Cleaning Methods for Pipeline Renewals

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***Abstract*— This paper explains the pipe cleaning operations which is the first step in pipe renewal methods. Pipeline cleaning methods vary from pipeline to pipeline and depend on many factors such as pipe product, service, diameter and length. These methods are basically divided into three categories such as mechanical, hydraulic and chemical cleaning. Mechanical cleaning includes the techniques such as Rodding, Balling and Power Bucket. Hydraulic cleaning includes Flushing, Jetting and Scooter techniques. Chemical cleaning deals with Foaming, Dusting and Liquid application. Pipe cleaning schedules and maintenance programs are based on the age of the pipe and the problems it encounter. The objectives of this study are to compare different pipe cleaning methods and discuss their advantages and limitations.**

***Index Terms*— pipe cleaning operations, Pipeline cleaning methods, Flushing, Jetting.**

I. INTRODUCTION

All pipelines needs cleaning at some point in their service life. Pipeline cleaning is an important method to improve the efficiency of the pipeline. In most distribution pipes, sediments accumulate and bio films develop which increases the risk of color, taste and odor problems in water (Ellison and Hoff, 2003). Before cleaning pipe initial data should be collected and analyzed. With this data, the problem can be diagnosed and the need for the cleaning can be established. This initial data consists of water quality, hydraulic and pipe leak conditions of pipe. In addition, customer complaints are also important for utilities to select the appropriate pipe cleaning method. Selection of pipe to be cleaned and the cleaning method to apply depends on diagnosis of the problem. Generally, selecting the cleaning method is left to the contractor's decision, provided that the required results are achieved. With adequate competition among contractors, the market place will determine the best cleaning method for a particular application.

II. PIPE CLEANING METHODS

Three principal methods of cleaning pipelines in-place that are used today are described in detail:
(1) Mechanical
(2) Hydraulic
(3) Chemical

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Figure 1 shows different types of pipe cleaning methods

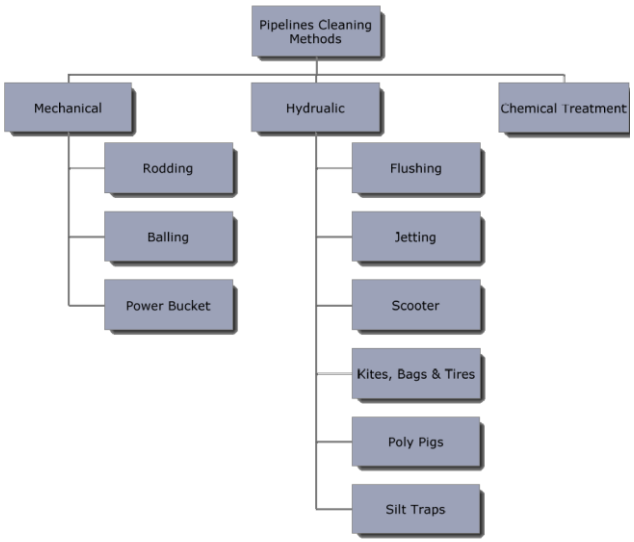

Figure 1 – Pipe Cleaning Methods

General requirements before cleaning include the following: (Najafi and Gokhale, 2005):

- Contractor must have means of trapping collected debris arising from cleaning.
- The disposal location must be identified in advance and proper permits obtained.
- The contract must be awarded to a contractor with trained and certified crew with documented experience.
- It is important to make sure that all safety requirements are met.
- The effectiveness of the cleaning operation is dependent on how well the equipment is maintained, as directed by the manufacturer.

III. MECHANICAL CLEANING METHODS:

A. Rodding:

This method is mainly used to break up grease deposits, cutting roots and debris loosening. It is also used for emergency removal of blockages to create way for TV inspection equipment in the pipeline. This equipment is available in two ways either power rodding machine or hand rods. Power rodding equipment involves applying a torque to the steel rod as it is pushed through the pipeline, rotating the cleaning device attached to the lead end of the rod. This method can be used for routine preventive maintenance.

B. Balling:

This equipment consists of sewer balls to fit different diameters of pipes, a tag line, winch, cable, reels, water source and a dump pick up. When the balls are passed in to the sewer,

water will be forced with high pressure and velocity to clean the pipe. Balling is effective in removing heavy concentrations of sand, grit, rock and grease from the sewers. This method is not suggested for basement fixtures and pipe having steep grade.

