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Top ten worst practices – cooling towers

The poor design and installation of pipe work associated with cooling towers continues to be a concern across the industry. Despite best practice guidelines available, it remains common to find examples of poorly designed and executed piping, which create a variety of hazards.

According to Clive Broadbent, Australia's foremost expert on cooling towers and legionnaires' disease, poor installation and design dog many cooling towers across Australia.

Whether the result of ill-informed or over-design (as can so often be the case in the HVAC&R industry), or a lack of knowledge at the coalface, such that shortcuts are taken during installation, the ever-present threat of *Legionella*, corrosion management and the ever-increasing need to reduce water consumption, make correct design and installation of cooling tower pipe work essential.

We asked Broadbent to cite the common poor practices he comes across out in the field, and the result is HVAC&R Nation's top ten worst practices for cooling towers.

1. The return line is run overhead, such that long lengths are located above basin level.

"Often the pump starts and stops depending on the load, and at each shutdown the water in the elevated line drains to the tower leading to overflowing at the basin, if the additional water in unable to be contained," explains Broadbent. "This is possibly the worst example of uncontrolled water losses."

Such needless waste of water is not only costly – in today's world it is environmentally irresponsible. Furthermore, the lost water contains biocides and inhibitors, and as this loss of water results in chemical concentrations being reduced, the control of microbes, corrosion and scale are all compromised. Thermal performance is also lowered as basin water is the cooled water in the system.

Best practice

Piping should be run at, or lower than, basin height keeping the riser to tower top deck of minimal length. Alternatively, a loop can be installed at the tower.

> **Clive says,**
>
> "Figure 1 illustrates the concern with overflowing, an all-too-typical occurrence. As cooling tower systems differ markedly in piping arrangements, the ramification for each system's hydraulics needs to be taken into account to ensure overflowing does not occur."

Figure 2. Tower overflowing with chemical loss

"The loop could take the form of a dropper from the overhead return line to below basin height before returning to the top deck," explains Broadbent. "The height of the loop must be at least eight metres, and must be unvented."

Another form of loop is taken from the return line to several metres higher than the top deck, fitted with an anti-siphon vent, and then dropped into the top deck. According to Broadbent, the effectiveness of this arrangement depends on the satisfactory shutoff action of a pump discharge line check valve in order to prevent reverse flow back to the basin.

2. Two or more cooling towers are connected to a single system without a balance line connecting their basins. (Figure 2)

"Although system balance valves may be fitted to tower returns, these rarely are so precise that water returns are evenly balanced under all operating conditions," says Broadbent.

"If there is a dedicated pump for each tower, the bad practice condition exists every time one pump shuts down on part load."

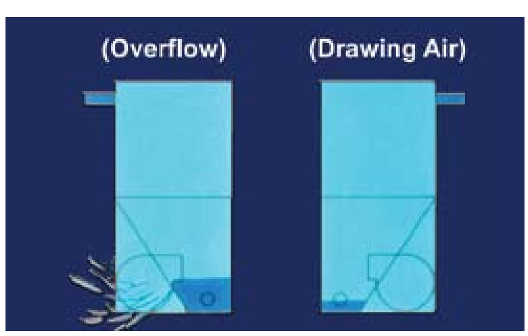


Figure 2. Problem

The result is excessive water returned to one tower, leading to that tower's basin overflowing, while the other tower basin is depleted and draws in air to its pump suction.

Best practice

The preferable solution is to arrange the two towers with their respective pumps and the condensers they serve as two independent systems, as this arrangement improves reliability.

"Joining the separate piping runs into a single line (by joining pump discharges into a single line which then splits at the condensers) to save on pipe costs is usually poor economics."

The alternative is to fit a balance line taking care to ensure its inherent 'deadleg' effect is nullified in one way or another.

3. Over-use of motorised valves

"The use of motorised valves for head pressure control, warm ups on Monday mornings, or simply to be able to shut down an item in a multi-tower arrangement while half the system continues can be over-design," says Broadbent.

