8.8.7 Scraper

This method is used for sewers of diameter larger than 750mm. The scraper is an assembly of wooden planks of slightly smaller size than the sewer to be cleaned. Where the scrapers cannot be lowered through the opening of a manhole, the scraper has to be assembled inside the manhole. The scraper chains, attached to a control chain in the manhole into which it is lowered, is then connected to a winch in the next downstream manhole by means of chains. The winch is then revolved to push the debris ahead of the scraper. The heading up of the 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 350mm dia for cleaning the body of the line. They are commonly known as discs and these discs are either of collapsible type made out of metal or a wooden pair separated about 200mm apart by steel rods.

8.8.8 Hydraulically Propelled Devices

The hydraulically propelled devices take advantage of the force of impounded water to effectively clear sewers. 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.

8.8.8.1 Flush Bags

A most 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 firehose coupler at one end and a reducer at the other end. The flusher is connected to the firehose 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. Caution must be exercised in using these types of devices as there is a likelihood of sewage flowing back into the house connections or breaking of the pipes or joints due to high pressures that may develop.

8.8.8.2 Sewer Balls

These are simple elastic pneumatic type rubber balls which can be blown upto varying degrees of inflation. They are manufactured in sizes from 150mm to 750mm dia 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 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 moving 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 obstructions 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 (Fig.8.4).

A wooden ball, also called a sewer pill, 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 produces a vigorous scouring action along the invert and the sides which has the effect of removing the growths and the deposits from the sewers. This method is economical and hence can be used at frequent intervals.

8.8.8.3 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 into 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 till the scooter reaches the downstream manhole where it may be removed or allowed to continue through the next section.

8.8.9 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 roding machine and gully emptier machine. Basically it includes a high pressure hydraulic pump capable of delivering water at variable pressure upto about 80 kg/cm^2 through a flexible hose to a sewer cleaning nozzle. The nozzle has one forward facing hole and a number of rear ward facing holes. The high pressure water coming out of the holes with a high velocity breaks up and 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 air flow devices 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 also carries fresh water tanks for the hydraulic jet and 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.

8.8.10 Suction Units (Gully Emptier)

Suction units create vacuum required for syphoning of mud, slurry, grit and other materials from sanitary, storm and combined sewerage systems. The vacuum created is such as to syphon the materials from the deep manholes catch-pits etc. having depth ranging from 1m to 8m in normal cases with an option to suck 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 pressurised 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 till the manhole is cleared off the silt. The silt deposited in the tank is then emptied at the predetermined dumping spot.

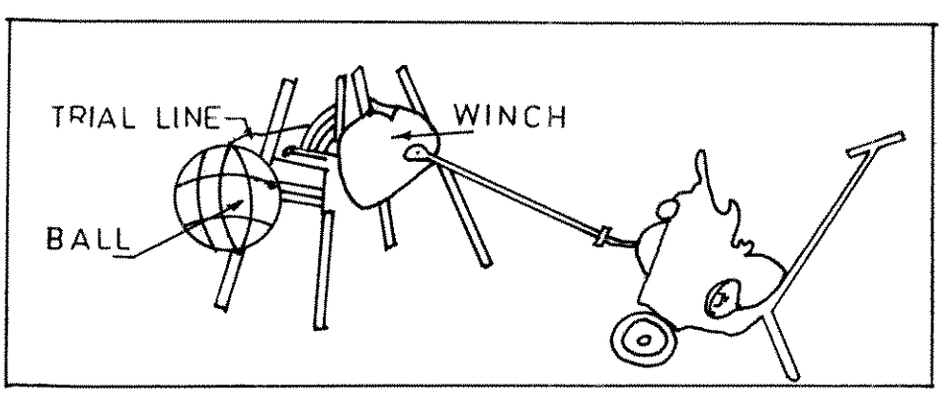

FIG. 8.4: SEWER BALL WITH MECHANICAL ARRANGMENT FOR SEWER CLEANING

This machine is very much useful in desilting surcharged manholes and in routine course the manholes can be desilted without the workers getting down into the manhole.

8.8.11 Pneumatic Plugs

The plugs are used for:

1. Isolating the gravity sewers for low pressure testing of sewer
2. Stopping the flow of sewage in the sewer line to carry out structural repairs
3. Stopping the flow to carry out routine maintenance on the downstream side of plugged sewer line.

The plugs are made of metal plates which can withstand the action of wastewater. The plates are bonded with suitable quality strong elastic material. The plugs should withstand the minimum hydrostatic back pressure likely to be encountered. The plugs can be inflated and deflated within the sewer line itself by suitable controls from the road level. Suitable hook and chain are provided to chain the plug in the manhole. Tethering life line and inflation hose are supplied with each plug. All plugs above 450mm dia should have a bye-pass fitting suitable for fixing a fire hose and suction hose.

8.9 HAZARDS

Personnel engaged in operation and maintenance of sewerage systems including sewage pumping stations are exposed to different types of occupational hazards like physical injuries, injuries caused by chemicals and radioactive wastes, infections caused by pathogenic organisms in sewage and dangers inherent with explosive or noxious vapours and oxygen deficiency.

The health and safety of personnel can be safeguarded to a great extent by taking the likely hazards into consideration at the time of designing the sewers, sewer appurtenances and pumping stations. Hazards which are still possible inspite of due consideration being given at the design stages, can be reduced by use of safety equipment and precautions appropriate for each hazardous condition. Finally to guard against human error and carelessness, proper job instructions and adequate effective supervision by competent personnel are most essential.

