

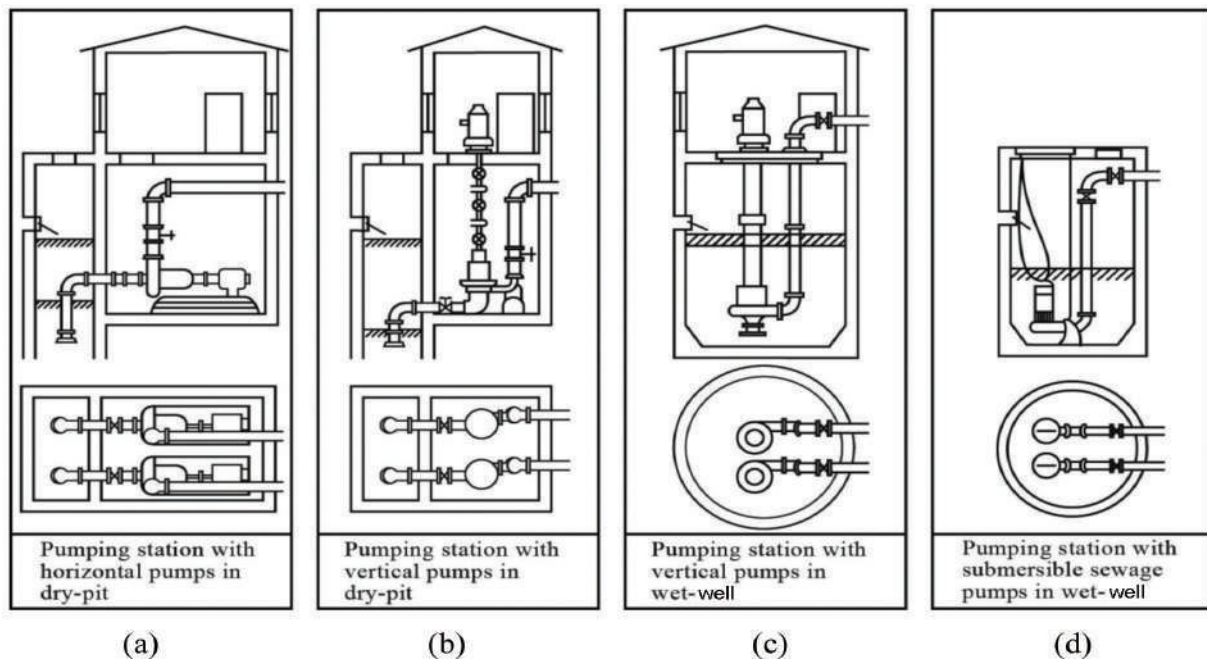
## CHAPTER 3: PUMPING STATION

### 3.1 INTRODUCTION

Pumping stations are either as in-line for lifting the sewage from a deeper sewer to a shallow sewer or for pumping to the STP or the out fall. They are required where low lying development areas cannot be drained by gravity to existing sewerage infrastructure, and/or where development areas are too far away from available sewerage infrastructure to be linked by gravity. The O&M of pumping systems presented here applies to all such types of pumping stations.

### 3.2 TYPES AND STRUCTURE OF PUMPING STATIONS

The type of pumping stations can be (a) Horizontal pumps in dry pit, (b) Vertical pumps in dry pit, (c) Vertical pumps in suction well and (d) Submersible pumps in suction sump. All these types include a sewage-receiving sump, which is called suction sump or wet well. These types of pump arrangements are shown in Figure 3.1.



Source: CPHEEO, 1993

Figure 3.1 Typical drywell and wetwell installations

#### 3.2.1 Dry Pit

The size of the dry pit should be adequate for the number of pumps planned and should be such as to handle the sewage load at the desired pumping capacity. Allowance should also be made for future requirements of additional or larger pumps. In the configuration, (a) separate dry pit and wet well are required: one to hold the sewage, and one to house the pumps and appurtenances. This option is required for installations where the pumps will otherwise need separate priming and where-as otherwise long suction pipes are needed.

It is typically used to pump large volumes of raw sewage, where uninterrupted flow is critical and sewage solids could clog suction piping. It is also used to pump solids in pipe galleries between digesters or other solids-handling equipment. While construction costs may be higher and a heating, ventilation and cooling system is necessary when installed below the floor level, this configuration is best for O&M activities because operators can see and touch the equipment.

