

## CHAPTER 2: SEWER SYSTEMS

### 2.1 INTRODUCTION

A sewerage system consists of the following:

- House Service Connections

They connect the house to sewers in the road.

- Sewers

These are pipes or conduits meant for carrying sewage and are laid along the roads and flow by gravity.

- Lift Stations

When sewers are at a deeper depth, lift stations are used which help to move sewage from lower elevations below the ground to the required higher elevation.

- Pump Stations

They transfer the sewage from one location to another.

- Sewage Treatment Plants

They treat the sewage to meet the permitted discharge qualities.

- Safe disposal system of final effluent

The sewers are the most important part of a sewerage system.

They are laid below the ground and are difficult to repair. Hence, great care is needed in their O&M and the following issues are addressed

- Objectives of maintenance
- Type of maintenance
- Necessity of maintenance

#### 2.1.1 Objectives of Maintenance

Quality maintenance of sewerage system consists of the optimum use of labour, equipment, and materials to keep the system in good condition, so that it can accomplish efficiently its intended purpose of collection of sewage.

#### 2.1.2 Type of Maintenance

There are three types of maintenance of a sewerage system – preventive, routine and emergency.

Preventive or routine maintenance should be carried out to prevent any breakdown of the system and to avoid emergency operations to deal with clogged sewer lines or over flowing manholes or backing up of sewage into a house or structural failure of the system.

Preventive maintenance is more economical and provides for reliability in operations of the sewer facilities. Emergency repairs, which would be very rare if proper maintenance is carried out well, also, have to be provided for. Proper inspection and preventive maintenance are necessary.

### **2.1.3 Necessity of Maintenance**

Sewer maintenance functions are most often neglected and given attention only as emergency arises. Adequate budgets are seldom provided for supervision, manpower and equipment, unlike the case for maintenance of other utilities like electric cables, telephone cables, gas and water mains. Such attitude towards sewer maintenance is found even in large cities. Considering the health hazards that the public at large has to face, it is appropriate to provide sufficient funds to take care of men, material, equipment and machinery required for efficient maintenance.

All efforts should be made to see that there is no failure in the internal sewerage system of premises; a serious health hazard results when sewage backs up through the plumbing fixtures or into the basements. The householder is confronted with the unpleasant task of cleaning the premises after the sewer line has been cleaned. Extensive property damage may also occur, particularly where expensive appliances are located in the basements.

Maintenance helps to protect the capital investment and ensures an effective and economical expenditure in operating and maintaining the sewerage facilities. It also helps to build up and maintain cordial relations with the public, whose understanding and support are essential for the success of the facility. The ULBs must ensure that sewerage systems are given their due importance to improve the sanitation in the country.

## **2.2 INSPECTION AND EXAMINATION OF SEWER**

### **2.2.1 Importance of Inspections and Examinations**

Sewer collection systems are intended to be a reliable method of conveying sewage from individual discharge to sewage treatment plants. Inspection and examination are the techniques used to gather information to develop operation and maintenance programmes to ensure that new and existing collection systems serve their intended purposes on a continuing basis. Inspection and testing are necessary to do the following:

- Identify existing or potential problem areas in the collection system,
- Evaluate the seriousness of detected problems,
- Locate the position of problems, and
- Provide clear, concise, and meaningful reports to supervisors regarding problems.

Two major purposes of inspection and examination are to prevent leaks from developing in the sewers and to identify existing leaks so they can be corrected.

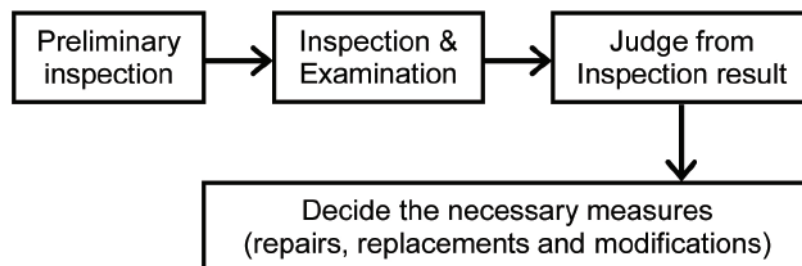
A designer's mistake and the failure in construction are directly responsible for many of the sewer failures. Due to age, deterioration of the material of the sewer by attack of hydrogen sulphide or other chemicals, settlement of foundations and leaking joints may result in the structural failure of the sewer. It takes a very long time from the onset of the first initial defect to the collapse of the sewer. A crack or a leaking joint will allow subsoil water and soil mixture to enter the sewer causing cavities around it leading to slow settlement of foundation and the eventual collapse of the sewer.

Very often soil with water is carried away below the bedding along the length of the sewer. The type of failures often gives a clue to the cause. A shear failure due to faulty foundation or movement of earth is a clean vertical break in the pipe or barrel. Excessive loading, either internally or externally, causes horizontal breaks. Breaks caused by internal pressure leads to cracks in the sewer while external overload causes the top of the pipe to be crushed. Regular inspection of the sewer can pinpoint the sewer that needs to be attended to before there is a complete failure or collapse. For preventing the above serious instances of damages to the sewer system, the maintenance engineer should establish adequate inspection and examination programmes.

### 2.2.2 Guidelines for Inspections and Examinations

Documents and data that can give information on the status of sewer facilities are necessary for operation and maintenance of the facilities. However, enormous time and costs are necessary for examining and inspecting the overall information on sewer facilities that extend over a wide area.

It is recommended that a preliminary inspection be implemented to acquire with comparative ease documents and data that can be used to decide the facilities to be examined/inspected and their priority, and then decide the facilities to be finally examined and inspected for effective acquisition of data. The methodology is to first acquire the basic information through preliminary inspection for the examination and inspection of the facilities in a given length or area of the sewers as given below.



The detailed method for conducting a preliminary inspection is described in the following section

### 2.2.3 Preliminary Inspection

During the preliminary inspection of the sewerage system, subsidence, collapse, and overflows on the roads on which sewers are laid, should be confirmed. Deformation or damage to facilities, and deposits of sand and silt are to be confirmed during observation from the manhole. If damage or possibility of damage to the facility or if any of the abnormalities listed below are confirmed during the preliminary inspection, the facility manager should examine and inspect the relevant locations for the following:

- Corrosion, wear, damage or crack in the facility
- Water infiltration
- Corrosion of steps, wear of covers, deformation of manhole, buried manhole
- Abnormal odours
- Clogging and overflowing

The suggested period of preliminary inspection is based on the best professional judgment prevailing in Indian conditions and shall be carried out as in Table 2.1, Table 2.2 and Table 2.3. In addition, clause 3.10 of Part A manual also deals with tracer study.

Table 2.1 Preliminary inspection during Defect Liability Period (DLP)

Category	Manhole	Sewer	Inverted siphon	Any other sewerage infrastructure
Inspection stages				
Initial/first inspection	During the first 3 months of start of DLP (to expose any hidden construction defects)			
Final inspection	During the last 3 months of DLP			
Additional inspections, if DLP is > 4 years	At a frequency of every 2 years after first inspection during DLP			

Table 2.2 Preliminary inspection for Manholes & Sewers

Category	Manhole	Sewer
Roads & Traffic Conditions		
Roads subjected to heavy & mixed traffic	Once a year	Once in 2 years
Roads 2m to 5m wide subject to mixed traffic	Once in 2 years	Once in 2 years
Roads and lanes less than 2m wide	Once in 3 years	Once in 3 years
Demarcated & kerbed /raised footpaths (likely along main roads)	Once in 2 years	Once in 3 years

Table 2.3 Preliminary inspection period for other facilities

Category	Inverted siphon	Force main and their appurtenance
Inspection period	Once a year	Once a year

Note: Remedial measures should be implemented immediately upon finding defects / distress/dysfunction in the components of the sewerage system.

## 2.2.4 Type of Inspections and Examinations

In order to assess the condition of the sewers inspections and examinations are necessary. There are two basic types of inspection and examination:

- Direct
- Indirect

### 2.2.4.1 Direct Inspection and Examination

This means a person walking through a sewer before it is commissioned and physically inspecting the condition visually. This shall never be done once a sewer has been put into service.

Even for new sewers, the inside diameter shall be more than 2 m. All safety precautions needed for working in confined spaces shall be taken. Hitting at the sidewall with a hammer or other device shall be totally prohibited. The only purpose it will serve will be to get a visual idea of whether the pipe joints are made fully. Once a sewer is put into service, this practice is to be banned forever.

#### 2.2.4.2 Indirect Inspection and Examination

The indirect inspection and examination of the sewers is mentioned in Table 2.4.

Table 2.4 Methods of indirect inspection and examination of the sewers

Technology		Sewer type			Pipe material	Pipe diameter mm	Defect detected			
		Gravity	Force main	Lateral			Internal condition	Pipe wall	Leakage	Pipe support
Camera	Digital cameras	•			Any	150-1500	•	•	•	
	Zoom cameras	•			Any	>150	•	•	•	
	Push-camera			•	Any	≤300	•	•	•	
Acoustic	In-line leak detectors	•	•		Any	≥100			•	
	Monitoring systems		•		PCCP	≥450		•		
	Sonar/ ultrasonic	•	•		Any	≥50	•	•		
Electrical / Electro-magnetic	Electrical leak location	•	•	•	Non-ferrous	≥75			•	
	Remote field eddy current	•	•	•	Ferrous, PCCP	≥50		•	•	
	Magnetic flux leakage	•	•	•	Ferrous	50-1400		•		
Laser	Laser profiling	•	•		Any	100-4000	•	•		
Innovative technologies	Gamma-gamma logging	•	•	•	Concrete	Not yet defined				•
	Ground penetrating radar	•	•	•	Any	Not yet defined			•	•
	Infrared thermograph	•	•	•	Any	Not yet defined			•	•
	Micro-deflection	•			Brick	Not yet defined		•		•
	Impact echo / SASW	•			Brick / Concrete	>1800		•		

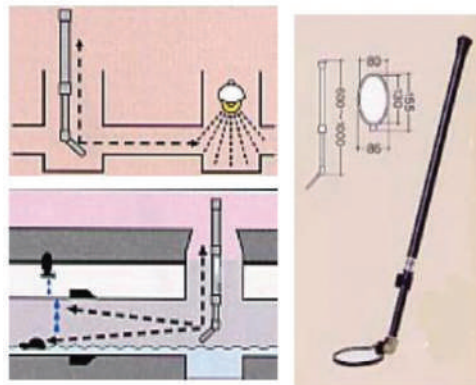
Source: EPA/600/R-09/049 | May 2009

Even though there are so many technologies available as above, the technology to be chosen will depend on the affordability by the user departments. A simpler and applicable technology compilation is as shown in Table 2.5 overleaf.

Table 2.5 Sewer System Inspection Technologies considered applicable to Indian conditions

No.	Technology	Applicability		
		Sewer Size	Sewer Material	Sewer Condition
1	Light and Mirror	Up to 300 mm	Any	Empty
2	Closed Circuit Camera	Any size	Any	Empty
3	Sonar Systems	Any size	Any	Fully flowing

The light and mirror is the oldest of known technologies is shown in Figure 2.1. Two successive manholes are opened and vented sufficiently for about an hour. Thereafter, a long hand-held mirror secured at 45 degrees to the handle is lowered into the bottom of the manhole and a torch light is focussed on the mirror from the above so that the light beam is deflected by 90 degrees to travel horizontally through the sewer pipe and the light is seen in the opposite manhole. This is easier at dusk. This can tell whether the bore of the pipe is choked or clear or laid straight.



Source: <http://www.sankyotrading.co.jp>

Figure 2.1 Mirror Test and Mirror with rod

The closed circuit camera is propelled through the sewer by a remote controlled wired power supply from a van and travels through the sewer and relays the picture of the inside to a TV in the van. The sonar system is similar. A robot is sent through the sewer and it emits high frequency sound waves, which impinge on the pipe surfaces and returns to the emitter as a reflection. By knowing the material of construction of the sewer pipe walls, this can be programmed to verify the structural condition of the wall of the sewers.

Indirect inspection is carried out by sending a camera through the sewer for taking photographs or a closed circuit television equipment (CCTV) to send pictures, which can be seen on a TV screen or recorded as video. The CCTV inspection can be used for sewer lines as small as 100 mm. Above 900 mm diameter there are limitations due to lighting problems and camera line angles.

Continuous advances are being made in the quality and range of TV cameras. The type of camera selected should be robust so that it can be used in sewers and give good quality pictures.

The traction of the cameras is by pulling winches, by pushing or self-traction. The former two are not used much at present. However, self-traction is suitable for use in sewers above 225 mm diameter. Other constraints in the use of self-traction are the weight of the trolley and electricity requirements.



Heavy silting of sewers precludes the use of self-traction. The cameras are attached to trolleys or mounted on a pair of skids or single flat tray. Inspection of the sewer by CCTV is limited to the top portion only. The objects under scrutiny are parallel to the camera and viewing is at 40 to 50 degrees. With radial scanning head, inspection normal to the sewer wall is also possible. A typical arrangement is as shown in Figure 2.2.

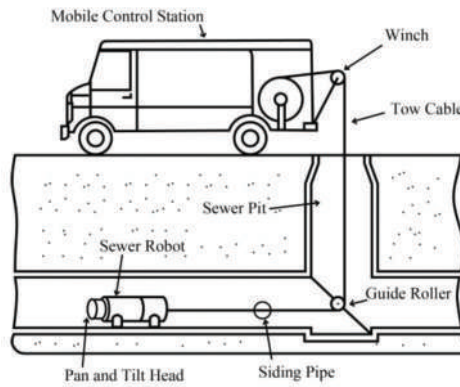


Figure 2.2 Typical CCTV equipment in position

A classical problem encountered in stoneware sewers laid through light forest or heavy garden areas is the roots of trees piercing through the joints and growing inside the sewers. These become like a plug and choke the sewer. This is shown in Figure 2.3. On the right is the photo of the bunch of roots inside the sewer taken by a CCTV camera.

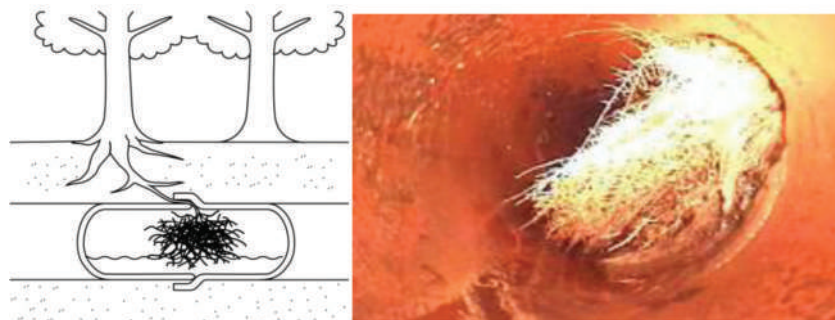


Figure 2.3 Tree roots and sewers

Similarly, the structural condition of old sewers like brick arch sewers and concrete pipes can be ascertained by sonar surveys, which can provide the frontal image of the wall on a 360-degree vertical spiral around the horizontal axis. These images can be analysed carefully. The system can also provide information on the deflection and sidewall breakages of the sewer as in Figure 2.4.

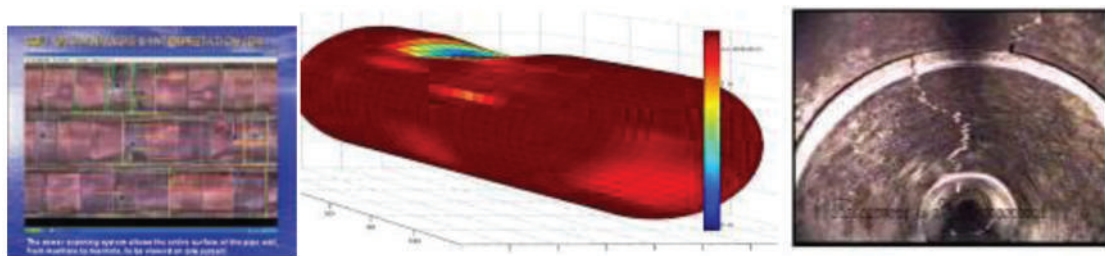


Figure 2.4 Photographs showing Structural Damage and Longitudinal cracked condition of the Sewer

## 2.2.5 Sewer Inspection and Examination

If an abnormality is detected during preliminary internal inspection or externally noticed from outside, the maintenance engineer should judge the urgency and the content of the abnormality, and then make a proper inspection and study.

### 2.2.5.1 Visual Examination

Visual examination is an inspection through images or by sight to detect an abnormality and includes direct visual inspection, and indirect visual inspection using pole-mounted inspection camera, and closed-circuit TV equipment (CCTV).

#### 2.2.5.1.1 Manhole Visual Inspection

The visual inspection of manhole is performed by visually checking the manhole cover and the environment of the internal parts of the manhole. To inspect the internal parts of the manhole, the inspector should enter the manhole with proper safety dress as in subsection 2.11.1.2 and check the items listed below. However, refer to the sub-section 2.7.1.2 for details of the inspection items.

- Status of internal surface of manhole
- Status of sewer on the upstream and downstream sides viewed from the manhole
- Status of groundwater infiltration

To inspect the internal parts of the sewer from the manhole, either a mirror or a strong light should be used for observation, or a TV camera meant for inspecting conduits should be used.

- Features of manhole visual inspection
  - Inspection accuracy is high because the inspector actually observes the abnormality personally.
  - Economical compared to inspection using a TV camera.
  - The inspected results become very useful O&M data.
- The procedure for manhole visual inspection is shown in Figure 2.5.

