Vitrified Clay Pipe
Operations & Maintenance Handbook

Since 1917

NCPI

NATIONAL CLAY PIPE INSTITUTE

A Century Of Leadership

No gravity sewer pipe material lasts longer than VCP. Experienced sewer professionals know the service life of any system is only as good as its maintenance.

Proper sewer cleaning is vital to reducing costly Sanitary Sewer Overflows (SSOs), and extending the usable life of a sewer system.

Four Keys to Effective Sewer Cleaning:

Select Cleaning Tools Appropriate for Various Pipe Materials (Page 10)
Technological advances in sewer tools have increased the ability of sewer professionals to clean VCP more efficiently. Many tools in today's marketplace are damaging to other pipe materials.

Why a Centralizer Matters (Page 14)
A centralizer is operationally safer, it saves water, protects the tool, and increases cleaning efficiency by nearly 75%.

Consistent and Effective SOPs Reduce SSOs (Page 19)
Utilization of an SOP also ensures consistency in cleaning which is particularly important when managing crew schedules and frequency of cleaning for each pipeline.

Proactive Maintenance vs. the Cost of Repairs (Page 33)
A proactive sewer maintenance program is a proven cost saving venture when compared to a reactive maintenance program. Proactive programs reduce emergency construction costs as well as reducing SSOs and governmental liabilities.

VITRIFIED CLAY PIPE
OPERATIONS & MAINTENANCE HANDBOOK

Maintenance & operations professionals across the country have come to appreciate the range of cleaning methods and tool options provided by the Vitrified Clay Pipe (VCP) in their systems.

- VCP allows for greater hydro-jet pressures and flow rates than flexible thermoplastic, fiberglass and CIPP materials.
- VCP allows for cleaning with a wider array of tools, nozzles and equipment which may damage other pipe materials.
- Mechanical cleaning methods are allowable and appropriate in VCP lines. Mechanical cleaning methods will damage flexible thermoplastic, fiberglass and CIPP materials.
- As a ceramic, even at 100-years old, there is no need to adjust pressures or cleaning methods for VCP due to age.

Operations & maintenance practices encountered throughout the country are many and varied. Those described here are considered sound, although it is recognized that there may be other equally satisfactory methods. Technical data presented are considered reliable, but no guarantee is made or liability assumed.

The information provided in this handbook is not intended to replace the judgment of an experienced maintenance professional. It is intended primarily as a beginning set of considerations for maintenance and design professionals as they consider the long-term implications of material selection in regard to the maintenance of sanitary sewer lines.

Additional information on the design and installation of clay pipelines can be found in NCPI's *Vitrified Clay Pipe Engineering Manual.*

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CHAPTER 1

BACKGROUND AND GOALS

When clay pipe was first installed in the U.S. (in the 19th century) the approach to “maintenance” was limited to rudimentary cleaning tools and processes that were considered “state of the art” at the time. Collection system designers planned for both inflow from rainwater and infiltration from groundwater to assist in flushing the pipe. Additionally, sewerage systems were designed to capture both stormwater and wastewater into one combined sewer system.

In 1972, the Clean Water Act lead to nationwide adoption of the modern, factory-applied sewer pipe joints and the leak-free standard. Today, this same Act also makes a Sanitary Sewer Overflow (SSO) risky for municipalities.

That is just a small part of why municipalities across the U.S. are taking a proactive and preventive approach to sewer cleaning and maintenance.

A sewerage system, although buried, can no longer be neglected.

A properly designed, installed and maintained sewer system improves the long-term performance of the system and reduces SSOs. A principal goal in maintaining any gravity flow sewer is to keep the system functioning as designed. Regular cleaning and inspection of sewer lines also provides public works departments with the valuable information needed to proactively plan and budget for personnel, equipment, upgrades and repairs.

A good maintenance and operations plan may include:

- Ability to plan and schedule work/maintenance
- Historical records built on harvested pipeline data
- Prioritized work/maintenance based on harvested pipeline data
- A plan for optimal capacity of the collection infrastructure

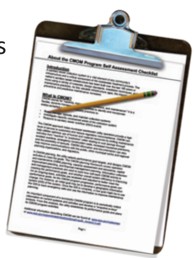
Formalized Maintenance Programs & CMOM

A maintenance program, whether it is part of a Capacity, Management, Operations and Maintenance (CMOM) requirement, an Asset Management program or a best practices method, is a responsible approach to managing a collection system. A proactive pipeline maintenance program also allows for a planned, systematic and scheduled inspection platform for prioritizing and scheduling repairs and system improvements.

CMOM is a flexible, dynamic framework for municipalities to identify and incorporate widely-accepted wastewater industry practices to:

- Better manage, operate, and maintain collection systems
- Investigate capacity constrained areas of the collection system
- Prevent and respond to SSO events

The Environmental Protection Agency's (EPA's) CMOM approach helps municipal wastewater utility operators provide a high level of service to customers and reduce regulatory noncompliance. CMOM programs can also help utilities optimize use of human and material resources by shifting maintenance activities from "reactive" to "preventive". CMOM information and documentation can also help improve communications with the public, other municipal works, regional planning organizations, and regulators.



Visit **www.epa.gov/npdes/pubs/cmomselfreview.pdf** to see the EPA's Self-Assessment Checklist.

CHAPTER 2

ASSESSMENT OF EXISTING PIPELINES

As sewer system networks age, municipalities are discovering the importance of proactive measures to improve performance levels of their sewer systems. Inspection and testing of sewer lines are essential to maintaining a properly functioning system.

Good inspection programs evaluating the condition of the pipe before undertaking replacement have saved municipalities millions of dollars. As VCP has been classified as non-age dependent pipe, there are many examples of pipe that are over 100-years old and in excellent condition. The only way to know is to perform a condition assessment.

Cleaning the pipe is the first step in that assessment.

Inspection Methods

The most common methods of inspection as part of a proactive, comprehensive asset management program are:

- Low-Pressure Air Test
- CCTV (which may include LIDAR, sonar, laser profile)
- Smoke Testing
- Flow Monitoring
- Dye Testing
- Deflection Mandrel Testing (primarily used in flexible pipe systems)
- Visual Inspection (of the pipeline and associated structures)

No matter the method selected, a qualified and trained staff is critical to the efficiency and accuracy of any condition assessment program.

