Distribution

As soon as finished water leaves a treatment plant and travels into the distribution system, the water’s quality begins to degrade. Main cleaning is an effective, sustainable way to maintain water quality and extend water main service life. **BY MELINDA FRIEDMAN, BRIAN LAKIN, AND RANDY MOORE**

**BEST PRACTICES CLEANING MAINS: CLEAN, PIG, OR DIG?**

*Editor’s Note:* Based on a series of AWWA webcasts, this article is the second of three on important distribution system issues. This article details best practices for cleaning water mains, as regular main cleaning can help extend distribution system service life. Last month’s article focused on storage tank operations and maintenance. The final article will provide operations and maintenance options for complying with the US Environmental Protection Agency’s Stage 2 Disinfectants and Disinfection Byproducts Rule. To order the original webcasts, visit [www.awwa.org/webcasts](http://www.awwa.org/webcasts) and click on the Webcast Library link. Also, check out the complete lineup of upcoming webcasts.

PERIODIC CLEANING of water mains can be an effective and sustainable water quality and asset management tool. Main cleaning improves water quality, reduces treatment and pumping costs, and extends equipment service life. There are three primary reasons to clean water mains. First, distribution system pipelines aren’t sterile environments. Numerous complex microbiological, chemical, and physical reactions occur between water and piping material that can degrade water quality. Second, tubercles, scale, and sediment buildup in water mains can cause pressure and flow problems. Third, water main cleaning can be part of a rehabilitation program.
Select a main-cleaning technique based on site-specific conditions and the cleaning objective. Options include (clockwise from top left) hydrant flushing to remove bulk water; using ice to form an ice pig that’s injected and removed through a hydrant; soft flexible swabbing pigs; and steel mechanical scrapers.
CLEANING TECHNIQUES
An appropriate main-cleaning technique should be selected based on site-specific conditions and the cleaning objective identified. This article reviews five cleaning techniques—flushing, ice pigging, swabbing, pigging, and mechanical cleaning—from least to most aggressive.

Six essential planning elements should be undertaken before any on-site cleaning work is done.

- Obtain up-to-date system maps.
- Coordinate stakeholders and define responsibilities.
- Obtain field equipment and permits.
- Develop loops and establish the feasibility of operation.
- Conduct pre-inspection valve and hydrant maintenance.
- Notify customers and the public.

Diligent attention to these steps is especially important when a third-party vendor is involved. Considerable time and money can be wasted if cleaning loops aren’t properly delineated, valves can’t be located or operated, or if there isn’t a suitable water disposal area.

FLUSHING
In unidirectional flushing (UDF), distribution system pipes are flushed in a controlled, sequential manner. Flow direction and velocity should be controlled through valve isolation. UDF is more effective than conventional flushing—for which valves aren’t isolated—because scouring velocities can be intensified and entrained materials removed from the distribution system. Conventional flushing isn’t a sustainable cleaning practice, because it uses a lot of water, doesn’t remove much sediment or biofilm, and it stirs up sediment and releases it to consumers. It should only be used for bulk water turnover.

**UDF Advantages:**
- UDF can be conducted in-house by any utility, because it doesn’t require expensive specialty equipment or third-party vendor support.
- Customer service isolation usually isn’t required.
- The process effectively removes loose deposits and loosely adhered materials from mains.
- It’s the lowest-cost cleaning technique.

**UDF Disadvantages**
- UDF uses large volumes of water and may be viewed as wasteful.
- Use of the process is limited to 12-in.-diameter or smaller pipes.
- Disposal of effluent and sediment must be considered.

ICE PIGGING
Used successfully in Europe and recently introduced in the United States, ice pigging involves pumping an ice slurry into a water main (filling about 10–20 percent of the pipe volume), and using upstream pressure to carry the ice “pig” downstream to an exit hydrant. Created on-site using utility water and special equipment, the ice slurry scours and entrains accumulated deposits as it moves downstream. NSF-grade salt is added to the ice to suppress freezing and slow the melting process. Injected through hydrants or valves without excavation, the ice slurry can navigate bends, diameter changes, and butterfly valves.

**Ice Pigging Advantages**
- Ice pigging uses less water than UDF and more effectively removes cohesive deposits with higher shear forces than water alone.
- The process usually doesn’t require specialty launching or retrieval stations.
- Customer service isolation usually isn’t required.
- If the ice gets stuck, it will melt without requiring excavation.