Facility management companies are appointed as period contractors, and are therefore often unaware of the intended original method of system operation. Similarly, work contracts are often on an 'as-needs' basis. Later, electrical alterations may lead to the motorised valves becoming inoperative or may cause part of the system, such as bypass lines, to become a deadleg.

Best practice

Broadbent believes systems should be kept as simple as possible, and the installation of such valves should only be when absolutely essential.

"If kept simple they are far more likely to operate as intended throughout the life of the plant, which incidentally may exceed 30 years, thus greatly outliving the knowledge life available from designers or those involved at installation."

4. Installation of a tower pump at the same height as the tower.

"There may be a suction strainer, an isolating valve and perhaps a long length of piping between the tower basin and the pump, followed by a long length of piping to the condenser. Usually there is a suction screen at the tower basin outlet," explains Broadbent.

Clive says,

"Cavitation is a two-stage phenomenon. As the water passes through the pump suction line, with its fittings, the liquid experiences a reduction in pressure that may cause it to be below the vapour pressure for liquid. In effect, the water boils and vapour pockets form in the flow stream.

When the pressure recovers at pump discharge, the pressure will now be much greater than the vapour pressure and the vapour pockets collapse, so releasing considerable energy that impacts against solid surfaces such as piping or the impeller, leading to noise and physical damage."

This installation can result in insufficient pump suction head (called Net Positive Suction Head) for satisfactory pump operation, gradually worsening as the strainer or screen collects debris. Cavitation at pump suction can also occur, eventually destroying the pump.

"Pump characteristic curves are usually very flat so that any increase in system resistance over time has a relatively large impact on the flow rate."

Best practice

This arrangement should be reviewed. A suction screen in the tower basin provides protection for the pump impeller, assuming it is regularly cleaned.

The strainer is not necessary for pump protection purposes; rather it provides protection of the condenser tubes ensuring maximum heat transfer occurs. Therefore, the strainer should be installed upstream of the condenser, and downstream of the pump. Elevating the tower basin water level also improves the suction pressure available for the pump.

5. Lengths of pipework installed for future connection. (Figure 3 & 3.1)

According to AS/NZS 3666.1, a deadleg is defined as 'a section of the system that does not permit circulation of water'. In this instance, pipework installed for future connections become deadleg(s) that support bacterial growth.

Figure 3

Figure 3.1

"As a deadleg does not permit circulation of water, the main concern is that the chemicals within that circulating water may not be able to meet all surfaces to protect them from corrosive effects, scaling and microbial growths."

Best practice

It is preferable to remove all unused lengths of piping (a valve fitted at the junction with the main line should suffice for the original purpose). If this is impractical, install small-bore tubing across the flow and return deadleg ends so bypassing some water continuously. Other elaborate schemes are possible depending on circumstances.

6. Pipe headers provided with branch valves mid-length while valves at header ends are intended for future connection. (Figure 4)

This practice results in deadlegs being created at the end(s) of the header.

Figure 4

Best practice

Pipes for immediate use should be connected by branches at the ends of the header.

"The header is then not a deadleg as water flows along its full length. Valved branches for future connection should be near the centre of the header. They should always be located on top of the header so they don't act as debris collecting pockets," says Broadbent.

A valved drain at the bottom of the header may be used to remove debris.

"Remember it is surfaces that encourage biofilm to develop. *Legionella* is a biofilm organism; it grows on surfaces and not in the bulk water. The debris and other extraneous matter in a system provide unnecessary surface area for such biofilm development."

7. A header constructed from stainless steel tubing while the general reticulation is made of copper.

Put simply, this poor practice leads to corrosion.

"Sometimes the header represents a very small item within a very long piping system. The stainless steel may not have been passivated properly, if at all, at installation due, perhaps, to project completion pressures. These metals are well apart in the electrochemical list (Galvanic series – refer to AIRAH Application Manual DA 18)," says Broadbent.