Common Operations & Maintenance Issues

Common Sewer Obstructions

Obstructions of various sorts are an unfortunate fact of life in the operations and maintenance of a sewer system, regardless of the pipe material. The three most common causes of these obstructions are root intrusion, FOG (Fats, Oils, and Grease) and debris.

Root Intrusion

More than 90% of municipal sewer systems have reported issues due to root intrusion. The large majority of intrusions originate from private lateral connections due to vegetation seeking moisture and nutrients. Once roots find their way into a pipe, two things happen:

1. The root mass creates a screen that traps grease, sand, paper, rags, and debris. (see Figure 1)
2. An unchecked root mass can cause structural damage to the pipe and/or the joint.

Figure 1: *Root mass which entered the pipe line from a lateral.*

Root growth is year-round but generally more aggressive seasonally on a regional basis. The use of chemical root control treatment, either alone or in conjunction with hydro-mechanical cleaning techniques, may be used as part of a pipeline maintenance program to combat root growth. Due to the inert nature of VCP, any chemical root control product as well as any odor control product in the marketplace are appropriate.

FOG (Fats, Oils & Grease)

EPA's Report to Congress on combined sewer overflows (CSOs) and sanitary sewer overflows (SSOs) identified that grease from restaurants, homes, and industrial sources are the most common cause (47%) of reported blockages. Grease solidifies, reduces sewer capacity, and blocks flow. Controlling FOG discharges helps municipalities prevent blockages that impact sanitary sewer systems.

Figure 2: *FOG is the most common cause of pipeline blockages.*

Hydro-mechanical cleaning techniques are a proven means of reducing FOG blockages.

Debris

Unfortunately, debris makes its way into the sewers. Debris such as sand, rocks, wood, toys, and concrete have long been common problems.

Figure 3: *Construction concrete is found in many locations.*

Household products (including some marked 'flushable') such as baby wipes, facial wipes, feminine hygiene products, and prophylactics have become a national problem as identified causes of clogged sewers.

Inflow and Infiltration

Inflow and Infiltration (I & I) of stormwater and groundwater into sanitary sewers can affect the capacity and operational efficiency of collection systems.

Inflow is surface or stormwater that can enter the collection system via:

- Gutter/Downspout Connections
- Sump Pumps
- Manhole Lids/Covers

Infiltration is groundwater that can enter the collection system via:

- Pipe Joints
- Manhole Structure
- Pipe Penetrations
- Service Connections

Figure 4: *Manholes can be a common source of inflow in a system.*

Excessive I & I can be a significant cause of sanitary sewer overflows (SSOs). Many utilities are investing significant resources to reduce I & I through sewer rehabilitation, separation of combined sewers and other efforts.

CHAPTER 3

CLEANING PIPELINES

About VCP

Vitrified Clay Pipe (VCP) is a rigid pipe manufactured from clays and shales. The weathering forces of nature allow the soluble and reactive minerals to leach from rock and soil over time, leaving an inert material. These chemically inert, raw materials are transformed into a dense, hard, homogeneous clay pipe by firing in kilns at temperatures of about 2000ºF (1100ºC). Vitrification occurs as the clay and shale fuse into an inert, chemically stable ceramic.

Ceramics are among the most abrasion-resistant materials known. As a ceramic, VCP is an asset to sewer system maintenance professionals. Systems with VCP lines allow for greater selection of cleaning tools and more aggressive cleaning methods for tough challenges. Abrasion-resistance has always been an important material property of VCP, but as modern cleaning methods develop, it becomes even more significant.

VCP Manufactured in the US can be cleaned using any jetting angle at jetting pressures of 5,000 psi with flows exceeding 125 gpm.

Because VCP is a dense, homogeneous material, it safely withstands greater jetting pressures and mechanical cleaning methods for longer periods of time than any other pipe material, allowing cleaning crews to operate more efficiently.

Caution: *While all of the cleaning and maintenance techniques discussed here are appropriate for VCP, they are not recommended for other pipe materials and may cause significant damage to flexible thermoplastic, fiberglass and CIPP materials. It is important to understand the limitations of your pipe material before beginning a cleaning and inspection process.*

Cleaning Preparation

- Identify type of installed sewer pipe:
  - VCP – Any and all cleaning methods covered in this *Handbook* are appropriate.
  - PVC, HDPE, CIPP, FRP/GRP – Care should be used. Many cleaning methods are not suitable for these pipe materials. See Table 1: Cleaning Tools In Various Pipe Materials on page 10.
  - Other / Unknown – Take great care. There are still many areas of the country where Orangeburg or Asbestos pipe can be found. These pipe materials are easily damaged and should be treated with great caution.
- Choose tools and cleaning methods accordingly.
- Review any available maintenance history for areas of concern.
- Safety is always a key element in sewer cleaning.
  - Ensure that all federal, state and local safety measures in regard to PPE (Personal Protective Equipment) and traffic control are observed.
  - Always follow manufacturers' instructions and safety protocols when operating tools and equipment.

Considerations affecting the operation of cleaning tools:

- Sufficient jetting thrust to drive the high-pressure hose, nozzle or tool up the sewer.
- Proportionate volume of water to dislodge and move debris towards the downstream recovery structure.
- Adequate jet impact strength at the outlet of the nozzle or tool to disintegrate and/or remove debris and obstructions.
- Ability to adjust the nozzle or tool to the volume and pressure of water supplied by the high-pressure pump.

- The hydro-flushing tool should be properly sized and weighted for the diameter of the sewer.
- Correct outlet angle of the water jet from the nozzle or tool for the type of cleaning to be performed.
- Properly designed centering skids

Cleaning Method Selection

Equipment manufacturers and government agencies recommend against the use of several aggressive cleaning methods in many of the non-ceramic pipe materials commonly found in sewers today. An advisory committee consisting of representatives of New England Interstate Water Pollution Control Commission (NEIWPCC) member state environmental agencies, EPA and wastewater consultants created a comprehensive manual titled *Optimizing Operation, Maintenance and Rehabilitation of Sanitary Sewer Collection Systems.* In this manual, the following guidance is provided for cleaning plastic pipe:

> *"With any mechanical cleaning equipment, the operator must know where plastic pipe has been installed in the wastewater collection system. High-velocity cleaning machines are least likely to damage a plastic pipe system. Power rodders can be used carefully to remove obstructions, but there is always the possibility of damaging the pipe wall if the cutter is suddenly deflected off the blockage and into the pipe wall. Mechanical cleaning tools such as cutters and brushes should not be used in plastic pipe since they can score the pipe and reduce the flow characteristics by increasing the pipe wall roughness. A suitable pipe identification system should be in place to warn the operator where plastic pipe has been installed."*

VCP manufactured in the U.S. is rated to 5,000 psi (pounds per square inch) with flow rates exceeding 125 gpm (gallons per minute), at all jetting angles when hydro-flushing. All common methods of cleaning sewer pipe can safely be used in VCP sewer pipelines including hydro-mechanical tooling, hydro-flush nozzles, mechanical rodding, bucketing, as well as chain/cable type cutters.