### **3.2.2 Suction Sump or Wet Well**

Sewage sump is a compartment or tank in which sewage is collected. The suction pipe of a pump may be connected to the wet well or a submersible pump may be located in the wet well. Sewage sump design depends on the type of pumping station configuration (submersible or dry well) and the type of pump controls (constant or variable speed). Wet wells are typically designed to prevent rapid pump cycling but small enough to prevent a long detention time and associated odour release.

Sewage sumps should always hold some level of sewage to minimise odour release. Bar screens or grinders are often installed in or upstream of the wet well to minimise pump clogging problems. Instead of manually operated screens at the bottom, which requires the staff to get down into the screen sump, it is better to install mechanical bar screens, which can automatically remove the screenings and lift the same safely above the ground level. There can also be two such screens one after the other for coarse screenings and fine screenings. This will require rectangular channels to maintain longitudinal non-turbulent linear flow.

### **3.2.3 Lift Stations**

In general, lift stations are invariably used in gravity sewer network where depth of cut of sewers poses a problem in high water prone areas. The procedure is to sink a wet well on the road shoulder or an acquired plot after the shoulder and divert the deeper sewer there. The submersible pump will lift the sewage and discharge it to the next on line shallow sewer. This is a very useful practice in such locations.

Equipment located in the wet well should be minimized, including suction and discharge valves, check valves, or other equipment that require routine, periodic maintenance. This equipment can be located in separate and suitable dry pits located adjacent to the wet well to facilitate accessibility and maintenance for the operator.

### **3.2.4 Operation and Maintenance**

Pumping machinery is subjected to wear & tear, erosion and corrosion due to its nature of functioning, and therefore it is vulnerable to failures. Generally, failures or interruptions are mostly attributed to pumping machinery rather than any other component. Therefore, correct operation and timely maintenance and upkeep of pumping stations and pumping machinery are of vital importance. Sudden failures can be avoided by timely inspection, follow up actions on observations of inspection and planned periodical maintenance. Downtime can be reduced by maintaining inventory of fast moving spare parts. Obviously due attention needs to be paid to all such aspects for efficient and reliable functioning of pumping machinery.

### 3.2.4.1 Operation of the Pumps

The following points should be observed while operating the pumps.

- A. Dry running of the pumps should be avoided.
- B. Centrifugal pumps if installed with negative suction should be primed before starting.
- C. Pumps should be operated only within the recommended range of the head-discharge characteristics of the pump.
  - If pump is operated at a point away from duty point, the pump efficiency normally reduces.
  - Operation near the shut-off point should be avoided, as it causes substantial recirculation within the pump, resulting in overheating of sewage in the casing and consequently, overheating of the pump.
- D. As far as possible positive suction is to be provided to avoid priming during design itself.
- E. Voltage during operation of the pump-motor set should be within  $\pm 10$  % of the rated voltage. Similarly, current should be below the rated current shown on the name plate of the motor.
- F. When parallel pumps are to be operated, the pumps should be started and stopped with a time lag between two pumps to restrict change of flow velocity to minimum and to restrict the dip in voltage in the incoming feeder and should be adequate to allow the pump head to stabilise.
- G. When the pumps are to be operated in series, they should be started and stopped sequentially, but with minimum time lag. Any pump next in sequence should be started immediately after the delivery valve of the previous pump is even partly opened. Due care should be taken to keep open the air vent of the pump next in sequence, before starting that pump.
- H. The stuffing box should allow a drip of leakage to ensure that no air passes into the pump and that the packing gets adequate wetness for cooling and lubrication. When the stuffing box is sealed with grease, adequate refill of the grease should be maintained.
- I. The running of duty pumps and standby pumps should be scheduled so that no pump remains idle for a long period and all pumps are in ready-to-run condition. Similarly, the running schedules should be ensured so that all pumps do not wear equally needing simultaneous overhaul.
- J. If any undue vibration or noise is noticed, the pump should be stopped immediately and the cause for vibration or noise should be checked and rectified.
- K. Generally, the number of starts per hour shall not exceed four. Frequent starting and stopping should be avoided as each start causes overloading of motor, starter, contactor and contacts. Although overloading lasts only for a few seconds, it reduces the life of the equipment.
- L. Troubles in a sewage pumping station can be mostly traced to the design stage itself. This is all the more true when too much grit is likely to come into the sewage pumping stations from sewage at monsoon time, which is difficult to handle. Hence, sewers should not collect any storm water.