8.9.1 Gases In Sewerage System

Sewer gas is a mixture of gases in sewers and manholes containing abnormally high percentage of carbon dioxide, varying amounts of methane, hydrogen, hydrogen sulphide and low percentages of oxygen caused by septic action through the accumulation of organic matter inside the sewer. The actual hazard is due to the presence of high levels of methane, forming an explosive mixture or the oxygen deficiency or hydrogen sulphide in excess of permissible levels. Some times trade wastes may also contribute to other gases like chlorine, ammonia, sulphur dioxide etc.

The characteristics of common gases encountered in sewers, sewage pumping stations and sewage treatment plants, their physiological effects and safe exposure limits are detailed in Appendix-8.1

A noxious gas or vapour is any gas or vapour that is directly or indirectly injurious or destructive to the health or life of human beings. It can be a simple asphyxiant, chemical asphyxiant, irritant, volatile solvent or a combustible gas.

Simple asphyxiants are the physiologically inert gases like nitrogen, carbon dioxide, methane and hydrogen which when breathed in high concentrations act mechanically by excluding oxygen.

Chemical asphyxiants are substances like carbon monoxide which by combining with the haemoglobin of the blood or with some constituents of the tissues either prevent oxygen from reaching the tissues or prevent the tissues from using it.

Irritants are substances like chlorine which injure the air passage and lungs and induce inflammation in the surface of the respiratory tract.

Volatile solvents and drug-like substances exert little or no effect on the lungs but affect the nervous system inducing anaesthesia. Inorganic and organic metallic poisonous substances in a volatile form prove toxic after their absorption into the body.

Combustible vapours will burn as long as they are in contact with flame, spark or a heated material having a temperature equal to or greater than the ignition temperature of the gas or vapour provided, there is enough oxygen present for combustion. The reaction of the gas or vapour with the oxygen of the air, resulting in progressive combustion, or propagation of flame, occurs only when the concentration of the gas or vapour is within certain limits expressed as percentage of gas or vapour in air by volume. These limits are called explosive limits. Outside these limits, local combustion may occur at the source of ignition but there will be no propagation of flame and hence the combustion ceases on removal of the source of ignition. Within the limits, alongwith the propagation of the flame through the mixture, there will be development of pressure leading to violent explosion.

8.10 PRECAUTIONS

8.10.1 Traffic Control

a) Place easily readable and clear warning signs well ahead of work area

b) Fence off adequate space around the manhole for placing equipment and deposition of silt removed

c) Place barricades or signs to channelise the traffic, if possible

d) Vehicles can be parked between the traffic and the work area

e) Use a flagman at the two ends for controlling flow of traffic from each direction and to avoid a traffic jam, if the road is narrow and only one lane of traffic is possible.

8.10.2 Manhole Safety

a) Ventilate the sewer line by opening two or three manholes on both the sides where work is to be carried out. This is more important when adequate blowers for ventilating sewers are not available. The manholes should be opened at least one hour before start of operations. The opened manholes should be properly fenced to prevent any person, especially children, accidentally falling into the sewer. Dummy covers with BRC welded fabric can be used

b) Where it is desirable to use the blowers, operate these for at least 30 minutes before start and during cleaning operations to ventilate the lowest working levels

c) Use safety harness and life line before entering the sewer line. Two helpers at the top should be provided for each person. The person standing at the top must send signals at every few minutes interval to the person in the manhole to ensure safety

d) Test for hazardous gases before entry of a person into the sewer line and also in between if the operations are for a longer time

e) Test manhole rungs or steps for structural safety before using

f) Ensure that, where portable ladders are used, they are properly seated or fixed

g) Ensure that no material or tools are located near the edge which can fall into the manhole and injure the workman

h) Lower all tools to the workman in a bucket

i) Use lighting equipment which must be explosion and fire proof

j) Use Gas masks when men have to enter into the sewer line.

8.10.3 Infection

The personnel working in sewerage maintenance systems are prone to infections and hence the following precautions should be taken :

i) emergency first aid treatment kits shall be provided to take care of all minor injuries like cuts and burns

ii) a physician's services should be available for emergencies

iii) the workers should be educated about the hazards of waterborne diseases such as typhoid and cholera through sewage and tetanus through cuts and wounds. Preventive inoculations should be given periodically to the workers

iv) the importance of personal hygiene should be emphasized and the workers should be instructed to keep finger nails short and well trimmed, wash hands with soap and hot water before taking food and to keep fingers out of nose, mouth and eyes, because the hands carry most infections

v) use of rubber gloves should be insisted so that sewage or sludge does not come in direct contact with the hands

vi) the workers should be provided with a complete change of work clothes to be worn during working hours. Gum boots should also be provided for the workers

vii) in laboratory work, only pipettes with rubber teats should be used to prevent contamination of the mouth. Laboratory glassware should not be used for drinking purposes. In no event food should be prepared in the laboratory.

8.10.4 Precautions of Pumping Stations

a) Guards, shields, fencing, railings, enclosures should be designed to help prevent slipping, falling or contacting machinery while in operation. Replace or repair if they are missing or damaged. When removed instal a temporary safety barrier

b) When dealing with equipment

i) Always stop the machine before removing any guard

ii) See that power supply to the equipment is cut off. Place a warning board on the switch so that some body does not accidently put it on

iii) Hoisting equipment should be able to lift the required load. Temporary support should be given to any machine or equipment jacked or hoisted up before going under it

iv) Keep tools in a bag or in a belt and not on the floor

v) When lubricating a machine in operation, fittings should be atleast 30 cms. from any moving part or piped outside a guard

vi) If oil or grease is split, clean up at once.

