Chlorine’s Effect on Corrosion in Drinking Water Systems

by Michelle Moore
NDWC Promotions Writer/Editor

Small drinking water treatment systems face a dilemma: two regulations from the U.S. Environmental Protection Agency (EPA), the Lead and Copper Rule and the Ground Water Rule, seem to work against each other, even though each rule is meant to benefit the public.

The Lead and Copper Rule, which EPA implemented in 1991, mandated water treatment systems sample their treated water for lead and copper. Internal pipe corrosion can lead to both aesthetic problems (staining fixtures and laundry) and consumer health issues.

The Ground Water Rule, which EPA will implement in the fall of 2001, requires that water systems be evaluated for disinfection needs. Operators must monitor systems for microbiological contamination. These systems must then remove or inactivate microorganisms to prevent them from reaching consumers. Because many smaller water systems rely on groundwater, this rule will affect them the most.

The most common disinfection method is to add chlorine, a corrosive agent, to water. Concerns arise because disinfecting to comply with the Ground Water Rule may push water systems out of compliance with the Lead and Copper Rule. Further, adding chlorine to the finished water may make other metals in a system more likely to corrode.

A team of researchers in Wisconsin sponsored by the Midwest Technical Assistance Center (MTAC) studied chlorine’s effect on corrosion in drinking water systems. Their research found that introducing free chlorine for disinfection increased corrosion. Adding free chlorine appears to affect iron the most. Chlorine also appears to have an effect on copper and lead, but it may or may not increase corrosion with these metals. See the accompanying tables for a general summary of the study.

Researchers Suggest Corrosion Control Measures

A pH below 7.0 creates highly corrosive water. However, a pH above approximately 7.8 to 8.0 greatly diminishes chlorine’s disinfectant efficacy.

Water with a high pH value may cause calcium carbonate flakes in the piping system, which in turn can cause flow problems.

If one or more metals in the drinking water system continue to show increased corrosion levels, or if raising the pH is not practical, operators can add orthophosphate (a corrosion control agent) to the chlorinated water. But, before adding orthophosphate, the pH of the water should be at a minimum of 7.0.

The operator must be aware that adding phosphate to drinking water may cause conflicts with phosphorus discharge limits at the municipal wastewater treatment plant and with allowable phosphorus runoff levels into nearby lakes and streams. Operators also need to be aware that adding orthophosphate may increase copper corrosion in the system. The increase can be tolerated if copper levels do not rise above 1,300 micrograms per liter in homes.

Proper monitoring is essential to adequate corrosion control. An established, effective monitoring method employs pipe loops of each metal in question. Pipes constructed of various metals can be connected at one or more locations in a water distribution system.

Routine samples taken from the pipe loops will show corrosive trends in the system and chemicals can be adjusted accordingly. This method’s advantages are that samples can be taken under more controlled conditions than in private residences. Also, the operator does not have to depend upon the good will of consumers to

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Lead Pipe Corrosion Summary</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Issue</strong></td>
<td><strong>Dane, WI (Higher Alkalinity)</strong></td>
</tr>
<tr>
<td>Corrosivity of untreated water with respect to lead</td>
<td>Corrosive (over the action limit*)</td>
</tr>
<tr>
<td>Effect of adding chlorine</td>
<td>Lowered the lead slightly</td>
</tr>
<tr>
<td>Effect of adding corrosion control chemicals to the chlorinated water</td>
<td>Orthophosphate lowered the lead substantially in the long term</td>
</tr>
</tbody>
</table>

Source: Midwest Technology Assistance Center. * Action limit: the concentration of lead and copper that requires treatment.

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obtain samples. The disadvantage of this system is that a small water utility may not have the resources and personnel to attend to the pipe loops.

Until new, effective, and economical corrosion monitoring techniques are developed, water utility operators who do not use pipe loops for monitoring should evaluate for corrosion of water distribution system metals by obtaining samples from buildings in their distribution system beyond those samples required by the Lead and Copper Rule. The Lead and Copper Rule sampling is weighted toward older buildings with lead service lines or lead solder in the plumbing system.

Operators should select and sample newer homes with copper plumbing systems in the same manner for evaluating copper corrosion. Other materials of concern in plumbing systems, such as iron, should be sampled by proper selection of buildings or residences and by obtaining these extra samples.

For More Information
The Effect of Chlorine on Corrosion in Drinking Water Systems Study by Abigail F. Cantor, P.E., Jae K. Park, Ph.D., and Prasit Vaiyavatjama, November 2000, was funded by the Midwest Technology Assistance Center (MTAC). The University of Illinois at Urbana-Champaign and the Illinois State Water Survey, both located in Champaign, Illinois, sponsored the report. Copies of the final report are available from MTAC by calling (217) 333-9321.

MTAC provides technical assistance to small public water systems and water systems serving Native American communities. Their mission is to provide small system administrators and operators with the information necessary to make informed decisions about planning, financing, and selecting and implementing technological solutions to address their needs.

Learn more about these and other corrosion control methods in NDWC’s Tech Brief #3, Item# DWBRPE32 available by calling (800) 624-8301.

### Table 2
Copper Pipe Corrosion Summary

<table>
<thead>
<tr>
<th>Issue</th>
<th>Dane, WI (Higher Alkalinity)</th>
<th>Lone Rock, WI (Lower Alkalinity)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corrosivity of untreated water with respect to copper</td>
<td>Not over the action limit</td>
<td>Not over the action limit</td>
</tr>
<tr>
<td>Effect of adding chlorine later on, copper level elevates</td>
<td>More corrosive than untreated water but still below action limit</td>
<td>Same as untreated water at first, but later on, copper level elevates</td>
</tr>
<tr>
<td>Effect of adding corrosion control chemicals to chlorinated water increased the copper levels more</td>
<td>Orthophosphate increased the copper levels further</td>
<td>Increasing pH increased the copper levels more</td>
</tr>
</tbody>
</table>

### Table 3
Iron Pipe Corrosion Summary

<table>
<thead>
<tr>
<th>Issue</th>
<th>Dane, WI (Higher Alkalinity)</th>
<th>Lone Rock, WI (Lower Alkalinity)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corrosivity of the untreated water with respect to iron</td>
<td>Not over the secondary limit</td>
<td>Not over the secondary limit</td>
</tr>
<tr>
<td>Effect of adding chlorine</td>
<td>No effect at first but elevated the iron later on</td>
<td>Chlorine elevated the iron levels</td>
</tr>
</tbody>
</table>

Source: Midwest Technology Assistance Center.

* Secondary limit: the regulations set to control contaminants that primarily affect drinking water's aesthetic qualities.

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**Corrosion Evaluation Sampling**

Paying attention to the following details will help you achieve accurate corrosion evaluation sampling:

- select buildings both close to the utility and at the extreme ends of the distribution system;
- verify piping materials in the buildings selected for sampling;
- make sure that sample water has not been softened or treated at the site;
- verify that no water flowed through the building's plumbing system for the prescribed stagnation time of a first-draw sample;
- be consistent in the stagnation time of each sample;
- after obtaining the first-draw sample for metals, gather other information, such as the temperature and pH of the stagnant water, the temperature and pH of the flowing water, plus the orthophosphate concentration (if using any phosphate product), the total phosphate concentration (if using a polyphosphate product), and the chlorine residual of the flowing water; and
- plot all information on graphs versus time. Note changes to corrosion control treatments or other system changes on the graphs.