Cleaning Tools In Various Pipe Materials					
Cleaning Process	Pipe Material				
	VCP	PVC	HDPE	CIPP	FRP/GRP
Hydro-Jetting	Yes	Yes	Yes	Yes	Yes
- Safe Hydro Pressure (psi)	5,000	1,500[5]	Unknown	1,500[4]	1,200[1,2]
- Jet Angle Range (degrees)	6 - 90	6 - 15[1]	6 - 15[1]	up to 40[4]	6 - 15[1,2]
- Max. Nozzle Weight	125 lbs.	Unknown	Unknown	Unknown	5.5 lbs.[2]
- Min. Jet Standoff from Pipe Wall	1/4 in.	1 in.[1]	1 in.[1]	Unknown	Unknown
- Jet Stationary Position	5 min.	60 sec.[1]	60 sec.[1]	Unknown	Unknown
Mechanical Rodders	Yes	No[3,6]	No[3,6]	No[4,6]	No[2,6]
Power Rodders	Yes	No[3,6]	No[3,6]	No[4,6]	No[2,6]
Bucket Machines	Yes	No[3,6]	No[3,6]	No[4,6]	No[2,6]
Brushes	Yes	No[3,6]	No[3,6]	No[4,6]	No[2,6]
Chain Flails	Yes	No[1,3,6]	No[1,3,6]	No[4,6]	No[2,6]
Cable Flails	Yes	No[1,3,6]	No[1,3,6]	No[4,6]	No[2,6]
Grinders	Yes	No[1,3,6]	No[1,3,6]	No[4,6]	No[2,6]
Root Saws	Yes	No[1,3,6]	No[1,3,6]	No[4,6]	No[2,6]
Tap/Can Cutters	Yes	No[1,3,6]	No[1,3,6]	No[4,6]	No[2,6]
Hydraulic Root Saws	Yes	No[1,3,6]	No[1,3,6]	No[4,6]	No[2,6]

[1] Plastics Industry Pipe Association of Australia Limited 2009, *Water Jet Cleaning of Plastics Pipes*, https://www.iplex.com.au/assets/Uploads/ec9c641256/POP205.pdf

[2] Iplex Pipelines Australia Pty Limited 2017, *Flowtite® GRP Pipe Systems Cleaning*, viewed 27 April, 2017 http://www.iplex.com.au/iplex.php?page=lib&lib=31&sec=232&chap=302

[3] New England Interstate Water Pollution Control Commission 2003, *Optimizing Operation, Maintenance and Rehabilitation of Sanitary Sewer Collection Systems*, viewed 25 June 2020, https://www3.epa.gov/npdes/pubs/sso_optimizing_enitre_doc.pdf

[4] Insituform Technologies, LLC 2018, *Inspection and Cleaning Guide for Cured-in-Place-Pipe (CIPP)-lined Pipes*

[5] Wright, D., Wolgamott, J., & Zink, G. (2005) *Safe Waterjet Cleaning of Sewer Pipe,* WJTA American Waterjet Conference, Houston, TX, August 21 – 23, 2005

[6] Black & Veatch Corporation for ASCE and U.S. EPA 2004, *Sanitary Sewer Overflow Solutions,* http://www3.epa.gov/npdes/pubs/sso_solutions_final_report.pdf

Table 1: *Cleaning Tools In Various Pipe Materials*

Hydro-Jetting

Hydro-Jetting is one of the most common and most effective methods of cleaning sewers.

Water is pumped into the sewer through a hose directing high-pressure jets of water against the pipe wall via a nozzle or hydro-mechanical tool.

Pressure and Flow

Water pressure and flow are especially important measures in hydro-jetting. Using high-flow and high-pressure is the most effective method for cleaning sanitary sewers.

- **Pressure** in pounds per square inch (psi) is the measure of force that the water has when it exits the pump and moves into the hose.
- **Flow**, measured in gallons per minute (gpm) is the amount of water that flows from the hose.

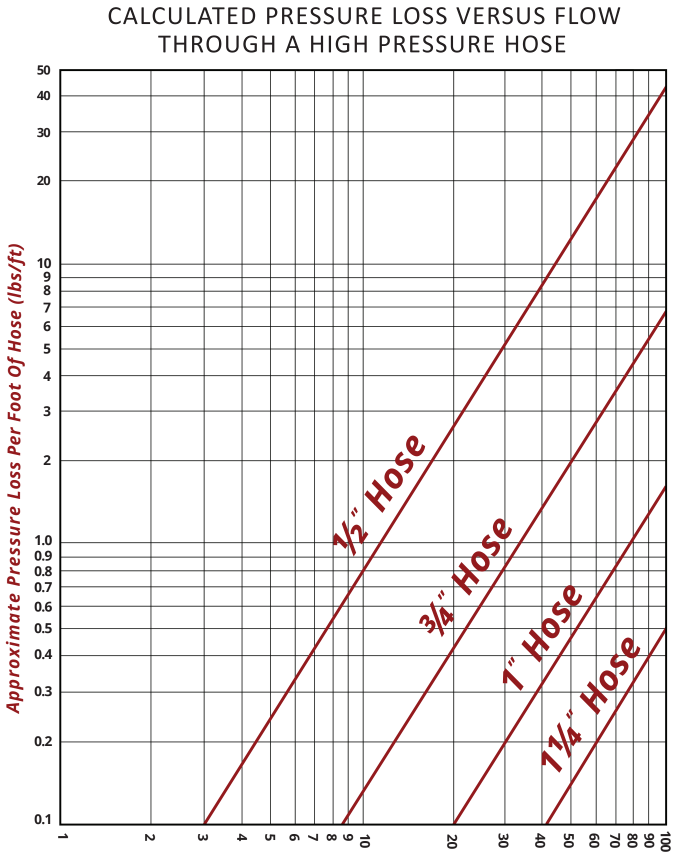


Figure 5: Pressure loss over the length of hose by hose size.