8.10.5 Precautions Against Electrical Shocks

a) Only qualified and specially trained personnel should be allowed to operate and maintain electrical equipment at the pumping stations

b) All electrical controls should be kept dry and in good condition

c) No metal ladders or metal tapes should be used around electrical equipment

d) Insulated rubber mats should be provided before all electrical control panels and they should be kept dry

e) Always test wires for current before working on any electrical item. Use tools with insulated handles and rubber gloves.

8.11 SAFETY EQUIPMENT

The various safety equipments that are normally required in sewer maintenance work are gas masks, oxygen breathing apparatus, portable lighting equipment, nonsparking tools, portable air blowers, safety belts, inhalators and diver's suit.

The use of the particular safety equipment is governed by the detection of various gases and oxygen deficiency.

A knowledge of the type of gases in the atmosphere and of the working location becomes essential for the selection of the right type of safety equipment. Equipment and simple tests for detection of various gases and oxygen deficiency are furnished in Appendix 8.2.

8.11.1 Gas Masks

General purpose gas masks are used for respiratory protection from low and moderately high concentrations of all types of toxic gases and vapours present in the atmosphere in which there is sufficient oxygen to support life. Masks afford necessary respiratory protection under many circumstances but it is most important to know the limitations of the various types available and to be familiar with their use. Even when masks are used properly, other precautions such as never using open flames or creating sparks in the presence of inflammable gases must be taken. The general purpose gas masks affords protection against organic vapours, acid gases, carbon monoxide upto 2 percent concentration, toxic dusts, fumes and smoke.

The gas mask consists of a face piece, a canister containing purifying chemicals, a timer for showing duration of service and a harness for support. Protection against specific contaminants can be achieved by the selection of appropriate canisters.

Persons using gas masks should practise regularly with them in order to become proficient in putting them on quickly and breathing through them.

Gas masks cannot be used in oxygen deficient atmospheres, in unventilated locations or areas where large concentrations of poisonous gases exist.

8.11.2 Breathing Apparatus

This is designed for respiratory protection from atmosphere that contains very high concentrations of toxic gases and vapours or that are deficient in oxygen. It fully protects a worker against all gases, vapours, dusts, fumes, smokes and oxygen deficiencies and can be safely used in petroleum vapours and is the most dependable device for work in atmospheres normally encountered in sewage works.

8.11.2.1 AIR HOSE RESPIRATOR

This is used where a source of fresh air is available within a distance of 50m from the working location. It is essential that the supply of air is obtained from an uncontaminated source.

It consists of a mask which is a tight fitting face piece attached to a large diameter flexible hose, breathing tubes and a harness. Fresh air is blown to the mask through either a power operated or a hand operated blower. An inhalation check valve in the breathing tube assembly and exhalation valve in the face piece permit air flow only in one direction, from the source to the mask, when the blower is in operation. Exhaled air is released into the surrounding atmosphere through the exhalation valve. The valve arrangement permits the wearer to breathe directly through the hose in the event of blower failure. The maximum length of hose will be about 50 M. The hose, being of large diameter, permits breathing without excessive resistance in the event of blower failure. A special pressure release valve on the blower permits regulation of air delivery and a fresh air bypass valve functions automatically in the event of blower failure permitting the wearer to breathe directly through the hose. When a hand operated blower is used the operator will be available to attend to any emergent situation also. This apparatus does not depend on chemical and may be used over extended periods at low costs.

Purified air is used where a source of fresh air is not available within 50 m to permit the use of an air hose respirator or in situations where an air hose would encumber the worker.

8.11.3 Portable Lighting Equipment

The equipment normally used are portable electric hand lamps of permissible types, electric cap lamps and explosion proof flash lights.

8.11.4 Nonsparking Tools

These are made of an alloy (containing atleast 80 percent of copper) that will not spark when struck against other objects and metals and yet retains the necessary strength and resistance to wear.

8.11.5 Portable Air Blowers

Forced ventilation of manholes, pits and tanks can be provided by portable air blowers. Special precautions should be taken to ensure that the blowers do not serve as a source of ignition for inflammable gases. Such precautions shall include placing of the blower upwind from the manhole or at right angles to the wind direction and atleast 2 m away from the opening. The use of such equipment requires a consideration of the depth of the manhole, size of enclosure and the number of openings to uncontaminated atmosphere. Trailer mounted blower having a capacity of 210 m^3/min can ventilate easily many metres of medium sized sewers.

8.11.6 Safety Belt

This consists of a body belt with a buckle and a shoulder harness. The life line is of high grade spliced manila rope, nylon rope or a steel cable anchored with rings on each side of the belt and provided with safety straps for anchoring or securing to a stable support. The life line should be about 15 m in length and the overall assembly should be capable of withstanding a tensile load of 2000 Kg. The safety belt and life line should be tested by lifting the wearer clear of ground before each day's use.

8.11.7 Inhalators

Approved inhalators employing a mixture of oxygen and carbon dioxide are used for resuscitating victims of gas collapse, drowning or electric shock. Artificial respiration should be started at once on the patient and an inhalator face piece attached to the victims mouth as soon as the equipment can be made ready. The carbon dioxide used in small percentages stimulates deep breathing so that more oxygen may be inhaled. Pure oxygen should be used only when irritant gases such as hydrogen sulphide or chlorine have caused the victim's collapse.

8.11.8 Diver's Suit

A good quality diver suit should be provided to the diver whose services are very necessary while plugging the sewer line or removal of some hard blockage due to stone etc. at the mouth of the pipe in the manholes. Depending upon the site condition, suit should have provision to connect an air line with compressor or oxygen cylinder.

8.12 EMERGENCY MAINTENANCE

Emergency maintenance becomes necessary for removal of obstructions in sewers caused by excessive silt accumulation or damage leading to the break down of the system with flows much lower than the normal.