Rapid corrosive attack of the stainless steel may then occur, particularly if, due to initial disinfection or ongoing decontamination needs, chlorine residual exists in the system water. In these circumstances, the chlorine ion is able to penetrate the protective oxide film on which stainless steel depends for its corrosion resistance. If the stainless steel is of thin-walled tubing it may be penetrated quickly, producing 'gun shot' holes.

Best practice

This is a design issue, which requires that compatibility of metals in aquatic systems is understood and ensured.

According to Broadbent, a similar circumstance is that of a stainless steel tower connected to an extensive copper pipe reticulation.

"Assuming materials cannot be changed; one solution found to be effective is to hard-bolt several magnesium blocks to the tower basin."

Requiring metal to metal contact, the magnesium acts as an anode and sacrificially corrodes. Not only does this confine the corrosive action principally to the magnesium blocks, but the blocks also act as an early warning sign indicating that eventually the stainless steel may suffer under the harsh conditions produced within a typical cooling tower with accelerated airflows, and pollutants, at intake and rapid turnover of aerated water.

8. The water sampling point, corrosion rack and system water blow-down (bleed off) is connected at the tower basin.

As chemicals are usually injected into the system at the basin, it is therefore untypical of the system water to draw the sample from the location having the highest concentration of chemical.

Rather, samples should be drawn from the return line to the tower as this is the body of water with the most depleted concentration of chemical. It is also the warmest water so the corrosion rate is higher in this line, meaning the corrosion rack should be connected into this water supply.

"Needless to say it is inefficient to blowdown (bleed-off) basin water which has undergone cooling at the tower. Again, it is the return water that is the poorest quality and should be blown down to waste."

Best practice

These connects should all be located at the return line taking care to ensure actions such as blowdown occur with water actually flowing (a pump interlock is needed), otherwise the line may be dry.

Chemical treatment should be to the pump suction line but usually it is the basin that is the most practical location although not as preferred due to aeration, evaporation and general dynamics of the tower.

"Chemical dosing plant, incidentally, is best located indoors (improved OH&S) and near the condenser plant.

Mounting the dosing equipment outdoors will shorten the life of the equipment," says Broadbent.

"This defect would be further aggravated if the chemical dosing equipment is physically mounted on the side of the vibrating tower."

9. The balance line is mounted below the level of the basins. (Figures 5 & 6)

The balance line then acts as a deadleg and may not be drainable.

Best practice

The balance line should be mounted at the same height as the basin sumps so that a full cleaning event includes the balance line. If the balance line must be lower than

Fig 5. Balance line too low, should be located at basin sump height.

Fig 6. Balance line acts as a deadleg, impossible to drain.

the basins, a secondary recirculating system is usually the most appropriate solution.

Such a system draws water from the balance line (only a small flow rate is needed so not affecting the normal function of the balance line) and discharges it into the basin(s). A further improvement is to install a water filter into this sidestream circuit. The filter rate should be designed to about 5% of the main flow rate if possible.

10. Chemical dosing system pipes are connected to the underside of main pipe runs.

Dosing, blowdown, corrosion rack and sampling lines, whether separate or combined, are generally of small-bore plastic piping and can collect debris if mounted to the underside of the main water lines.

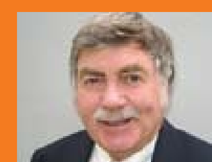
Best practice

These water treatment lines should be installed at the side or top of the main pipes, and it is important to ensure the pipes will run full of water when drawoff to the water treatment plant occurs.

"With some systems, such as those serving emergency power generators operated infrequently, it may be necessary to run the main water circulating pumps daily for, say, two hours while simultaneously dosing chemical," said Broadbent.

A more elaborate system involves installation of a continuously recirculating sidestream system that ensures there is flow throughout the complete raw water system although at a much lower flow rate than that when the generators are energised. ▲

Clive Broadbent AM



Clive Broadbent AM

Clive is Australia's foremost expert on the management of *Legionella*. He is an experience trainer in this field and has carried out extensive research into *Legionella* in cooling towers. He is the Chairperson of the committee that developed the AS/NZS3666 standard and has carried out numerous *Legionella* risk management plans for large industrial applications as well as smaller commercial installations.