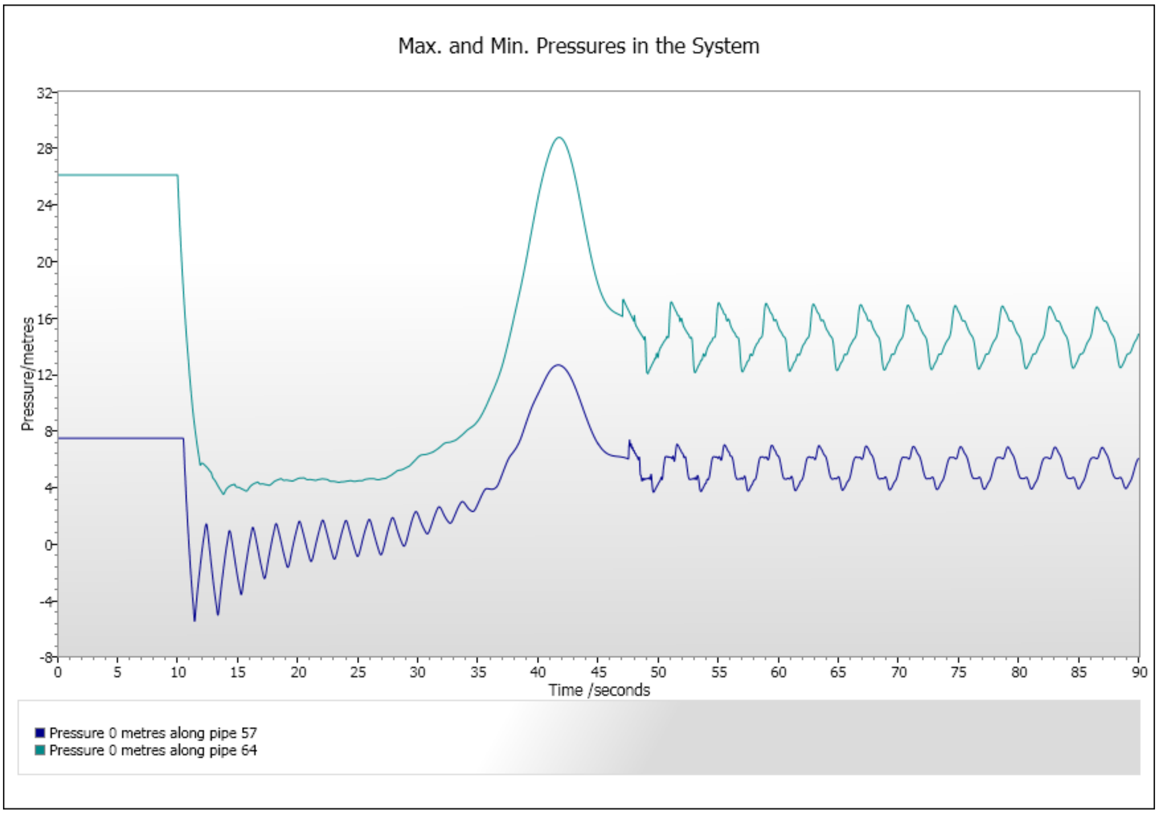


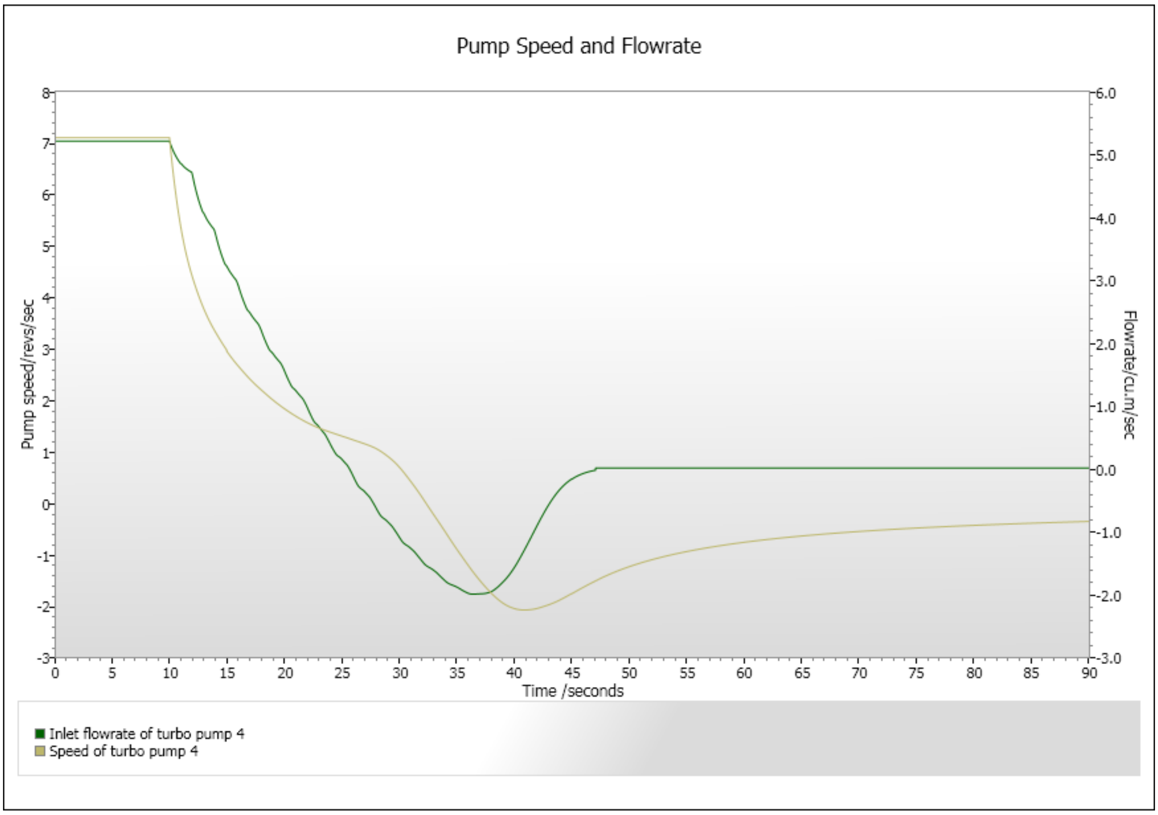
SCENARIO 3 – The downstream valves close after the pump trip

