

Boiler & Cooling Tower Control Basics

By James McDonald, PE, CWT,
Technical Support Manager

For those of us who have been around boilers and cooling towers for years now, it can be easy to forget how we may have struggled when we first learned about controlling the chemistry of boilers and cooling towers. After running all the chemical tests, where do you start when the phosphate is too high, conductivity too low, sulfite nonexistent, and molybdate off the charts? Even better, how would you explain this decision process to a new operator?

Cycles of Concentration

The first place you always start is cycles of concentration (cycles). You may measure cycles by measuring conductivity or chlorides. If everything else is running normally, when the cycles are too high, everything else should be proportionally too high. When the cycles are too low, everything else should be proportionally too low. When the cycles are brought back under control, the other parameters should come back within range too.

Example

We wish to run a boiler at 2,000 μ mhos, 45 ppm phosphate, and 40 ppm sulfite; however, the latest tests show 1,300 μ mhos, 29 ppm phosphate, and 26 ppm sulfite. The conductivity is 35% lower than what it should be. Doing the math $((45-29)/45=35\%)$, we see that the phosphate and sulfite are also 35% too low. By reducing boiler blowdown and bringing the conductivity back within control, the phosphate and sulfite should be within their control range too.

Beyond Cycles

Whether we're talking about boilers or cooling towers, we know if we reduce blowdown, cycles will increase, and if we increase blowdown, cycles will decrease. We also know the other constituents in the water (phosphate, sulfite, molybdate, etc.) will change in the same direction as the cycles change. The only time this rule will not hold true is when there are other variables at work.

What if you've accounted for the change in cycles but the other constituents are still out of range? This requires you to think a little harder.



Chemical Overfeed & Underfeed

Maybe the chemicals are simply being overfed or underfed. This is easily remedied by turning the feed pumps up or down or changing the amount added to the day tank for a boiler.

Simply changing the feed rate sounds easy, doesn't it? Not so fast! Unless you understand the chemistry, you may not get the results you expect. You may grossly over estimate the change required.

Remember that a lot of the chemistry applied has a "demand" and a "residual" component to the chemistry. For example, when feeding bleach to a cooling tower, you first must meet the free chlorine "demand" before you establish



a “residual.” If you currently test 0.2 ppm free chlorine residual but want 0.4 ppm, you may be tempted to double the setting on the bleach pump. By doing this, you have completely ignored that the system had a 60 ppm free chlorine “demand” as well. Currently the total chlorine dosage was 60.2 ppm (60 + 0.2 ppm). If you double the pump setting, the new dosage will be 120.4 ppm (2 * 60.2). The new free chlorine residual will be 60.4 ppm (120.4 – 60 ppm)! Somehow, I don’t think this is what you expected.

This same “demand” versus “residual” logic applies to chelants (EDTA), phosphate, sulfite and other oxygen scavengers, etc. The lesson here is to know your chemistry.

Beyond Overfeed/Underfeed

There are other factors that can lead to a constituent being out of range besides a chemical overfeed or underfeed, and these must be considered before a change to the feed rate is made. Perhaps a piece of equipment isn’t operating properly or process contamination is occurring. By knowing the system, equipment, and what each individual chemical constituent does, it shouldn’t take you long to figure out the cause and proper corrective action. Instead of going into a general vague discussion of this subtopic, I think it will be more useful to describe several examples. Each of these examples assume that cycles have been corrected or considered already.

Sulfite Level Too Low

Sulfite is added to a boiler system to remove oxygen from the water. When a deaerator is used, sulfite removes what oxygen is left after the deaerator mechanically scrubs the oxygen from the water. If the deaerator is not functioning properly, then more oxygen will be left in the water, and more sulfite will be required to remove it. This easily explains

why sulfite levels may be too low or why more sulfite than usual has to be fed to maintain levels. If the deaerator temperature is too low (typically <220°F) or if the deaerator isn’t being vented enough (15-33 inches of actively moving plume), then not enough oxygen is being mechanically scrubbed from the water and the sulfite “demand” increases. Another source for the problem may be a mechanical failure in the deaerator itself such as bad spray nozzles or jumbled trays.



Chelant Too Low

The purpose of the chelant (typically EDTA) in a system is to combine with metal ions to keep them soluble so they won’t form scale in a boiler. Any metal ions that are in a boiler such as calcium, magnesium, iron, etc. make up the “demand.” The free chelant residual you wish to carry is the “residual.” If anything happens to increase the chelant demand such as hardness leaking past a softener or corrosion byproducts coming back in the condensate, then the chelant residual is going to drop accordingly.

Phosphate Too Low

Phosphate, in a low pressure boiler system, is used to precipitate hardness into a loose sludge that can easily be blown down. If more hardness is introduced to the system than usual due to malfunctioning pretreatment equipment or



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hard water leakage into the condensate system, then the phosphate demand increases and less may show up in the phosphate test. I say “may show up” because the phosphate test can indicate both the combined and uncombined phosphate, and the result will only be lower if appreciable amounts of phosphate sludge are blown down from the boiler. Running filtered and unfiltered phosphate tests on the boiler water will give a better understanding of what is happening.

Constituent Levels Too High

For the same but opposite reasons in the examples above, constituent levels may be too high. Perhaps a heat exchanger has been fixed and hardness is no longer contaminating the condensate. Then chelant or phosphate levels may suddenly be higher. Perhaps oil is no longer leaking into the cooling tower, so the chlorine demand has gone down, resulting in higher free residuals. Perhaps the deaerator is finally venting properly and sulfite demand has dropped, resulting in higher residuals.



Never rule out malfunctioning chemical feed pumps and chemical control equipment. I have seen chemical feed pumps behave erratically because of shorts in their control switches.

I’ve seen cooling towers overfeed/underfeed chemicals or blowdown improperly because the sample line with the conductivity probe had its water flow turned off. This resulted in the controller thinking the cooling tower conductivity was higher or lower than it actually was and feeding chemicals and blowing down accordingly. I’ve seen chemical pump settings changed, but no one owns up to making the change. This is why it is good to log the chemical pump settings. I’ve seen softener multiport valves leak through so the sample you tested showed hardness while the unit was actually making soft water. I’ve seen operators change pump settings by decreasing the speed and increasing the stroke, not realizing that they may have actually increased the chemical feed instead. Changes in makeup water characteristics can also affect system control (such as phosphate added to city water for corrosion control by the city or hardness levels changing).

Test Interferences

Don’t rule out test interferences either. Knowing your tests, how they should look, and what interferes with their results is invaluable. Keep a running inventory of chemical usage so you can compare test results to actual usage rates.

Conclusions

There is a lot to consider when it comes to process control and water systems. The more you do it, the more second nature it becomes. Whether you are new to the water field or an old timer, just remember to start with the cycles (conductivity or chlorides) and work your way up from there.

For more information about the control specifics of your water system, please contact your water management professional.