Most municipal sewer hydro-jetters operate between 2,000 to 3,000 psi and 50 to 125 gpm. These pressure and flow ranges are needed to effectively clean sanitary sewer systems depending on the pipe sizes to be cleaned and the tools used.

Generally speaking, larger pipe sizes (8 inches and above) need higher pressure and flow to move the settled and dislodged debris down the pipe. The higher pressure and flow help to overcome the challenges presented by the flow levels occurring in larger pipe.

Smaller pipe sizes (6 inches and below) need lower flow to avoid possible surcharging.

Nozzles and hydro-mechanical tools need to have the jet orifices calibrated to the psi and gpm of the hydro-jetter output at the end of the hose. The loss of pressure over various hose lengths is an important part of the calculation (see Figure 5 on page 11). This calibration is key to achieving the optimal performance for both maximum cleaning efficiency and flushing power from the tool to ensure the pipe is returned to 95% of operational capacity.

Flexible thermoplastic, fiberglass and CIPP materials can be damaged by high-flow and high-pressure cleaning. When cleaning lines that are a mix of pipe materials and/or lined sections, it is imperative that crews are aware of the type of materials present so they can adjust their cleaning methods accordingly. Please refer to NCPI's Cleaning Tools In Various Pipe Materials chart on page 10 for reference to the limitations introduced by these materials.

Hydro-jetting removes debris and grease build-ups, cuts roots, clears blockages and flushes the sewer pipe. The nozzle is typically sent upstream from a manhole structure and pulled back under pressure, typically 50 to 80 gpm at 2,500 to 3,500 psi. Debris is then removed by a vacuum tube, utilizing specialty hand tools, or a debris trap located at the downstream maintenance hole.

Nozzles

The most common and effective nozzles are static and rotational, which have replaceable jets allowing the operator to trim the nozzle to the flow rate and pressure of the pump to achieve maximum efficiency. Static and rotational nozzles are available with a wide range of jet angles to suit any cleaning need.

Static Nozzles

Non-rotational, fixed nozzles are manufactured in a variety of sizes and shapes.

Figure 6: *Centered, static hydro-jet cleaning nozzle.*

- Cleaning nozzle - A nozzle primarily used to clean the entire circumference of the pipe. Jets are radially indexed at a higher jetting angle (21 to 45 degrees).
- Flushing nozzle - A flushing nozzle is designed to move debris from sewer pipes with the use of radially indexed jets set at a lower jetting angle (6 to 20 degrees).
- Dredging nozzle - A weighted nozzle primarily used to move debris from the bottom of larger sewer pipes, a dredging nozzle uses lower degreed jets (6 to 20 degrees).
- Stoppage nozzle - A powerful nozzle, used to break up sewer blockages, a stoppage nozzle uses forward-facing jets and rear-facing thrust jets. The forward-facing jets are designed to penetrate and break-up a blockage in the line.

Rotational Nozzles

A series of nozzles delivering water jets throughout the entire internal circumference of the sewer pipe, using a revolving head.

Figure 7: *Governed rotational nozzle. Photo provided by StoneAge Tools.*

- Governed - This type of rotational nozzle utilizes an internal clutching mechanism to govern the rotational speed of the nozzle head delivering a consistent jetting speed and impact to the pipe wall. Rotational nozzles are available with a wide range of jet angles to fit any cleaning application.

- Spinning - These non-governed nozzles deliver variable speed and velocity water jets to the circumference of the pipe based on the pressure and volume. Both pressure and volume can be adjusted by the operator at the pump control.

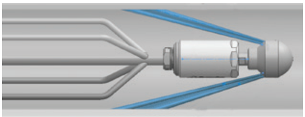
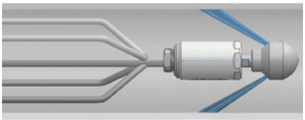
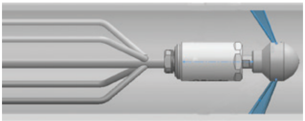
<table>
<tr><th colspan="4">Jetting Angles Balancing Cleaning & Thrust</th></tr>
<tr><th>Nozzle Jet Angle (degrees)</th><th>Thrust Power</th><th>Impact Force/ Cleaning Effectiveness</th><th>Balance of Force & Thrust</th></tr>
<tr><td>6 to 15</td><td>Excellent</td><td>Insufficient</td><td rowspan="2">
High thrust and minimal cleaning power</td></tr>
<tr><td>16 to 20</td><td>Good</td><td>Marginally Adequate</td></tr>
<tr><td>21 to 29</td><td colspan="2">Balanced jetting angles thrust to impact force cleaning ratio</td><td rowspan="2">
Balanced thrust and cleaning power</td></tr>
<tr><td>30 to 35</td><td>Adequate</td><td>Moderate impact force</td></tr>
<tr><td>36 to 45</td><td>Marginally Adequate</td><td>Good for removing deposits</td><td rowspan="2">
Low thrust and excellent cleaning power</td></tr>
<tr><td>46 to 90</td><td>Insufficient</td><td>Excellent for removing calcium, roots, calcified grease, etc.</td></tr>
</table>

Table 2: *Jetting Angles Balancing Cleaning & Thrust*
Illustrations provided by StoneAge Tools.

Whether it's a rotational or static hydro-jet nozzle, a low number of larger orifice jet inserts will ensure greater force and cleaning strength across the pipe circumference. A higher number of inserts with smaller orifices will enable more spreading of the water for cleaning while the impact force is weaker across the pipe circumference. See the Jetting Angles Balancing Cleaning & Thrust table above for a comparison of thrust power and cleaning effectiveness with varying jet angles.

Nozzle Orientation Management (NOM)

To prevent "Catfishing" (see definition below) and to obtain the maximum cleaning efficacy for the entire circumference of the pipe, a nozzle or a hydro-mechanical tool should be centered within the pipe.

Catfishing describes the behavior of a sewer cleaning nozzle when it is dragged across the bottom of the pipe without the use of a skid or centering device.

"Catfishing" can reduce the cleaning effectiveness of the nozzle and potentially damage the equipment or create a safety concern.

Centering of the tool within the pipe can be managed through a finned or wire-legged proofing skid, also called a centralizer. This device is essential for effective cleaning of the pipe crown and prevention of mineral deposit buildup.

