By Pat McCool, KRWA Consultant

Combined Chlorine – Getting the Chlorine and Ammonia Feed Rates Correct

Recently KRWA was contacted by two water suppliers from different parts of the state with two different problems. Upon investigation it was determined that the cause of both problems was the same. The chlorine to ammonia feed ratio was incorrect and that caused the operators considerable worry until the cause was determined and problem corrected.

High trihalomethanes (THMs)

One supplier was a surface water treatment plant that had a sampling the past summer for THMs that caused the maximum contaminant level (MCL) to be exceeded. The plant had been in compliance for many years and so the high THMs were a very unwelcome surprise to the operators. If fact, the THMs were so high that public notification has been required for three and maybe four quarters as compliance is based on a four-quarter, running average.

Amperometric titrators such as the one shown here can distinguish different types of chlorine residuals (free, combined, monochloramine, and total).

The water supplier contacted KRWA to help determine what had been the cause so that it would not happen again. The plant had been in compliance with THMs for many months after the high THMs sampling; but the cause of the high THMs the past summer was still unknown and they were worried that it might happen again.

The operator had suspected that the high THMs might be due to the warmer water temperatures in the summer and the very long detention time from the plant to the sampling point at the maximum residence time in the distribution.

The plant adds ammonia to produce combined chlorine residual for the distribution system. Once combined chlorine is formed, the THMs will not increase in the distribution system. A review of the plant flow schematic and the CT calculations determined that the THMs leaving the plant should have been in compliance if the combined residual was formed correctly.

The operators mentioned that they were having varying combined residuals at the plant and in town; varying to the extent that improper combined chlorine residual formation was suspected. The plant records contained good information on the chlorine and ammonia feed rates. The chlorine and ammonia feed rates were calculated for each of the twenty or so days before the high THM sample and it was determined that the residual leaving the plant on some of those days was in fact free chlorine residual and not combined chlorine residual.

Free chlorine residual is well known to continue to produce THMs in the distribution system. Thus, the cause of the high THMs was improper chlorine to ammonia feed rates. Also, once the chlorine and ammonia feed rates were adjusted to the proper rates, the widely varying combined chlorine residuals in and leaving the plant were eliminated.

Low residuals in town

Another water supplier contacted KRWA during the late winter because the combined chlorine residuals in town were low. The supplier operated a treatment plant to remove iron from well water. Ammonia was added for meeting the MCL for THMs. The residual in town was low.

Daily usage for calculating ammonia dosage is measured by graduations on the tank to show how much ammonium sulfate solution is used.

It was easily determined that water temperature in the elevated storage tank was not causing the problem as the problem was in all areas of town. As in the aforementioned water supplier, the operator mentioned varying residuals in both the treatment plant and the distribution. Again, the varying residuals suggested that the chlorine and ammonia feed rates were not adjusted correctly.

Quick calculations suggested that the ammonia feed rate was near the borderline of what was needed. In fact, it was suspected that the ammonia feed rates was at times too low when considering the varying free chlorine residual after reaction with the iron in the well water.

Once the ammonia feed rate was correctly set, the chlorine residual was then too high. In fact, the resultant free and combined residual did not agree with the chlorine feed rate based on the gas chlorinator rotometer reading. The operator began to keep daily records of the pounds of gas chlorine used based on the weight of the chlorine gas cylinders.

Adjustments in the chlorine feed rate were made based on the daily chlorine weight reading and the residual become constant at the predetermined, desired levels. Likewise, in this case the cause was improper chlorine and ammonia feed rates. But here the borderline ammonia feed rate, the improper rotometer reading, and the possible varying chlorine demand made the situation difficult.

Takeaways from these two examples

In general, in Kansas the two most difficult chemical feeding situations for water suppliers are: 1) feeding coagulants for proper coagulation, flocculation, and turbidity removal; and, 2) feeding chlorine and ammonia to form combined chlorine. When problems develop in the feeding of coagulants, the operator usually recognizes the problem soon and knows what actions to take.

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Daily gas chlorine usage in pounds is measured with weight scales. Then the pounds used can be used to calculate the free chlorine dosage.

may be occurring. Other possible causes of varying or low chlorine residuals are nitrifying bacteria in the distribution system during the late summer and early fall; or varying chlorine demand in the water being treated; and inconsistency in feeding equipment.

Sometimes the chlorine residual measurement method and procedures can in fact cause one not to recognize the problem. That was the case in the first example. That plant relied on automatic chlorine residual measurement equipment for total chlorine. Thus, when the combined chlorine residual went to free residual, it was not notice because the operators thought they were having more “varying” total residual.