C. Power Bucket:

Power bucket machines are another type of mechanical cleaning device used to remove debris, roots, grease or sediments from main line sewers. A bucket machine is equipped with a set of specialized winches that pull a special bucket through a pipe to collect debris. The captured materials are then physically removed from the pipe. These machines are very powerful and offer the best output with the least opportunity for operator's error that could affect the results. Since a full-size cutter and brush can be pulled through the line, each cleaning should be thorough and no residual debris should be left in the sewer main. Operating bucket machines is a very labor-intensive process. Therefore, power buckets are normally used only for specific cleaning purposes, especially removing large amounts of debris from larger sewers.

IV. HYDRAULIC CLEANING METHODS

A. Flushing:

Flushing is the oldest and effective pipe cleaning technique, cleaning an existing pipe inexpensively. It helps to remove disinfectant residual, expel harmful bacteria, remove suspended sediment, and clear up other problems of water discoloration or objectionable taste and odor. It can also help to clean the pipes by lifting loose sediments, reduce chlorine demand, and mitigate water quality risks. This technique cannot clean away tuberculation and other hard scales. It is not effective in cleaning sediments and bio films from large pipes. Moreover, it cannot solve stem from source water problems, treatment deficiencies, cross connections, and unlined cast iron pipe.

B. Techniques of Flushing:

There are two techniques available in flushing which are conventional flushing and unidirectional flushing. Conventional flushing is nothing but opening up one or more fire hydrants and allowing the water to run in to the sewers until the sediments, bio films and poor quality water are removed. Unidirectional flushing is a technique in which valves are closed and fire hydrants are opened in a systematic way. Initially, the water travels towards hydrant in a single direction. Water in single direction produces high velocities in the main, which makes the cleaning more effective. Secondly, the water is flushed in a sequence such that the water is being flushed comes from pipes that have been previously cleaned. Unidirectional uses less water compared to conventional flushing and can be used to locate hydrants in need of repair. Figure 2 presents the flushing operation and different nozzles for flushing.

Figure 2 – Flushing Operation and Different Nozzles (Courtesy: Kinloch Equipment &Supply, Inc.)

C. Jetting:

Hydro jetting is the process of using water under high pressure to scour the pipe walls. It also helps in cleaning of grease, debris deposits, roots, sand or dirt and flushes it all away downstream. The high pressure jet cleaning was used widely in recent years. However, it is a challenge for workers to work in the high pressure environment. Comparing with mechanical cleaning and chemical cleaning method high pressure water jet cleaning has many advantages such as high cleaning efficiency, low cleaning cost, and easy mechanization, convenient operation, safe and reliable. In this operation the pressure should range between 10,000 psi to 22,000 psi. The equipment consists of a truck mounted with high velocity water machine, maintenance hole hose guide, debris traps and a dump pick up or debris trailer. Figure 3 presents the jetting operation in the field.

D. Scooter:

This method is also a hydraulic method for cleaning of a sewer line. This is effective to remove heavy debris in large diameter sewers. These are also suitable for storm drains of large diameters. Precautions should be taken in case of basement fixtures and steep grades. This equipment consists of scooter assembly, dump pick-up truck, power winch, water tank truck, and a tag line. The scooter assembly comprises of steel frame work on small wheels with rubber rimmed, round metal shield at one end. In this technique the upper half consists of shield which is controlled by a spring system and the lower half is attached to the scooter itself. The shield acts as a plug to build up pressure head. As the pressure increases the shield pushes the scooter frame along the downstream to clean the pipe.

Figure 3: Pipe Cleaning by Jetting (Courtesy: AAA Pipe Cleaning Corporation)

E. Kites, Bags and Tires:

This method is similar to the balling technique. These are more suitable for cleaning large sanitary sewers. Rigid rims on bag and kite induces scouring action. The kite's shape creates a forward jet of water that scours the pipe wall. It is very effective in moving accumulations of decayed debris and grease downstream.