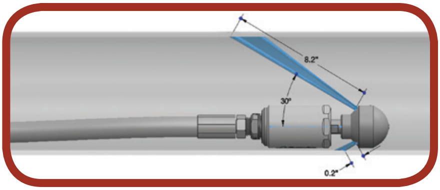


Figure 8: "Catfishing" – results in a non-uniform standoff distance.

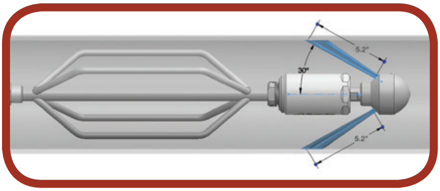


Figure 9: With Centralizer – provides a uniform standoff distance.

Illustrations provided by StoneAge Tools.

Centering of the tool provides uniform water jet standoff distance as shown in figures 8, 9 and 10. In these figures showing an 8-inch pipe with 30° rear-facing jets, the standoff distance between the nozzle and the pipe crown is reduced by almost 40% with a centralizer.

NCPI recommends use of a centering device because it not only provides more effective cleaning of the pipe, it is also an integral safety tool during the hydro-cleaning process. A centralizer offers greater control and keeps the cleaning tool from turning up a lateral or turning around in the pipe, compromising operator safety.

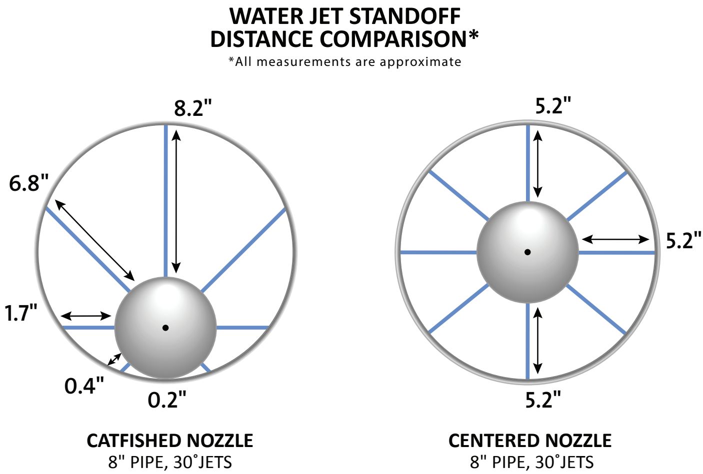


Figure 10: *Using a centralizing skid ensures even pressure and flow around the full circumference of the pipe.*

The farther a water jet stream travels before it contacts the surface of the pipe, the more it loses its impact force and cleaning effectiveness.

Hydro-Mechanical Tools

Hydraulic Cutter

A hydraulic cutter is a low rpm, high torque (70 to 100 ft. lbs.) tool that cuts or scrapes the inside of the pipe wall utilizing a circular saw, blades or grinding head attached to the drive shaft of the hydraulic motor.

Figure 11: *Hydraulic milling cutters.*

Tap Cutter, Chain/Cable Flail

A tap cutter, chain/cable flail is a high-speed cutting tool utilizing an attached chain, cable or cutting can that rotates and scrapes the inside of the pipe to remove roots, hardened debris, protruding laterals, and most other solid obstructions.

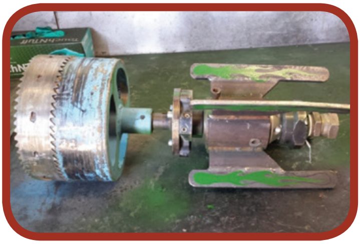


Figure 12: *Hydro-Mechanical tap cutter.*

Mechanical Rodding

Mechanical rodders have been utilized with success for cleaning municipal sewers for over 70 years. Because no water is required for cleaning with these machines, their popularity is showing a resurgence due to the national water conservation movement.

Figure 13: *A mechanical rodding machine has 1,200 feet of continuous rod. Photo provided by Haaker Equipment Company.*

In fiscal year 2016-2017 the City of Los Angeles saved over 30 million gallons of water utilizing mechanical rodders to clean sewers. The water saved represents roughly the annual usage of 275 households. Mechanical rodders use an engine and a drive unit with hardened continuous rods or sectional rods to push, pull and/or turn various cleaning tools. As the tools rotate, they break up grease deposits, cut roots, and loosen debris.

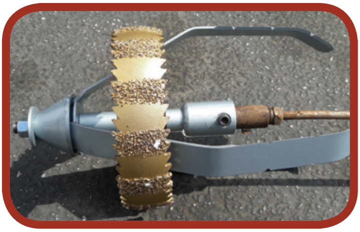


Figure 14: *An example of a root-cutting device used with a mechanical rodder.*

Mechanical rodders can hold approximately 1,200 feet of rod in a reel-type cage that can push and pull. These units have a typical pulling capacity of up to 7,000 pounds continuous pull in low gear and 3,500 pounds in high gear.

Mechanical rodders also help thread the cables for CCTV inspections and bucket machines and are most effective in lines up to 15 inches in diameter.

Although the use of mechanical rodding is fully acceptable in VCP, it is not acceptable in flexible thermoplastic, fiberglass and CIPP lines.

Bucketing

This method utilizes a special device that is pulled along the sewer pipe invert for the removal of debris from the line. The bucket has one end open with the opposite end having a set of jaws. When pulled from the jaw end, the jaws are automatically opened. When pulled from the other end, the jaws close. In operation, the bucket is pulled into the debris from the jaw end to a point where some of the debris has been forced into the bucket. The bucket is then pulled out of the sewer from the other end, causing the jaws to close and retain the debris. Once removed from the manhole, the bucket is emptied and the process repeated.

Balling

A method of hydraulically cleaning a sewer or storm drain by using the pressure of a water head to create a high cleansing velocity of water around the ball. In normal operation, the ball is restrained by a cable while water washes past the ball at high velocity. Special sewer cleaning balls have an outside tread that causes them to spin or rotate, resulting in a “scrubbing” action of the flowing water along the pipe wall.

NCPI Suggested Standard Operating Procedure

The overall responsibility of a sewer cleaning crew is to safely remove all obstructions and deposits from a pipeline and to restore a minimum of 95% of operational design capacity. In order to achieve this objective, the following effective standard operating procedure (SOP) of a sewer cleaning crew has been successfully applied in the field.

Figure 15: *A Morro Bay, CA combination sewer cleaning truck being used to hydro-flush and vacuum sewer lines.*

Utilization of an SOP ensures consistency in cleaning which is a very important factor in scheduling the frequency of pipe section maintenance.