### 3.2.4.2 Undesirable Operations

The following undesirable operations should be avoided:

#### A. Operation at higher head

A pump should never be operated at a head higher than the maximum recommended head otherwise such operation may result in excessive recirculation in the pump, and overheating of the sewage and the pump. Another problem that arises if a pump is operated at a head higher than the recommended maximum head is that the radial reaction on the pump shaft increases causing excessive unbalanced forces on the shaft, which may cause failure of the pump shaft. As a useful guide, appropriate marking should be made on the pressure gauge. Efficiency at a higher head is normally low and such an operation is also inefficient.

#### B. Operation at lower head

If a pump is operated at a lower head than the recommended minimum head, the radial reaction on the pump shaft increases causing excessive unbalanced forces on the shaft, which may cause premature wear of bearings and possibly shaft failure if persisted. As a useful guide appropriate marking should be made on both pressure gauge and ammeter. Efficiency at a lower head is normally low, hence such an operation is inefficient. In such cases, it is advisable to throttle the delivery side valve to create more head to work within safe head. This will also reduce the power. If this is a design flaw additional head has to be created at tail end by elevating the delivery. However, these are not energy efficient solutions; change of impeller to suit the actual head is the solution.

#### C. Operation on higher suction lift

If a pump is operated on suction lift higher than the permissible value, pressures at the eye of impeller and the suction side fall below vapour pressure. This results in flashing of sewage into vapour. These vapour bubbles collapse during passage, resulting in cavitation in the pump, causing pitting on the suction side of impeller and casing, and excessive vibrations. In addition to mechanical damage due to pitting, pump discharge also reduces drastically. Typical damage to impeller and sometimes to the casing is shown in Figure 3.2.



Source: <http://greathub.hubpages.com/hub/piping-and-pipes#>

Figure 3.2 Typical Cavitation Damage of an Impeller

#### D. Operation of the pump with low submergence

Minimum submergence above the bell-mouth or foot-valve is necessary to prevent entry of air into the suction of the pump, which gives rise to the vortex phenomenon, causing excessive vibration, overloading of bearings, reduction in discharge and in the efficiency. As a useful guide, the lowest permissible sewage level should be marked on the water level indicator. Usually the pump manufacturer indicates the minimum height of submergence. In the case of submersible pumps, the minimum depth is needed to ensure cooling of the motor while running.

#### E. Operation with occurrence of vortices

If vibration continues even after taking all precautions, vortex may be the cause. Vortex should be stopped by using anti vortex fittings as described in chapter 4 of Part A of the manual:

A well-planned maintenance programme for pumping systems can reduce or prevent unnecessary equipment wear and downtime. (The following maintenance information applies to both sewage and solids pumping systems.)

The following is a maintenance checklist for a basic pumping-station:

- Check the wet well level continuously (whenever necessary).
- Record each pump's "run time" hours (as indicated on the elapsed-time meters) at least once in a day and confirm that the pumps' running hours are equal.
- Ensure that the control-panel switches are in their proper positions.
- Ensure that the valves are in their proper positions.
- Check for unusual pump noises.
- At least once a week, manually pump down the wet well to check for and to remove debris that may clog the pumps.
- Inspect the float balls and cables and remove all debris to ensure that they operate properly. Twisted cables are to be released that may affect automatic operations.
- If a pump is removed from service, adjust the lead pump selector switch to the number that corresponds to the pumps remaining in operation. (This allows the lead pump levels to govern the operating pump's starts and stops.)

#### **3.2.4.3 Piping and Appurtenance Maintenance**

Properly maintaining pumping-station pipelines and other appurtenances can minimize pump loads.

Excessive head losses on either the suction or the discharge side of a pump can increase energy use and the wear rate and consequently, the O&M costs. Excessive head losses also may lead to process or treatment problems because solids move slower, so the proper solids balance is not maintained. Operators can monitor head losses by routinely checking the pressure gauges on both sides of the pumps.