The sewer gang for this type of work should consist of specially trained men who are aware of the hazards and capable of coping with situations calling for prompt action. The supervision in this case should be entrusted to a responsible person well-versed in the use of the special sewer cleaning equipment, safety equipment and in first aid.

For locating the exact position of blockages, it is necessary to commence observation from the overflowing manholes down the line until the first manhole with little or no flow is reached. The section between this manhole and the one immediately upstream is the one which is blocked and requires to be tackled.

In the case of simple blockages, the split bamboo rods can be effectively used. The end of the bamboo rod is tied with cloth to make a small ball of 30 to 50mm thick and is inserted into the sewer line from the lower manhole where there is little or no sewage flowing. The bamboo rods are then inserted and pushed until the place of blockage is reached. The rod is then pulled out a little and struck against the blockage with a jerk. This is repeated a number of times till the blockage is removed. In case of a persistent blockage, flexible bamboo splits are inserted from the upper manhole also. This can be done by an experienced person even though the manhole is filled with sewage. The operation of striking against the blockage is carried out simultaneously from both ends continuously till it is removed.

Sectional sewer rods with a cutting edge are also used where available. A ferret in conjunction with a fire hose is also used for removing sand blockages. Sewer jetting machines and gully emptiers are successful and effective also in removing blockages.

When the above methods are not successful or damage to the sewer is suspected, the location

of the blockage can be found by the use of sectional rods from either end of the blocked sewer. Once this is located, the sewer length near the blockage can be exposed by open excavation to examine and set right the sewer line. Before puncturing the sewer line, foundation concrete for a new manhole is laid and the walls of the manhole are raised to a height to contain the sewage. The sewer is then punctured and the headed up sewage flows down to normal, after which the top of the sewer is completely broken and a channel formed in the manhole. The sides of the manhole are then raised upto the ground level and the manhole completed as in normal construction.

If the damage to the sewer is extensive and is caused by poor foundation then the stretch between the two manholes may have to be relaid on a proper foundation.

In the case of a small diameter sewer which is broken to remove the blockage, repair can be affected by using a piece of pipe one size larger than the one being repaired. The patch should be the shape of the cut and near the same size and should be well cemented on with cement mortar.

8.13 INSPECTION

8.13.1 Necessity for Inspection

A designer's misjudgment and the construction man's carelessness are directly responsible for many of the sewer failures. Due to age, deterioration of the material of the sewer by the 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 to enter into the sewer causing cavities round 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 break 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. Horizontal breaks are caused by excessive loading, either internally or externally. Breaks caused by internal pressure gives cracks in the sewer while external overload causes the top of the pipe to crush. Regular inspection of the sewer can pinpoint the sewer that needs to be attended to before there is a complete failure or collapse.

8.13.2 Type of Inspection

In order to assess the condition of the sewers inspections are necessary.

There are two basic types of inspection:

i) Direct
ii) Indirect

8.13.3 Direct Inspection

Direct inspection is carried out manually by crawling or walking through the sewer line. Direct inspection can be carried out in sewers above 500 mm dia. where a man can crawl through. Above 900 mm diameter, a man can walk through.

8.13.4 Indirect Inspection

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 on a video tape. The CCTV inspection can be used for sewer lines as small as 100mm. Above 900mm diameter there are limitations due to lighting problems and camera line angles.

Continual advances in range of TV cameras and also in quality are being made. The type of

camera selected should be robust for use in sewers and be able to give good quality pictures.

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 225mm diameter. Other constraints in the use of self traction is the weight of the trolley and electricity requirements. Heavy silting of sewers preclude the use of self traction. The cameras are attached to trolleys or mounted on 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 possible.

8.13.5 Planning for Sewer Inspection

Very old sewers are the ones that are likely to give trouble and require to be inspected. However, this may not always be the case and there are instances when even newly laid sewers have given trouble.

An experienced maintenance engineer will be able to identity critical sewers which require to be inspected in the first phase. If proper watch is kept during the sewer cleaning operations it will be possible to observe damages to manholes due to deterioration in the joints and collapse of bricks and/or removal of bricks and soil by the sewer cleaning machines regularly from the same area. These may be the early warning signs of an impending disaster. Settlement of road surfaces, pollution of water by sewage, high chloride contents of the subsoil water are other signs indicating leaking joints or cracks in the sewers. History of previous collapses of sewer lines will also indicate the priority areas for sewer inspection.

A list of such critical areas should be drawn up and a programme of sewer inspection chalked out. Other areas singled out for sewer inspection would be the heavily built up and congested areas where a sewer failure would have very severe repercussions.

8.14 SEWER REHABILITATION

Sewers which are determined to be critical after inspection, have to be taken up for rehabilitation. Sewer rehabilitation is necessitated either to improve the hydraulic performance of the existing line or due to danger of the sewer line deteriorating further and leading to eventual collapse or failure.

8.14.1 Methods

Sewer rehabilitation may be carried out by renovation or by renewal of the sewer.

When the condition of the sewer is improved either to increase its carrying capacity or to increase its life, it is known as renovation.

When the sewer line is reconstructed or replaced to the same dimensions as existing, it is known as renewal.

8.14.2 Sewer Renovation

In the renovation of sewers, the original sewer fabric is utilised and improvements carried out. The various methods utilised are:

a) Stabilisation where painting or chemical grouting of the joints is carried out

b) Pipe linings in which pipes of slightly smaller diameter than the sewer are inserted.