### Comparative Cost Approximations

**It’s difficult to develop “apples-to-apples” cost comparisons. Actual costs are site-specific and subject to numerous variables.**

<table>
<thead>
<tr>
<th>Technique</th>
<th>Objective</th>
<th>Estimated Total Cost – O&amp;M and Capital ($/mi)*</th>
<th>Estimated Total Cost – O&amp;M and Capital ($/LF)*</th>
<th>Estimated Frequency (years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>UDF</td>
<td>Bulk water, loose deposits, cohesive deposits</td>
<td>$5,000, first time $3,000, repeat</td>
<td>0.95</td>
<td>0.5–3</td>
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<tr>
<td>Ice Pigging</td>
<td>Loose deposits, cohesive deposits</td>
<td>$9,000–$29,000</td>
<td>1.7–5.5</td>
<td>3–7</td>
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<tr>
<td>Swabbing</td>
<td>Adhered deposits, and hard scale</td>
<td>$30,000–$48,000</td>
<td>5.7–9.1</td>
<td>3–7</td>
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<tr>
<td>Pigging**</td>
<td></td>
<td>$85,000–$111,000</td>
<td>16.1–21</td>
<td>≥ 10</td>
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<tr>
<td>Mechanical Cleaning***</td>
<td></td>
<td>$422,400–$517,440</td>
<td>80–98</td>
<td>≥ 20</td>
</tr>
</tbody>
</table>

Adapted from work conducted by Confluence Engineering Group and Kennedy/Jenks Consulting for two West Coast utilities. Cost information for ice pigging provided by Utility Service Group.

*Assumes labor rate of $100/hour. Cost significantly affected by the number of people per crew, number of loops per mile, etc.

**Assumes no rehabilitation or major system modifications because need is site-specific.

***Assumes rehabilitation and system modifications required for implementation.
Ice Pigging Disadvantages
- Ice pigging requires special equipment and a third-party vendor.
- Use of the process is limited to 18-in.-diameter or smaller pipelines.
- Salt discharge requirements must be considered.
- The process requires more rigorous loop planning than UDF to ensure no other water is drawn into the main that would dilute or disturb the ice pig.
- Ice pigging is a cleaning technique only; it shouldn’t be used for pipe rehabilitation preparation.

Swabbing relies on the physical shearing action of a low-density, highly compressible foam cylinder or cube against the pipe wall. Compared with pigs, swabs are lighter, softer, and lack a pig’s hard, abrasive coating and surface features. Because swabs are usually 125 percent of the pipe’s nominal inside diameter, they’re compressed during use, which boosts frictional shear forces against the pipe wall and improves soft deposit and biofilm removal. Swabs are forced through existing hydrants or launching stations using a pumper truck.

Swabbing Advantages
- Swabs provide flexibility.
- Pipes of nearly any diameter can be cleaned with swabs.
- Swabs are made in a variety of materials and sizes.
- Swabbing is more aggressive and effective than UDF for removing cohesive deposits.

Swabbing Disadvantages
- Swabbing is more labor intensive than UDF.
- Swabs can become stuck and require excavation for manual removal.
- The process may require launching and retrieval stations for 12-in.-diameter or greater pipes.

The process typically requires isolation of customer service lines.

Mechanical Cleaning Advantages
- Mechanical cleaning doesn’t rely on water pressure or flow.
- The process can remove the hardest deposits.
- Mechanical cleaning minimizes material to be disposed of.
- It’s the most-effective and long-term cleaning/rehabilitation method.

Mechanical Cleaning Disadvantages
- Borderline or brittle pipes can break.
- Equipment can get lodged at obstructions.
- Relining is required.
- Temporary water service is needed for customers.

PIGGING
A pig is a rigid, bullet-shaped object that’s pushed along a predetermined pipe route, and it scours the sides of a main as it passes through. As in swabbing, a pumper truck is used to force the pig into the main. Distribution system water is used to propel the pig and force it to a predetermined recovery point in the system, where used pigs and material removed from the pipe walls are retrieved. Because pigging is more aggressive than swabbing, ice pigging, and flushing, pipe relining may be required.

Pigging Advantages
- Pigging can remove adhered deposits.
- Pigs come in a variety of materials and sizes to target cleaning objectives and desired aggressiveness.
- The process is more effective than UDF and swabbing for adhered deposits.
- Pigging provides longer-lasting improvements than less-aggressive techniques.

Pigging Disadvantages
- Pigging requires launching and retrieval stations in 8-in.-diameter or larger pipes.
- Pigs can’t pass through butterfly valves or pipe diameter changes.
- Pigging typically requires a third-party vendor.
- The process often requires pipe relining.

Regular water main cleaning and rehabilitation helps maintain water quality and extends distribution system service life.