Although the following SOP is designed for high velocity hydro sewer cleaning, the basics of the procedure may be utilized on other types of sewer cleaning.

- The crew shall locate the structures where the cleaning is to be preformed.
- The crew shall place all required safety and traffic control devices as needed.
- A black sewer leader hose shall be attached at the end of the colored hydro hose.
- Properly position the hose reel in line with the pipe to be cleaned.
- The crew shall install a debris trap or a vacuum tube in the downstream maintenance hole (MH).
- If safety permits, open the upstream MH during the cleaning process to prevent toilet burping.
- The nozzle shall be attached to a “95% capacity proofing skid” (or centralizer) calibrated to the size of the pipe.

- Place the hose, nozzle, and skid into the pipe before engaging the pump.
- The initial cleaning pass should be 50-100 feet traveling upstream. Depending on the results, you may need to change the nozzle, repeat the cleaning process or continue to clean the entire pipe.
- The crew shall visually verify the cleaning equipment has traveled from MH to MH.
- If the crew is unable to verify 95% capacity on the first attempt, the crew must change the nozzle/tool and remove the obstruction(s) in the line.
- The crew shall remove all debris that has been collected in the trap.
- The crew shall remove all traffic/safety control devices and clean the work area.
- The crew leader shall complete the work order and note any pipeline anomalies found.

CHAPTER 4

POINT REPAIRS

Point repairs refer to “sectional dig and replace” construction required to correct a severe problem or structural deficiency at a specified location in a sewer line. These repairs are complete line replacements ranging in length from one pipe section or more performed at locations previously identified during internal sewer inspections. The length of pipe to be replaced as defined by video inspection should be treated as a rough estimate as it may not reflect the actual extent of work required.

Figure 16: *Repairing a length of pipe in an older, established community.*

Excavation and Removal of Existing Pipe

Exercise reasonable care during the initial excavation of the defective pipe so as not to disturb existing pipe that is still acceptable and structurally sound. After the defective pipe has been exposed, additional pipe shall be uncovered as is necessary to allow room for the installation to connect and join the new pipe.

The defective pipe can be cut using a demolition saw equipped with a diamond impregnated saw blade or a chain snap cutter dependent on the pipe diameter. The cut ends of the pipe should be square, straight, smooth, and free of chips or cracks. The cuts need to produce a smooth plain-end spigot at both ends to receive the replacement section. The defective pipe shall be removed from the trench as well as the former embedment materials.

Figure 17: *Use of a chain snap cutter is demonstrated in a VCP operations and maintenance workshop.*

CHAPTER 5

INSTALLATION OF REPLACEMENT PIPE

Foundation

Trench load design for all pipe is based upon a firm and unyielding foundation. It is essential that the trench bottom remain stable during backfilling, compaction, and under all subsequent trench operations. This foundation provides uniform longitudinal support to minimize differential movement of the pipeline.

Stable uniform support for the pipe is critical to the performance of the repair section of the line. The foundation must be firm and unyielding, as it needs to support the bedding, pipe, backfill, and compactive efforts.

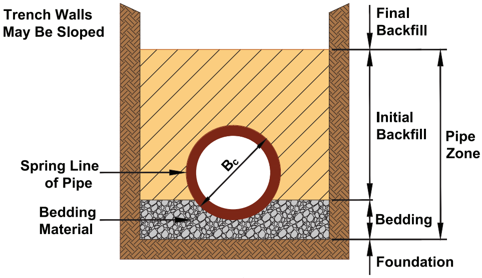


Figure 18: *Trench Cross Section (Class C shown)*

For trench bottoms above the water table, a general rule-of-thumb is that the foundation is firm and unyielding if a person can walk on the foundation without sinking into the soil or feeling it move underfoot. When an unstable trench bottom is encountered, it is necessary to over-excavate and create a firm and unyielding foundation.

Replacement with native materials, crushed rock, gravel, slag or coral are commonly used to build a foundation capable of properly supporting the bedding, pipe, backfill and compactive efforts.

When necessary, these materials can be combined with a geotextile, or the geotextile can be used in place of those materials to stabilize the trench bottom. The over-excavation depth, as well as whether a geotextile is necessary to stabilize the trench bottom, will vary according to the field conditions encountered.

Bell or Coupling Holes

Pipe are generally installed with the bells pointing upgrade. Bell or coupling holes must be carefully excavated so that the bells or couplings support no part of the load. The pipe barrel is designed to support the trench load and must rest firmly and evenly on the trench bottom or bedding material. Bell or coupling holes must be dug to ensure the pipe barrel, and not the bells or couplings, support the trench load as shown in Figure 19.

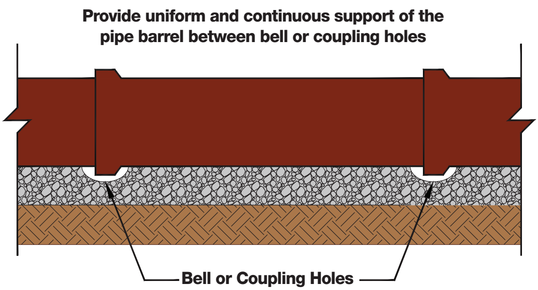


Figure 19: *Clay bell or couplings should support no part of the trench backfill load*

When properly installed, there should be room to slide a hand around the lower half of the bell or coupling before the next pipe is installed.

If a trench box is used within the limits of the pipe zone, re-excavation of the bell hole may be necessary on the last pipe laid if the bell hole is filled with bedding material as the box is advanced.

Reconnecting to Existing Pipeline

Repair Coupling Installation

Figure 20: *Torque wrench used for installation of repair couplings.*

Rubber repair couplings should be sized to fit the outside diameter of the existing pipe and the newly installed pipe. Vitrified clay pipe outside diameters vary by manufacturer and pipe strength designation, which correlates to the date of original installation. Measure both pipe ODs using a diameter tape measure that wraps around the circumference of the pipe and record the measured diameter to the nearest hundredth of an inch. This will confirm that the pipe OD is within the tolerance range provided by the coupling manufacturer and ensure a leak-free connection when installed.

Before installation, loosen all tightening bands completely but do not remove from the coupling. Loosen the bolts on the stainless-steel shield assembly (worm drive clamps) and end clamps (nut & bolt or worm drive). Do not remove the shield assembly (if equipped) or end clamps from the gasket.

