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 2000°F (1100°C). 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.

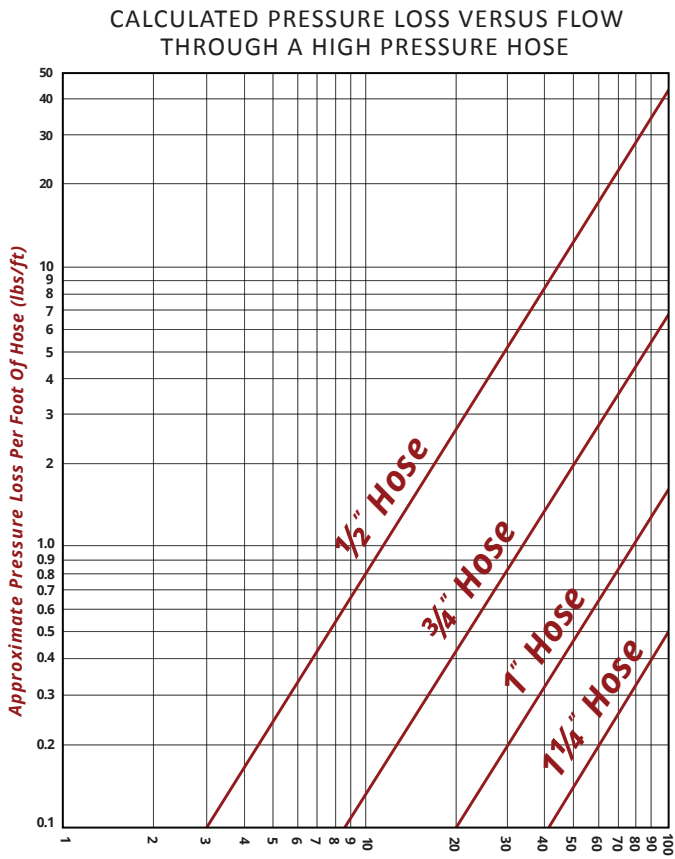


Figure 5: *Pressure loss over the length of hose by hose size.*

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.

Jetting Angles Balancing Cleaning & Thrust

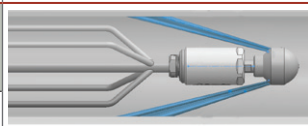
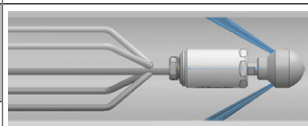
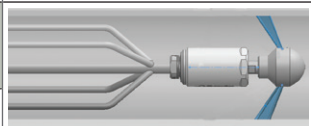
Nozzle Jet Angle (degrees)	Thrust Power	Impact Force/ Cleaning Effectiveness	Balance of Force & Thrust
6 to 15	Excellent	Insufficient	
16 to 20	Good	Marginally Adequate	High thrust and minimal cleaning power
21 to 29	Balanced jetting angles thrust to impact force cleaning ratio		
30 to 35	Adequate	Moderate impact force	Balanced thrust and cleaning power
36 to 45	Marginally Adequate	Good for removing deposits	
46 to 90	Insufficient	Excellent for removing calcium, roots, calcified grease, etc.	Low thrust and excellent cleaning power

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.

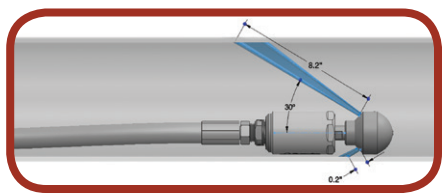


Figure 8: *"Catfishing" – results in a non-uniform standoff distance.*

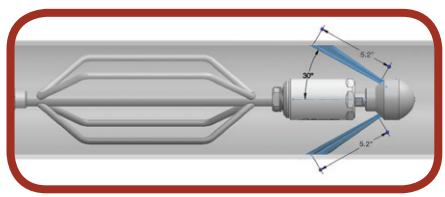


Figure 9: *With Centralizer – provides a uniform standoff distance.*

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.

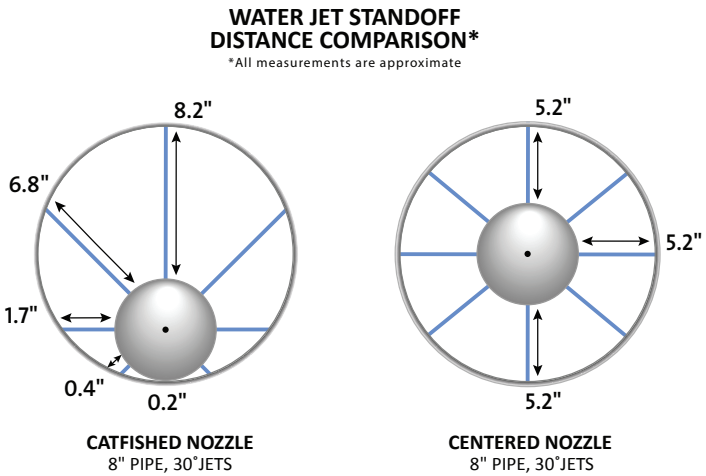


Figure 10: *Using a centralizing skid ensures even pressure and flow around the full circumference of the pipe.*

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.

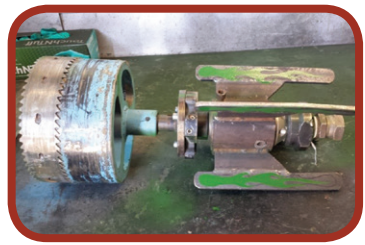


Figure 12: *Hydro-Mechanical tap cutter.*

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.

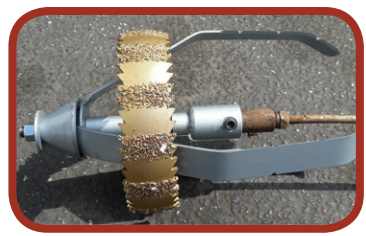


Figure 14: *An example of a root-cutting device used with a mechanical rodder.*

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.