Pipes may be of Glass Reinforced Plastic (GRP) and HDPE or MDPE which can be butt fusion welded

The insitu tube, manufactured of polyester felt and impregnated with a resin mixed with a special catalyst is tailored to suit the internal diameter/dimension of the pipe. The insitu tube is inserted from any manhole, opening etc. During insertion, the tube turns inside out so that the polyurethane side forms the inside surface of the pipe. Water is pumped into the tube to a predetermined head and the tube travels down the pipe to be repaired. As the insitu tube travels, the pressure of the water firmly presses the resin impregnated side against the pipe wall. When the insitu tube reaches the downstream manhole, addition of water is stopped and the water heated to cure the resin. The result is a cast in situ pipe within a pipe. Alternative method of pulling the tube in and then inflatining it is also used for small diameter pipes. Recent development is the use of photo curing resins i.e. curing by light.

c) Segmental linings of glass reinforced cement, GRP, resin concrete and precast gunite are used when man entry is possible

d) Coatings by insitu grouting

When linings are used, annulus grouting is necessary in majority of the cases for a satisfactory performance.

8.15 SAFETY PRACTICES

An uptodate record of the fatal injuries, injuries causing permanent disabilities and those causing temporary and total disabilities in the sewerage industry may not be available. However, it is known that the number of such injuries is large. Besides pain and suffering caused, the financial cost to the injured and the authorities is tremendous. Hence, there is a need for a safety practice programme.

8.15.1 Safety Practice Programme

It is necessary that a person in the authority responsible for sewerage facilities should be made responsible for the programme. In a smaller authority, it may be the Engineer or Superintendent Incharge of the works while in large organisations, a person who can devote part or full time to the job may be so designated.

The safety practice programme would provide for:

8.15.2 Keeping Records of Injury

This is most important. Special formats can be worked out and it may include for the following:

i) Accident report

ii) Description of the accident

iii) Report of Doctor

iv) Corrective action taken

v) Accident analysis

8.15.3 Searching out Hazards

The person responsible for the programme must constantly review and look out for hazards that may be responsible for injury to a workman. Safety manuals, insurance companies policy brochures etc. are some of the sources from which information can be gathered.

8.15.4 Safe Equipment, Working Methods

It is necessary to eliminate causes due to which accidents occur by replacement of faulty equipment or provision of safety equipment. Methods of working or site conditions can be improved. Protective equipment like helmets, boots, gloves etc., should be provided.

8.15.4.1 MOTIVATION AND TRAINING

It is necessary that the employees are motivated to get them trained in the safety practice programme.

8.15.4.2 CHANGING WORKING HABITS

While a job may be done in several ways, it is necessary to identity and insist on a safe method. This would include proper use of tools i.e. selecting the right tool and using it properly. Good footing to prevent slipping, not using tools near moving machinery, not leaving tools at high places where they may fall on a workman below are some examples of working habits.

8.16 RECORDS

8.16.1 Maps and Profiles

Uptodate maps and profiles of the sewerage system are a must not only for the proper maintenance of the system but also for assessing its adequacy. Unfortunately, most of the cities do not have any such maps and if they have them, they are outdated.

In many places in a city, due to relocation, repair or upgrading of roads, the manhole covers are not traceable. It is possible to relocate the same by utilising the knowledge of old workmen and owners of near by properties. Equipment for locating hidden manhole frames and covers are available and can be used.

After location of the various manholes, mapping of the sewers should be carried out. A special task force can be employed for this purpose or the work entrusted to specialised firms having the necessary equipment and knowledge.

Where, however, this cannot be done, records can be prepared by using the sewer cleaning and maintenance gangs. These gangs when attending to any cleaning work or complaint can measure the depth of the manhole and also the size of the sewer, which information can be recorded in the office and maps slowly built up. A record of House Service Connections in the sewerage system may be obtained.

8.16.2 Data

Records should be maintained of:

a) All complaints received regarding sewer blockages or stoppages and clearance of the same with dates and times
b) The condition of the sewer found at the time of attending to the complaint, damage, noticed, if any, should be recorded by the attending staff
c) The record of cleaning of the sewers should be maintained by the staff/gangs responsible for the same
d) All data regarding the construction, repair, rehabilitation of sewers.

CHAPTER 9

SEWAGE AND STORM WATER PUMPING STATIONS

9.1 GENERAL CONSIDERATIONS

Pumping stations handle sewage/storm-water either for lifting the sewage so as to discharge into another gravity sewer or for treatment/disposal of the sewage/effluent.

Pumping for drainage is necessary, where gravity drainage is either not feasible as in low-lying localities and areas close to the sea-shore or gravity drainage is not economical, because of the cost of excavation, especially if a sewer has to pass across high spots like hillocks between the area to be drained and the point of discharge.

The availability of land, scope of expansion, the type of equipment to be used and their arrangement, the structure, its external appearance and general aesthetics are the basic considerations in the design of pumping stations.

9.2 LOCATION

Proper location of the pumping station requires a comprehensive study of the area to be served, to ensure that the entire area can be adequately drained. Special consideration has to be given to undeveloped or developing areas and to probable future growth, as the location of the pumping station will often be determined by the future overall development of the area. The site should be aesthetically satisfactory. The pumping station has to be so located and constructed that it will not get flooded at any time. The storm-water pumping stations have to be so located that water may be impounded without creating an undue amount of flood-damage, if the flow exceeds the pumping station capacity. The station should be easily accessible under all weather conditions.

9.3 CAPACITY

The capacity of the station has to be based on present and future sewage-flows, considering a design-period of 15 years. The civil structure and pipeline of both the dry sump and the wet well should be designed for a flow 30 years hence. The needs of future-expansion need special attention, especially in respect of provision of additional space for replacing the smaller pumping units by larger ones, increasing the capacity of the wet well and constructing new pumping stations to cope with the increased flows. The initial flows are generally too small and the effect of the minimum flow should be studied before selecting the size of the pumps for the project to be commissioned, in order to avoid too infrequent pumping operations and long retention of sewage in wet wells.