Slide the repair coupling over the existing pipe end, and then insert the second pipe. Center the mated pipe ends to the midpoint of the coupling. Tighten all band clamps with a torque wrench as recommended by the rubber coupling manufacturer/supplier.

Factory Compression Joint Assembly

Figure 21: *A finished repair coupling near a manhole.*

Compression joints should be assembled in accordance with the manufacturer's recommendations. Particular care should be taken to keep foreign materials from interfering with proper joint assembly. The mating surfaces of the joint should be clean and lubricated prior to assembly.

All compression joints are manufactured in accordance with ASTM C425 *Compression Joints for Vitrified Clay Pipe and Fittings*. Lubricate both joint surfaces, line up the bell and spigot and shove the pipe together with a steady pressure. Pipe should be in straight alignment during assembly.

For small diameter pipe, joint assembly can be done by hand or with a bar as an aid. When using a bar, care should be taken not to damage the edges of the bell or coupling. A wood block may be used to cushion the bar pressure. For larger sizes, a nylon sling, cable, or other approved device used to lower the pipe can be used as an aid in the assembly of the compression joint. Care must be taken to ensure that the joint is fully-homed.

Bedding and Haunching

Haunching of the bedding or initial backfill should be performed along the length of both the excavated portion of the existing pipe and the new replacement pipe. Haunching can be done via shovel slicing which will fill the voids and consolidate the materials in this area (see Figure 22).

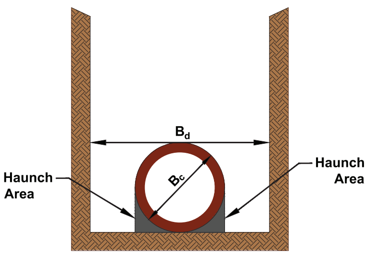


Figure 22: *Terminology*

B_c = the outside diameter of the pipe.
B_d = the design trench width measured at the horizontal plane at the top of the pipe barrel.

Shovel slicing should be done when the bedding material is no higher than one-fourth of the pipe diameter. **Shovel-slicing the bedding material in the haunch areas is critical.** It takes little time, maintains grade, eliminates voids beneath the pipe and in the haunch areas, consolidates the bedding, and adds little or nothing to the cost of the installation.

Good haunch support:

Figure 23: Shovel slicing the pipe haunches

- Significantly increases the load carrying capacity of buried pipe
- Requires compacting the soil in the haunch area using a shovel, spade, or other suitable tool
- Can be attained by using CLSM (flowable fill) with the proper flowability
- Is not attained by dumping gravels and crushed rock beside the pipe
- Can be aided by pipe settling into uncompacted bedding to mobilize the strength of the haunch soil

Initial and Final Backfill

The initial backfill is then carefully placed to a minimum height of 12" above the top of the pipe. This is done to maintain pipe alignment and protect the pipe from damage during final backfilling. The initial backfill should be free from large material and conform to Allowable Bedding Material & Initial Backfill per Bedding Class (Table 4) on page 29.

The final backfill extends from the initial backfill to the top of the trench. Final backfill shall be placed in lifts or stages not to exceed 10 feet when using water or as required by designated methods of mechanical compaction. Final backfill shall have no rock or stones having a dimension larger than 6 inches within 2 feet of the top of the initial backfill.

Uniform Soil Groups for Pipe Installation from ASTM C12[1]

Soil Class	Definition	Symbols
Class I[2]	**Crushed Rock** 100% passing 1-1/2 in. sieve, </= 15% passing #4 sieve, </= 25% passing 3/8 in. sieve, </= 12% passing #200 sieve	
Class II[3]	**Clean, Coarse Grained Soils** Or any soil beginning with one of these symbols (can contain up to 12% fines) Uniform fine sands (SP) with more than 50% passing a #100 sieve should be treated as Class III material	GW, GP, SW, SP
Class III	**Coarse Grained Soils With Fines** Or any soil beginning with one of these symbols	GM, GC, SM, SC
	Sandy or Gravelly Fine Grained Soils Or any soil beginning with one of these symbols, with >/= 30% retained on #200 sieve	ML, CL
Class IV	**Fine-Grained Soils** Or any soil beginning with one of these symbols, with < 30% retained on a #200 sieve	ML, CL
Class V[4]	**Fine-Grained Soils, Organic Soils** High compressibility silts and clays, organic soil	MH, CH, OL, OH, Pt

[1] Soil Classification descriptions and symbols are in accordance with ASTM D2487 *Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)* and ASTM D2488 *Standard Practice for Description and Identification of Soils (Visual-Manual Procedures)*
[2] For Class I, all particle faces shall be fractured.
[3] Materials such as broken coral, shells, slag, and recycled concrete (with less than 12% passing a #200 sieve) should be treated as Class II soils.
[4] Class V soil is not suitable for use as a bedding or initial backfill material.

Table 3: *Uniform Soil Groups for Pipe Installation (from ASTM C12 "Standard Practice for Installing Vitrified Clay Pipe Lines")*

<table>
<tr><th colspan="7">Allowable Bedding Material & Initial Backfill per Bedding Class</th></tr>
<tr><th rowspan="2">Bedding Class</th><th colspan="3">Allowable Bedding Material</th><th colspan="2">Allowable Initial Backfill</th></tr>
<tr><th>Soil Class</th><th>Gradation</th><th>Size</th><th>Soil Class</th><th>Particle Size</th></tr>
<tr><td>Class D</td><td>N/A</td><td>N/A</td><td>N/A</td><td>I, II, III or IV</td><td>1"</td></tr>
<tr><td>Class C</td><td>I or II</td><td></td><td>1"</td><td>I, II, III or IV</td><td>1½"</td></tr>
<tr><td>Class B</td><td>I or II</td><td rowspan="3">- 100% passing a 1" sieve
- 40 – 60% passing a ¾" sieve
- 0 – 25% passing a ⅜" sieve</td><td>1"</td><td>I, II, III or IV</td><td>1½"</td></tr>
<tr><td>Crushed Stone Encasement</td><td>I or II</td><td>1"</td><td>I, II, III or IV</td><td>1½"</td></tr>
<tr><td>CLSM</td><td>I or II</td><td>1"</td><td>I, II, III or IV</td><td>1½"</td></tr>
<tr><td>Concrete Cradle</td><td>N/A</td><td>N/A</td><td>N/A</td><td>I, II, III or IV</td><td>1½"</td></tr>
</table>

Table 4: *Allowable Bedding Material and Initial Backfill per Bedding Class (from ASTM C12)*

Compaction

Compaction of the backfill material is usually required to prevent settlement of the ground surface or to support paving or structures. In areas where support of the pavement over a trench is required, compaction of part or all of the backfill material may be specified.