In this case, in the event of a reverse rotation of 2.36 revs/s, a 40s cubic valve closure is initiated in order to prevent extensive reverse flow and pump reverse rotation.

The maximum calculated pressure is 28.68 m of head (gauge) with -5.53 m of head (gauge) minimum pressure. The maximum reverse flowrate comes to -2 m^3/s and the maximum reverse rotation speed is -2.07 revs/s. The figures below show this in more detail.



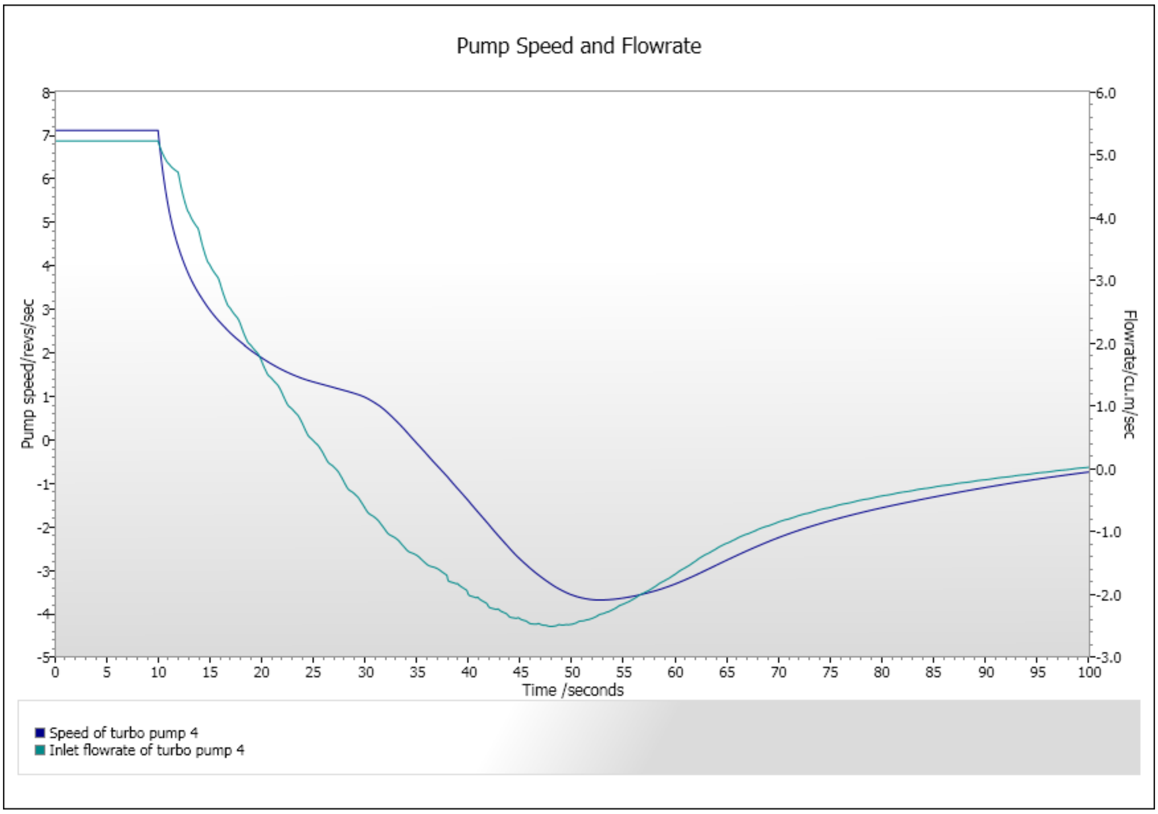




SCENARIO 4 – The effect of liquid level in the water tower silo

In the previous scenarios, the cooling tower silo is modelled by several pipes in which the water level remains unchanged during pump trip. It can be expected that this approach increases the safety margin for pressure surge and pump reverse rotation, due to the large static head generated. In order for our results to be more accurate, the dry pipe model can be used to calculate the liquid level in the pipes as ambient air enters the system. This scenario is identical to scenario 1, except the dry pipe model has been activated.

The maximum and minimum pressures are 26.36 m of head (gauge) and -6.58 m of head (gauge) respectively, indicating that there is still no cavitation after the pump trip, even with refined values. The figure below shows that the maximum reverse rotation was -3.705 revs/s.



CONCLUSIONS

It has been shown that in a direct cooling system in a water tower, cavitation does not occur after a pump trip, due to the large static head in the tower silo. Therefore vacuum breakers are not needed in this eventuality, as they in fact worsen the effect of water hammer. It has also been shown that the butterfly valves at the pump outlet should be closed in order to avoid reverse rotation overspeed.

If you have any questions about this case study, or any other of PIPENET's capabilities, please email us at Pipenet@sunrise-sys.com.

Sunrise Systems Limited • Sunrise Business Park
Ely Road • Waterbeach • Cambridge CB25 9QZ • United Kingdom
Email: Pipenet@sunrise-sys.com • Web Site: www.sunrise-sys.com