EnviroAqua CONSULTANTS INC.

Water Talk

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Zero Blowdown, Reality or Fantasy? A Critical Look at the Claims and Possibilities

Discussion of Reality

With the ever-increasing need to conserve water, the cooling water customer is being inundated with promises of water savings by means of "zero blowdown" treatment schemes. What is zero Blowdown? Zero Blowdown refers to a treatment scheme that promises the customer the ability to turn off the cooling tower bleed and literally reduce their blowdown needs to zero, or in other words cycle their water without limit. Is this possible? The answer is a **qualified** yes.

In naturally soft waters, zero blowdown can be achieved with proper considerations for treatment of corrosion, increased deposition potential and microbiological activity. For a number of years a sort of zero blowdown was and has been common in the east where some common water supplies have been relatively soft. Hardness levels at less than 1 grain i.e. less than 17 ppm of total hardness and low alkalinities seemingly made these waters good candidates for zero blowdown programs. In those areas very high cycles with good water treatment has allowed many cooling water users the ability to run at high cycles of concentration. In many cases, the small amount of drift or windage loss was sufficient to keep dissolved solids at a constant level. *(If we assume that drift and or windage is around .1% and delta T at 20 degrees the actual rate of loss is equivalent to the blowdown rate at 16 cycles of concentration.) Happy ending? NO! By no means was it a happy ending.

Windage is water loss from an open cooling system in the form of fine water droplets or spray. The loss in water is due to the effect of wind flow across the tower or the effect of water droplets caught in the flow of air through the tower. The amount of water loss can vary greatly depending on the type of tower and the condition of the fill (mist eliminators.)

Type of Tower	Average Windage/Drift Loss D
Mechanical draft towers	0.05% to 0.1%
Evaporative condensers	0.05% to 0.1%
Atmospheric towers	
With fill	0.6%
Without fill	1.5%

Windage/drift can be easily calculated with the following simple formula:

W = Average % Loss X Recirculation rate *(% loss expressed as a decimal)

*For a mechanical draft tower at 0.1% this would be 0.1.

The maximum cycles of concentration is also easily calculated with the following simple formula: Cycles = $(0.075 \times \Delta T + W)/W$

This equation holds true regardless of the towers size. For a tower that has a 10-degree temp drop this would calculate as follows:

Maximum Cycles = $((.075 \times 10) + 0.1)/0.1$

Maximum Cycles = $(.75 + .1)/.1$

Maximum Cycles = $.85/.1$

Maximum Cycles = 8.5

While running these seemingly wonderful programs, intended to save big bucks in water and chemical, it was soon discovered that suspended solids at this level of concentration, even in relatively soft water and even with the windage loss, were a big problem.

Entrained solids from air scrubbing, precipitates and microbiological deposits became major issues. Heavy deposits in the cooling tower basins were breeding grounds for bacteria, especially sulfate reducers, which caused slime and corrosion in the system. It was not unusual to have the entire fill of a cooling tower collapse under the weight of the deposited salts, mud and microbiological masses. So instead of zero blowdown users settled for greatly reduced blowdown. Between the loss expected from drift and windage and **greatly reduced blowdown** the users were able to achieve greater water savings but not zero blowdown.

At this point one might ask why would anyone want to consider zero blowdown? The answer to that question lies not in achieving actual zero blowdown but in the definition of zero blowdown as it is used. The current definition of "Zero Blowdown" is zero bleed from the tower. In that context zero blowdown is achievable but as will be shown in the following discussion it is neither zero or is cheap.

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Achieving Zero Blowdown

Hard water- Zero blowdown using hard water make up is especially difficult and should never be considered. Many have been lulled into trying it with disastrous results. Towers fill up with precipitate, heat exchangers will plug with both scale and sludgy deposits and tower fill will often collapse under the weight of the entrained deposits. Some have proposed that a tower can be treated using controlled precipitation with pH adjustments and sludge conditioning. It is a recipe for trouble because it is chemically impossible to keep all of the solids entrained and soluble. Eventually the sludge will collect in all areas of the system, causing heat transfer and flow problems, and would have to be manually cleaned.