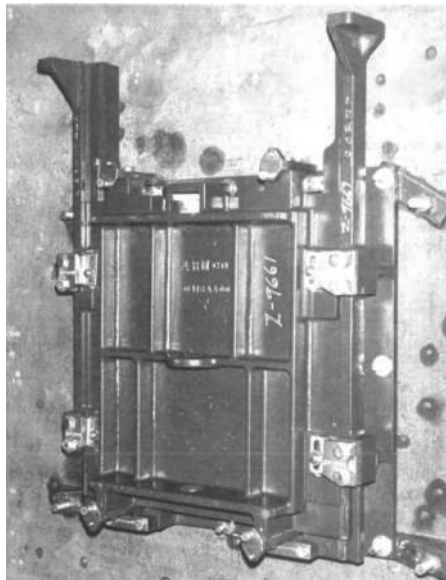
When operators notice excessive head losses (indicated by a pressure drop on the suction side of the pump or an increase in pressure on the discharge side), they should determine whether the losses are a result of partial clogging, a restriction somewhere in the line, or materials built up on the pipe wall. To find clogs, operators should start by checking the pressure at various points in the suction and discharge piping, and look for spots with abrupt head loss (such as valves or other constrictions). If something is caught in a valve or other appurtenance, the operator should stop the pump and physically open out the valve head and remove the blockage. In smaller pumps, it is easier to remove the entire valve, disassemble and remove the blockage, reassemble and refit. During such time, other pumps shall be run. Scum build-up problems typically are addressed via source control (for instance, by installing grease traps in the collection system at locations suspected or known to generate grease, such as restaurants, etc.).

### 3.3 GATES, VALVES AND ACTUATORS

#### 3.3.1 Sluice Gate

A sluice gate (Figure 3.3) is traditionally a wooden or metal plate, which slides in grooves in the sides of the guide channel.

Sluice gates are commonly used to control sewage levels in STPs.



Source: EPA, 2008

Figure 3.3 Sluice gate

Attention should be paid to the following points for proper operation:

A. Test for proper operation

Operate inactive sluice gates by smearing grease on stem threads.

B. Clean and paint

Clean sluice gate with wire brush and paint with proper corrosion-resistant paint.

C. Adjust for proper clearance.

For gates seated against pressure, check and adjust top, bottom, and side wedges until each wedge applies nearly uniform pressure against gate in the closed position. This shall be done by the manufacturer and not the operator.

D. Check for the following:

- Ensure unobstructed operation of gate and headstock.
- Ensure that the spindle is not touching the stem guide.
- Remove foreign matter like paint, concrete, etc. in the fully open position of gate.

E. Do's for sluice gates

- Operate the gate at least once in every three months.
- Check the nuts of all construction and foundation bolts once in a year. Tighten the bolts, if loose.
- Examine the entire painted surface for any signs of damage to the protective paint.

F. Don'ts for sluice gates

- Do not remove lock plates until the gate has been properly installed.
- Do not keep the gate out of operation for more than three months.
- Do not forget to set the stop nut in the correct position.
- Do not disturb the adjustment of wedge block bolts/studs.
- Do not over torque the crank handle/hand wheel.

### 3.3.2 Valve

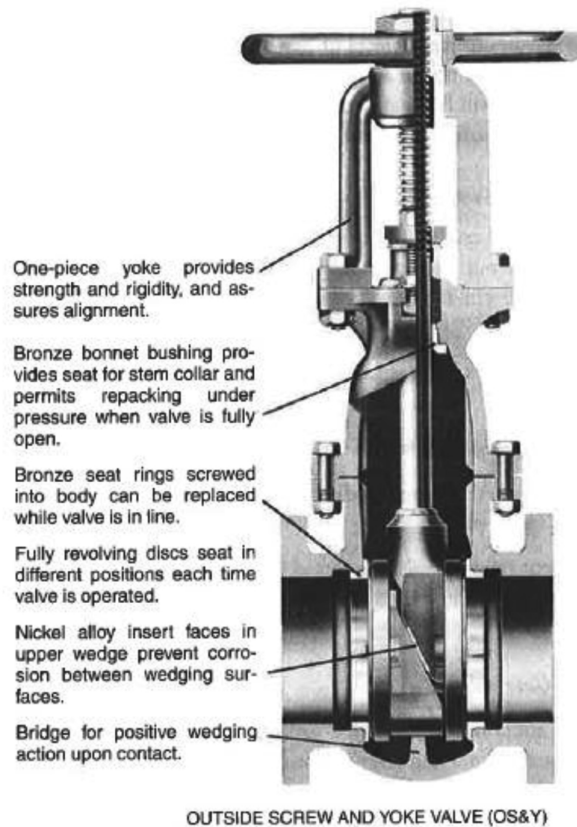
On the delivery side of centrifugal pumps, a non-return valve is necessary to prevent back-pressure from the delivery head on the pump, when the pump is shut off. To avoid water-hammer, which is likely to be caused by the closure of the valve, the valve may be provided with an anti-slam device, which may be either a lever and dead-weight type, a spring-loading type or the dash pot type.

