by Pat McCool

Chlorine and ammonia reactions: maintain the correct ratio

One of the most important duties that water operators perform is achieving and maintaining adequate chlorine residuals. Adequate residuals are necessary to ensure that adequate disinfection occurs and regulatory requirements are met.

Maintaining chlorine residuals at desired levels in surface water treatment plant processes is particularly challenging in that there are many factors that can cause an unexpected decrease in, or even a complete loss of, chlorine residuals. For example, sunshine can cause loss of chlorine in outside basins. Also, an unexpected chlorine demand in the raw water can cause a loss of chlorine; such demand can be from increased organics, iron, and manganese in the water from rainfall runoff.

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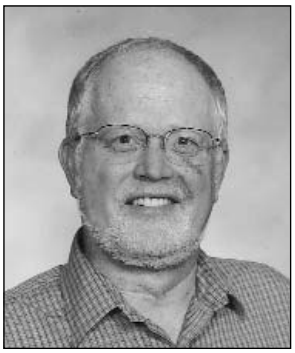

Most surface water treatment plants in Kansas add ammonia to form a combined chlorine residual after adequate disinfection when free chlorine occurs. The formation of combined chlorine is necessary to control and limit the formation of disinfection byproducts including trihalomethanes and haloacetic acids. The formation of combined chlorine also has other benefits. Combined chlorine residuals can be maintained in the distribution system better than free chlorine residuals. Combined chlorine residuals have less taste and odor in the water than free chlorine residuals. Sometimes, the cost of ammonia addition can be more than offset by the savings in chlorine costs.

Adequate residuals are necessary to ensure that adequate disinfection occurs and regulatory requirements are met.

If the chlorine and ammonia are not added in the proper amounts and in a proper way, there can be significant decreases or complete losses of combined chlorine residuals. This can occur in the treatment plant processes or in the distribution system or both.

Ratios need to be right

Common complaints of an operator might be "I keep turning the chlorine up but my residual keeps going down" or "I am using too much chlorine for the resulting combined chlorine levels in the water." Also, complaints might be "I am losing my chlorine residual in the clearwell or too soon in the distribution system." This is particularly significant because combined chlorine residuals are easier to

KRWA Tech Pat McCool and Daryl Couter, Operator at Valley Falls, use a titrator to check chlorine residuals. McCool and KRWA Surface Water Tech Lonnie Boller reviewed proposed plant upgrades with KDHE, the city and their consultant to help the city meet new regulations.

maintain than free chlorine residuals. The causes of these types of complaints are commonly improper chlorine-to-ammonia-ratios in the plant processes.

The problem of lower than expected or desired combined chlorine residuals is often caused by not adding enough ammonia for the amount of free chlorine in the water. When this happens, there is still excess free chlorine in the water after the ammonia reacts to form combined chlorine. The excess free chlorine then reacts with the combined chlorine resulting in both the free chlorine and combined chlorine residuals decreasing until either the free chlorine or combined chlorine is gone. This decrease in residuals also has a monetary loss in the operation of the plant.

Understanding reactions

When an operator has trouble maintaining constant combined residuals in plant processes or in the clearwell or in the distribution, the operator should first determine if the cause of the low residuals is the chlorine and ammonia feed rates and reactions. Chlorine and ammonia react proportionally in the water in an approximate three-to-one (3:1) ratio; that is, 3.0 mg/l of free chlorine reacts with 1.0 mg/l of ammonia to produce 3.0 mg/l of combined chlorine. If the chlorine-to-ammonia-ratio is lower than 3:1, then the combined chlorine produced will be less than it should be.

For example, a typical operation in a small city may be adding free chlorine to the rapid mix ahead of a solids contact basin where the operator wants to maintain a 2.4 mg/l free chlorine residual in the basin's effluent in order to meet CT requirements for disinfection. Then ammonia is added to the solids contact basin effluent before the water goes to the filters. The operator would want to add at least 0.8 mg/l of ammonia in order to achieve the 3:1 ratio (2.4 / 3 = 0.8; or 2.4 / 0.8 = 3 ratio).