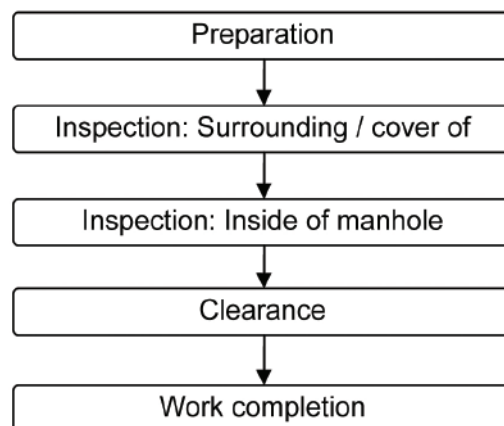
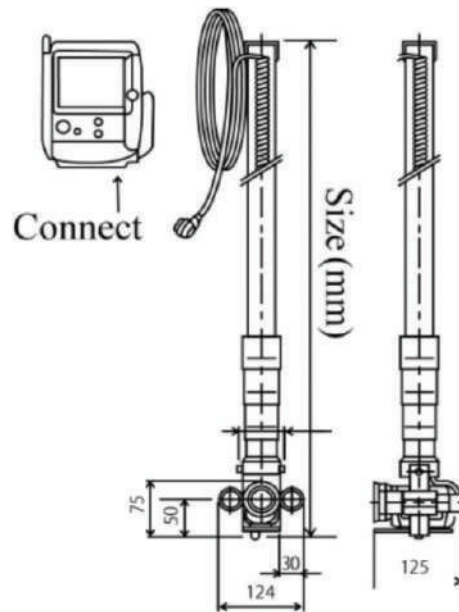


Figure 2.5 Manhole Visual Inspection Procedure



### 2.2.5.1.2 Inspection Using a Pole-mounted TV Camera

A pole-mounted TV camera as in Figure 2.6 is used.



Source: JASCOMA, 2007

Figure 2.6 Pole-mounted inspection camera

It consists of an extendable operating rod at the front of which a camera and light are fitted. This arrangement is inserted in the manhole from the ground, and the inspector on the ground observes a monitor and inspects the internal parts of the pipe through the camera.

The features of direct visual inspection are compared with those of inspection by TV camera and shown below.

- Advantages
  - The inspection is easy and observations can be made in a short period. Moreover, the data of inspection can be recorded as images.
  - Since the inspector works above ground, there is no chance of oxygen deficiency or accidents by fall, and the work is safe.
- Disadvantages
  - The scope of inspection is limited to the area around the mouth of the pipe.
  - Offset in the horizontal direction or fine cracks cannot be detected.
  - The condition of the side surfaces in the sewer pipe cannot be grasped (sides cannot be viewed).

This check may also be used for pre-inspections.

The method of inspection is shown in Figure 2.7 overleaf.

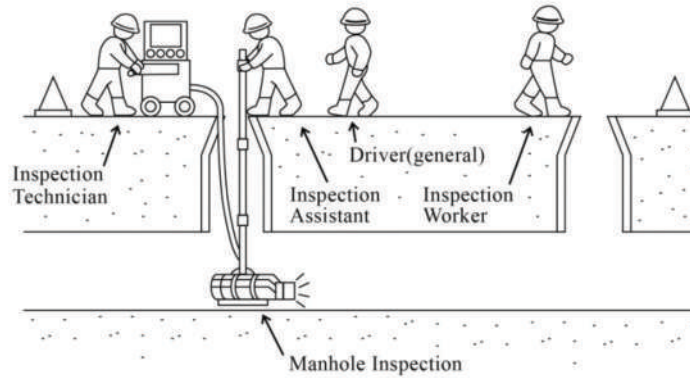


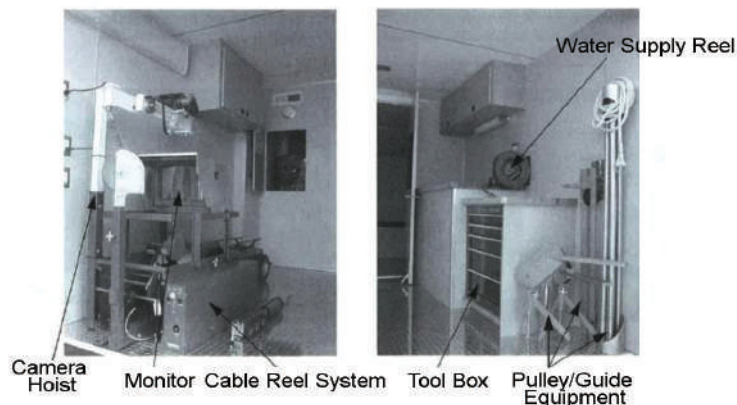
Figure 2.7 Illustration of pole-mounted TV camera inspection

**2.2.5.1.3 Inspection using Closed-Circuit Television (CCTV)**

Pipes that can be inspected by CCTV have inside diameters ranging from 150 mm to 900 mm, but large diameter pipes may also be inspected by CCTV. The TV camera may be the traveling type or the towed type. Either the direct method (taking panoramic shots of the overall scene) or the side view method of taking local shots of only abnormal locations may be used. House connection TV is described in a separate section (2.10.1). Figure 2.8 shows the TV camera and the vehicle on which it is loaded. The illustration of the TV inspection work is shown in Figure 2.9 overleaf.



Step Van



Source: EPA,2003

Figure 2.8 Step van CCTV system

The features of TV camera inspection are

- i. By opening a manhole at one location, inspection using the traveling TV camera is enabled.
- ii. Continuous inspection up to a maximum distance of 100 to 200 m (cable length) is possible.

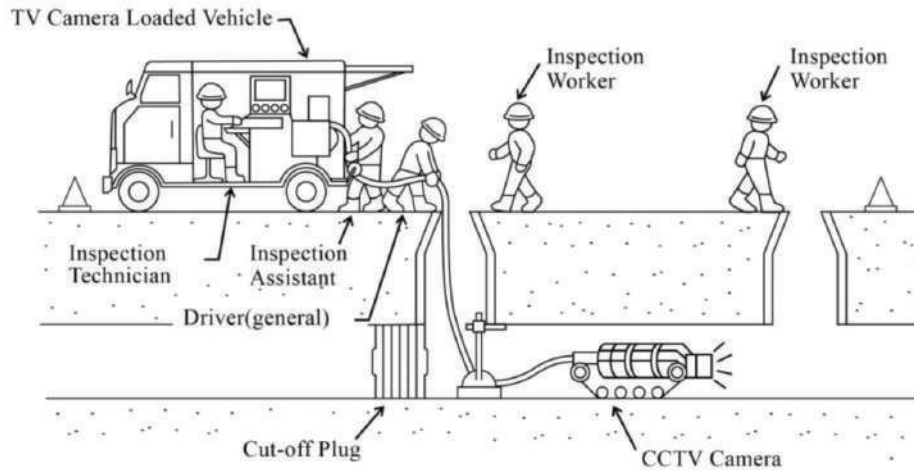


Figure 2.9 Illustration of CCTV camera inspection

iii. The connections of the lateral sewer and main sewer and defective locations should be photographed by the side view method.

A typical TV camera inspection work procedure is shown in Figure 2.10.

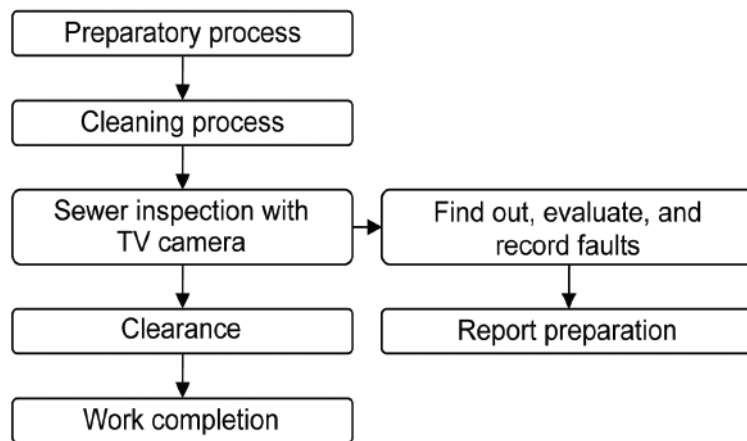


Figure 2.10 Work Procedure for TV Camera Inspection

CCTV Camera Inspection Record

Abnormalities detected in the pipeline during the CCTV camera inspection should be recorded on video tape or as photographs, according to the judgment criteria.

Figure 2.11 (overleaf) and Figure 2.12 (overleaf) show examples of the record.

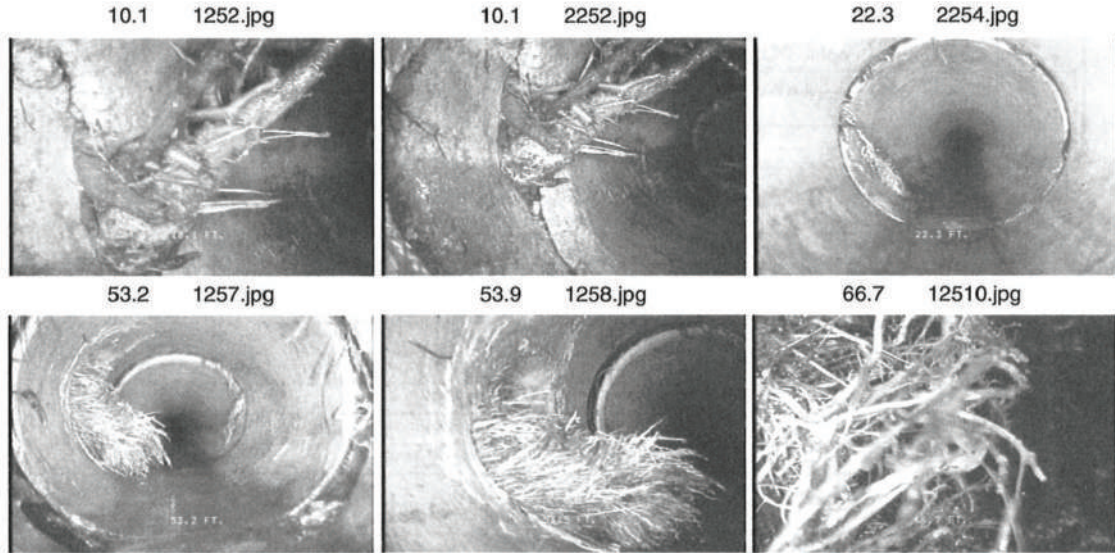
The inspected results should be recorded in the inspection record.

Examples of forms of the inspection record are shown in Figure 2.13 (overleaf) and Figure 2.14 (overleaf).



**Site Data and Photos: Ukiah, Demo**

<b>Site ID</b>	<b>City</b>	<b>Street</b>	<b>Date</b>	<b>Time</b>
1	Ukiah	300-Hillcrest	10/02/2002	01:14:29 PM
<b>M.H. Start</b>	<b>M.H. Stop</b>	<b>Type of Pipe</b>	<b>Pipe Size (i/mm)</b>	
344	end	Concrete	6	
<b>Operator</b>	<b>Comment</b>			<b>Surface Condition</b>
Rich	Demo on 10-02-02 for the city of Ukiah			Paved Asphalt



Source: EPA,2003

Figure 2.11 CCTV data No.1

**Photo #2 Data for Project: Ukiah, Demo**

<b>Site ID</b>	<b>City</b>	<b>Street</b>	<b>Inspection Date</b>	<b>Time</b>
1	Ukiah	300-Hillcrest	10/02/2002	01:14:29 PM
<b>From Manhole</b>	<b>To Manhole</b>	<b>Pipe Size</b>	<b>Type of Pipe</b>	<b>Direction</b>
344	end	6	Concrete	Away-D
<b>Observation ID</b>	<b>Category</b>	<b>Category Details</b>	<b>Clock Position</b>	<b>Severity Level</b>
2	Pipe Problem	Roots	9 O'Clock	Level 2
<b>Operator</b>	<b>Observation Comment</b>			<b>Surface Condition</b>
Rich	Root coming through joint and or repair			Paved Asphalt



Photo #2 2252.jpg

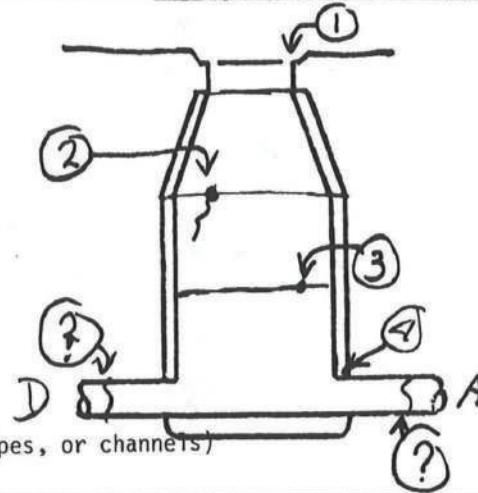
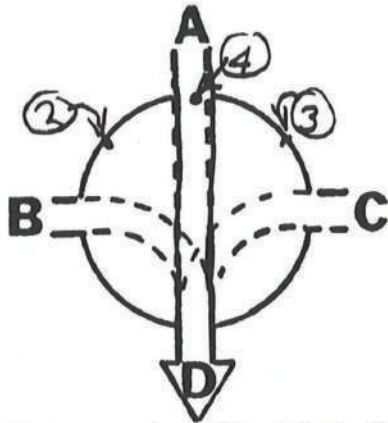
Distance (ft/m): 10.1

Source: EPA,2003

Figure 2.12 CCTV data No. 2

MANHOLE INSPECTION REPORT

MH NO. 6822 DATE 7-20-02 TIME 10:15AM INSPECTOR J.S.  
 ELEVATION \_\_\_\_\_ DEPTH TO INVERT 9'7" CLEANLINESS OK  
 TYPE CONSTRUCTION CONC-CAST STREET REFERENCES 34 AVE & AITKIN



DEFECTS:  
 (Cover, frame, grout, walls, steps, shelf, pipes, or channels)

1. MH RING DEPRESSED 1/4"
2. DIAGONAL CRACK IN BARREL
3. SEAL FAILURE AT JOINT - 1-GPM LEAK
4. SEAL FAILURE & PIPE CRACK - 2-GPM LEAK
5. \_\_\_\_\_
6. \_\_\_\_\_
7. \_\_\_\_\_
8. \_\_\_\_\_

(USE REVERSE SIDE FOR ADDITIONAL DEFECTS TO BE NOTED.)

	PIPE SIZE	LENGTH TO MH#	EST. FLOW	TYPE FLOW
A-	<u>8</u>	<u>275 6823</u>	<u>2"</u>	<u>SOAPY</u>
B-	_____	_____	_____	_____
C-	_____	_____	_____	_____
D-	<u>8</u>	<u>320 6821</u>	<u>2"</u>	_____

REMARKS:  
 (Include need for repairs)

AUDIBLE LEAK(S) IN PIPES NEAR MANHOLE. DEPRESSED RING MAY INDICATE DROP JOINTS OR BREAKS IN LINE.

MANHOLE INSPECTION FORM

Completed manhole inspection report

Figure 2.13 Forms of inspection record



CITY OF PHOENIX SANITARY SEWER REPORT									
1/2 SEC. #: 12-24 T.V. OPER: RENTFRO			DATE: 10-15-02			ROUTINE: <input checked="" type="checkbox"/>			
PIPE DIA: 8" PIPE TYPE: VCP PIPE LENGTH: 6'			EQUIP. #: 481			COMPLAINT: <input type="checkbox"/>			
M.H.# 303			M.H.# 304			START: 000			
			V.T. # 34			STOP: 135			
STREET: W. CAHELBACK			COMMENTS: SEVERE CRACKED PIPE AS NOTED ROD LINE - ROOTS CLEAN LINE - SLUDGE & ROCKS						
STA. #:	M.H. #	VT	STA. #:						VT
D+00	M.H. # 303								
D+16.5	TN FACT.								
D+18.5	TS TAP		3+28.0	PIPE CRACKED (5)					092
D+42.0	Roots @ JOINT (4)	000	3+40.0	" "	(9)				101
D+54.0	" "	(5)	010	3+58.5	TN FACT.				
D+72.5	PIPE CRACKED (2)	D14	3+60.5	TS FACT.					
D+84.5	" "	(6)	D20	3+84.0	Roots @ JOINT (1)				105
D+90.5	TN TAP		3+90.0	" "	(1)				↑
D+92.5	TS FACT.		3+96.0	" "	(4)				
1+16.5	OFF-SET JOINT 1"	D28	4+02.0	" "	(6)				
1+22.0	2" WATER & SLUDGE	D31	4+08.0	" "	(8)				
1+28.0	3" WATER	D33	4+14.0	" "	(5)				↓
1+34.0	C UW	D36	4+20.0	" "	(8)				130
1+37.0	C OW	D39	4+32.0	MH # 304					
1+52.0	PIPE CRACKED (9)	D42							
1+64.5	TN FACT.								
1+66.5	TS TAP								
1+90.0	OFF-SET JOINT 1"	D47							
2+10.0	SLUDGE - HVY.	D51							
2+14.0	ROCKS - SLUDGE	D55							
2+20.0	LOW JOINT - 1 1/2" WATER	D60							
2+32.0	TN FACT.								
2+34.0	TS FACT.								
2+64.0	ROOTS @ JOINT (1)	D66							
2+70.0	" "	(4)	D69						
2+90.0	TN FACT - CRACKED (6)	D72							
2+92.0	TS TAP - CRACKED (9)	D78							
3+10.0	OFF-SET JOINT 2"	D84							
3+16.0	" " " 2"	D88							

**SERVICE REQUEST SUBMITTED**  
 TYPE: CONST. - ROD - CLEAN  
 DATE: 10-17-02  
 H. M. [Signature]

Reviewed TV inspection report

Source: EPA,2003

Figure 2.14 Forms of inspection record

### 2.2.5.2 Inspecting Infiltration of Water

If infiltration of water is more corresponding to the planned water flow in the sewerage plant, the pipelines and treatment facilities will be adversely affected.