Pumps may be run in parallel with different permutation of the standbys. Isolation valves would be needed to isolate those pumps, which are to be idle. Generally, the isolating valves are gate valves, which should preferably be of the rising stem type, since this type offers the advantage of visual indication of the valve-position.

For exterior underground locations, gate valves are generally used.

#### 3.3.2.1 Gate Valve

A gate valve is a valve that opens by lifting a round or rectangular gate/wedge out of the path of the fluid as shown in Figure 3.4 overleaf. The distinct feature of a gate valve is that the sealing surfaces between the gate and seats are planar. The gate faces can form a wedge shape or they can be parallel. Typical gate valves should never be used for regulating flow, unless they are specifically designed for that purpose. Gate valves require maintenance as indicated overleaf:



Source: EPA, 2008

Figure 3.4 Gate valve

#### A. Replace packing

Modern gate valves can be repacked without removing them from service. Before repacking, open the valve wide. This prevents excessive leakage when the packing or the entire stuffing box is removed. It draws the stem collar tightly against the bonnet bushing on a rising stem valve.

#### B. Operate valve

Operate inactive gate valves to prevent sticking.

#### C. Lubricate gearing

Lubricate gate valves as recommended by the manufacturer. Lubricate thoroughly any gearing in large gate valves. Wash open gears with solvent and lubricate with grease.

#### D. Lubricate rising stem threads

Clean threads on rising stem gate valves and lubricate with grease.

#### E. Lubricate buried valves

If a buried valve is hard for working, lubricate it by pouring oil down through a pipe that is bent at the top end oiling the packing follower below the valve nut.



### 3.3.2.2 Non-Return Valve (Check Valve)

Normally, a check valve is installed in the discharge of each pump to provide a positive shutoff from force main pressure when the pump is shut off and to prevent the hydraulic force from draining back into the wet well. The most common type of check valve is the swing check valve, which is shown in Figure 3.5.

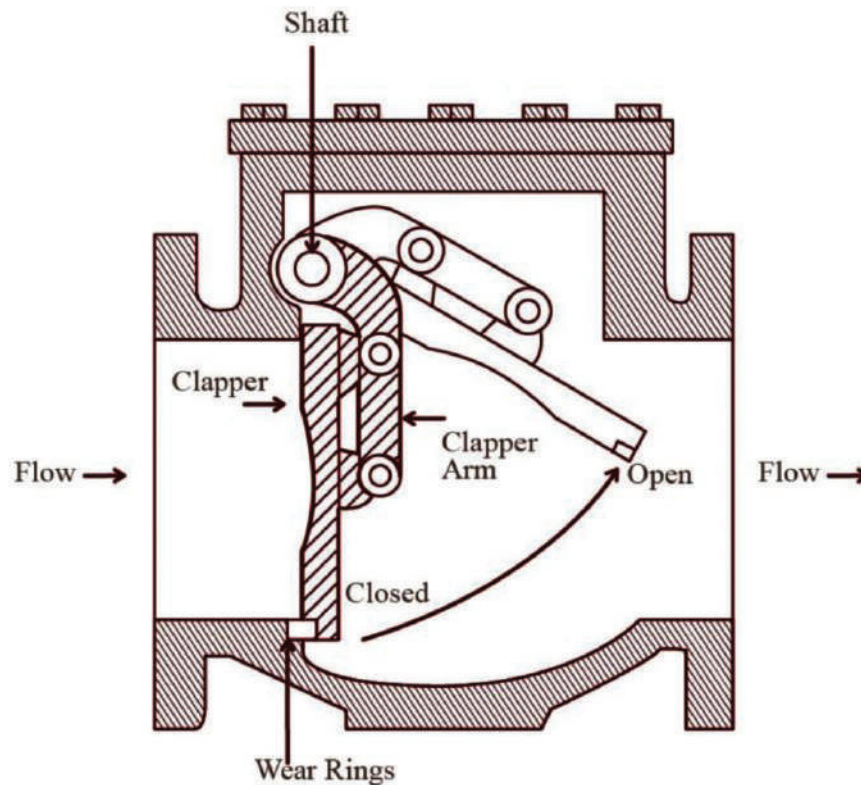


Figure 3.5 Check valve

This valve consists of a valve body with a clapper arm attached to a hinge that opens when the pump starts operating and closes to seal when the pump is shut off.