To achieve the specified compaction with the lowest risk and cost, the correct selection of compaction equipment and methods is necessary. Depending upon the soil type and requirements, a wide choice of compaction equipment is available.

Extreme care should be taken when using heavy mechanical compaction equipment. There should be a minimum of 5 feet of cover over the top of the pipe before any heavy mechanical compaction equipment is employed. This will tend to reduce dangerous impact loads on the pipeline. Walk behind and hand-held, light compaction equipment within the trench can be used at cover depths less than 5 feet.

Testing Newly Repaired Lines

All acceptance tests must be performed by qualified personnel.

Low-Pressure Air Test

The Low-Pressure Air Test is the most commonly used post-installation acceptance testing method because it is not subjective and allows no room for interpretation. The low-pressure air test is not a subjective test.

Complete procedures for the Low-Pressure Air Test are available online in the *Low-Pressure Air Test for Sanitary Sewers* booklet, or in ASTM C828 *Standard Test Method for Low-Pressure Air Test of Vitrified Clay Pipe Lines.*

CCTV Inspection

The high-quality video and images now available using CCTV have led to wide-spread usage of these systems. The visual record created has become an important reason for many agencies to require CCTV inspections as part of final acceptance testing on newly installed pipelines. This visual record has become a useful tool in the overall assessment of the collection system. However, it may not be an option when repairing a section of a line and operators should be aware that the wheels or tracks can damage some pipe materials.

Figure 24: *CCTV wheels show evidence of damage to flexible thermoplastic pipe.*

Ongoing training for CCTV operators is also critical as unintentional errors and incorrect observations have led to unnecessary and expensive repairs. See the NCPI document *A Guide to Analyzing CCTV Inspection.*

CHAPTER 6

NEW LATERALS

Adding New Service Connections

Connection of a new service lateral to an existing sewer main can be accomplished by the use of various available tap saddle connection kits. The installation requires core drilling a hole using a diamond impregnated core bit into the existing sewer main (see Figure 25). Tap saddle connection kits are commonly available in two styles:

1. connects to the mainline internally through the core drilled hole (see Figure 26).
2. connects externally to the mainline using epoxy or strap clamps around the pipe barrel.

Figure 25: *Core drill used to add a service to an existing pipe line.*

Figure 26: *Hole cored in clay jacking pipe to reconnect a lateral following a pipe burst.*

Another method is to cut and remove a section of the existing mainline followed by inserting a plain end tee or wye fitting with rubber compression couplings on each end. Cutting of the pipe can be accomplished by using a demolition saw equipped with a diamond impregnated saw blade or a chain snap cutter. For reconnection to the existing mainline pipe, two couplings are needed for each new fitting installed. The replacement branch spur can be a plain end or jointed pipe (see Figures 27 and 28).

Figure 27: *Cutting out a section of main line to insert a factory made, plain-end wye fitting.*

Figure 28: *Wye fitting for lateral service connection to main line made using shielded rubber couplings.*

CHAPTER 7

LONG-TERM VALUE OF GOOD MAINTENANCE

Proactive Sewer Maintenance

A proactive sewer maintenance program is a proven cost saving venture when compared to a reactive maintenance program. Proactive programs reduce emergency construction costs as well as reducing SSOs, community inconvenience and governmental liabilities.

The long-term benefits of good maintenance are well-documented and well-known. When it comes to applying principles of a good maintenance program to collection systems, the value to a community cannot be ignored. In many communities the collection system represents one of the largest and most important community assets. Planned, professional maintenance is not only fiscally responsible, it is also environmentally sound.

Figure 29: *Operations and maintenance staff should be trained in various options for installing laterals and repairing lines.*

Specifically, in sanitary sewers, a good maintenance and inspection program is a critical element in ensuring that they continue to provide the hydraulic capacity needed to serve as intended.

Pipelines made of vitrified clay pipe give maintenance professionals the ability to:

- Clean aggressively
- Jet at any angle and at pressures of 5,000 psi with flows exceeding 125 gpm
- Use mechanical cleaning tools including rodders, flails, root saws and grinders

Figure 30: *The best long-term value is realized when crews are trained to take full advantage of the cleaning options that are only available in VCP systems.*

No other pipe material offers maintenance professionals the same options or the same level of control when it is time to clean and inspect a pipeline that has been in-service for 50, 60 or even more than 100 years. Even most of the steam-pressed, glazed, terra cotta clay pipe, manufactured before there were ASTM standards, can withstand the stresses imposed by “modern” cleaning methods and tools.

Our Member Companies

For specific questions about your project, please contact your pipe supplier.

missionclay.com
951-277-4600

gladdingmcbean.com
800-776-1133

loganclaypipe.com
800-848-2141

buildingproductscompany.com
602-269-8314

no-dig-pipe.com
740-385-2184

Design – Installation – Inspection – Maintenance

NCPI offers the tools and training to ensure successful design, installation and long-term performance of vitrified clay pipe as part of your sanitary sewer system. Properly designed, installed and maintained, VCP lines will serve the community for hundreds of years.

- **NCPI Toolbox**
  Take advantage of our Leastcost, Hyflow & Trench Load programs online at ncpi.org.
- **National Clay Pipe Institute's YouTube Channel**
  Available videos range from the manufacture of VCP to installation, and from various cleaning methods, and inspections to a recent tradeshow.
- **NCPI's *Vitrified Clay Pipe Engineering Manual***
  A design and installation guide for VCP applications.
- **NCPI's *Vitrified Clay Pipe Installation & Inspection Handbook***
  A compact, but thorough guide designed to be used at the jobsite.
- **Educational Workshops (in-person or virtual)**
  NCPI offers a variety of workshops at no charge to engineers, designers, contractors, installers, inspectors, operations and maintenance personnel. We want to ensure your long-term success using VCP. Workshops qualify for PDH credits.

For more information, or to schedule your free workshop, contact one of our member-companies or call the NCPI office at 262-742-2904.

The National Clay Pipe Institute represents the clay pipe industry to sewer system decision makers. We offer the unique perspective, history and knowledge of the longest-serving and longest-lasting pipe product available.

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