This also leads to an increase in the treatment costs of the STP. The cause of infiltration of water is either the pipeline is inadequate or the drainage system is inadequate.

For this reason, inspection of cross connections, flow-rate inspection and waterproofing inspections need to be combined and the route of infiltration water should be checked. Flow-rate inspections help since useful data for improvements and modifications to the piping facilities can be collected.

#### 2.2.5.2.1 Inspecting Cross Connections

Inspection has to be performed to check that storm water equipment is not connected to the sewers in a separate sewer system. The scope of work is from the main pipe of the sewerage works to the house drainage facility.

There are three typical methods for inspecting cross connections.

##### A. Smoke Test

The smoke test makes use of smoke emitters in a separate sewerage system pipeline. A cross connection can be judged by checking for smoke rising from the house inlet or rain gutter.

This test identifies locations where storm water inlet or rain gutter drainage is directly connected to sewer pipe house inlet and locations where storm water has permeated the ground from the ground surface or gutter and has indirectly permeated the wastewater pipe or house inlet.

Figure 2.15 shows the materials to be used. Figure 2.16 shows illustrative sketches.



Manhole Smoke Blower



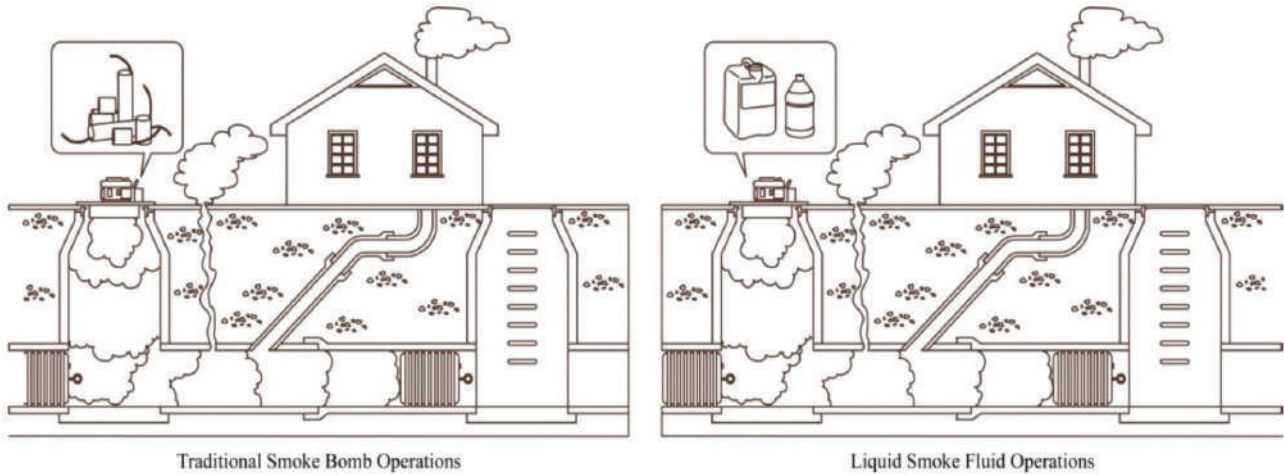
Smoke Emitter



Smoke Fluid

Source: EPA, 2003

Figure 2.15 Materials for smoke test



Source: EPA,2003

Figure 2.16 Illustrative Sketches of Smoke Test

- Features of the smoke test
  - The status of connection of drain pipes in each space can be checked in a short time.
  - Inadequacies in the house drainage facility can be quickly detected.
- Smoke test procedure is shown in Figure 2.17.

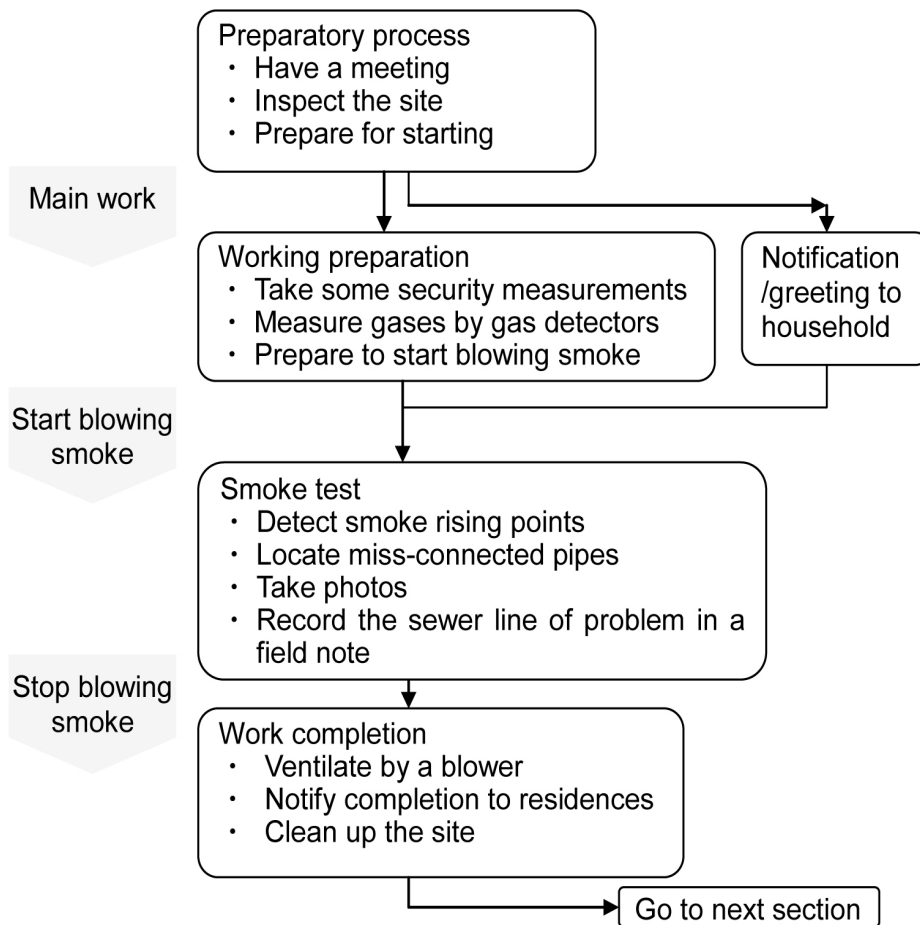


Figure 2.17 Work Procedure of Smoke Test



B. Echo Sound Test

This is a method for confirming that piping facilities are correctly connected, and is also an effective method for knowing the plumbing systems and the routes of sewers and lateral sewers. Ultrasonic waves are used (transmitter and receiver). Figure 2.18 shows the test method.

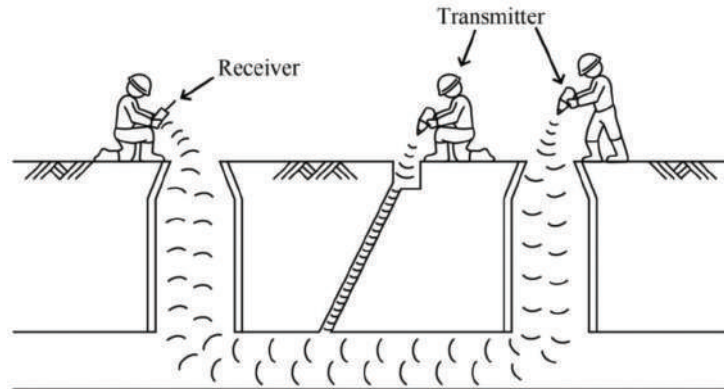


Figure 2.18 Illustration of Echo Sound Test

- Features of the echo sound test
  - Simple method to confirm that a pipe has been connected or not.
  - Effective especially in the connections of lateral sewers.
  - Cannot judge clogging or trap.
- Echo sound test procedure is shown in Figure 2.19.

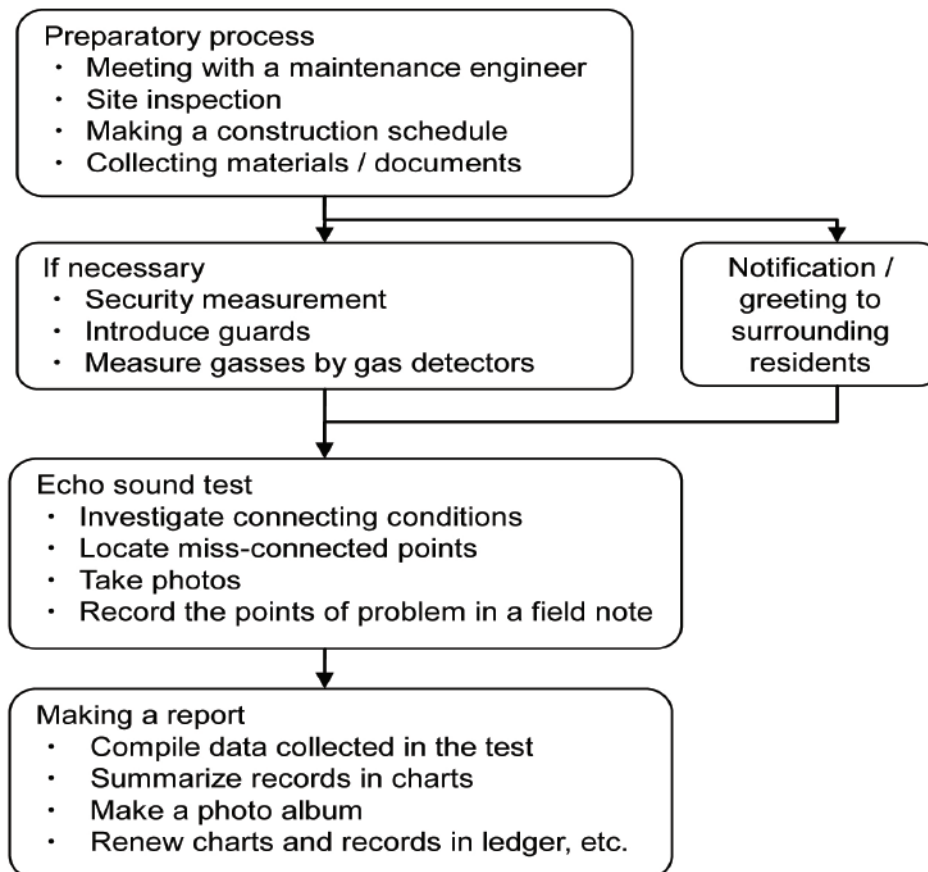


Figure 2.19 Work Procedure of Echo Sound Test

### C. Dye Test

The dye test is carried out using water diluted with harmless fluorescent dye. This diluted water is made to flow from the upstream side of the STP within the range of the sewer, lateral sewer and drainage equipment. The water flow route, leakage route and reaching time are examined. Outflow route should be checked quickly if notification of foul odour due to outflow of wastewater, particularly from masonry or pump tank, is received. The method can also be used for checking the flow status in the pipe and for measuring the flow velocity. The test method is shown in Figure 2.20. In addition, clause 3.10 of Part A manual dealing with dye tracer study may be referred to.

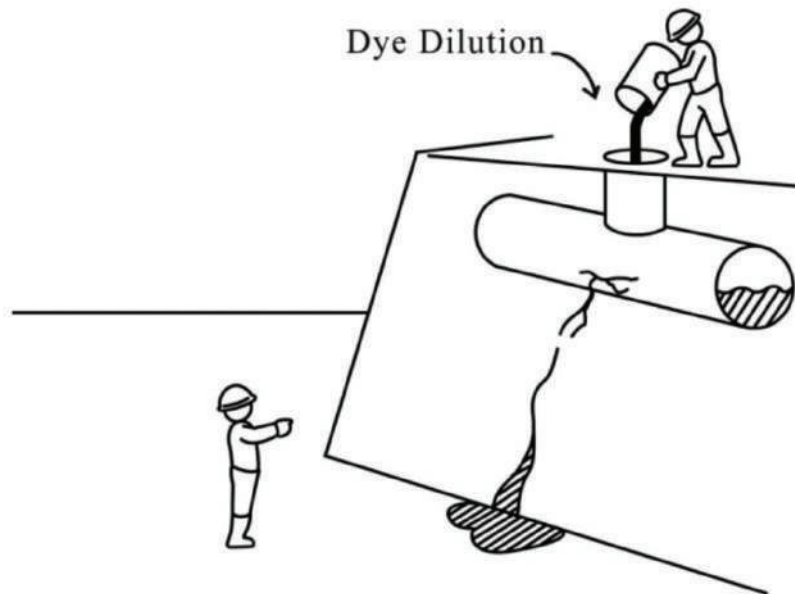


Figure 2.20 Drawing of dye test

#### 2.2.5.2.2 Flow Rate Inspection

- About important areas for inspecting flow rate

Inspection should be carried out at locations where possibility of infiltration is high, e.g. where groundwater level is high, at a part of a river crossing, or at a location adjacent to rivers.

##### A. Flow Rate Measurement

Simple flow velocity meters (Palmer Bowlus flume, electromagnetic flow meter, water level gauge, ultrasonic flow meter) should be installed tentatively at the mouth of the manhole for flow measurements in the piping facilities and fixed period measurements carried out. For details of flow meters, refer to Sec. 3.10 of Chapter 3 of Part A manual.

##### B. Pumping Test

This is a method for measuring the flow rate of water that has infiltrated the pipeline. The flow rate of infiltrated water into the space or the system can be known within a short time. However, the flow rate of infiltrated water varies with the variation in groundwater and thereafter, precipitation and weather at the time of measurement should be confirmed.



To drain out household wastewater from the test during inspection of each space, a cut-off plug should be installed. This should preferably be implemented during the night time when the volume of household sewage generated is small. Figure 2.21 shows the pumping test.

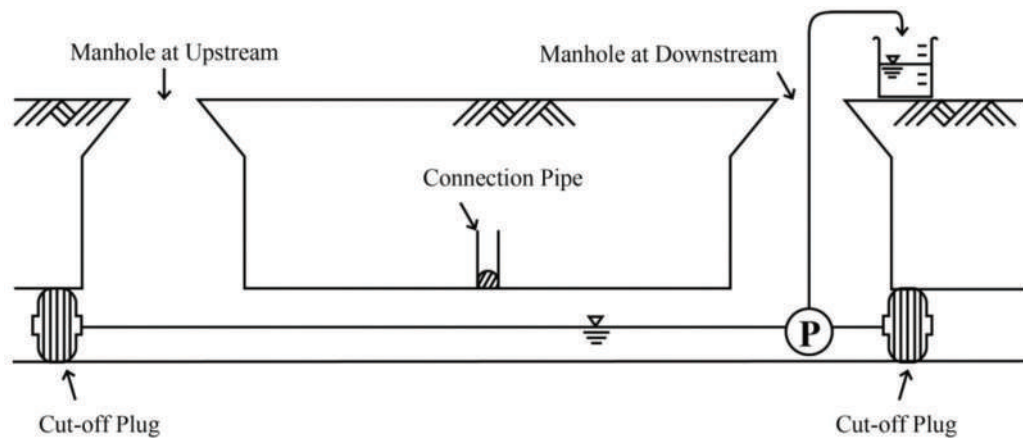


Figure 2.21 Pumping test

- Features of measurements during pumping test are
  - The flow rate of infiltrated groundwater for each space or system can be measured within a short time.
  - The measured values differ widely depending on the variation in the groundwater level.
  - During measurements of several spaces or each system, it is difficult to remove household wastewater late at night.
- Work procedure for measurement of pumped water is shown in Figure 2.22.

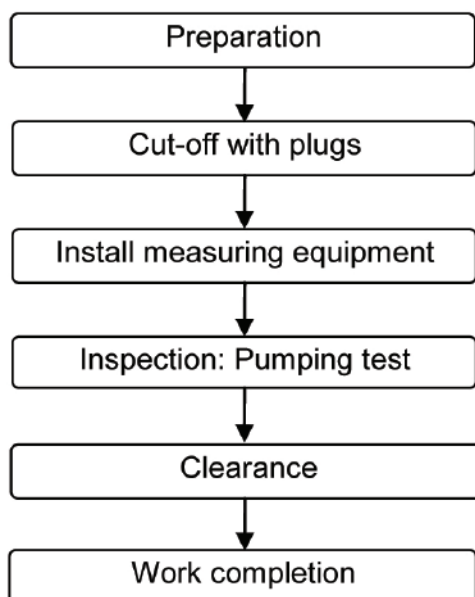


Figure 2.22 Work procedure of pumping test

### 2.2.5.3 Inspecting Corrosion and Deterioration

The status of deterioration or corrosion within the sewer should be judged by TV camera. The materials in the piping facility are of various kinds: concrete pipe, ceramic pipe, hard UPVC, brick, HDPE pipe, ductile pipe, and GRP pipe; and hence the corrosion and deterioration conditions vary.

Methods for inspecting corrosion and deterioration conditions of a sewer include the following:

- Inspection by TV camera of the wall surface condition
- Crack inspection
- Neutralization test

The causes of deterioration of structural concrete parts of the piping facilities are the following:

- Crack in concrete due to concentrated loads (live loads)
- Deterioration of structure due to changes with aging
- Deterioration of concrete structures (concrete corrosion) due to sulphuric acid from the generation of hydrogen sulphide

#### 2.2.5.3.1 Concrete Corrosion

In a facility where sewage resides for a long period, sewage is likely to become anaerobic and dissolved sulphide will be generated, which leads to concrete corrosion because of its formation to sulphuric acid. Locations where concrete corrosion is likely to occur in sewage

- Piping facilities at the discharge destination of pressure pipe (including manhole pump)
- Upstream and downstream ends of locations where sump discharge occurs
- Upstream and downstream ends of locations where discharges containing sulphide occurs
- Locations downstream of inverted siphon

For details of the corrosion mechanism, refer to chapter 3 of Part-A manual.