If an operator is measuring for total residual, then the operator cannot tell whether it is free or combined. That is the case with many operators and so an additional determination should be made to insure whether free or combined residual is occurring.

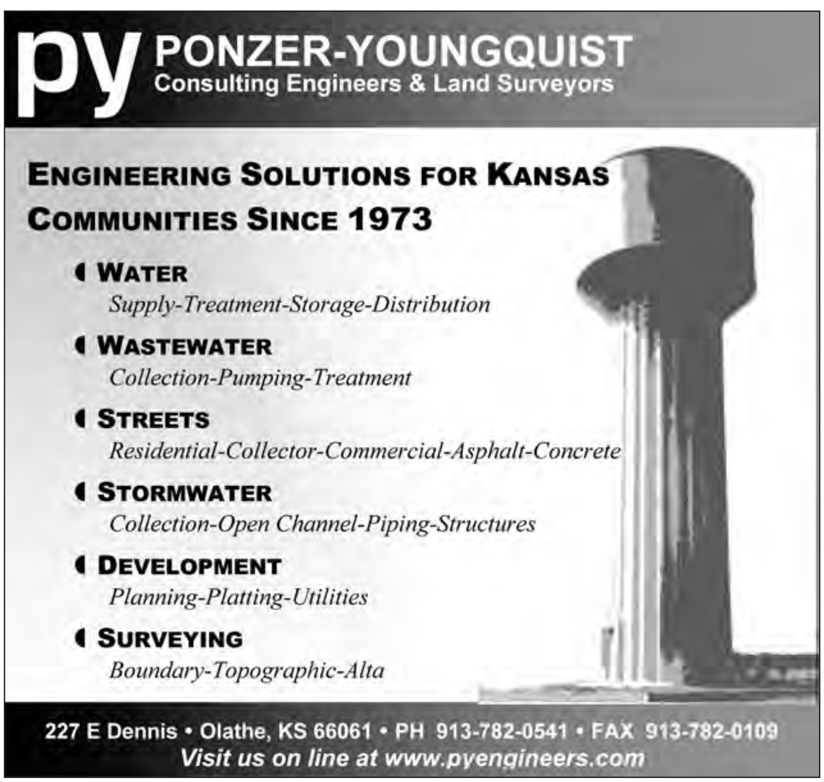
I have found that the two best, simplest ways to determine whether the residual is free or combined is: 1) amperiometric titration; and, 2) calculation of the chlorine and ammonia feed rates. One of these methods should be used periodically to insure that DPD total chlorine measurements are either free or combined.

The second example showed that the best way to determine chemical dosages is by weight of chemical used. In that situation, it was determined that the actual weight of the chlorine gas used daily was best for calculating chlorine dosage. Also, the daily usage in gallons of ammonium sulfate mix was best for determining ammonia dosage. Ammonia test kits are sometimes misleading or incorrect so always check data by calculations of ammonia dosage.

Chlorine to ammonia calculation

The calculation of the chlorine and ammonia feed rates (in addition to helping determine the type of chlorine residual) determines if chlorine or ammonia is being inefficiently feed; that is, if overfeeding is occurring and money is being wasted.

Anytime there are significantly varying chlorine residuals in treatment plant processes, the clearwell, or the distribution



Daily chemical usage for small systems can be as simple as this.

system an operator should first determine if the chlorine and ammonia feed rates are correct. Chlorine and ammonia react proportionally in the water in a 4.2 to 1.0 ratio.

That is, 4.2 mg/l of free chlorine residual in the water will react with 1.0 mg/l of ammonia in the water to produce 4.2 mg/l of combined chlorine residual. In feeding chlorine and ammonia, if there is not enough ammonia (or in other words, if there is too much chlorine) the resultant residual will be lower; and additional chlorine will drive the residual even lower.

The 4.2 to 1.0 ratio may be too high if there is not good mixing of the chemicals at the application points.

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Sometimes to be assured of getting it correct initially and to provide a more "forgiving" and more consistent chemical reaction, the ammonia feed rate is increased so that the resultant chlorine to ammonia feed ratio is approximately 3.0 or 3.5 to 1.0.

It you ever suspect that you might have a problem with the chlorine and ammonia feed rates, or you wish to have someone calculated your dosages so that you can compare with the residuals measured, please contact KRWA as we will be glad to discuss your operation with you.

Pat McCool has been with KRWA since January 2004. He previously worked for KDHE for 30 years. Pat has a B.S. in Chemical Engineering and a M.S. in Environmental Engineering from the University of Kansas. He is a registered Professional Engineer in Kansas.