Check valves must close before the water column in the pipe reverses flow; otherwise, severe water hammer can occur when the clapper arm slams against the valve body seat. If this occurs, an adjustment of the outside weight or spring is usually required. A traditional clapper type of check valve has a lever on the extended shaft, which allows adjustment of the weight on the arm or spring to vary the closing time. Wear occurs within the valve primarily on the clapper hinge-and-shaft assemblies and should be checked annually for looseness.

The preventive maintenance is to be done only by the manufacturer.

#### A. Inspect Clapper Facing

Open valves to observe condition of facing on swing check valves equipped with neoprene seats on clapper.

If metal seat ring is scarred, dress it with a fine file and lap with fine emery paper wrapped around a flat tool.

## B. Check Shaft Wear

Check shaft wear on balanced disc check valve since disc must be accurately positioned in the seat to prevent leakage.

### 3.3.2.3 Non-Return Valve (Ball Type)

Non-return valve depends on a light weight and suitable coated ball moving inside the flowing pipe to occupy an elevated angular position while the fluid is in pumping and dropping back to close the reverse flow through the pipe. Because it is a sphere sitting over a circular opening, it is expected to seat properly and seal the reverse flow. The material of the ball, the coating and its sturdiness against dents caused by the slide are important aspects. The ball is replaced by opening the top flange after switching off the pump. This can be installed in any position, vertical or horizontal. A non-return valve is shown in Figure 3.6.

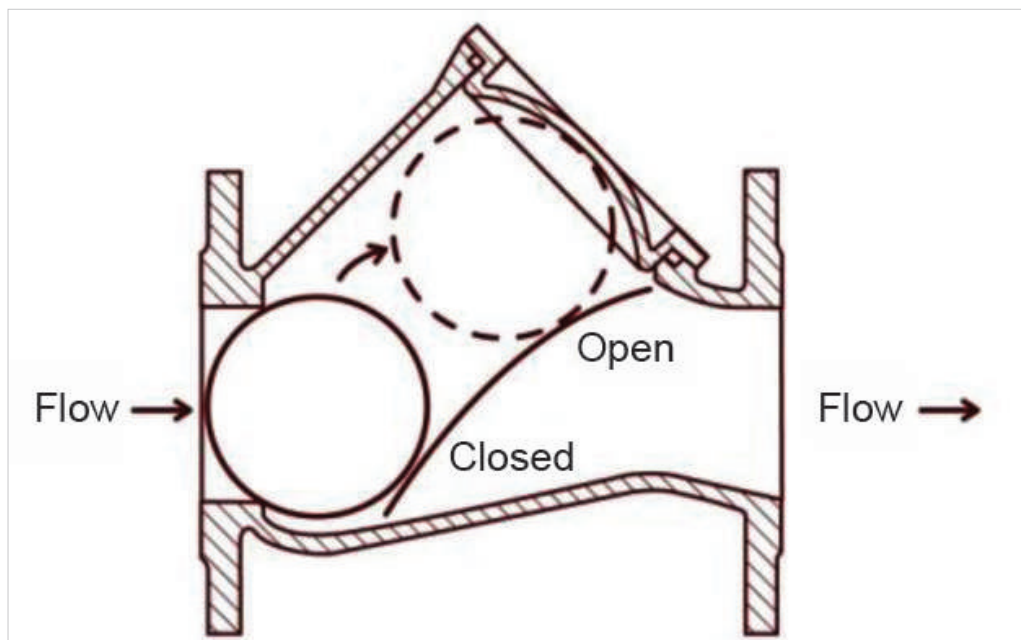


Figure 3.6 Typical ball type check valve

When flow occurs, the ball is lifted into the angular piping and is held there because its weight is lighter than the sewage and the velocity of flow. When the flow stops, it slides back and seals.

### 3.3.2.4 Butterfly Valve

Butterfly valves are another type of valve that have been successfully used as suction and discharge isolation valves in pumping stations. They are frequently used in sewage plants where waste streams with a high solids content are encountered, such as in sludge pumping systems. A butterfly valve consists of the valve body and a rotating disc plug that operates through 90 degrees.

This is usually a disc rotated by 90 degrees by external handle. In the open position, the disc is in line with the flow. In the closed position, the disc is at 90 degrees to the flow and it stops the flow. Usually, the axis is vertical although horizontal axis arrangement may also be used in smaller sizes.