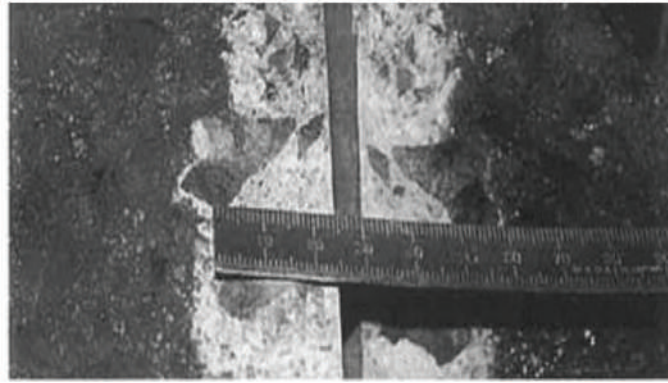
##### A. pH Measurement of Concrete Surfaces

For sulphuric acid corrosion of concrete, the pH on the surface of concrete is measured by pH test paper or pH meter, which is placed on concrete surface directly, and the generation of sulphuric acid in the concrete structure can be confirmed. When sulphuric acid is generated in a manhole, the pH of the concrete surface may indicate strong acidity of as low as 1 to 2.

##### B. Neutralization test (neutralization depth test by phenolphthalein)

One of the indices for judging durability of reinforced concrete structures is the “neutralization depth”. This is the method of judging alkalinity with pH of 10 and above as non-neutralized part and non-coloured parts as neutralized parts, enabling quantitative information to be obtained easily by simple measurements in Figure 2.23 overleaf.

When neutralization reaches the vicinity of the reinforcement, the reinforcement is likely to be corroded easily. When corrosion of reinforcement progresses, volume expansion of corrosive



Source: JASCOMA, 2007

Figure 2.23 Neutralization test

products causes crack or delamination in concrete, leading to excessive loss in the durability of the structure. For the procedure, refer to BS-103: “Guidelines on Non-destructive Testing of Bridges.”

**2.2.5.4 Other Examinations**

Special examinations to study in detail the conditions of a facility are as given below. For more details, please refer to relevant documents for each item. Various kinds of information relevant to analysis for studying gas exploration are given.

- Sewer invert elevation examinations: Understanding pipeline conditions and collating with sewerage facility records.
- Sediment examination: Check sediment material, such as sand and silt, which may have entered damaged sewer or through loose joints from outside the sewer. This sand and silt may accumulate around the sewer and form voids.
- Dangerous gas detection examination: Confirming gases generated in the piping facilities.

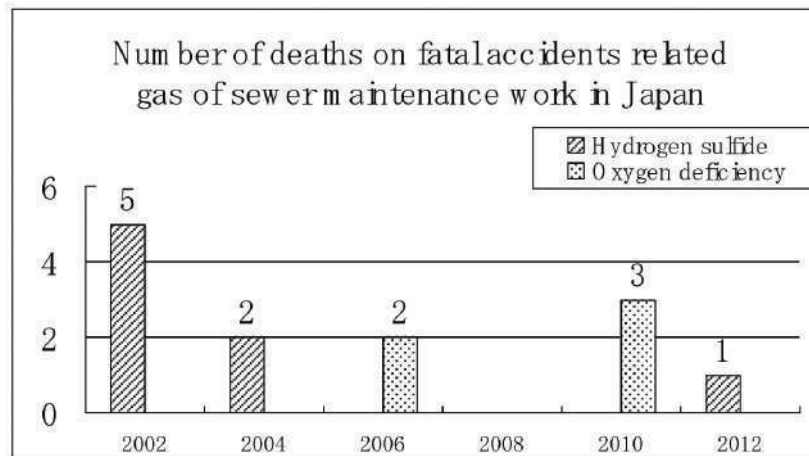
Water quality and gases encountered in a piping facility are closely related. Table 2.6 shows the gas analysis items in a piping facility.

Table 2.6 Gas analysis

Name of Gas	Symbol	Unit	Name of Gas	Symbol	Unit
Carbon monoxide	CO	( % )	Oxygen	O <sub>2</sub>	( % )
Carbon dioxide	CO <sub>2</sub>	( % )	Methane	CH <sub>4</sub>	(ppm)
Hydrogen sulphide	H <sub>2</sub> S	(ppm)	Nitrogen oxide	NO <sub>x</sub>	(ppm)
Ammonia	NH <sub>3</sub>	(ppm)			

Source: JASCOMA, 2007

In Japan the accidents caused due to gases generated from sewerage system are shown in Figure 2.24 overleaf. Accidents and casualties should be properly recorded mentioning all the relevant details.



Source: JASCOMA, 2012

Figure 2.24 Fatal accidents due to gases from sewerage system between 2002 and 2012

The causes of the gas-related accidents were hydrogen sulphide, carbon monoxide and oxygen deficiency. There is no data on accidental death in India and there should be such monitoring in India at least hereafter.

#### 2.2.5.5 Precautions

Cleaning equipment and machinery for sewers are shown in the following sections:

When entering manholes, safety measures during the work should be to ensure traffic safety, prevent oxygen deficiency, precautions against hydrogen sulphide and so on. For securing workers' safety, manual sewer/septic tank cleaning should be avoided because persons are likely to come in direct contact with sludge and sewage.

Therefore, cleaning machinery and equipment are needed. Furthermore, necessary safety measures before entering manholes for cleaning should be taken. "Machinery and equipment for sewer pipes" are explained in section 2.3 of this manual. The explanations on "Cleaning of on-site systems" are in Chapter 10 of this manual.

The contamination of drinking water with sewage may occur when water supply pipe passes through sewer manholes, generally in narrow streets, especially when water supply pipe joints are enclosed in sewer manholes and whenever water supply pipe joints leak, contamination of drinking water supply occurs.

As such, water supply pipelines should never be enclosed in a sewer manhole. If any such situation is observed, water supply pipe be made non-functional immediately by stopping flow of drinking water and affected public be supplied clean drinking water by other temporary means, such as water tankers or laying separate pipe over the ground / road surface and portion of water supply lines lying in sewer manholes be shifted out of manholes.

Special attention should be paid to decentralized sewer system, particularly when small-bore sewer system or shallow sewer system is adopted.

## 2.2.6 Judgment of Inspection and Examination Results

It is necessary to judge whether urgent repairs or modifications are necessary, or normal operation and maintenance are sufficient to ensure that the functions of piping facilities are maintained when an abnormality is detected by studies and analyses. The facility manager should make the judgment considering material of the pipe, age of the pipe, location where buried, quality of wastewater, status of groundwater, regional environment, and so on.

The criteria given below may be used as judgment criteria.

- Emergency response criteria
- Judgment based on results of inspection or examination
- Testing criteria

### 2.2.6.1 Emergency Response Criteria

Abnormalities related to piping facilities are generally detected from inspections or from outside reports.

Prompt action should be taken when an accident has already occurred. Moreover, when the events below are confirmed, action should be taken immediately.

- Road surface: Irregularity exists that can cause level difference leading to subsidence or obstruction to operation.
- Manhole: Level difference exists that can lead to obstruction of operation.
- Inverted siphon: Water level on the upstream side is excessively high.

### 2.2.6.2 Judgment based on the Results of Inspection and Examination

Testing of the overall span and by each pipe should be carried out based on the results of visual inspection. Table 2.7 and Table 2.8 (overleaf) show examples of testing criteria.

Table 2.7 Testing criteria for overall sewer span

Items		Rating		
		(A)	(B)	(C)
Corroded pipe		Reinforcing bars exposed	Aggregate exposed	Rough surface
Vertically deflected pipe	ID: < 700 mm	≥ ID	ID - 1/2 ID	< 1/2 of ID
	ID: 700 – 1650 mm	≥ 1/2 of ID	1/2 ID - 1/4 ID	< 1/4 of ID
	ID: ≥ 1650 mm	≥ 1/4 of ID	1/4 ID - 1/8 ID	< 1/8 of ID

Source: JASCOMA, 2007



Table 2.8 Testing criteria for each pipe of sewer

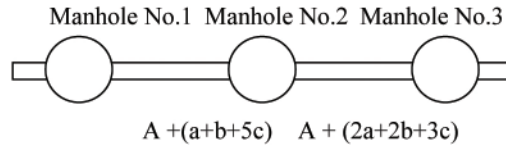
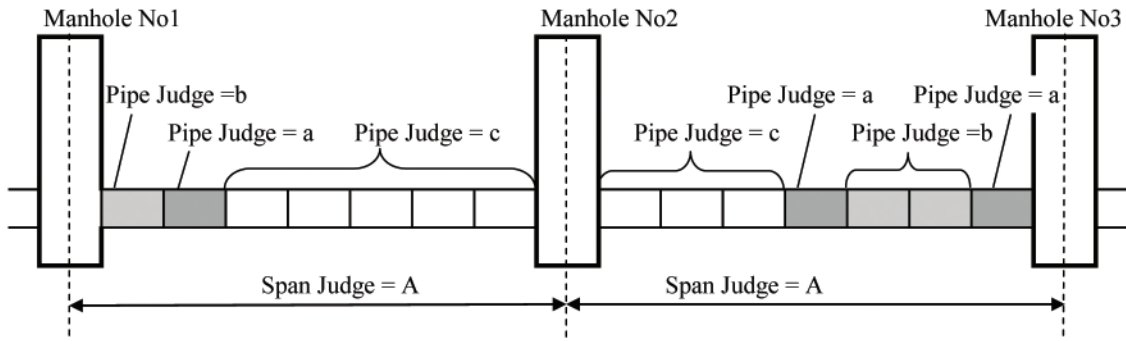
Items		Rating			
		(a)	(b)		(c)
Ruptured pipe	Reinforced concrete pipes, etc	Partially missing /holed pipe	Axial crack of 2 mm width or more		Axial crack of less than 2 mm width
		Axial crack of 5 mm width or more			
	Stoneware pipes	Partially missed /holed pipe	Axial crack shorter than 1/2 of the pipe length		-
		Axial crack of 1/2 of the pipe length and longer			
Cracked pipe	Reinforced concrete pipes, etc	Circumferential crack of 5 mm width or more	Circumferential crack of 2 mm width or more		Circumferential crack of less than 2 mm width
	Stoneware pipes	Circumferential crack of 2/3 of the pipe circumference and longer	Circumferential crack shorter than 2/3 of the pipe circumference		-
Gap at coupling pipes	Slip off (Joint displacement)	Reinforced concrete pipes, etc	≥70 mm	Reinforced concrete pipes, etc	<70 mm
		Stoneware pipes	≥50 mm	Stoneware pipes	<50 mm
Infiltration	Splashing in	Flowing in		Soaking	

Source: JASCOMA, 2007

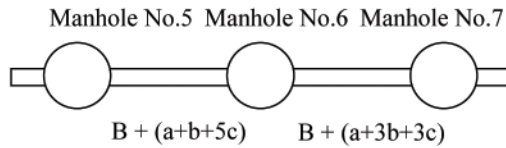
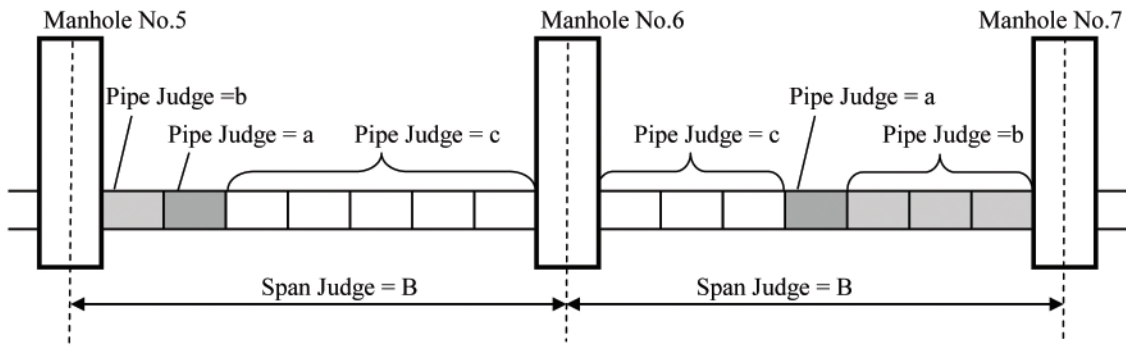
The testing of the overall span is divided into the three categories (A, B and C)

- Functional degradation,
- Deterioration and
- Abnormalities

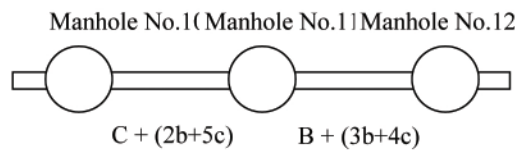
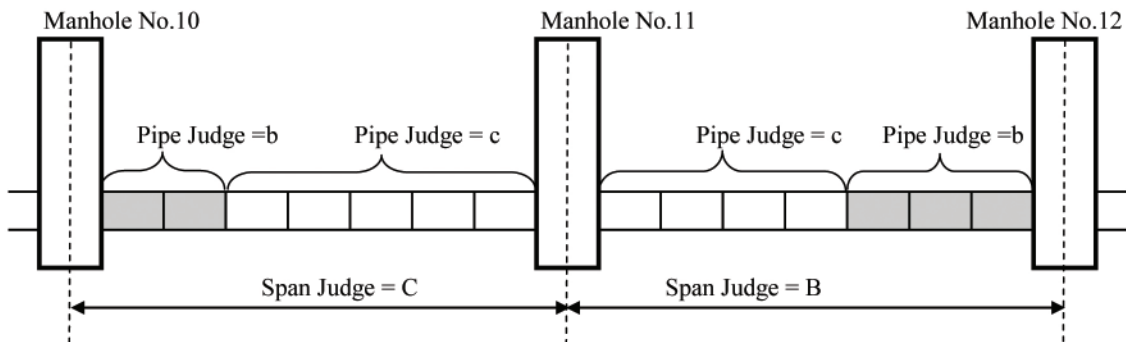
clarified by inspection and examination should be assessed as shown in Figure 2.25 overleaf.



**Example of Emergency Level -I (In Table 2.9)**



**Example of Emergency Level -II (In Table 2.9)**



**Example of Emergency Level -III (In Table 2.9)**

Figure 2.25 Illustration of testing criteria for sewer

**2.2.6.3 Testing Criteria**

A maintenance engineer should judge what counter measure are applied for inspected sewers in accordance with Table 2.9, e.g., by usual operation and maintenance or by emergency repairs and modifications.

Based on the criteria shown in Table 2.7 and Table 2.8, emergency level I is a state where immediate response is necessary.

Emergency level II indicates that simple response may be adopted and radical measures implemented within the next five years.

Furthermore, emergency level III indicates response adopted by operation and maintenance, and implementation of simple response partially.

Table 2.9 Testing criteria for sewer

Emergency Level	Category	Testing criteria	Criteria for measures
I	Important	(A)s are more or (a)s are more in the testing results	Prompt measures are necessary
II	Medium importance	(A)s are less frequent and (B)s are more; or (a)s are less and (b)s are more in the testing results	Necessary actions may be taken by provisional measures and the proper measure will be implemented within 5 years
III	Minor importance	(A)s (B)s are few, (C)s are many, or (a) and (b) are few, ) (c )s are many in the testing results	Actions may be taken by provisional measures, if required

A's, B's, and C's are judgement results of Table 2.7,  
a's, b's and c's are judgment results of Table 2.8.

**2.2.7 Maintenance of Records and Follow up Action**

To reflect the inspection and testing results in appropriate O&M of piping facilities, the test results should be recorded and stored in the format shown here.

**A. Inspection Sheet**

When inspections and examinations are implemented, an inspection sheet should be prepared and recorded as shown in Table 2.10.

Table 2.10 Inspection sheet

Inspection Sheet			No.
Location (Manhole No. etc)			
Inspection Date		Inspector	
Inspection items	Manhole cover	Abrasion, backlash, difference in level, invaded pavement, damaged, location unknown	
	Inside of manhole	Corrosion, damage to the floor, infiltration, metal steps corroded, inferior pipe end, rubbish, odour	
	Pipe	Corrosion, damage, coupling displacement, inadequate inclination, infiltration, roots of trees, earth, sand and mortar, road subsidence	
	House inlet	Cover (no damage), difference in level, corrosion, damage, damaged invert, earth and sand, location unknown, odour	
	Lateral	Damage, displacement, earth and sand, road subsidence	
Inspection Date		Inspector	
Inspection Result			
Follow up actions	<input type="checkbox"/> Necessary <input type="checkbox"/> Not necessary	<input type="checkbox"/> Contracted <input type="checkbox"/> Self	
Date of order			
Date of schedule			
Date of completion			
Remarks			

Source: JASCOMA, 2007

### B. Log

The log should be used to record daily work results, which can be used in the O&M of piping facilities. The format is shown in Table 2.11 overleaf.

### C. Monthly Reports

The daily record should be summarized in monthly reports. The format of the monthly report is shown in Table 2.12 overleaf.

Table 2.11 Daily report

Daily Report										Date		Weather	
Receipt No.		Receipt date	Location: address	Work description		Inspector		Tool/Material		Remarks			
1													
2													
3													
4													
Diameter (mm)										Name of cleaned area		Daily total	
Crew A										District:		person	
Crew B										System No:		person	
Removed sand volume												m <sup>3</sup>	
Cleaned distance												m	
Direct works		Name of place repaired	Name of place repaired	System No.	Entrusted works	Name of place repaired	Name of place repaired	Name of drainage area	Name of drainage area	System No.	Tool/Material	Daily total	
Manhole					Work description								

Source: JASCOMA, 2007



Table 2.12 Monthly report

Monthly Report		Date							Weather			
Response to complaint / breakdown	Category	1.Lateral	2.Inlet	3.Manhole	4.Ground subsidence	5.Odour	6.Others	Total				
	Number											
Trunk cleaning	Diameter (mm)											Total
	Direct crew											
	Entrusted crew											
	Removed sand											
	Cleaned distance											
Manhole repair	Manhole type	1	2	3	4	5	6	7	Special	Direct	Entrusted	Total
	Cover replaced											
	Ring repaired											
	Barrel repaired											
Noise												

Source: JASCOMA, 2007

## 2.3 SEWER CLEANING

To operate and maintain a sewer collection system to function as intended, the maintenance engineer should try to strive towards the following objectives:

- Minimize the number of blockages per unit length of sewer, and
- Minimize the number of odour complaints.