Using Sodium Zeolite Softened Make Up and it's Associated Costs

In the search for methods to reduce water usage many sites are considering the use of zeolite softened water as a means to zero blowdown and water savings. It is indeed true that by using softened water more cycles of concentration can be achieved but does the use of softened water make sense from an operational and economic stand point. Considerations for this type of water reduction scheme must include capital costs for buying and installing a softener package, which would include not only the costs of the softeners but the infrastructure needed to install and operate them, ongoing cost of salt and salt handling, and consideration for brine disposal if that is an issue.

For the sake of this discussion we will assume that the site has excess softener capacity and can support the make up requirements of a tower that has a recirculation rate of 10,000 gpm and a Δ T of 15 degrees. Let's assume that the tower is older and has a windage or drift loss (W) of .1%

The total water requirements will be as follows:

Make up = Evaporation + Bleed + Windage
Evaporation = 0.001 x 15 degrees x 10,000 x .75* (Assume convection cooling is 25%)
Evaporation = **113gpm**
Windage = Recirculation x 0.001 or 10,000x 0.001
Windage = **10gpm**
Bleed or blowdown = E/Cycles-1 for our example assume cycles to be 3
Blowdown = 113/2 = 56.5gpm
Since our bleed will be zero our equation becomes, Make up = Evaporation +Windage

Therefore our softened tower water make up requirements are 123gpm or about 180,000gpd. Our make up water is at 300 ppm as CaCO3 of total hardness. Given the above let's now consider what we will need in terms of water requirements from our softener as well as softener regeneration water and salt requirements.

Suggested Operating Conditions for a NaCl Regenerated Softener

Ideal service flow rate – 2 gpm
Backwash rate - 6 gpm per sq ft of surface for at least 10 min (some can be higher)
Regenerant flow rate – 1 gpm of 10% brine solution per cu ft for a minimum of 30min to use about 15 lbs of salt per cu ft
Slow rinse rate – 1 gpm per cu ft
Fast rinse flow rate – 1.5 to 2.0 gpm per cu ft
Total rinse requirements – 50 to 75 gal per cu ft for

Given the make up requirement of the tower we find that we will need to have a softener that is capable of delivering at least 2 to 3 gpm to keep up with our tower evaporation rate. That means we need a softener that has a resin capacity of at least 70 cu ft to satisfy our make up flow requirements as well as the minimum flow requirements of a softener. To accommodate the resin needed the size of our softeners bed is 5 ft in diameter and has a resin bed that is about 4.5 ft deep. Given its size and calculated capacity our softener will require regeneration about once every 13 hours per softener to assure soft water is always available for the tower.

Given the above let's now look at the total water requirements of regeneration for the above softener.
Backwash water = 6gpm x 10min x 15.6 sq ft = 936 gal/regen cycle
Regenerant water = 1gpm x 70 cu ft x 30 min = 2100 gal/regen cycle

Total rinse water = 60gal x 70 cu ft = 4,200gals/regen cycle
Total water requirement per regeneration is about 7,300 gallons or approximately 13,500 per 24 hr day. The blowdown water requirements would have been about 81,000 gallons therefore we are saving nearly 67,500 gallons per day. *At water rates of $2.50 per 1000 gal that is a daily savings of $168.75 per day. Not bad!*

Salt Costs

Now let's consider the cost of salt as part of the total savings of zero blowdown. Given salt usage requirements to obtain efficient regeneration of 15 lbs of NaCl per cu ft of resin per regeneration we can calculate the amount of salt required per daily regeneration. That number per 24 hour day is about 1,940 lbs of salt.