The closing and opening can be manual or mechanized. The butterfly valves occupy less space and are generally preferred for pipe sizes larger than 150 mm.

Many agencies specify butterfly valves as opposed to gate valves because they are less susceptible to plugging.

Butterfly valves require the following preventive maintenance to be done by the manufacturer:

#### A. Adjust gland

The adjustable gland holds the plug against its seat in the body and acts through compressible packing, which functions as a thrust cushion.

Keep gland tight enough at all times to hold plug in contact with its seat. If this is not done, the lubricant system cannot function properly, and solid particles may enter between the body and plug and cause damage.

#### B. Lubrication

Apply lubricant by removing lubricant screw and inserting stick of butterfly valve lubricant for stated temperature conditions.

Be sure to lubricate valves that are not used often to ensure that they are always in operating condition. Leave lubricant chamber nearly full so that extra supply is available by turning the screw down. Use lubricant regularly to increase the valve efficiency and service, promote easy operation, reduce wear and corrosion, and seal valve against internal leakage.

### 3.3.3 Actuators

These are replacements for physical operation by the operators. Actuators are used for automation of valves. An actuator rotates the valve spindle or lifts and drops the same.

#### A. Electric geared motor actuator

The actuator consists of a rotor stator unit driving an output shaft through a single stage-worm reduction gear, which incorporates an automatic mechanical device for changing manual drive to power drive. The actuator includes a travel-limit switch unit and a torque switch unit, and is of totally enclosed construction. When power fails, electric motor driven gear actuators retain their positions. When power supply returns, pay attention how the valves move. The electric motor driven gear actuator is shown in Figure 3.7 overleaf.

#### B. Solenoids

Solenoids are the most common actuator components. It consists of a moving ferrous core (a piston) that moves inside wire coil. Normally the piston is held outside the coil by a spring. When a voltage is applied to the coil and current flows, the coil builds up a magnetic field that attracts the piston and pulls it into the centre of the coil. The piston can be used to supply a linear force. Diaphragm valve have small holes on it. The holes should be free from clogging by debris otherwise the diaphragm may not open.



Figure 3.7 Electric motor driven gear actuator

### C. Pneumatics

Pneumatic systems have much in common with hydraulic systems with a few key differences. The reservoir is eliminated as there is no need to collect and store the air between uses in the pneumatic system. Also because air is a gas, it is compressible and regulators are not needed to recirculate the flow; however, since the gas is compressible, the systems are not as stiff or strong.

In general, the pneumatics are liable to cause accidents such as when the air hose suddenly pulls out of the hose clamp and jets high pressure air on persons nearby. This should be avoided. The electric geared motor type is to be preferred. The pneumatic valve is shown in Figure 3.8.



Figure 3.8 Pneumatic valve

### D. Hydraulic system

Actuator (hydraulic motor and hydraulic cylinder) is operated by hydraulic fluids (hydraulic oil), which is pressurised by hydraulic pump driven by an electric motor. Generally, a smooth movement and variable speed can be achieved. Moreover, the installed relief valve can prevent the system from breakdown. It should be noted that hydraulic oil leaks as pressure increases. Check for oil leakage regularly. Hydraulic system should be kept clean because it is vulnerable to dust or rust. Take precautions to avoid fires because the hydraulic oil is combustible.

In all cases, preventive maintenance by manufacturer shall be done periodically and a wall chart exhibited on site.

### 3.4 SCREEN

Screenings in sewage from the incoming sewer below the ground level need to be separated and lifted above ground level, and removed either by mechanical or manual method.

#### 3.4.1 Types of Screens

##### 3.4.1.1 Coarse Screens

Coarse screens are usually bar screens consisting of vertical or inclined bars spaced at equal intervals across a channel through which sewage flows. The openings are usually 25 mm. Hand-cleaned screens are usually inclined at 45 degrees to the horizontal.

##### 3.4.1.2 Medium Bar Screens

Medium bar screens have clear openings of about 12 mm.