For this purpose, sewer-cleaning using hydraulic or mechanical cleaning methods needs to be done on a scheduled basis to remove accumulated debris in the pipe such as sand, silt, grease, roots and rocks. If debris is allowed to accumulate, it reduces the capacity of the pipe and blockage can eventually occur resulting in overflows from the system onto streets, yards and into surface waters. Roots and corrosion also can cause physical damage to sewers.

### 2.3.1 Cleaning Equipment and Procedures

Sewer cleaning works require usual implements like pick axes, manhole guards, tripod stands, danger flags, lanterns, batteries, safety lamps, lead acetate paper, silt drums, ropes, iron hooks, hand carts, plunger rods, observation rods, shovels etc.

In addition, sewer cleaning work calls for the following special equipment and devices like a portable pump-set running on either diesel or petrol engine, rope and cloth balls, sectional sewer rods, a sewer cleaning bucket machine, a dredger, a rodding machine with flexible sewer rods and cleaning tool attachments such as augers, corkscrews, hedgehogs and sand cups, scraper, and hydraulically propelled devices such as flush hags, sewer balls, wooden bail and sewer scooters, sewer jetting machine, gully emptiers and pneumatic plugs. The krait type of flexible rods in a portable reel is useful in attending to house sewers.

#### 2.3.1.1 Manila Rope and Cloth Ball

The most common way of cleaning small diameter sewers up to 300mm diameter is by the use of a manila rope and cloth ball. Flexible bamboo strips tied together are inserted in the sewer line by a person on top. If necessary, another person inside the manhole with full safety gears, precautionary measures and safety equipments help in pushing the rod through the sewer line. When the front end of the bamboo strip reaches the next manhole, a thick manila rope, with cloth ball at one end, is tied to the rear end of the bamboo splits. The bamboo splits are then pulled by another person in the downstream manhole and pushed through the sewer line. As the rope is pulled, the ball sweeps the sewer line and the accumulated grit is carried to the next manhole where it is removed out by means of buckets. This operation is repeated between the next manholes until the stretch of sewer line is cleaned. This action requires a careful supervision.

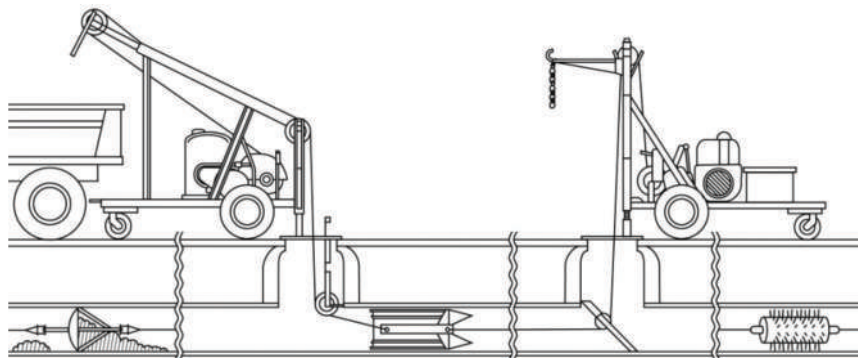
#### 2.3.1.2 Sectional Sewer Rods

These rods are used for cleaning small sewers. The sewer rods may be of bamboo or teak wood or light metal usually about one meter long at the end of which is a coupling, which remains intact in the sewer but can be easily disjoined in the manhole. Sections of the rods are pushed down the sewer.

The front or the advancing end of the sewer rod is generally fitted with a brush, a rubber ring for cleaning or a cutting edge to cut and dislodge the obstructions. These rods are also useful to locate the obstruction from either manhole in case a particular portion of the sewer has to be exposed for attending to the problem.

### 2.3.1.3 Sewer Cleaning Bucket Machine

The bucket machine consists of two powered winches with cables in between. For cleaning a section of sewer; the winches are centred over two adjacent manholes. To get the cable from one winch to the other, it is necessary to thread the cable through the sewer line by means of sewer rods or flexible split-bamboo rods. The cable from the drum of each winch is fastened to the barrel on each end of an expansion sewer bucket fitted with closing device, so that the bucket can be pulled in either direction by the machine on the appropriate end. The bucket is pulled into the loosened material in the sewer until the operator feels that it is loaded with debris. The winch is then thrown out of gear and the opposing winch is put into action. When the reverse pull starts, the bucket automatically closes and the dirt is deposited in a truck or a trailer. This operation is repeated until the sewer is cleared. Various bucket sizes are available for sewers of 150 mm to 900 mm in size. The machine is also used along with other scraping instruments for loosening sludge banks of detritus or cutting roots and dislodging obstructions as in Figure 2.26.



Source: EPA, 2003

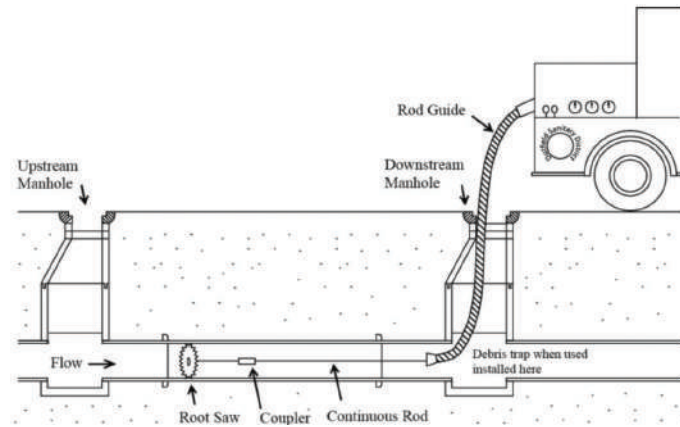
Figure 2.26 Power bucket machine setup

### 2.3.1.4 Dredger (Clam-shell)

It consists of a grab bucket on a wire rope, which is lowered into the manhole in the open condition with the help of a crane and pulley. On reaching the bottom of the manhole, the segments are closed, and the accumulated silt is picked up. The bucket is then raised above ground level where the bucket opens and the silt is automatically dropped into a truck or a trailer. The bucket can be closed by wire ropes or by a pneumatically operated cylinder. The disadvantage in this system is that it cannot clean the corners of the catch pits of manholes. Sometimes the deposits at the corners may become so hard that the same may be required to be chiselled out.

### 2.3.1.5 Rodding Machine with Flexible Sewer Rods

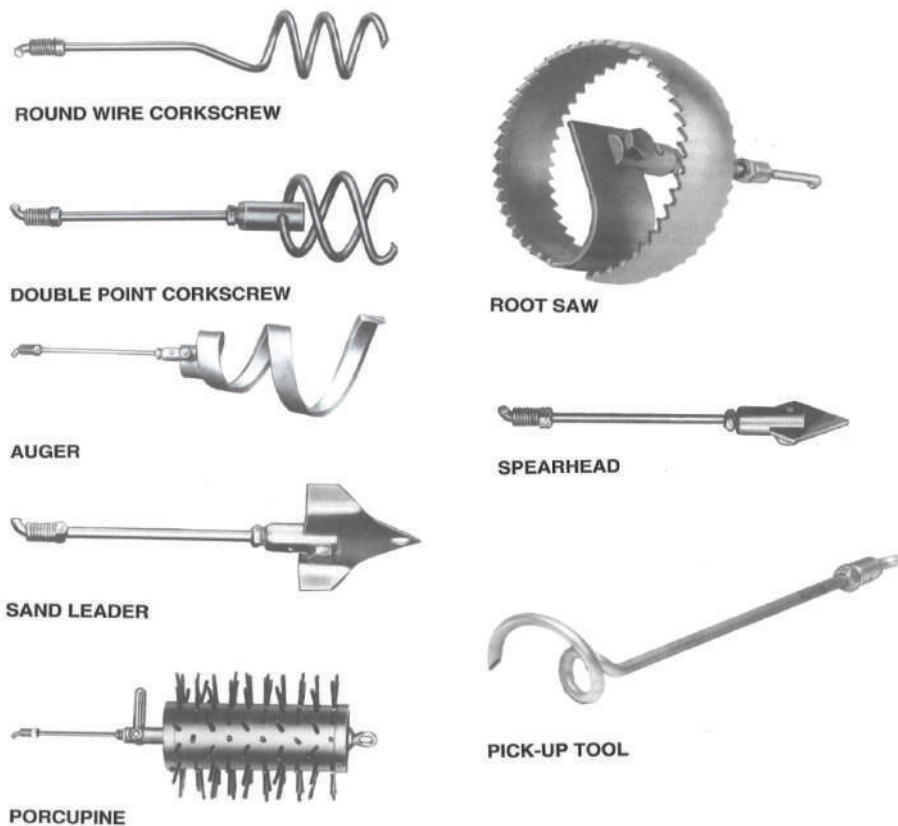
This consists of a machine, which rotates a flexible rod to which is attached a cleaning tool such as auger, corkscrew or hedgehog and sand cups (Figure 2.27 overleaf).



Source: EPA, 2003

Figure 2.27 Power rodding operation

The flexible rod consists of a series of steel rods with screw couplings. It is guided through the manhole by a bent pipe. The machine propels the rod with the tool attached to one end, the other end being fixed to the machine. The rotating rod is thrust into the bent pipe manually with clamps with long handles for holding the rod near the couplings. As the rod is thrust inside, the machine also is drawn towards the manhole. The rod is pulled in and out in quick succession when the tool is engaging the obstruction, so as to dislodge or loosen it. When the obstruction is cleared, the rod is pulled out by means of clamps keeping the rod propelled to facilitate quick and easy removal. The various tools are shown in Figure 2.28.



Source: EPA, 2003

Figure 2.28 Rodding heads



### 2.3.1.6 Scraper

This method is used for sewers of diameter larger than 750 mm. The scraper is an assembly of wooden planks of slightly smaller size than the sewer to be cleaned. If the scraper cannot be lowered through the opening of manhole, it has to be assembled inside the manhole. The scraper chains, attached to a control chain in the manhole into which it is lowered, are then connected to a winch in the next downstream manhole by means of chains. The winch is then operated to push the debris ahead of the scraper. The upward flow behind the scraper and the water dropping from the top of the scraper will also assist in pushing it in the forward direction. This ensures that the bottom and the sides of the sewer are cleaned thoroughly. The scraped debris is removed manually.

Circular scrapers are used on small sewers below 350 mm diameter for cleaning the body of the line. They are commonly known as discs and these discs are both collapsible and made of metal or a wooden pair separated by about 200 mm by steel rods.

### 2.3.1.7 Hydraulically Propelled Devices

The hydraulically propelled devices take advantage of the force of impounded water to effectively clear sewers. The efficiency depends on the hydraulic principle that an increase in velocity in a moving stream is accompanied by a greatly increased ability to move entrained material. The transporting capacity of water varies as the sixth power of its velocity.

#### A. Flush Bags

A very effective tool for cleaning portions of sewers where rods cannot be used is the sewer flusher or flush bag. The flusher is a canvas bag or rubber bag equipped with a fire hose coupler at one end and a reducer at the other end. The flusher is connected to the fire hose and placed in the downstream end, from the point where a choke is located. The bag is allowed to fill up until it expands and seals the sewer. The upstream pressure built up due to this damming effect breaks loose the obstructions.

#### B. Sewer Balls

These are simple elastic pneumatic type rubber balls, which can be blown up to varying degrees of inflation. They are manufactured in sizes from 150 mm to 750 mm diameter when fully inflated. When used in cleaning a sewer, the ball is first inflated and then wrapped in a canvas cloth, the edges of which are sewed together. A trial line, little longer than the distance between the manholes, is attached securely to the covering. The size of the ball and the covering shall be such as to fit fairly snugly into the sewer. Immediately after the ball is thrust into the sewer, sewage commences to back up in the manhole and continues to rise until such time as its pressure is great enough to force sewage under the ball and move it downstream through the pipe. Acting as a compressible floating plug, it affords enough obstruction, so that a continuous high velocity jet spurts under and to some extent around the ball, thereby sluicing all the movable material ahead to the next manhole. If the ball encounters an obstruction, which is immovable, the ball merely indents to the necessary degree and moves forward. The only fixed obstruction, which will stop the forward progress of the ball is a root mass or some similar obstruction tightly wedged into the pipe.

Bricks, stones, bottles, loose metal parts, broken pieces of pipes, sand, gravel and settled sludge are easily moved ahead. If the ball stops momentarily, a pull on the trial line is usually sufficient to set it in motion again. If the pipe is very dirty, the trial line can be tied to a step in the upper manhole and the ball's progress can be retarded to the required degree as the lower manhole is reached, thus giving time for complete removal of accumulated silt and debris, which has piled up ahead of the ball. Equipment arrangement is shown in Figure 2.29 and Figure 2.30.

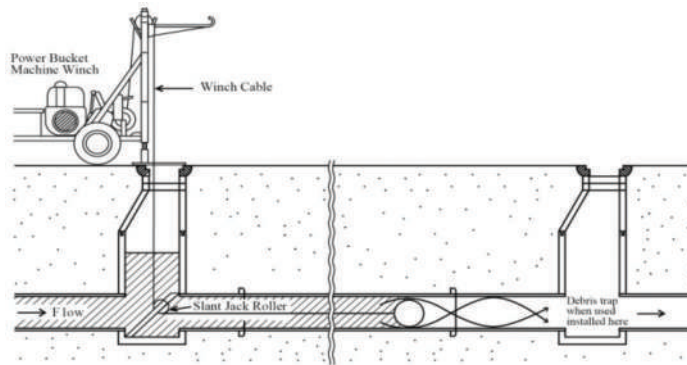


Figure 2.29 Typical setup for Hydraulic cleaning using Sewer Ball



Source: EPA, 2003

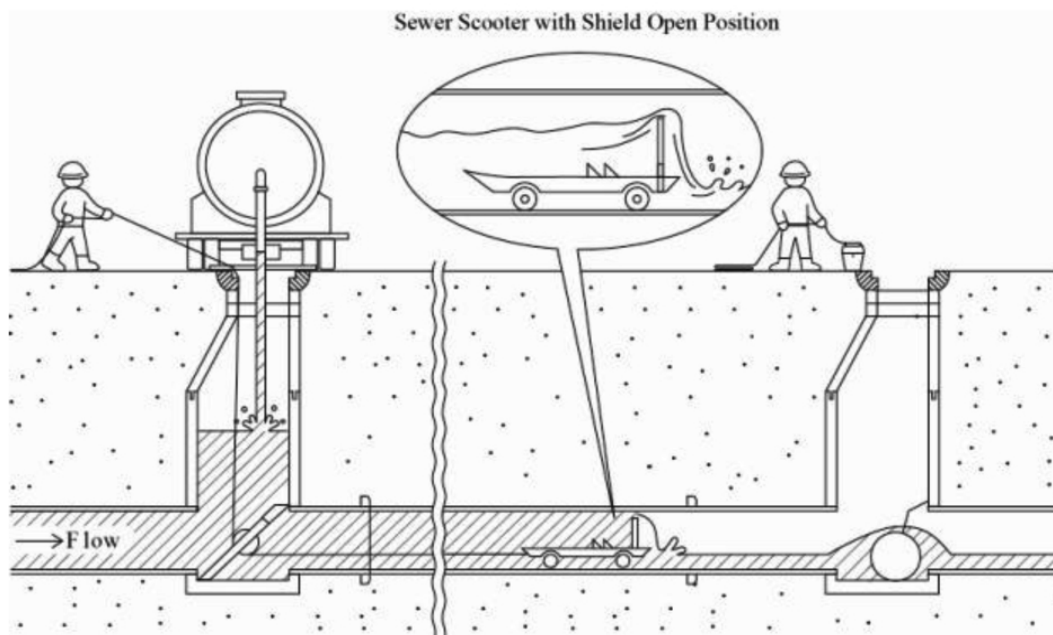
Figure 2.30 Balling equipment

A wooden ball, also called a sewer pile, can also be used for this purpose, particularly for cleaning large outfall sewers. It is dropped into the sewer and owing to its buoyant action rolls along the invert of the sewer. The obstructions caused by it to the flow produce a vigorous scouring action along the invert and the sides, which has the effect of removing tree growths and the deposits from the sewers. This method is economical and hence can be used at frequent intervals.

### C. Sewer Scooters

This arrangement is an improved version of the scraper and consists of two jacks, a controlling rope and the scooter with a tight fitting shield. In contrast to the scraper, the scooter completely stops any flow of sewage. The scooter, attached to the control rope, is lowered into the manhole and then into the downstream sewer line. The downstream manhole jack is lowered into place from the road and the upper manhole jack set across the top of the manhole. When the scooter is introduced in the line, it stops the flow of sewage thus building up a head behind the shield. The resulting pressure causes the scooter to move through the sewer until it accumulates enough debris to stop its movement.

The head is then allowed to build up approximately one meter before the control rope is pulled, causing the shield to fold back, thus allowing the accumulated sewage to gush into the sewer downstream, flushing the debris ahead to the next manhole from where it is removed. The control rope is released, clearing the shield against the sewage and causing the scooter to advance again until the debris stops its movement. This process is repeated until the scooter reaches the downstream manhole where it may be removed or allowed to continue through the next section. The operation of the sewer scooter is shown in Figure 2.31.