In actual operations additional considerations need to be made. First, it is a good practice to add a little additional ammonia in case the free chlorine residual should go up because, for example, of a decrease chlorine demand or from a cloudy day. If additional ammonia is not in the water, the increase in free chlorine residual will result in a lowering of the combined chlorine formed. Thus, an operator might add additional 0.1 mg/l (for a total ammonia addition of 0.9 mg/l) so that the free chlorine in the solids contact basin effluent can go to 2.7 mg/l (resulting in 2.7 mg/l of combined chlorine) before additional free chlorine results in a drop-off in the combined chlorine residual.

Point of location is critical

Ammonia must be added to the water at a location and in a manner that results in an efficient and rapid mixing into the water containing the free chlorine residual. The ammonia feed rate must be accurately calculated and then set-up. Then the feed rate must be calibrated and checked on a regular basis. Monitoring of ammonia with test kits can be helpful; but the ammonia test kits are not necessary and, sometimes, may be misleading.

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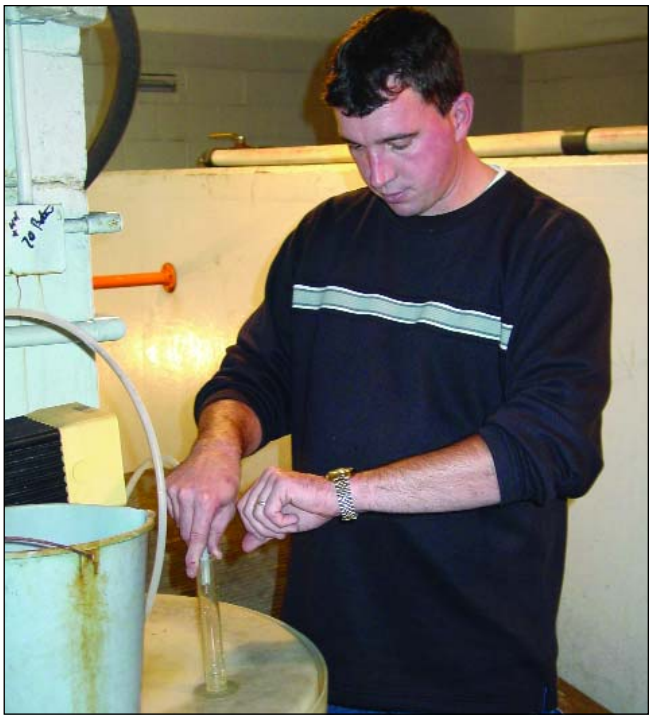
The free chlorine and combined chlorine residuals are best measured in the lab with an amperometric titrator. Also, DPD total chlorine residual reagents are good for measuring total residual, but the free chlorine residual reagents may give erroneous results when measuring in water containing significant combined chlorine residual from ammonia addition. Thus, an operator can not necessarily determine a combined chlorine residual with the DPD total chlorine residual reagent only. All plants adding ammonia should have and regularly use an amperometric titrator. An operator must be sure that the free and, especially, the combined chlorine residual tests are accurate.

As with all chemical addition and laboratory testing, complete and accurate records should be kept. These records are very important in evaluating the costs and operation of a water treatment plant. These records are particularly helpful in troubleshooting a plant when chlorine residuals cannot be maintained or are lower than they should be. Such data would include chlorine and ammonia feeder settings, feeder calibration and checks, amounts of bulk chemical use over time, residuals including time and location, and problems encountered.

Many water supplies in Kansas purchase water that has a combined chlorine residual. That water can be rechlorinated, if necessary, back to a level that represents the 3:1 ratio; however, if the water is re-chlorinated higher, the result will be lowering of the residual and chlorine waste. The purchaser should contact the water supplier to know what that level is.



KRWA Tech Lonnie Boller is shown calibrating an ammonia feed pump at Valley Falls. The ratio of ammonia to chlorine is typically 3:1.

If you have any chlorine residual problems in your water treatment plant or distribution system, or wish to have a review of the plant operations to determine if chlorine and ammonia are being added effectively and efficiently, contact me through KRWA at 785/336-3760. Either I or other KRWA staff will provide answers to your questions and visit on-site to review your situation.

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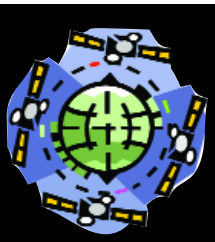

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