9.4 TYPES OF PUMPING STATIONS

Pumping stations traditionally have two wells, the wet well receiving the incoming sewage, having alongside a dry well housing the pumps. Use of wet-pit pumps does not need the dry well. Wet pit pumps are installed vertically either mounting the motor on the floor above the ceiling of the wet well or using submersible pumps.

When both the wet and dry wells are to be provided, these may be of any of the following types:

i) rectangular, with dry and wet wells adjacent to each other

ii) circular with central dry well and peripheral wet well and

iii) circular with a dividing wall to separate the dry and wet wells.

9.5 STRUCTURE AND LAYOUT OF THE PUMPHOUSE

The site should be adequately protected from flooding. The structure must be designed to withstand floatation forces. Isolated pumping stations, particularly unmanned should be protected against vandalism. The site should be aesthetically satisfactory. The dry wells should have a separate entrance. For easy access to the sub-structure of wet wells, cast iron steps should be provided. Alternatively, portable aluminium ladders may be used.

Both the dry and the wet well are generally of R.C.C-Construction. IS:3370 and IS:4111 (Part 4) shall be followed for their design and construction. In many parts of the country, especially in the arid western regions, the ground-water contains very high concentrations of sulphates leached from the soils, which may cause corrosion. Under these conditions sulphate-resistant cement should be used in the concrete.

9.5.1 Provision of Essential Accessories

At all sewage pumping stations, flow-measuring devices such as venturimeter shall be provided. The throat of the venturimeter should be a hard metal so that it would not get abraded fast by the grit and sand entraining in the flow. The abrasion would give incorrect reading.

9.5.2 Provisions for Functional Requirements

9.5.2.1 Ventilation

Since toxic gases emanate from the sewage, it is necessary to ensure proper ventilation for hazard-free working in the stations. Normally 8 to 12 air-changes per hour are recommended to be provided. For dry wells upto 4 m depth, natural inlet with exhaust fans can be used. If the depth of dru well is more than 4 m below Ground Level and for the wet wells, force inlet and forced outlet may be used. Such ventilation is mandatory as per the safety regulations for moderate and large sewage pumping installations.

When the ventilation equipment is of continuous operation type, the minimum capacity shall be 6 turnovers per hour. Ventilation design should provide for the dissipation of the heat generated from the electric motors, especially during hot weather. Wet wells and screen chambers with mechanical equipment shall be provided with positive ventilation equipment to provide 12 turnovers per hour, as this equipment is operated intermittently.

9.5.2.2 Safety Measures

Railing shall be provided around all manholes and openings where covers may be left open during operation and at other places, where there are differences in levels or where there is danger for people falling. Guards shall be provided on and around all mechanical equipments, where the operator may come in contact with the belt-drives, gears, rotating shafts or other moving parts of the equipment. Staircases shall be provided in preference to ladders particularly for dry well access. Straight staircases shall be provided as against spiral or circular staircases or steps. The steps to be provided in the staircase shall be of the non-slippery type.

Telephone is an essential feature in a pump-house, as it will enable the operator to maintain contact with the main office. In case of injury, fire or equipment-difficulty, telephone will provide facility to obtain proper assistance as rapidly as possible.

Fire-extinguishers, first-aid boxes and other safety devices shall be provided at all pumping stations.

A system of colours for pipes shall minimise the possibility of cross-connections.

To prevent leakages of explosive gases, the wet well should not be directly connected by any opening to the dry well or superstructure.

All electrical equipment and wiring should be properly insulated and grounded and switches and controls should be of non-sparking type. All wiring and devices in hazardous areas should be explosion-proof.

9.5.2.3 OTHER FACILITIES

All sewage and storm-water pumping stations should have potable water-supply, wash-room and toilet facilities and precautions taken to prevent cross connections.

Hoisting equipment shall be provided for handling of equipment and materials which cannot be readily lifted or removed by manual labour. In large pumping stations, gantries of adequate capacities shall be provided to lift the pumps, motors and large piping.

Fencing shall be provided around the pumping station to prevent trespassing.

The station should be landscaped to make it blend with the surroundings and to add to the aesthetic effect, particularly when residential areas are in the near vicinity of the station.

Adequate lighting is essential at the plinth and at all working levels of the pumping station. Glares and shadows shall be avoided in the vicinity of machinery and at floor openings.

9.6 DESIGN CONSIDERATIONS FOR THE DRY AND WET WELLS

9.6.1 Dry Well

The size of the dry well should be adequate for the number of pumps planned of such sizes as will handle the sewage-load at the desired capacity of pumping. Allowance should also be made for future requirements so that additional or larger pumps can be installed.

Provision should be made to facilitate easy removal of pumps and motors for periodic repairs, overhauls or replacements. This shall be done by providing a gantry of suitable capacity and with suitable travelling type chain and pulley blocks. A dewatering pump of the non-clog type shall be provided for the dry well. For easy access to the dry wells of the pumping stations, the dry wells should have a separate entrance and suitable stairways, preferably not less than 90 cm in width shall be provided alongwith 90 cm high railings, wherever required.

9.6.2 Wet Well

The size of the wet well is influenced by the storage capacity to be provided. The storage capacity is required to be designed, especially for all sewage and storm water pumping stations, where automatic controls and variable speed drives are not provided to match pumping rates exactly with inflow-rates to the station. The selection of the proper storage capacity is critical because it affects:

a) the time for which the liquid will be retained in the pumping station and

b) the frequency of operation of the pumping equipment.