Salt is available in bag and bulk and varies in price from about $ .03 per lb for bulk salt to as high as $.20 per lb for bagged salt; a large user would typically use bulk salt and pay around $.05/lb, unless buying in very large quantities, so for a typical day we can expect to spend about $100 for regeneration costs. The actual savings from water are evaporating (no pun intended) and the user is now actually realizing much less than expected savings for his cooling program.

In many areas of the country and especially in CA there is still another cost associated with the use of softeners for water pretreatment, brine disposal. In southern California brine disposal costs are around $500 per tanker load. Considering that a tanker load is limited to 40,000 lbs we are looking at a limit of about 4500 gallons per load. Since our brine water usage is around 2100 gallons we will need to ship a tanker of brine per day for disposal. The cost is therefore about $500.00 per day. Suddenly zero blowdown doesn't look to good; does it? Moreover, we have not included the infrastructure costs of a tank and transfer pumps for make up water storage or the costs of spent brine storage and transfer pumps and tank. These costs could easily add $75 to $100 K of initial capital costs.

Considering the cost of water, salt, and brine disposal we can see that zero blowdown using softened water does not seem to be an economical alternative to regular operation. In addition, we have not even considered the costs associated with the purchasing and handling of the salt, nor have we considered the costs associated with the maintenance of the softener system, adding in those additional costs would make the zero bleed option even less attractive. Once again, it seems that savings touted in a zero bleed programs are more fantasy than fact.

Corrosion Considerations

Several potential corrosion issues need consideration when using a soft water zero blowdown program. They are, potential corrosion of galvanized towers, also known as white rust and corrosion of stainless tell due to high levels of chlorides causing chloride stress cracking.

High cycles achieved in softened water zero blowdown programs will also contribute to the cycling of alkalinity, resulting in elevated pH, and chlorides.

In that high pH water, without the corrosion inhibition of calcium or some other inhibitor or without acid modification a Zinc Galvanized cooling tower will experience severe white rust attack on the zinc in the cooling tower. Even if a system was previously passivated, the high alkaline low hardness water will reverse the passivation and cause corrosion of the wetted parts of the galvanized system. Of note is that many owners of galvanized towers, because of white rust, have switched to stainless cooling towers, however the issue of corrosion does not go away in softened zero blow down systems.

Stainless steel is susceptible to corrosion from high concentrations of chlorides in the grain boundaries of the metal. The corrosion is especially severe in any area or equipment that has highly stressed surfaces, such as welds and bends, and can become an area of concern under the right chemical conditions. It is especially important to look at any stainless component in a cooling system that may get hot or has periods of low flow conditions, (exchangers that stand by, flat plate exchangers with high heat transfer rates, welded areas of wetted equipment). It is also important to examine welded areas that may experience low flows and even stagnant conditions. The higher levels of chlorides, present in the recirculating water, can and will increase the potential for corrosion in stainless components.

Deposition Considerations

Though conventional deposit problems from hardness salts are not an issue in softened cycled water there is a considerable problem with salt deposition on the drift eliminators and cooling tower fills. Modern cooling systems are built for exceptional cooling efficiencies. They are smaller than old conventional towers but exceptionally good at distributing water to create a very large surface area that allows for rapid evaporation and cooling of the recycled water. That very design characteristic makes this type of towers very susceptible to deposit build up on the louvers and fill of the tower. In a softened water system, the deposits are typically sodium chloride (salt) that builds up in those areas where water flow becomes restricted, usually the outer surfaces of the fill. Because of the restricted flows, the deposition occurs ever more rapidly and impedes the airflow and thus evaporation for cooling. The restricted airflows will decrease the rate of cooling and thus causing decreased rates of heat-transfer, reduced process efficiency and increased energy costs. Keeping the fill clean and deposit free is a necessity and becomes an essential part of the preventative maintenance program.

Demineralization for Zero Blowdown

An alternative to softening is complete demineralization. Like softening it has its associated costs that make that approach even less feasible than softening. Adding to the costs of regenerants are the costs of safety and handling when working with caustic and acid. Adding still the costs of disposal or neutralization to the spent regenerants makes the approach completely not feasible for the application. Demineralization for zero blowdown is not an economical alternative.