F. Poly Pigs:

Poly Pigs provide a fast, simple and economical way to clean water mains and are frequently used to clean pressure pipes. According to Purinton (1984) poly pigs are mainly classified into two types mechanical and jelled chemical pigs which are used to remove scale inside the pipe. The pig works like a hydraulic ram to remove deposits and tuberculation from the main. They can be launched in a line through an existing fire hydrant or by removing a section of the main. Poly Pigs are available in many styles to tackle even the toughest pipe cleaning jobs. The length of the Poly Pigs is approximately 2 times the diameter of the pig. These are effective in moving accumulated decayed debris and grease. The other types of pigs available are Turbo Pigs and Steel Mandrel Pigs. Turbo Pigs are made up of highest polyurethane elastomer which gives linger wear and abrasion resistance. These are mainly used to clean crude oil, natural gas, salt water pipelines. Steel Mandrel Pigs are made with polyurethane attached with split-ring steel wire brushes. These are used for bidirectional operation. Caution should be taken in case of basement fixtures and steep grades. Figure 4 presents various types of pigs and their operation in field.

(a) Poly Pigs

(b) Turbo Pigs

(c) Steel Mandrel Pigs

Figure 4: Pipe cleaning by various types of pigs
(Courtesy: Par-Group.Co.UK)

G. Silt Traps:

This method has been successfully used to collect sewer sediments at convenient locations within the system. According to this method, the pipe must be emptied on a regular basis as part of the maintenance program. Information on design procedures and methodology for silt traps is scarce.

V. CHEMICAL TREATMENT

Several chemical methods are available to kill and retard the re-growth of roots in the wastewater collection system. The methods of application depend on specific sewer condition. It includes foaming, dusting and liquid application. Special equipment is required for all the above three application methods. If the problem is associated with roots alone then chemical treatment is the most cost-effective method of cleaning. Grease can also be cleaned from sewers by the addition of chemicals. Various chemicals are available, such as enzymes, hydroxides, caustics, biocides, and neutralizers, for removing and/or controlling grease buildups. The effectiveness of a particular chemical mainly depends on the exact nature of the problem and site specific circumstances. In most cases, these compounds tend to be an expensive method of treatment if they are applied routinely on an ongoing basis. There should be thorough evaluation and planning for chemical dosing program. The planner should know the following points:

- This method cannot clear stoppages or blockages in sanitary sewer lines.
- It is very expensive method, hence cost effectiveness must be considered.
- Chemicals may be hazardous to employees, and environment.

Hence it is required to have field demonstrations from prospective suppliers. Table 2 presents the effectiveness of cleaning operations.
Table 1 presents all cleaning operations, their uses, applications and their limitations:

Table 1: Pipe Cleaning Applications and Limitations (Najafi and Gokhale, 2005)

Pipe cleaning methods	Uses and applications	Limitations
Rodding	• Uses an engine and a drive unit with continuous rods or sectional rods. • As blades rotate they break up grease deposits, cut roots, and loosen debris. • Rodders also help thread the cables used for TV inspections and bucket machines. • Most effective in lines up to 12 in. (300 mm) in diameter.	Continuous rods are harder to retrieve and repair if broken and they are not useful in lines with a diameter of greater than 12 in. (300 mm) because the rods have a tendency to coil and bend. This device also does not effectively remove sand or grit, but may only loosen the material to be flushed out at a later time.
Bucket Machine	• Cylindrical device, closed on one end with two opposing hinged jaws at the other. • Jaws open and scrape off the material and deposit it in the bucket. • Partially removes large deposits of silt, sand, gravel and some types of solid waste.	This device has been known to damage sewers. The bucket machine cannot be used when the line is completely plugged because this prevents the cable from being threaded from one manhole to the next. Set-up of this equipment is time-consuming.
Baling	• A threaded rubber cleaning ball that spins and scrubs the pipe interior as flow increases in the sewer line. • Removes deposits of settled inorganic material and grease build-up. • Most effective in sewers ranging in size from 5 – 24 in. (130 – 600 mm).	In general, these methods are only successful when necessary water pressure or head is maintained without flooding basements or houses at low elevations. Balling - Balling cannot be used effectively in pipes with bad offset joints or protruding service connections because the ball can become distorted.
Flushing	• Introduces a heavy flow of water into the line at a manhole. • Removes floatables and some sand and grit. • Most effective when used in combination with other mechanical operations, such as rodding or bucket machine cleaning.	This method is not very effective in removing heavy solids. Flushing does not remedy this problem because it only achieves temporary movement of debris from one section to another in the system.
Jetting	• Directs high velocities of water against pipe walls.	Jetting - The main limitation of this technique is that cautions need to be used