Source: EPA, 2003

Figure 2.31 Sewer Scooter operation

### 2.3.1.8 Velocity Cleaners (Jetting Machines)

The high velocity sewer-cleaner makes use of high velocity water-jets to remove and dislodge obstructions, soluble grease, grit and other materials from sanitary, storm and combined sewerage systems. It combines the functions of a rodding machine and gully emptier machine. It includes a high-pressure hydraulic pump capable of delivering water at variable pressure up to about 8 MPa through a flexible hose to a sewer cleaning nozzle. The nozzle has one forward facing jet and a number of peripheral rearward facing jets. The high-pressure water coming out of the holes with a high velocity, breaks up, dislodges the obstructions and flushes the materials down the sewer. Moreover, by varying the pressure suitably, the nozzle itself acts as a jack-hammer and breaks up stubborn obstructions. A separate suction pump or airflow device may also be used to suck the dislodged material. The entire equipment is usually mounted on a heavy truck chassis with either a separate prime mover or a power take off for the suction device. The high-pressure hose reel is also hydraulically driven. The truck carries secondary treated sewage, if available, and if not untreated fresh water for the hydraulic jet. The truck also has a tank for the removed sludge and the various controls grouped together for easy operation during sewer cleaning. The manufacturer's operating and servicing manuals should be carefully followed for best results in the use of the machine.

### **2.3.1.9 Suction Units (Gully Emptier)**

Suction units create the vacuum required for siphoning of mud, slurry, grit and other materials from sanitary, storm and combined sewerage systems. The vacuum elevated is such as to siphon the materials from the deep manholes catch-pits etc., having depth ranging from 1m to 8m in normal cases with an option to suck an additional 4m with the help of special accessories for the purpose. The unit can be vehicle or trolley mounted.

Silt and heavy particles settled at the bottom can be agitated and loosened by pressurized air with the help of the pump and then sucked in a tank. Once the silt tank is full, the effluent is discharged in the nearby storm water drain or manhole and the operation is repeated until the silt is cleared off the manhole. The silt deposited in the tank is then emptied at the predetermined dumping spot.

### **2.3.2 Notification to STP**

Before clearing a large septic stoppage, be sure to notify the operator on duty at the downstream STP. Septic stoppages develop when the sewer has been blocked for considerable time and/or the air temperature is hot. Under these conditions, the wastewater and organic solids turn black and smell like rotten eggs. If a large diameter sewer is blocked and a large volume of sewage backs up in the pipes, there might not be sufficient fresh water arriving at the treatment plant to dilute the septic sewage. When a large volume of septic sewage reaches the STP, the treatment processes may fail to do their intended job. By notifying the operator in advance of the location of the stoppage and approximate volume of septic sewage flowing towards the STP, the operator can be alerted and can prepare to minimize the impact on the treatment processes.

### **2.3.3 Disposal of Silt and Sludge**

Sludge from sewers can be disposed of along with grit and sludge of the STP (if available) or the sludge and silt can be co-disposed in an eco-friendly manner with MSW.

### **2.3.4 Cleaning Records and their Utilization**

Records of all cleaning operations should be entered and filed for future reference. These records should include the data, street name or number, line size, distance and manhole numbers or identification. Also the kind and amount of materials removed, wastewater flow, and auxiliary water used should be noted. If particular problems were encountered, these too should be noted, especially the exact location of obstructions. A record-form sample is shown in Figure 2.32 overleaf.

During the routine cleaning operations discussed in this chapter, many manholes should be opened and used for high-velocity cleaning or flushing of sewer. Manhole Inspection form detailing its location, condition, and any problems observed should be completed. If this is done each time a manhole is opened during cleaning operations, over a time the database for these structures will include up-to-date information on a high percentage of them and allow better decisions to be made in regard to routine maintenance, repair, or rehabilitation.

If pieces of broken sewer are removed, a TV inspection may be needed and repairs may need to be made on the broken sections of pipe.





## 2.4 SEWER REHABILITATION

### 2.4.1 Introduction

Deterioration of sewers proceeds over the surface as a whole, and repair takes considerable time, therefore, it is necessary to implement renewal and repair according to a plan on the basis of the results of inspection and examinations. This practice will prevent accidents.

In older cities, most sewers have already exceeded the service life. In such cities, adequate renewal and repair may resolve urgent problems and help extend the service life of the facilities, reducing O&M expenses. The two terms renewal and repair are clearly segregated as follows. Renewal is not included in O&M duties but in construction because the time of implementation is the starting point of the new service life and changes must be made to fixed assets

#### A. Renewal.

This means improvement and replacement of facilities not caused by expansion of drainage area. It includes improvement, which is reconstruction or replacement of the facility that has not yet reached the specified service life and replacement which is reconstruction or replacement of the facility that has reached the specified service life.

#### B. Repair

This refers to partial replacement or repair of damage to the facility. Repair provides utility, but not an increase in functions, so it does not contribute to extension of the service life of the facility. Repair simply maintains the capacity and life and does not cause a change in fixed assets.

However, making a clear distinction between O&M and construction duties is often difficult for implementation of renewal and repair according to the plan. In certain cases, it is therefore desirable to plan these duties as one package. Improvement of functions of existing sewers while incorporating elements related to planning and construction projects is generally called rehabilitation. The definition of terms related to rehabilitation is given in Table 2.13 overleaf.

### 2.4.2 Rehabilitation Method

Under the traditional method of sewer relief, a replacement is made or additional parallel sewer line is constructed by digging along the entire length of the existing pipeline, while these traditional methods of sewer rehabilitation requires digging and replacing the deficient pipe with (the dig-and-replace method), trenchless methods of rehabilitation use the existing pipe as a host for a new pipe or liner. Trenchless sewer-rehabilitation techniques correct pipe deficiencies that require less restoration and cause less disturbance and environmental degradation than the traditional dig-and-replace method. Trenchless sewer-rehabilitation methods include:

1. Pipe bursting or in-line expansion
2. Slip lining
3. Cured-in-place pipe
4. Modified cross-section liner

Table 2.13 Definition of terms

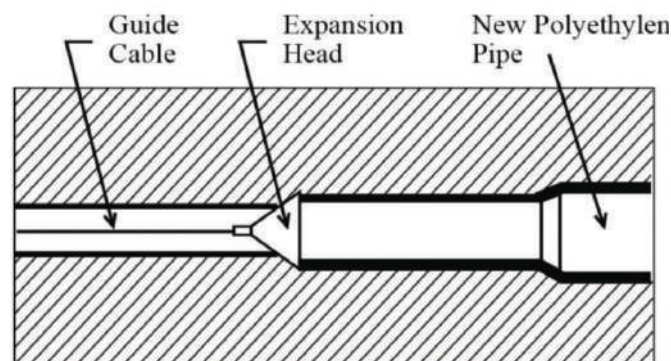
Terms	Definition	Classification
Rehabilitation, reconstruction	All concepts to improve functions of existing sewer pipes.	All measures
Repair	Repair of structural damage or partial renewal of sewer pipes	Structural measures
Renovation	Functional improvement of a certain section while utilizing the existing pipe structures	
Renewal	Renewal of new pipes, with basic functions and capacities remaining equal to original pipes.	
Replacement	Replacement with new pipes to reinforce functions and capacities	Hydraulic measures
Reinforcement pipes	Installation of new pipes to enhance the flow capacity of the entire system.	

Source: JICA, 2011

These alternative techniques must be fully understood before they are applied. These four sewer rehabilitation methods are described in detail in the following sections.

**2.4.2.1 Pipe Bursting or In-line Expansion**

Pipe bursting or in-line expansion is a method by which the existing pipe is forced outward and opened by a bursting tool. During in-line expansion, the existing pipe is used as a guide for inserting the expansion head (part of the bursting tool). The expansion head, typically pulled by a cable rod and winch, increases the area available for the new pipe by pushing the existing pipe radically outward until it cracks. The bursting device pulls the new pipeline behind itself. The pipe bursting process is illustrated in Figure 2.33.

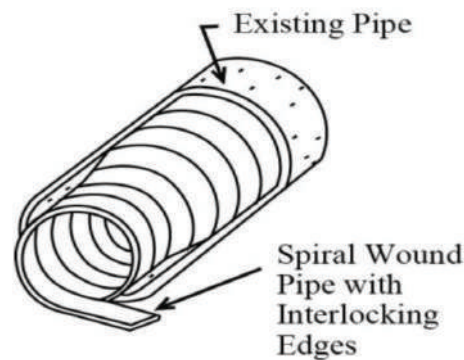


Source: JICA, 2011

Figure 2.33 Pipe bursting process

### 2.4.2.2 Slip Lining

Slip lining is a well-established method of trenchless rehabilitation. During the slip lining process, a new liner of smaller diameter is placed inside the existing pipe. The annular space, or area between the existing pipe and the new pipe, is typically grouted to prevent leaks and to provide structural integrity. If the annulus between the sections is not grouted, the liner is not considered a structural liner. Continuous grouting of the annular space provides the seal. Grouting only the end-of-pipe sections can cause failures and leaks. In most slip lining applications, manholes cannot function as proper access points to perform the rehabilitation. In these situations, an insertion pit must be dug for each pipeline segment. Due to this requirement in most applications, slip lining is not a completely trenchless technique. However, the excavation required is considerably less than that for the traditional dig-and-replace method. System and site conditions will dictate the amount of excavation. Methods of slip lining include continuous, segmental and spiral wound methods. All three methods require laterals to be re-connected by excavation or by a remote cutter. In continuous slip lining, the new pipe, jointed to form a continuous segment, is inserted into the host pipe at strategic locations. The installation access point, such as a manhole or insertion pit, must be able to handle the bending of the continuous pipe section. Installation by the segmental method involves assembling pipe segment at the access point. Slip lining by the segment method can be accomplished without rerouting the existing flow. In many applications, the existing flow reduces frictional resistance and thereby aids in the installation process. Spiral-wound slip lining is performed within a manhole or access point by using interlocking edges on the ends of the pipe segments to connect the segments. The spiral wound pipe is then inserted into the existing pipe as illustrated in Figure 2.34.



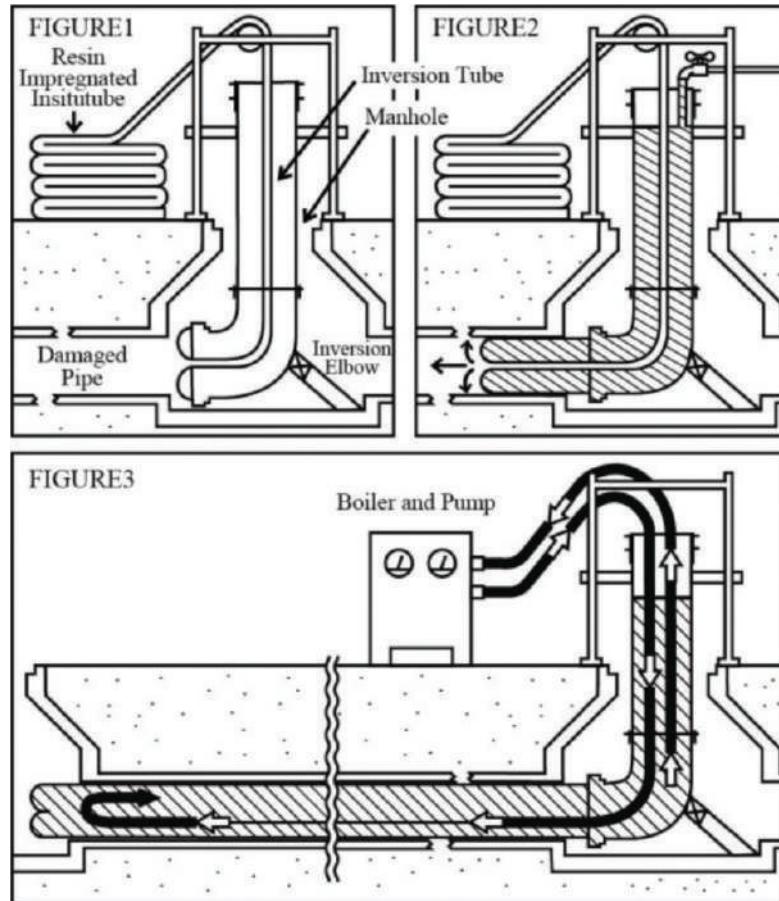
Source: JICA, 2011

Figure 2.34 Spiral wound Slip Lining Process

### 2.4.2.3 Cured-in-place Pipe

A typical cured-in-place pipe (CIPP) process by the water-inversion method is illustrated in Figure 2.35 overleaf. During the CIPP renewal process, a flexible fabric liner coated with a thermosetting resin is inserted in the existing pipeline and cured to form into a new liner. The liner is typically inserted in the existing pipe through an existing manhole. The fabric tube holds the resin in place until the tube is inserted in the pipe and ready to be cured. Commonly manufactured resins include unsaturated polyester, vinyl ester, and epoxy, each having distinct chemical resistance to domestic sewage. The CIPP method can be applied to rehabilitate pipelines with defects such as cracks, offset joints and structurally deficient segments.





Source: EPA, 1996

Figure 2.35 Cured-in-place pipe installation procedure

The thermosetting resin material bonds with the existing pipe materials to form a tighter seal than most other trenchless techniques. The two primary methods of installing CIPP are winch-in-place and invert-in-place. These methods are used during installation to feed the tube through the pipe. The winch-in-place method uses a winch to pull the tube through the existing pipeline. After being pulled through the pipeline, the tube is inflated to push the liner against the existing pipe walls.

The more typically applied inversion-in-place method uses gravity and either water or air pressure to force the tube through the pipe and invert it, or turn the tube inside out. This process of inversion presses the resin-coated tube against the walls of the existing pipe. During both the winch-in-place and invert-in-place methods, heat is then circulated through the tube to cure the resin to form a strong bond between the tube and the existing pipe.

#### 2.4.2.4 Modified Cross-section Lining

The modified cross-section lining methods include deformed and reformed methods, sewage lining and roll down. These methods either modify the pipes cross-sectional profile or reduce its cross-sectional area so that the liner can be extruded through the existing pipe. The liner is subsequently expanded to conform to the existing pipe's size. During deformed and reformed pipeline renewal, a new flexible pipe is deformed in shape and inserted into the host pipe. While the method of deforming the flexible pipe varies, with many processes referred to as fold and form methods,

a typical approach is to fold the new liner into a “U” shape, reducing the pipe’s diameter by about 30 %. After the liner is pulled through the existing line, the liner is heated and pressurized to conform to the original pipe shape. Another method of obtaining a close fit between the new lining and existing pipe is to temporarily compress the new liner before it is drawn through the existing pipeline.

The sewage lining and roll down processes use chemical and mechanical means, respectively, to reduce the cross-sectional area of the new liner. During sewage lining and a typical draw down process, the new liners are heated and subsequently passed through a reducing die. A chemical reaction between the die and liner material temporarily reduces the liner’s diameter by 7 to 15 % and allows the liner to be pulled through the existing pipe. As the new liner cools, it expands to its original diameter. The roll down process uses a series of rollers to reduce the pipe-liner’s diameter. As in deform-and-reform methods, heat and pressure are applied to expand the liner to its original pipe diameter after it has been pulled through the existing pipe. Unlike CIPP, the modified cross-section methods do not make use of resins to secure the liner in-place. Lacking resin-coated lining, these methods do not have the curing time requirement of CIPP. A tight fit is obtained when the folded pipe expands to the host pipe’s inside diameter under applied heat and pressure. As with the CIPP method, dimples are formed at lateral, junctions and similar methods of reconnecting the laterals can be employed. Materials typically used for modified cross-section linings include Unplasticised Polyvinyl Chloride (UPVC) and High Density Polyethylene (HDPE).

### **2.4.3 Maintenance of Machinery and Apparatus for Rehabilitation**

Emergency cleaning and a repair are required in case of an emergency response.

Therefore, a maintenance engineer should repair machinery and equipment to the original. In addition, he should have enough maintenance and repair materials required (for example pipes, lid, the mounting tube). In addition, the maintenance engineer should stock construction materials such as sand, rock crushing and asphalt for the cave-in repair of roads.

The maintenance engineer should ensure that the materials, equipment and facilities, necessary safety equipments are in standby state at all times.

## **2.5 PROTECTION OF SEWER SYSTEMS**

A sewer may get damaged if other facilities such as water pipe or electric cable work are done beside or at the cross-section of a sewer. Especially, fluctuations due to ground excavation (pile, underground water drops and pile method) may have a serious impact.

To avoid damages of sewer, the maintenance engineer should do the following:

1. Collect all related information about the construction activities which are planned around the sewer location,
2. Advise appropriate construction methods to minimize impact for sewer, and
3. If necessary, request the concerned agencies to adopt the protective measures for sewer prior to the work commencement.

Typical protective measures are as follows:

1. Protection for existing sewer (an example is shown in Figure 2.36)
2. Temporary laying of supported sewer pipe
3. Changing sewer material in advance

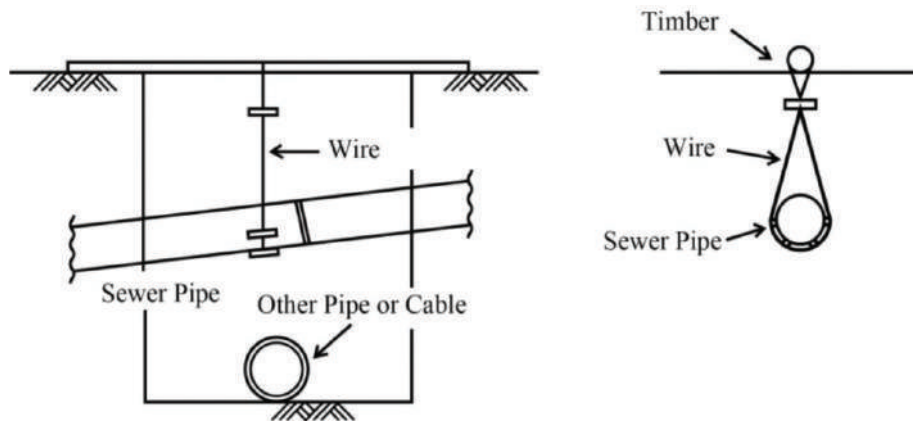


Figure 2.36 Protection method for existing sewer

## 2.6 PROTECTION AGAINST INFILTRATION & EXFILTRATION

Infiltration and inflow, while overlooked in many collection systems for decades, have now gained recognition as major defects that can cause failure of a collection system. In most cases, this failure results in hydraulic overloads (too much water) of the collection system or the sewage treatment plant. In the case of a collection system, hydraulic overloads result in surcharged manholes, overflowing manholes and exposure of community to diseases and pollutants carried by the waste water in a collection system.