The shape of the wet well and the detention time provided shall be such that deposition of solids is avoided and sewage does not turn septic. The capacity of the wet will is also concerned with the difference between the highest level of the liquid in the wet well and the minimum level after the depletion by pumping. This should be such that the pump of minimum duty also would run for at least 5 minutes. The capacity of the well is to be so kept that with any combination of inflow and pumping, the cycle of operation for each pump will not be less than 5 minutes and the maximum detention time in the wet well will not exceed 30 minutes of average flow.

In the wet well, baffles should be provided at required places to ensure uniform flow at each pump-suction. The wet well flooring should have benching like a hopper with a minimum slope of 1:1, to avoid deposition of solids. Yet there should be provision for the removal of the accumulated sludge. Suitable provision for overflow should also be made, where feasible, as a protection against flooding, especially in the event of the breakdown of the plant on the failure of the power-supply.

Wherever possible, grit removal ahead of pumping should be adopted to increase the life of the pumps. Coarse screens before the wet wells should have a clear opening of 40 to 50mm between the bars for the manually cleaned type and 25mm for the mechanical type. The screening units shall always be provided in duplicate. The screens shall conform to IS:6280.

While positioning of the pump-intakes or wet-pit pumps in the wet well, the following points need to be taken care of :

a) Flow approaching the pump-intake should be uniform along the width of the channel

b) No disturbance which generates kinetic energy should take place in the proximity of the intake

c) The mean velocity of flow should be low, but not less than 0.7 m/s to prevent deposition of the solids

d) Benching and corner fillets should be provided to prevent stagnation of the flow

e) In order to prevent flow-separation, bell-mouths should be provided at the entrance of the suction-pipes. Diameter of the bell-mouth, D should be 1.5 d to 1.8 d, where d is the diameter of the suction-pipe

f) The clearance of the bell-mouth from the floor should be between 0.5 D to 0.75 D. Unsteady flow in the bell-mouth occurs, if the clearance is less than 0.25D. If the clearance is too much, the upward flow-component becomes unstable and causes swirling and vortex-formation

g) The distance of any wall or fillet from the lip of the bell-mouth should be between 0.25 D to 0.5 D. The proximity of the end and the side walls prevents swirling flow and vortex-formation

h) The width of the sump should be between 2 D and 3 D

i) The depth of water above the lip of the bell-mouth should be greater than 1.5 D

j) Where multiple pumps are used, the spacing between the lips of two adjacent suction bell-mouths should be between 2 to 2.5 D. With splitters, i.e. separation walls between the suction pipes, their lengths should not be less than 4 D.

9.7 PUMPS

The selection of pumps is based on many considerations such as the type of pump, the size of pumps, the number of pumps, the capacity or flow-rate of each pump, the range of throttling of each pump, the head of pumping, and others.

9.7.1 Capacity

The capacity of the pumps shall be adequate to meet the peak rate of flow with 50% standby. To obtain the least operating cost, the pumping equipment shall be selected to perform efficiently at all flows, including the peak flow. Two or more pumps are always desirable at sewage pumping stations. The size and the number of units for larger pumping stations shall be so selected that the variations of inflow can be handled by throttling of the delivery valves of the pumps or by varying the speed of the pump, without starting and stopping the pumps too frequently or necessitating excessive storage.

The capacity of a pump is usually stated in terms of Dry Weather Flow (DWF), estimated for the pumping station. The general practice is to provide 3 pumps for a small capacity pumping station comprising 1 pump of 1 DWF, 1 of 2 DWF and third of 3 DWF capacity. For large capacity pumping station, 5 pumps are usually provided, comprising 2 of 1/2 DWF, 2 of 1 DWF and 1 of 3 DWF capacity, including standby.

9.7.2 Size of the Pump

For protection against clogging, the suction and delivery openings of the pumps shall not be less than 100mm and the pumps shall be capable of passing a ball of at least 50mm dia.

9.7.3 Pump-Types

Both the centrifugal type pumps, including the submersible pumps and pneumatic ejectors are used in sewage and storm water stations. The pneumatic ejectors are not recommended, unless a centrifugal pump is impractical as may be in small installations. Screw pumps of the single-screw, progressive cavity, helical rotor type also present themselves as a worthwhile option and are coming into vogue.

Pumps for sewage and storm water pumping are generally of all cast iron construction. If the sewage is corrosive then the stainless steel construction may have to be adopted. Also, where the sewage or storm water would entrain abrasive solids, the pumps in abrasion-resistant material or with elastomer lining may be used.

9.7.4 Centrifugal Pumps

These are generally classified as radial flow, mixed flow and axial flow pumps. The classification is usually based on the specific speed of the pump (n_s), which is obtained from the following formula:-

$$n_s = \frac{3.65 n \sqrt{Q}}{H^{0.75}} \qquad (9.1)$$

where,

n = speed of the pump in rpm

Q = flow-rate in m^3/s

H = head of the pump in m

The specific speed of the pump is akin to a shape number and forms the basis for the design of the impeller of a centrifugal pump. The shape of the impeller is identifiable by the relative proportions of the inlet size, outlet width and the outside diameter. Broader inlet size and outlet width are logical for larger flows. For higher head-to-speed ratio the impeller would be logically narrower than broader. So, the specific speed is larger and the shape broader proportional to the flow-rate and inversely proportional to the head-to-speed ratio.

The descriptions narrow and tall or broad and short are of course relative, to be indicative of the shape and not the size. A large size impeller can yet be broad and short by its shape. So also a small size impeller can yet be narrow and tall by its shape.