	• Removes debris and grease build-up, clears blockages, and cut roots within small diameter pipes. • Efficient for routine cleaning of small diameter, low flow sewers.	in areas with basement fixtures and in steep-grade hill areas.
Scooter	• Round, rubber-rimmed, hinged metal shield that is mounted on a steel framework on small wheels. • The shield works as a plug to build a head of water. • Scours the inner walls of the pipe lines. • Effective in removing heavy debris and cleaning grease from line.	Scooter - When cleaning larger lines, the manholes need to be designed to a larger size in order to receive and retrieve the equipment. Otherwise, the scooter needs to be assembled in the manhole. Caution should be taken in areas with basement fixtures and in steep-grade hill areas.
Kites, Bags, and Poly Pigs	• Similar in function to the ball. • Rigid rims on bag and kite induce a scouring action. • Effective in moving accumulations of decayed debris and grease downstream.	When using this method, use caution in locations with basement fixtures and steep-grade hill areas.
Silt Traps	• Collect sediments at convenient locations. • Must be emptied on a regular basis as part of the maintenance program.	Pipe must be emptied on regular basis.
Grease Traps and Sand/Oil Interceptors	• The ultimate solution to grease build-up is to trap and remove it. • These devices are required by some uniform building codes and/or sewer-use ordinances. Typically sand/oil interceptors are required for automotive business discharge. • Cleaning frequency varies from twice a month to once every 6 months, depending on the amount of grease in the discharge. • Need to educate restaurant and automobile businesses about the need to maintain these traps.	Need to be thoroughly cleaned to function properly.
Chemicals	• Used to control roots, grease, odors (H_2S gas), concrete corrosion, rodents and insects. • Root Control - longer lasting effects than power rodder (approximately 2-5 years). • H_2S gas - some common chemicals used are chlorine (Cl_2), hydrogen peroxide (H_2O_2), pure oxygen (O_2), air, lime ($Ca(OH)_2$), sodium hydroxide (NaOH), and iron salts. • Grease and soap problems - some common chemicals used are bioacids, digester, enzymes, bacteria cultures, catalysts, caustics, hydroxides, and neutralizers.	It is an expensive cleaning method, hence cost effectiveness must be considered. And chemicals may be hazardous to employees, and environment.

Table 2: Effectiveness of Cleaning Methods (Najafi and Gokhale, 2005)

Cleaning Methods	Emergency Stoppages	Grease	Roots	Sand, Grit, Scaling and Debris	Odors
Balling	-----	High	-----	High	Moderate
High Velocity Cleaning	Lowest	Highest	-----	High	Moderate
Flushing	-----	-----	-----	-----	Moderate
Sewer Scooters	-----	Moderate	-----	Moderate	-----
Bucket Machine Scrapers	-----	-----	-----	Moderate	-----
Power Rodders	High	Lowest	Moderate	-----	-----
Hand Rods	High	Lowest	Low	-----	-----
Chemicals	-----	Low	Moderate	-----	Moderate

VI. CONCLUSIONS

Pipe cleaning plays a major role in maintaining the service life of the pipe. Selection of a pipe cleaning method depends on the type of the pipe, nature of the problem, type of the equipment and also the cost. For most problems, flushing is usually the first choice of action. This is an inexpensive and easily implemented method which requires less equipment. After the pipe is cleaned and if it is not followed by relining, it may increase the problem rather than decreasing. Bucketing and pigging can be effective in removing large deposits of silt, sand, gravel and some types of solid waste. Pigging is also effective in removing accumulations of sedimentation, hard scale, bio film and grease whereas scooters can effectively remove heavy debris and grease. Cleaning with chemicals and water jetting can effectively clear the pipe line but sometimes creates new problems. High pressure water jetting can remove roots in the pipe line. A cutting tool can help with jetting incase of large roots. The benefits of pipe cleaning are higher operating efficiency, lower maintenance cost, and less internal corrosion.

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