Reverse Osmosis (RO) for Zero Blowdown and it's Costs

Still another alternative to softening the make up water is using water that has been purified using reverse osmosis membranes. Once again the idea sounds feasible but a thorough review of the method may reveal limitations and costs that need to be considered before deciding whether the method is applicable.

In reverse osmosis treatment of raw water high pressure is used to literally force filter the raw water through a membrane to separate the dissolved minerals from the bulk water. It is a proven method of treatment for all sorts of water and waste waters that can provide for very high quality purified water that, depending on need, can be used directly or further treated for final use. The RO method is effective but has a number of limitations.

Reverse osmosis limitations are substantial when considering an application. Initial equipment costs are very high. Our particular application that requires about 120 gpm has an initial capital cost of about $100 K for the RO unit only. That cost does not include a cleaning skid, RO membranes need regular cleaning, that would add another $10 K to the cost. Membrane life is limited with regular replacement costs of $5 to $10 K per year. The through put requirements, based on daily variations in evaporation and makeup of the tower, would necessitate the addition of a bulk water storage/surge tank to keep flows through the unit from varying to greatly. A 20K storage tank with transfer pumps, level controls and other infrastructure needed for it would add another $50 to $75 K to the initial capital cost.

Still another limitation is the amount of actual useful through put that can be obtained from the unit. Depending on water quality an RO unit will have a through put of anywhere from 50% of flow to as high as 90% of flow. What this means is that 10 to 50% of the water flow through the RO unit is reject water. Using our make up water as source water without any pretreatment we would fall into the 50% reject category. What this means in practical terms is that we would reject (blowdown) one gallon for every gallon of purified water, that means that we would have 180,000 gallons of blowdown everyday. That is what our blowdown is anyway! So why bother?

We can increase the through put by pretreating the water, with softening, to about 75% through put; but we have already calculated the cost of softening and that would only add to the already unreasonable operating cost. And, we haven't even considered the, very high, cost of energy for operating the RO system. We could go on and add in the other costs associated with any scheme we wish to consider for pretreatment of source water for RO purified water but the bottom line is that RO is not a practical method of water pretreatment for achieving zero blowdown.

Water Recycle/Reuse

There are many opportunities water use that are often overlooked by many sites that allow the user to realize both operational savings as well water savings. Many areas of the country are encouraging the use of Utility or Gray water (water from sewage treatment) for cooling tower make up. There are of course considerations for the use of this water but it doesn't involve much more than a modification to the current chemical treatment program used in the facility. Cooling tower blowdown, depending on solids content, has been used alone or blended with other sources of water as a source for watering the lawns and grounds.

Case Histories

A large auto parts manufacturer in Ohio used their entire waste water flow as a watering source. Not only did they save hundreds of thousands in water and sewer costs but they had the finest grounds in the locality.

A large waste to energy plant in Florida tapped into their community's Utility Water main and saved thousands by using that water for dust control on the trash piles used for fuel.

Many water recycle/reuse projects may or may not be easily realized unless considerations to the logistics, practicality and economics of reuse and recycle are fully looked at and analyzed. However, reuse and recycle may be the only real path to water savings.

Conclusion

In theory Zero Blowdown means reduced water consumption by eliminating water losses but if examined closely, Zero Blowdown is not a realizable goal for most cooling towers unless there is available and cheap high purity source water. Even then the actual reality of zero blowdown is less than many have promised and claimed. Zero Blowdown really ends up in the category of "If its sounds to good to be true..." There are however ways to economically achieve the dual goal of reduced water consumption and dollar savings that involve more practical and realistic means to the desired end. Increasing cycles thru better chemistry and control is easily achieved but it requires a higher level of attention to the cooling water program. Working with experienced and knowledgeable water treaters provides the means to that end. Still another way is to investigate opportunities for water conservation through water reuse and recycle.