This type of failure is also known as a sanitary sewer overflow. In the case of an STP, infiltration and inflow can result in plant loads exceeding the plant capacity.

Bypassing raw sewage to the environment has been the only answer in the past, but this practice is no longer allowed.

### 2.6.1 Measures against Infiltration of Rainwater

Inflow detection and collection depend upon the type and source of inflow causing the problem. Inflow is water that enters a sewer as a result of a deliberate illegal connection or by deliberate drainage of flooded areas into the sewer system.

In many areas the main line portion of the collection system is relatively tight.

A major source of infiltration in this situation can be the house service lines. They can be tested for leaks using smoke tests and by deployment of small cameras and robotic equipment. Collection or elimination of inflow/ infiltration depends on the type and location of the source of problem.

Typical solutions to inflow / infiltration problems are shown overleaf.

### A. Manholes

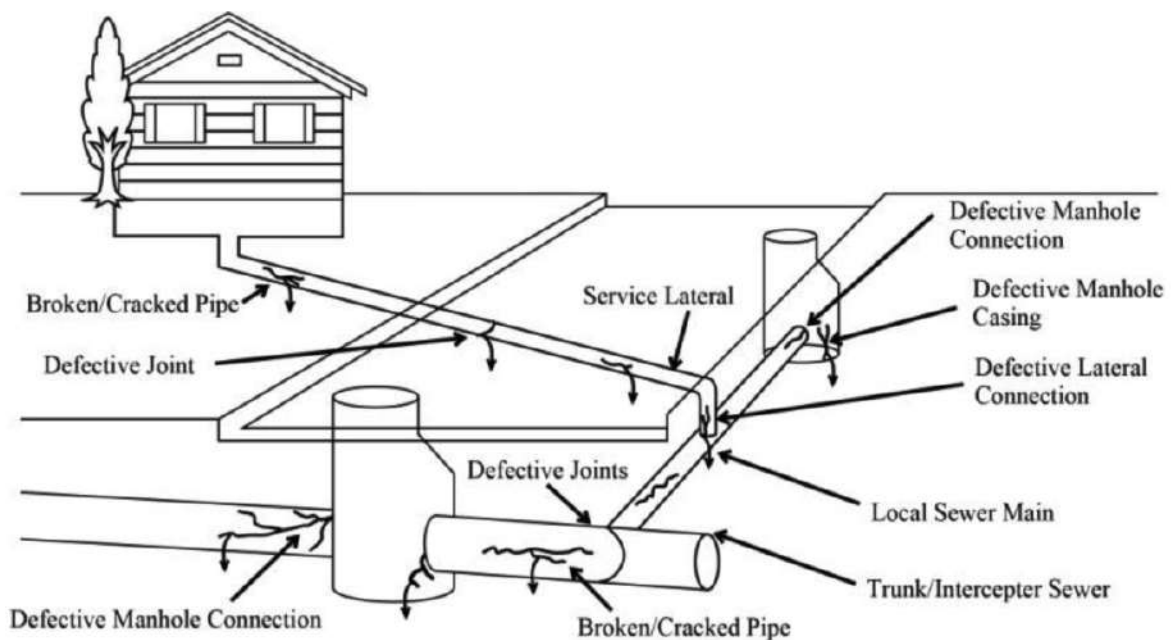
- Raise rim elevation by use of grade rings if not located in streets (inflow).
- Install watertight covers where needed (inflow).
- Install inflow protection covers (inflow).
- Seal covers (inflow).
- Seal or repair barrels (infiltration).

### B. Sewer Pipes (Infiltration)

- Seal segment of damaged pipes and joints.
- Dig up and replace damaged pipes and joints.
- Line sewer with a plastic liner and/or fibre liner material.

## 2.6.2 Measures against Exfiltration of Untreated Sewage

Exfiltration is the leakage of sewage out of the collection system through broken or damage pipes and manholes as shown in Figure 2.37.



Source: EPA/600/R-01/034

Figure 2.37 Sewage leaking locations

All the sewage collection systems, except some constructed in recent years, have many leaks. These systems may exfiltrate sewage through defective pipe joints and cracks. The sewage that does exfiltrate may contaminate shallow wells or open ditches where children and pets play. To make an old collection system airtight would be extremely expensive and not very cost-effective. Major points of infiltration or exfiltration in a collection system can be identified by the use of television or smoke testing and can then be corrected.

The proper selection of corrective or rehabilitation methods and materials depends on a complete understanding of the problems to be corrected, as well as the potential impacts associated with the selection of each rehabilitation method. Pipe rehabilitation methods to reduce exfiltration (and simultaneously infiltration) fall into one of the two following categories:

1. External Rehabilitation Methods
2. Internal Rehabilitation Methods

Certain conditions of the host pipeline influence the selection of the rehabilitation method. It is therefore necessary to assess these factors to prepare the pipe for rehabilitation. Rehabilitation is preceded by surface preparation by cleaning the pipes to remove scale, tuberculation, corrosion and other foreign matter.

The concerned departments, corporations, urban local bodies, town planning authority, Jal Nigam, etc. have to participate in the total sanitation programme. These departments should be part of a co-ordination committee constituted at a local level and are required to meet half yearly to plan appropriate co-ordination specific to total sanitation. These meetings however, can be more frequent during specific items such as drought, floods, etc.

#### **2.6.2.1 External Sewer Rehabilitation Methods**

External rehabilitation methods are performed from above the ground surface by excavating adjacent to the pipe, or the external region of the pipe is treated from within the pipe through the wall. Some of the methods used include:

1. External Point Repairs
2. Chemical Grouting (Acryl amide Base Gel and Acrylic Base Gel)
3. Cement Grouting (Cement , Micro fine Cement and Compaction)

#### **2.6.2.2 Internal Sewer Rehabilitation Methods**

Internal sewer rehabilitation methods are the same as infiltration measures.

### **2.7 MANHOLES AND APPURTENANCES**

Because they are part of the collection system, manholes require the same inspection and attention as the rest of sewer network.

When located in streets, these structures are subject to vibrations and pounding by vehicle traffic. Manholes may settle at a different rate than connected sewer, creating cracks in sewer pipe joints.

The objectives of manhole inspection are therefore, to determine the proper elevations or grades around the lid, to confirm that the lid is not buried, and to examine structural integrity (look for cracks) of the manhole and its functional capacity.

The condition of the pipelines coming into a manhole may be known merely by observing the content and volume of flows from a specific direction.



## 2.7.1 Inspections and Examinations

Manhole inspection and examination are made by visually inspecting the condition of the cover and the internal parts.

Manhole inspection should be carried out together with the inspection and examination of sewer. It is generally carried out together with the cleaning of the sewer.

Before entering any manhole, adequate safety measures should be taken in accordance with subsection 2.11.1.2.

Safety measures during the work should be formulated giving consideration to traffic safety, oxygen deficiency, poisoning due to toxic gas such as hydrogen sulphide and so on.

### 2.7.1.1 Manhole

Damage or wear in the manhole cover obstructs passage and is a risk. The facility manager should inspect the manhole cover for damage, wear, play, non-coincidence of heights of cover and road surface, offset of manhole block and so on as in Figure 2.38, Figure 2.39 and Figure 2.40.



Figure 2.38 Wear of cover



Figure 2.39 Offset of manhole block



Figure 2.40 Not coinciding with height of road surface

**2.7.1.2 Conditions inside Manhole**

Manhole is an essential structure for O&M of sewers. It helps the O&M to be performed safely.

For smooth flow of sewage through the sewer pipe, the following are to be properly inspected: scouring of sewer bottom, differential settlement, manhole block, crack in side wall, sediments and condition of mouth of connected sewer pipe.

Inspection should be performed on ground, while examination should be performed by the relevant person entering the manhole and working inside. The inspection items and their descriptions are given in Table 2.14.

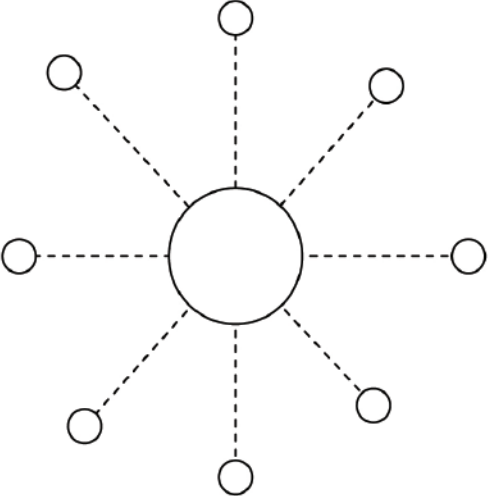
Table 2.14 Inspection and Examination items for Manhole

Item inspected		Description of inspection
Exterior condition	Ground surface	<ul style="list-style-type: none"> <li>a. Check for crack, subsidence, and cave-in</li> <li>b. Check for overflow stream</li> <li>c. Check for any invaded pavement</li> <li>d. Check surrounding condition</li> </ul>
	Manhole cover	<ul style="list-style-type: none"> <li>a. Visual check for backlash, abraded surface, and corrosion (Check if any mark on external or internal surface of cover is erased.)</li> <li>b. Check for any malfunction of float preventive function, locking device, fall preventive function, etc.</li> <li>c. Others (damage on rising spacer, difference in grade of cover and grade ring, damaged grade ring, caved in manhole cover, offset, etc.)</li> </ul>
Interior condition	Flow and sediment	<ul style="list-style-type: none"> <li>a. Check for stagnant water or flow</li> <li>b. Check for any accumulation of sand and soil, pieces of wood, and mortar including remains of construction works and illegal disposals.</li> <li>c. Check for appearance of inverts such as scouring, damage, etc.</li> </ul>
	Damage	<ul style="list-style-type: none"> <li>a. Check steps for corrosion, rattling, and missing items (No.).</li> <li>b. Check blocks for damage, crack, corrosion, gap, and deteriorated caulking.</li> <li>c. Check barrel and base for damage, crack, and corrosion.</li> <li>d. Check for any improper joint of main sewers and laterals.</li> <li>e. Check for any irregular subsidence.</li> </ul>
	Infiltration	Check for infiltration
Others		<ul style="list-style-type: none"> <li>a. Check inflow for unacceptable or inferior quality.</li> <li>b. Check for toxic gases or odour.</li> </ul>

Source: JASCOMA, 2007

An example of the form for recording inspections is shown in Table 2.15.

Table 2.15 Inspection record

Manhole maintenance		Manhole No. - - -							
Manhole type	Type no: Specific (      )			Constructed year		FY (____)			
				Type of cover		Nodular graphite cast iron (flat, tapered), Gray cast iron, Concrete			
					Manhole		Fair / Poor		
					Steps		Total no.		
							Fair no. Poor no.		
					Water depth downstream		cm		
No.	Pipe diameter		Type		Depth to base		Condition		
Replace cover Month / Year	M/Y /	/	/	/	/	/	/	/	/
Cleaning Month / Year	M/Y /	/	/	/	/	/	/	/	/
Inspection Month / Year Conditions	M/Y /	/	/	/	/	/	/	/	/
	M/Y /	/	/	/	/	/	/	/	/
(Condition)									
Cover	a) Wear, b) Backlash, c) Difference in level, d) Pavement hiding the manhole, e) Damaged, f) Location unknown								
Interior	g) Corrosion, h) Damage base, i) Infiltration, j) Corroded steps, k) Inferior pipe joint, l) Rubbish, m) Odour								
Sewer	n) Corrosion, o) Damage, p) Coupling displacement, q) Inadequate inclination, r) Infiltration, s) Roots of trees, t) Silt, soil, and mortar, u) Road subsidence								

Source: JASCOMA, 2007

### **2.7.2 Judgment of Examination Results**

Judgment criteria for inspection and examination show ranked levels of abnormal locations, and can be used for judging the need for cleaning and repairs and for selecting repair methods, etc.

Judgment criteria are used to categorize by symptom the abnormal locations detected during inspection and examination, to assess the risk level and their impact on others, to judge the need for cleaning and repairs and to select repair methods, etc.

### **2.7.3 Cleaning**

Manhole cleaning should be performed by the most appropriate work method that suits the actual conditions of the work location.

In manholes at starting point, junction manholes and manholes at sharp curve of sewers, sand and silt get deposited and environmental problems such as foul odours occur. For this reason, periodic cleaning is necessary. Moreover, when large debris flows in, it should be removed immediately otherwise there is a possibility of an overflow accident, float-off and dispersion of cover.

Manhole inspection should be generally carried out together with the cleaning of the sewer. The work on the silt and sand in the bottom part should be pursuant to cleaning of the sewer pipe, while the dirt on the sidewall should be cleaned by high-pressure jet washing vehicle.

### **2.7.4 Rehabilitation**

Degradation of functions due to damage should be confirmed and necessary repairs and rehabilitation of the manhole should be carried out.

Manhole repair methods may be classified into watertight construction method, lining method, partial repair method (open-cut method), and manhole cover replacement method. (Refer to Sec. 3.37 of the Part A manual)

Before repairs, the objectives of the repairs should be clarified, work conditions studied, and items below should be paid attention to, and then repairs should be carried out.

1. If cover is worn out or damaged, it should be replaced immediately.
2. If steps are corroded, and if they need to be replaced, they should be replaced with corrosion resistant fittings.

If internal parts of manhole and sewer bottom are damaged or worn out, the entire manhole should be replaced immediately.

## **2.8 CROSS DRAINAGE WORKS**

For sewer collection system, cross drainage work in an inverted siphon is a typical work. Therefore, in this section, maintenance work is described hereafter.

### 2.8.1 Inspection and Examination

Inspection of inverted siphon should be carried out by inspection methods similar to those of the manhole and this is shown in Table 2.16 .

Table 2.16 Typical inspection items for inverted siphon

Item Inspected	Points Inspected
Flow condition	Check difference in levels at upper and lower chambers of inverted siphon Check for absence of any suspended debris
Structural condition	Check for improper functioning of gate, stop log, etc.

Source: JASCOMA, 2007

However, inspection of inverted siphon itself should be carried out considering the characteristics listed below.

- The inverted siphon pipe is always in full flow, and the inverted siphon chamber in the upstream part is constructed such that suspended substances and sand/silt are likely to accumulate and deposit easily. There are risks of corrosion or gas generation in the facility because of the decomposition of these substances.
- The inverted siphon chamber is provided with a flashboard, and it should be checked to confirm that it is usable.

### 2.8.2 Criteria for Judging Examination Results

Judgment criteria for inspection and examination show ranked levels of abnormal locations, and can be used for judging the need for cleaning and repairs and for selecting repair methods. The judgment criteria for inverted siphon should be the same as the judgment criteria for sewer pipe.

### 2.8.3 Cleaning

The construction of the inverted siphon is such that wastewater always remains in it at all times, hence sand, silt and sludge is likely to deposit easily. This requires periodic cleaning to prevent overflow and foul odour problems beforehand. An effective cleaning method should be selected when cleaning the inverted siphon, and work that gives adequate consideration to safety measures should be implemented. Cleaning should be performed at least once a year.

#### A. Replacing water in the inverted siphon

The submersible pump and generator used for replacing water in the inverted siphon should be selected appropriately considering the influent flow rate and the head, and a replacement plan with adequate margin should be formulated.

#### B. Cleaning of inverted siphon manhole

The main cleaning methods of sand trap of inverted siphon manhole are vacuum truck cleaning and manual cleaning. Table 2.17 mentions the cleaning method.



Table 2.17 Cleaning method

Cleaning method	Application
Cleaning by vacuum vehicle	Cleaning of manholes for inverted siphons
Manual cleaning	By crew with proper safety outfit getting down into the siphon by using a crane equipped truck.

Source: JASCOMA, 2007

C. Cleaning of inverted siphon sewer

Inverted siphon sewer should be cleaned together with the cleaning of general sewers. After sucking up the sewage in the manhole by submersible pump, the manhole on the upstream side should be cleaned, and then the manhole on the downstream side and the insides of the sewer should be cleaned. The ease or difficulty of work depends on the pipe diameter, number of cables and closing equipment, but if the head exceeds 20 m, especially powerful vacuum trucks may need to be used. Work should be performed according to sewer cleaning by combining mechanical and manual means. Figure 2.41 shows the cleaning work.