In a narrow and tall impeller, the flow through the impeller will be radial i.e. across a plane perpendicular to the axis of rotation. Hence these are called as radial flow pumps and are pumps of low specific speed, generally between 40 to 150.

In a broad and short impeller, the flow through the impeller will be partly radial and partly axial. Hence, these are called as mixed flow pumps and are pumps of specific speeds in the range from 150 to 350.

In the impellers in the pumps of specific speeds higher than 350, the flow is more or less parallel to the axis of rotation and hence these pumps are called as the axial flow pumps.

In a double-suction pump, the impeller is actually a composite impeller, with two identical flow-passages combined back to back. Each side is practically an independent impeller and each such impeller handles only half the flow. So, the specific speed for such pumps is calculated by taking only half the flow. By this the specific speed of a double-suction pump is only 70% of what the specific would have been with a single-suction design.

Generally pumps of low specific speed can work with more suction-lift than the pumps of higher specific speed. With the pumps of very high specific speed as of the axial flow pumps not only that they would not work with any suction-lift, instead they would need positive suction head or minimum submergence for trouble free working. It is always advisable to avoid suction-lift for any centrifugal pump. In sewage stations the pumps are hence installed either to work submerged in the wet well itself or installed in the dry well at such a level that the impeller will be below the level of the liquid in the wet well. Some typical installations are illustrated in Fig.9.1

The power-characteristics of the centrifugal pumps are also related to the specific speed. The radial flow pumps having low specific speed have such power-characteristics that the required input power to the pump increases as the capacity i.e. the flow-rate of the pump increases. Obviously, in radial flow pumps the power demand is the minimum with zero flow, i.e. with the delivery valve closed. Since the pump should be started with the pump exerting the minimum load on the driver/motor, the radial-flow pumps should be started with the delivery valve closed.

The power-characteristics of the mixed flow pumps are almost flat or with very little gradient. So, the mixed flow pumps can also be started in the manner similar to that for the radial flow pumps.

However, in the case of axial flow pumps, the power needed to be input to the pump is maximum at zero flow. These pumps should hence be started with the delivery valve fully open.

The impellers of centrifugal pumps have vanes which are either open or have shrouds. Open impellers have no shrouds. Semi-open impellers have only a back shroud. Enclosed impellers have both the front and the back shrouds. Axial flow pumps would have only the open impellers. The mixed flow pumps, especially of the higher specific speed would be generally semi-open. But the impellers of radial and mixed flow pumps can be constructed in all the three types. Because the centrifugal pumps used more commonly for clean, clear liquids, enclosed impellers are the most common

construction. The impellers are constructed of the semi-open or open type depending the size of the

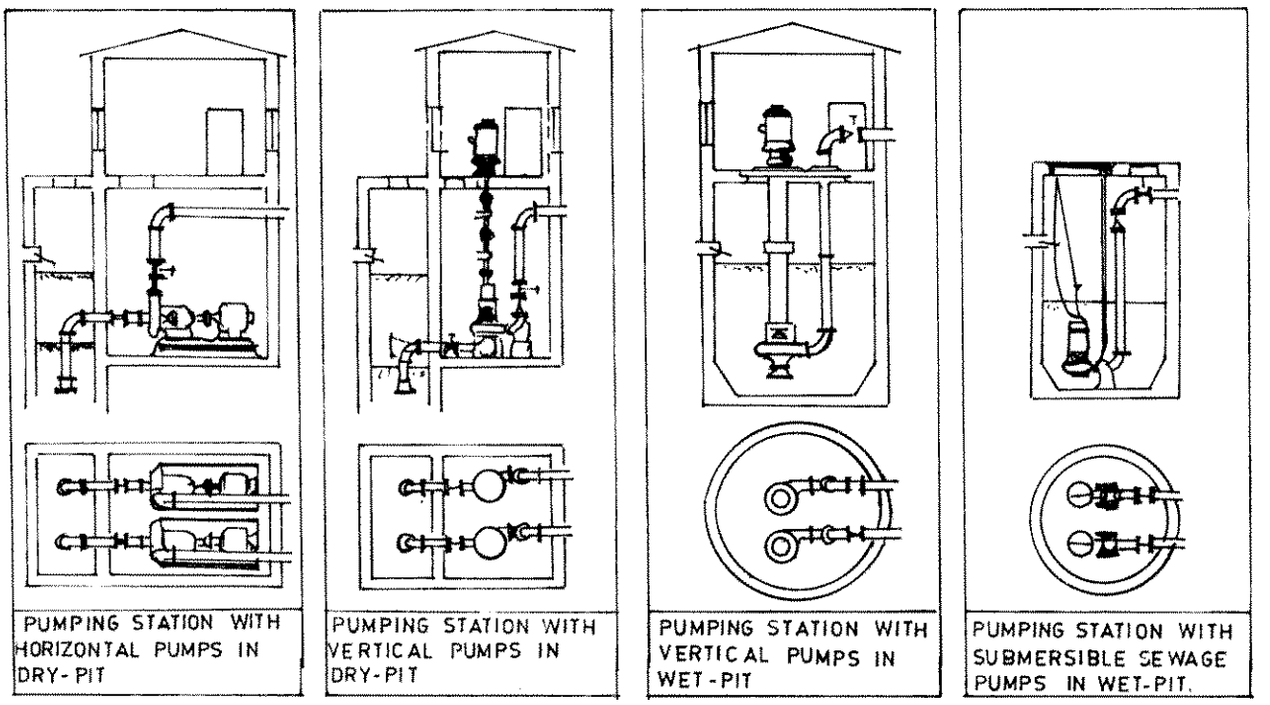

FIG.9.1:TYPICAL DRY-WELL & WET-WELL INSTALLATIONS