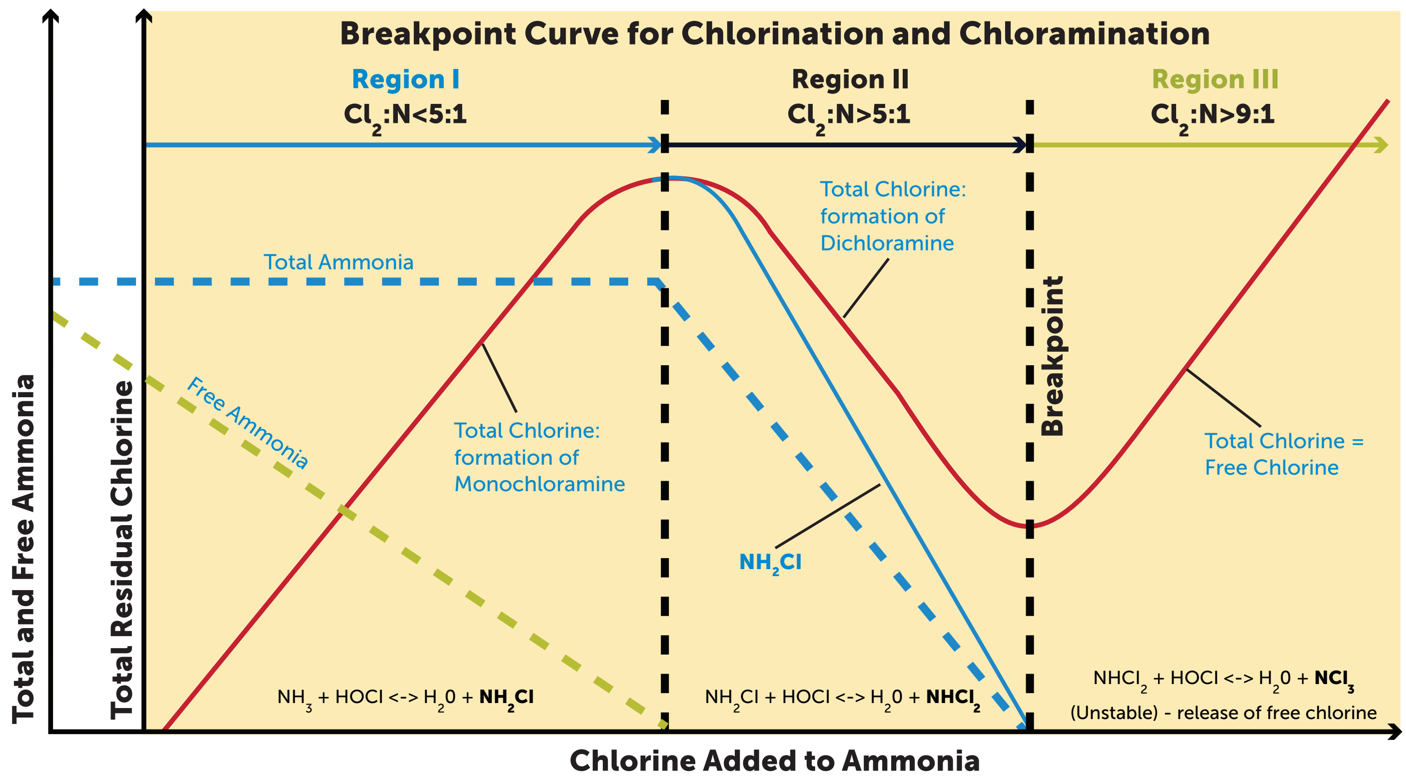
How The Chloramination Curve Should Be Shaping Your Disinfection Process

Disinfection during the final step of drinking water production is based on chlorine reacting with matter in the water, such as bacteriaand organics. At some point in this process, the amount of chlorine present in the water overtakes the demand to generate a residual.Maintaining the proper level of this residual is critical to ensuring water quality as it travels through the distribution system to customers.

Chloramination, the mixing of chlorine and ammonia, is a popular method to achieve longer-living disinfectant residual at a lower risk of DBP formation. This can be done by adding chlorine to water with existing ammonia, dosing both chlorine and ammonia together, or adding ammonia to water that has already been chlorinated.

The rate at which chlorine residual occurs when ammonia is added or present in the water during chloramination follows a different course than straight chlorination. Plotting that course is known as the chloramination curve, or breakpoint chlorination curve. A common mistake made by water quality managers is not comprehending the curve and its implications. Even when explained in a simple schematic, the subject is still complex.

Here is a breakdown of the basics of the curve to make it easier to understand.



Plotting A Position

So, how can you tell where your water falls on the curve at any given time? Knowing the key parameters to look for in each section makes it is easy to determine your position.

When adding chlorine to water that contains ammonia, the ammonia sheds a hydrogen atom and the chlorine takes its place. As this is happening, the curve is trending upward as chlorine residual is created. When one chlorine molecule has effectively bonded with each molecule of ammonia, which is reflected by a 5:1 Cl_2 to N mass ratio, the ideal state of monochloramine disinfectant has been achieved.

If more chlorine is added at this point, water systems will see a decrease in total chlorine residual as dichloramine and trichloramine form. This creates less-than-ideal conditions as the disinfectant residual drops and customers will likely experience taste and odor problems. Once the additional chlorine has bonded with all the nitrogen from the ammonia, the upward trend will return with additional chlorine added to the system.

When the municipality adds ammonia to water that has already been chlorinated, the concept stays the same. Water quality managers just need to follow a reverse path along the graph to plot the curve.

A common mistake when trying to plot the curve is not using enough data. At a minimum, total chlorine and free ammonia need to be measured. Ideally, monochloramine, total ammonia, and free chlorine should also be monitored. When free ammonia, total ammonia, and monochloramine are present, the water system is in Region I of the curve—monochloramine formation zone. If total ammonia and monochloramine are present, but free ammonia is absent, it is on the downward slope in Region II—dichloramine formation zone. If any ammonia is absent and only total chlorine is present (and equal to free chlorine), then breakpoint has occurred and the process is in a “free chlorine zone.”

What is the difference between free and total chlorine? Free chlorine refers to both hypochlorous acid and the hypochlorite ion, or bleach. When ammonia is also present, the monochloramine, dichloramine, and trichloramine known as combined chlorine are formed. Total chlorine is the sum of free chlorine and combined chlorine.

Avoiding A Mad Scramble Disinfection is a critical step in the water treatment process. While severe over-chlorination can quickly lead to smell and taste issues for consumers, nitrification is a problem that happens with under-chlorination and is much worse while develops slowly and likely represents a systemic problem with chloramination control. Depending on the season and the condition of the distribution system, nitrification can happen faster and cause severe problems, both with water quality and regulations.

Once disinfection processes are out of control, water quality managers are usually left scrambling to get a handle on the problem with excessive flushing and boil notices. Not only does this impose a financial cost on the municipality, it damages trust with consumers.

Water quality managers are responsible for keeping tight control of the treatment process, and understanding the chloramination curve can go a long way toward that goal. Additionally, equipment such as ammonia/monochloramine analyzers that can measure all three major parameters can prove to be invaluable. These machines, available with manual alarms as well as automatic controls to maintain the proper Cl_2:N ratio, facilitate online analysis to allow water utilities to adjust within minutes. By comparison, taking grab samples and analyzing them in a laboratory can take hours.

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