The Search for Good Mixing & Water Quality

Tom Caulfield
Commercial Development Manager
UGSI Solutions
Chloramines are used in about a third of municipal water systems, provide longer protection in distribution systems, and are less prone to encourage DBP formation

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\text{NH}_3 + \text{OCl}^- \leftrightarrow \text{NH}_2\text{Cl} + \text{HO}^-
\]

Monochloramine is formed by the reaction of chlorine and ammonia with a chlorine atom substituting for one of the three ammonia hydrogen atoms.
There are three “chloramine” variants - only one of which is desirable in a water system.

Only monochloramine is considered a suitable disinfectant.

This reaction is reversible - under certain conditions, products can decompose into reactants.
Chloramine usage has been problematic due to difficulty in accurately controlling ammonia and chlorine dosage in a dynamic distribution system.

- Introduction of ammonia can lead to nitrification as it is a nutrient to AOB’s.
- Over-chlorination can create chloramine variants which lead to taste and odor problems in drinking water (dichloramine and trichloramine).
- Low residual levels can also lead to costly mitigation efforts such as:
  - Chlorine burns
  - Line flushing
  - Tank dumping
  - Hydraulic acrobatics

Ammonia Oxidizing Bacteria (AOB)
In a distribution system, chloramine levels are challenged by a number of factors:

- Temperature stratification in tanks
- Chemical stratification in tanks
- Multiple water source compatibility
  - Surface, ground, purchased
- Distribution pipeline conditions
  - Unlined cast iron, biofilm buildup
- Water aging in tanks and pipelines

Changes in constituent ratios over time (Chlorine & Ammonia)
Chloramine Breakpoint Curve: Know where you are on the curve
Temperature & Chemical stratification in tanks:

Properly sized active tank mixing eliminates tank stratification
Effective disinfectant residual control completely eliminates the threat of nitrification

**Before**: August-October (4) tank nitrification events as water temperature remained high

**After**: August-October next year with residual control - steady 3.3ppm residual through “nitrification season”
Multiple water source compatibility:

- **Surface water sources**
  - Have warmer water temperatures during summer
  - Varying water quality

- **Ground water sources**
  - Have constant cooler water temperatures
  - More constant water quality

- **Purchased water sources**
  - Can be highly variable water quality
  - Completely dependent upon the supplier of the water
Distribution pipeline conditions:

- Unlined cast iron pipes
  - Create chlorine demand
  - Provide a perfect environment for biofilm growth
  - Inhibit flushing efforts due to decreased ID
- Oversized water mains
  - Creates horizontal storage tankage
  - Increases water age - aids in residual loss
  - Decreases water velocities - allows biofilm growth
  - Could inhibit flushing efforts due to large flow required for scouring velocities
- Distribution systems with limited pipe replacement programs
Water aging in tanks and pipelines

- Storage tanks were designed for:
  - Hydraulic pressure for the system
  - Fire suppression requirement
  - Future development - 15 to 30 years
  - Emergency reserve
- Storage tanks were NOT designed for:
  - Water quality
  - Rapid turnover
  - Minimizing water age

- Examples:
  - Standpipes vs. elevated storage
  - Small operating ranges for water levels in order to maintain pressure
  - Common inlet/outlet pipes
  - Large unused volumes of water
Conclusions

- Powerful & continuous mixing is key to make informed process decisions
- Knowing your tank’s hydraulics helps understand the problem
- In-tank chemical dosing allows for continuous water quality adjustment

Tank Cl₂ residual taken June 13th, 2017
- Ambient air temp 95°F
- Inlet Cl₂ ≈ 1.5 mg/L

Tom Caulfield
UGSI Solutions
215-882-0866
Tcaulfield@ugsicorp.com