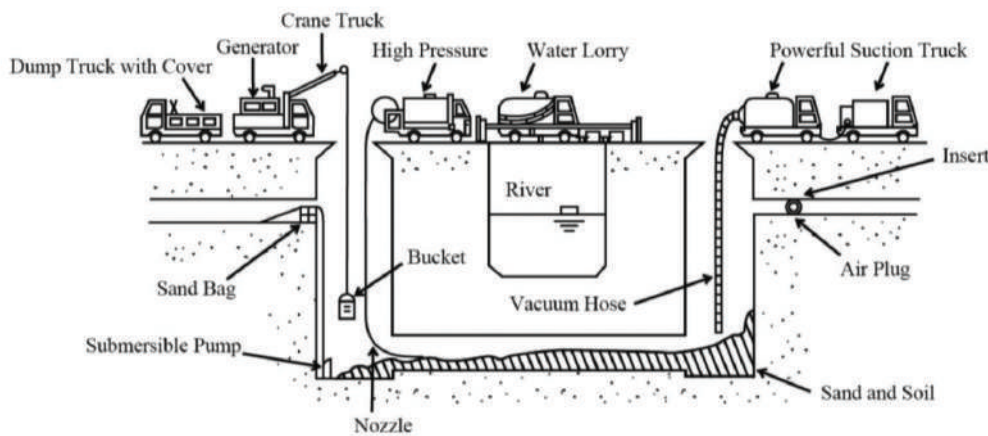


Figure 2.41 Inverted siphon cleaning work

2.9 PRESSURE / VACUUM SEWER

2.9.1 Pressurized Sewer System

Pressure sewers are meant for collecting sewage from multiple sources to deliver to an existing collection sewer, and/or to the STP. These sewers are not dependent on gravity. The principle advantages are the ability to sewer areas with undulating terrain, rocky soil conditions and high groundwater tables as pressurized sewers can be laid close to the ground and anchored well without infiltration. Exfiltration can be quickly detected and corrected. Moreover, this sewer allows smaller diameter pipes and road crossings by CI or DI pipes with trenchless technology to be laid inside a casing pipe and installation without disrupting traffic, without opening trenches across paved roadways, or moving existing utilities, etc. A disadvantage is the need to ensure unflinching power supply to the grinder pump.

### 2.9.2 Vacuum Sewer System

The vacuum sewer collects sewage from multiple sources and conveys it to the STP. As the name suggests, a vacuum is maintained in the collection system and when a house sewer is opened to atmospheric pressure, sewage and air are pulled into the sewer, whereby the air forms a “plug” in the line, and air pressure pushes the sewage towards the vacuum station. This differential pressure comes from a central vacuum station. These sewers can take advantage of available slope in the terrain, but have a limited capacity to pull water uphill may be to approximately 9 m. A disadvantage is the need to ensure unfailing power supply to the grinder pump.

### 2.9.3 O&M of Systems

The pressurized systems or vacuum systems are not familiar in India. Therefore, O&M is not explained here. Only systems characteristics of pressurized sewer and vacuum sewer are shown in Table 2.18.

Table 2.18 Pressurised sewer and vacuum sewer

Issues	Vacuum sewer	Pressurised sewer
Collection principle	Sewage pulled and conveyed by vacuum force.	Sewage pressurized and conveyed by a grinder pump.
Typical facility configuration	A vacuum valve unit for one or some households, vacuum sewer laterals, and a lift station	A grinder pump unit for one or some households, and pressurized sewer laterals.
Pipe diameter	Typically $\phi$ 100 to 250 mm	Typically $\phi$ 32 to 150 mm
Laying depth	Can be laid in a shallow depth without gradient.	
Topographical requirements	Adequate for flat terrain which can hold certain degree of vacuum force so that sewage can be pulled, and for densely populated area to an extent.	Applicable for wide range of terrain types.
Power source	Required for lift station	Required for each grinder pump unit.
O&M cost	O&M cost and energy cost for vacuum valve unit and lift station. Generally, higher than that of gravity sewer.	O&M cost and energy cost for grinder pump unit. Generally, higher than that of gravity sewer.

Source: JASCOMA, 2007

### 2.10 HOUSE SERVICE CONNECTION

House connections or service connections to the public or municipal sewer, should preferably be approved by the Maintenance Engineer. It is necessary to ensure that the fittings and pipes in the houses are according to the bye laws or rules or regulations in force.

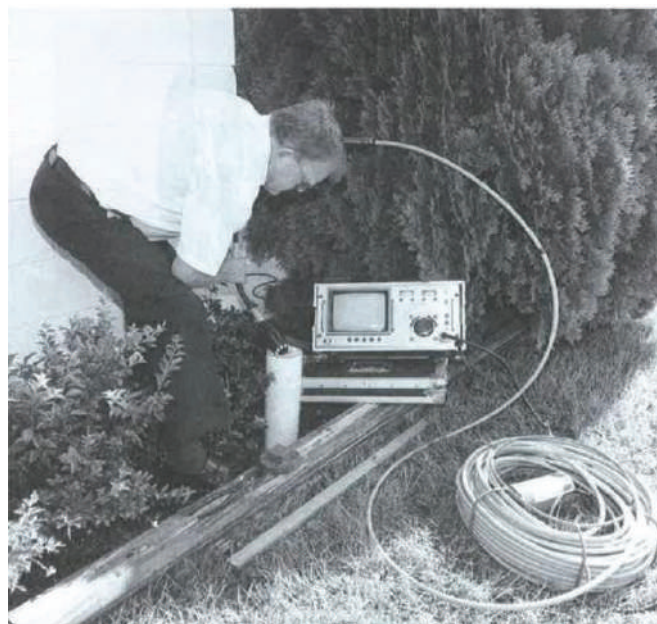
If such bye laws, rules or regulations do not exist, then reference may be made to the relevant IS code of practice. House connections may be of minimum size of 100 mm in diameter and should preferably be connected to the Municipal or Public sewer through a manhole. When the “Y or T” connections are allowed, extreme care must be taken when breaking the sewer pipeline and inserting the “Y or T” saddle. It should be noted that “Y or T” connections are not allowed for future systems and is allowed only for existing in public sewers. Similarly, the connection to the manhole must be properly done and closed. Care has to be taken so that the brickbats or construction materials are not allowed to fall and gather in the manhole. This extraneous material is largely responsible for persistent clogging of the sewer lines.

It should also be ensured that the house fittings are properly equipped with traps not only to prevent the ingress of sewer gases into the houses but also to ensure that large objects do not find their way into the sewers. Similarly, it should be ensured that any liquid or material which is likely to be injurious to the material of the sewer line or to prejudicially interfere with its contents or be a hazard to the workmen engaged in the maintenance of the sewer lines, like very hot water, acids, chemicals, etc., are not allowed.

### 2.10.1 Inspection and Examination

Inspection of lateral sewer and house inlet (household) should be carried out if deemed necessary from documents and data, and cross connections and mains should be studied. Clogging of lateral sewer and sedimentation of house inlet are the items to be inspected.

Examination of lateral sewer by TV camera should be carried out after high pressure washing of the lateral sewer. The insides of the pipe should be examined by TV camera, and recorded on video tape. TV camera for lateral sewer is used as a direct view camera, and the camera head is pushed by a rod towards the main from the public inlet. In addition, there is a method of examination by which the camera head is pushed in by a hard cab tire cable. Figure 2.42 and Figure 2.43 (overleaf) show working diagrams of examination of lateral sewer by TV camera.



Source: EPA, 2003

Figure 2.42 Portable TV system for small-diameter pipe



Source: EPA, 2003

Figure 2.43 Applications of portable TV system in difficult to access locations

Features of examination of lateral sewer by TV camera

1. If power supply is ensured, the vehicle loaded with TV camera can work even in locations where access for humans is not possible.
2. By connecting the monitor to the vehicle loaded with TV camera, character data can be displayed on the monitor screen.
3. The standard examination distance per location during examination of lateral sewer by TV camera is 5 m maximum.
4. Procedure for examination of lateral sewer by TV camera is shown in Figure 2.44.

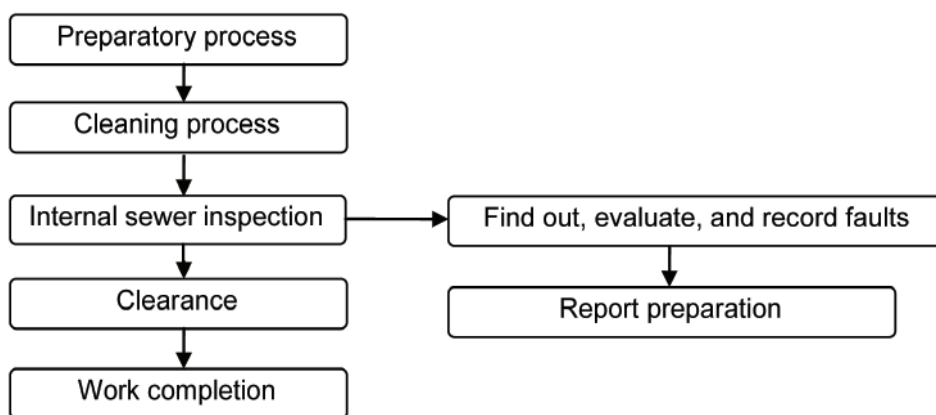


Figure 2.44 Work procedure for examination of lateral sewer by TV camera

### **2.10.2 Criteria for Judging Examination Results**

These criteria should adhere to the inspection criteria for sewer pipes.

### **2.10.3 Cleaning**

Cleaning should conform to the cleaning procedure for sewer pipes.

### **2.10.4 Rehabilitation**

Rehabilitation should conform to the rehabilitation procedure for sewer pipes.

## **2.11 SAFETY PRACTICES**

Sewer cleaning is an occupation that has an overall accident frequency rate that is relatively higher than any other industry. The employer has the responsibility of providing the worker with a safe place to work. Nevertheless, the worker has the overall responsibility and must ensure that it is a safe place to work. This can only be done by constantly thinking of safety and working safely.

The worker has the responsibility of protecting not only himself, but also all other plant personnel or visitors by establishing safety procedures for the plant and then ensuring they are followed. He must train himself to analyze jobs, work areas and procedures from a safety standpoint and learn to recognize potentiality hazardous actions or conditions. When he recognizes a hazard, he must take immediate steps to eliminate it through corrective action. If correction is not possible, guard against the hazard by proper use of warning signs and devices / by establishing and maintaining safety procedures. As an individual, the supervisor can be held liable for injuries or property damage, which results from an accident caused by his negligence.

Remember, “accidents don’t happen - they are caused!” Behind every accident, there is a chain of events, which leads to an unsafe act, unsafe condition or a combination of both. Accidents may be prevented by using common sense, applying a few basic safety rules and acquiring a good knowledge of the hazards unique to the job as a plant supervisor.

### **2.11.1 Accidents related to Sewer Facilities**

#### **2.11.1.1 Need for Traffic Control**

The primary function of streets is to provide for the movement of traffic. A common secondary use within the right-of-way of streets is for the placement of public and private utilities such as sanitary sewers. While the movement of traffic is very important, streets need to be constructed, reconstructed or maintained, and utility facilities need to be repaired, modified or expanded. Consequently, traffic movements and street or utility repair work must be regulated to provide optimum safety and convenience for all.

Working in a roadway represents a significant hazard to a collection-system operator as well as pedestrians and drivers. Motor vehicle drivers can be observed doing random things like reading, talking on cell phones, etc., rather than concentrating on driving.



At any given time of the night or day, a certain percentage of drivers may be expected to be driving while under the influence of drugs or alcohol. Given the amount of time collection-system operator's work in traffic while performing inspection, cleaning, rehabilitation and repairs, the control of traffic is necessary, if we want to reduce the risk of injury or death while working in this hazardous area. The purpose of traffic control is to provide safe and effective work areas and to warn, control, protect, manage vehicular and pedestrian traffic. It can be accomplished by appropriate use of traffic control devices.

Most states, counties, and cities have adopted regulations to control traffic and reduce the risk under different circumstances. This section illustrates examples of traffic control, which may or may not meet the specific requirements of the laws in all geographical areas, but should serve to create awareness of various aspects of traffic control.

At any time traffic is affected, appropriate authorities in the area must be notified before leaving for the job site. These could be state, country or local depending on whether it is a state, country or local street. Frequently, a permit must be issued by the authority that has jurisdiction, before traffic can be diverted or disrupted. In some cases, traffic diversion or disruption may have an impact on the emergency response system in the area, such as access by fire or police, and so these agencies may be involved as well in most cases, to plan ahead to secure permits and notify authorities. This may mean only a phone call or two or it could mean several days or weeks of advance planning, if the need is to make extensive traffic control arrangements.

Upon arrival at the job site, look for a safe place to park vehicles. If they are to be parked in the street to do the job, route traffic around the job site before parking vehicles in the street. If practical, park vehicles between oncoming traffic and the job site to serve as a warning barricade and to discourage reckless drivers from ploughing into operators.

#### **2.11.1.2 Safety Measure to be taken before any manhole entry**

All workers assigned to enter sewer manholes should be provided with proper safety equipment as recommended here.

1. Approved gas detector (Properly calibrated)
2. Fresh air blower
3. Safety harness, rope and tripod safety system
4. Approved hard hat

Following guidelines may be adopted to ensure safety in manhole:

- A. Oxygen content must be at least 19.5 % in the confined space of the manhole measured at all levels (bottom, middle and top). Safe oxygen level is considered if it ranges between 19.5 % and 21 %. Nobody should enter the manhole if oxygen level is below 19.5 % and more than 21 %.
- B. Ventilate the sewer line by opening at least two or three manholes on both upstream and downstream where work is to be carried out. This is mandatory where adequate blowers for ventilating sewers are not available. The manholes should be opened at least one hour before the start of operation.

The opened manhole must be properly fenced or barricaded to prevent any person, especially children, from accidentally falling into the sewer. Dummy cover with BRC welded fabric or wire-net may be used.

- C. Fresh air blower ventilation system should be used as far as practicable. It is desirable to operate blowers for at least 30 minutes before start and during the cleaning operation.
- D. Measure gas inflammability in manholes using detector.
- E. Presence of toxic gases may be tested before entry of a person in manhole/ sewer line and also in between if the operations are for longer period.
- F. All workers should use safety harness and lifeline before entering the sewer line. At least one support person at the top must be provided for each person entering the manhole. The person entering the manhole/ sewer line must be monitored using signal/camera /CCTV etc., throughout the operation period.
- G. Structural safety of manhole rungs or steps must be tested before entering the manhole. Portable aluminium ladder must be available during the work period where necessary. The portable ladder must be properly seated or fixed during use.
- H. Ensure that no material or tools are located near the edge, which can fall into the manhole and injure the workmen.
- I. Lower all tools to the workmen in a bucket fixed with rope and pulley.
- J. Lighting equipment used during sewer cleaning must be explosion-proof and fire-proof.
- K. Caution signboards must be displayed around open manholes during working period.
- L. Smoking, lighting open flames or gadgets producing sparks must be prohibited inside the manhole as well as in the immediate vicinity of open manholes.
- M. All workers entering the manhole must be provided with protective gear and proper equipment. Use of portable gear and equipment must be monitored strictly.
- N. Gas masks for respiratory protection must be available for use by the workers. The workers must be trained to use the gas masks properly.
- O. Sewer inspection and examination guidelines referred to in Section 2.2.5 may be followed as and when necessary.

(The Honourable Supreme Court of India has directed the need for proper equipment, adequate protection and safety gear to sewer workers, who enter into the manhole for cleaning blocks. Ref: Delhi Jal Board Vs. National Campaign for Dignity & Rights of Sewerage and Allied Workers and others.). Please refer to Appendix B.9.3 of this manual.

When entering a large sewer system, it may be required to use special equipment. The type of equipment might include atmospheric monitoring devices with alarms.

In the event of a sudden or unpredictable atmospheric change, an emergency escape breathing apparatus (EEBA) with at least a 10-minute air supply should be worn for escape purposes.

### 2.11.2 Measures against Accidents

These are dealt with in Chapter 9.

### 2.11.3 Information to Prevent Accidents and Records

Information to prevent accident and records are dealt with in Chapter 9.

## 2.12 TROUBLESHOOTING

Refer to appendices for troubleshooting for sewerage collection system.

## 2.13 SUMMARY

The purpose of maintenance of sewerage collection system is to minimize stoppage of functions. The following cycle should be adhered to:

O&M engineers find out problems related to their sewer system based on information obtained from inspections or examinations on the facilities. To solve the problems, they need to make a decision on rehabilitation actions considering prioritization of each facility.

When the facilities are rehabilitated, records of inspections as well as those of rehabilitation should be kept.

The following cycle shown in Figure 2.45 is regarded as essential to achieve the goal of sewer system O&M: “Inspection”, “Condition assessment”, “Decision making on rehabilitation actions”, “Rehabilitation”, and “Next inspection.”

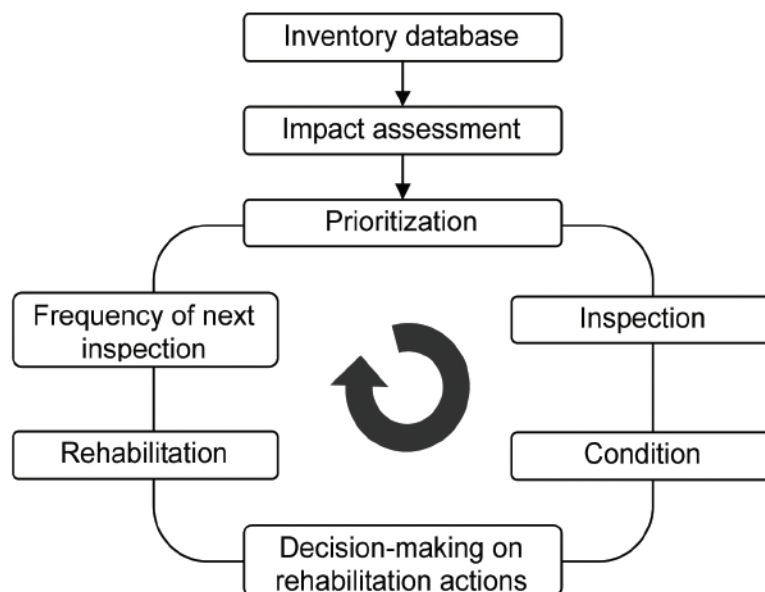


Figure 2.45 O&M cycle