Distribution System Water Quality
Maintaining a Disinfectant Residual

As part of a multi-barrier regulatory framework to control microbial contamination, public water systems (PWSs) supplied by or under the direct influence of surface water must maintain a disinfectant residual for water that is delivered to customers through a distribution system. Disinfectant residuals in the distribution systems serve three main purposes: to protect against microbial contaminants, to act as an indicator of distribution system upset, and to limit growth of heterotrophic bacteria and *Legionella* within the distribution system. This fact sheet is part of EPA's Distribution System Toolbox developed to summarize best management practices that PWSs, particularly small systems, can use to maintain distribution system water quality and protect public health.

Examples of Utility Actions

A PWS serving 6,000 people in the mid-Atlantic region struggled to maintain a disinfectant residual in the distribution system. Sampling showed that extremities of the distribution system had free chlorine residuals <0.1 mg/L. The PWS implemented a spot flushing program by installing automatic flushing units at three areas of low disinfectant residuals. As a result, free chlorine residuals increased to >0.2 mg/L.

A PWS in the eastern U.S. serving more than one million people occasionally experienced localized pockets of low chlorine residuals in the distribution system. An investigation of one problem area identified several factors, including pipe materials, water temperature, and low flow due to seasonal variations in water use. Low velocity spot flushing was effective in restoring chlorine residual from September to June when water use was relatively high. But during July and August, when water use was lowest, spot flushing alone did not restore chlorine residuals. The PWS next replaced cast iron pipes, associated with high chlorine demand, with pipes of ductile iron. Chlorine residuals improved, rising above 0.1 mg/L.

Understand Disinfectant Demand and Effects of Water Age

Conditions that exert a demand on disinfectants limit the system's ability to maintain a disinfectant residual. For example: biofilms and sediments in piping and tank surfaces can harbor microorganisms that consume the disinfectant. Corrosion products and other compounds present in finished water can also react with disinfectants. Breaks or leaks in a distribution system can lead to contaminant intrusion that further consumes disinfectants.

The length of time water spends in the distribution system is called "water age." The higher the water age, the more reaction time for the disinfectant residual, leading to reduced concentration of disinfectant residual, increased potential for microbial growth, and detriments to water quality. Causes of high water age in the distribution system can include:

- Oversized pipes and tanks,
- Decreased water demand due to conservation efforts,
- System configuration (e.g., dead end mains), and
- Incorrect valve position (e.g., when a valve that is not reopened after maintenance, preventing water circulation).

What follows is some practical advice for maintaining disinfectant residuals.

Diagnose Issues with Maintaining Disinfectant Residuals

- Compile historical water quality data. Identify specific locations and times (e.g., times of year, like during warmer months) where residuals are below state regulatory thresholds.
- Review system configuration and operational records to identify locations with potentially slow water turnover and high water age. Monitor disinfectant residual at those locations.
- Review sanitary survey reports and related corrective actions to identify known sanitary defects (e.g., cracks and leaks) that need to be addressed.
- Review maintenance records to assess whether infrastructure issues (e.g., pipe materials, pipe condition, or presence of sediment and/or biofilm) could be contributing to excessive disinfectant demand.
- For systems using chloramination, conduct monitoring to determine if nitrification occurs in the distribution system.
- Review the quality of water provided to consecutive systems.

Keep the Distribution System Clean and Add Booster Disinfection if Needed

- Reducing the amount of organic matter and nutrients in the water entering the distribution system can help limit the growth of biofilms on pipe and tank surfaces.
- Flushing and pigging can remove sediments and biofilms.
- Replacing or rehabilitating older pipes, such as unlined cast iron water mains, can remove corrosion tubercles; lining mains also can reduce disinfectant demand from pipe materials.
- Finished water storage facility cleaning can remove sediments and corrosion deposits from tank floors as well as biofilms and other deposits from tank wall surfaces.
- Booster disinfection facilities can be added at selected locations in the distribution system to increase the disinfectant residual.

Using a field test kit to measure chlorine residual in the distribution system

Reduce Water Age with Design and Operational Changes

- Hydraulic models such as EPANET can be used to design distribution systems and optimize their operation.
- Dead-end piping can be eliminated (e.g., as part of capital projects).
- Pumping and storage facility filling/draining operations can be optimized to increase water turnover.
- Mixing devices can be added to storage facilities to improve water circulation.
- Spot flushing programs for dead-end piping or low water use areas can be implemented to remove stagnant water and restore disinfectant residual.

Table 1. Resources and Guidelines for Disinfectant Residual Maintenance	
Resource Title and URL	**Relevance to Maintenance of Disinfectant Residual**
ASDWA. 2020. Distribution System Survey White Paper. https://www.asdwa.org/	Summarizes state responses to a survey on distribution system issues; topics include minimum disinfectant residual requirements in the distribution system.
Hill et al. 2018. WRF 4653 Flushing Guidance. https://www.waterrf.org/	Reports research findings and guidance on flushing as a technique to restore water quality in the distribution system.
GLUMRB. 2018. Ten States Standards. https://www.mngovpublications.com/catalog/Default.asp?CatalogID=21656&Provider_ID=1241868	Describes how to design water distribution systems to maintain treated water quality, including maintaining disinfectant residual.
AWWA. 2017. M68 Manual of Water Supply Practices. Water Quality in Distribution Systems. https://www.awwa.org/	Summarizes federal disinfection requirements and discusses simultaneous compliance issues between disinfection requirements and DBP formation prevention requirements. Describes pros and cons of various disinfectants for maintaining a disinfectant residual and strategies to prevent disinfectant decay in the distribution system. Describes how to estimate water age.