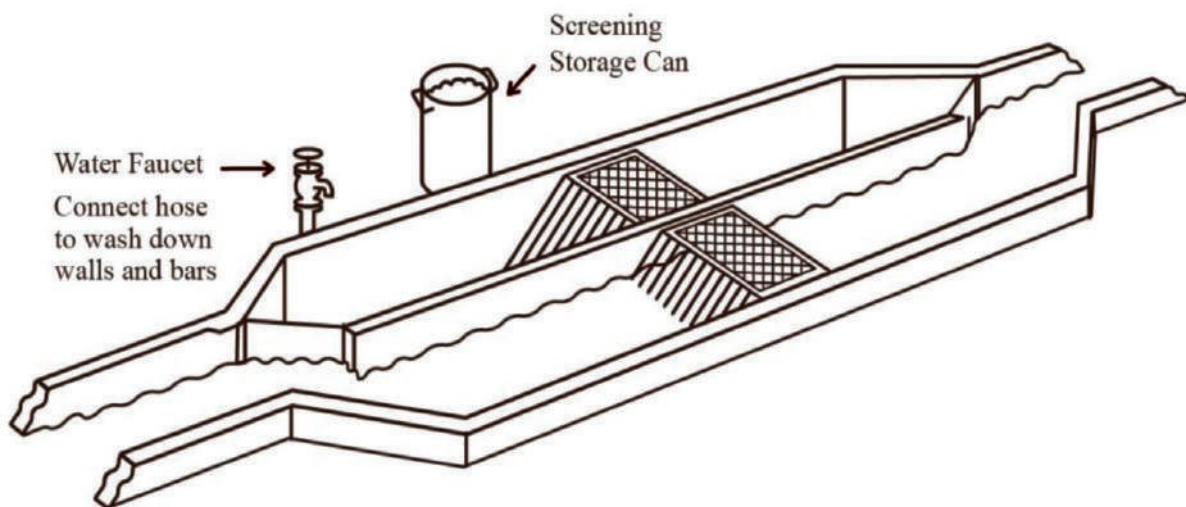
##### 3.4.1.3 Fine Screens

Fine screens are mechanically-cleaned devices. Fine screens may be of the drum or disc type, mechanically cleaned and continuously operated. They are also used for protecting the beaches where untreated sewage may have to be discharged into the sea for disposal by dilution.

#### 3.4.2 Screenings Removal Method

##### 3.4.2.1 Manual Bar Screen

Hand cleaned screens should be cleaned as often as required to prevent backing up of sewage. A manually-cleaned bar screen is shown in Figure 3.9.



Source: EPA, 2008

Figure 3.9 Manual bar screen

The following are important for O&M of manual bar screen:

A. Preventive maintenance for checking and repairing the following once a week

Check whether the standing platform is at least 2 m wide with the first 1 m as slotted. An example of a risky platform is presented in Figure 3.10.



Figure 3.10 An example of risky platform

There is no space for the operator to stand after he has lifted and dumped screenings on the platform. Because of the lack of space, he may move backwards and fall into the sewage channel. Also, screens should be inclined to the horizontal by an angle of 60 degrees or more, otherwise, the operator has to bend forward. The rear side of the platform should have handrails. If handrails are not provided, enter this point in the site book.

1. Check the condition of ladders and paint them periodically.
2. Verify that there are no broken metal parts that protrude outside.
3. Once a month check the rigidity of handrails.
4. Verify the platform for its sturdiness by gently setting the foot on it.

Verify that the lighting is not in front or behind the operator. It should be above the operator, at least 2.5m high and mounted on the sidewall or separate lamp posts. These lights should not have local on-off switches and must be fully lit in the nights. Verify that the operator platform and slotted platform have 3m head room and provided with roof so that the operator is not drenched and he can lift the cleaning rake freely.

B. Regular maintenance on a daily basis and repairs

1. Verify that the screen rods have not broken loose.
2. Verify that the cleaning rake is well washed in running water after each use.
3. Verify that gum boots are kept inside a locker covered with mesh.
4. Verify that disposable gloves are available for all 3 shifts and a stock of one month is available.
5. Verify that helmet is available.

### C. Operation

1. Before daily operation, verify all the above. If these points are not met, do not enter the screen area. Enter all missing items in the site register.
2. If all items are in order, do the cleaning once in four hours in each shift.
3. Ensure that operators do not stand one behind the other. This may cause an accident because while pulling the rake backwards, the operator in the front may hit and push the operator in the rear into the sewage channel.
4. Once the screens are cleaned and screenings are deposited on the slotted platform allow them to drip dry till the next cleaning after 4 hours.
5. Push the screenings with the rake to the side of the platform to drop them into the tipper positioned there.
6. Move the tipper to the vermin compost site, dump the contents in the pit and cover with earth as prescribed in Sec.3.4.4 "Disposal of Screenings."

#### **3.4.2.2 Mechanical Screen (Intermittent and Continuous)**

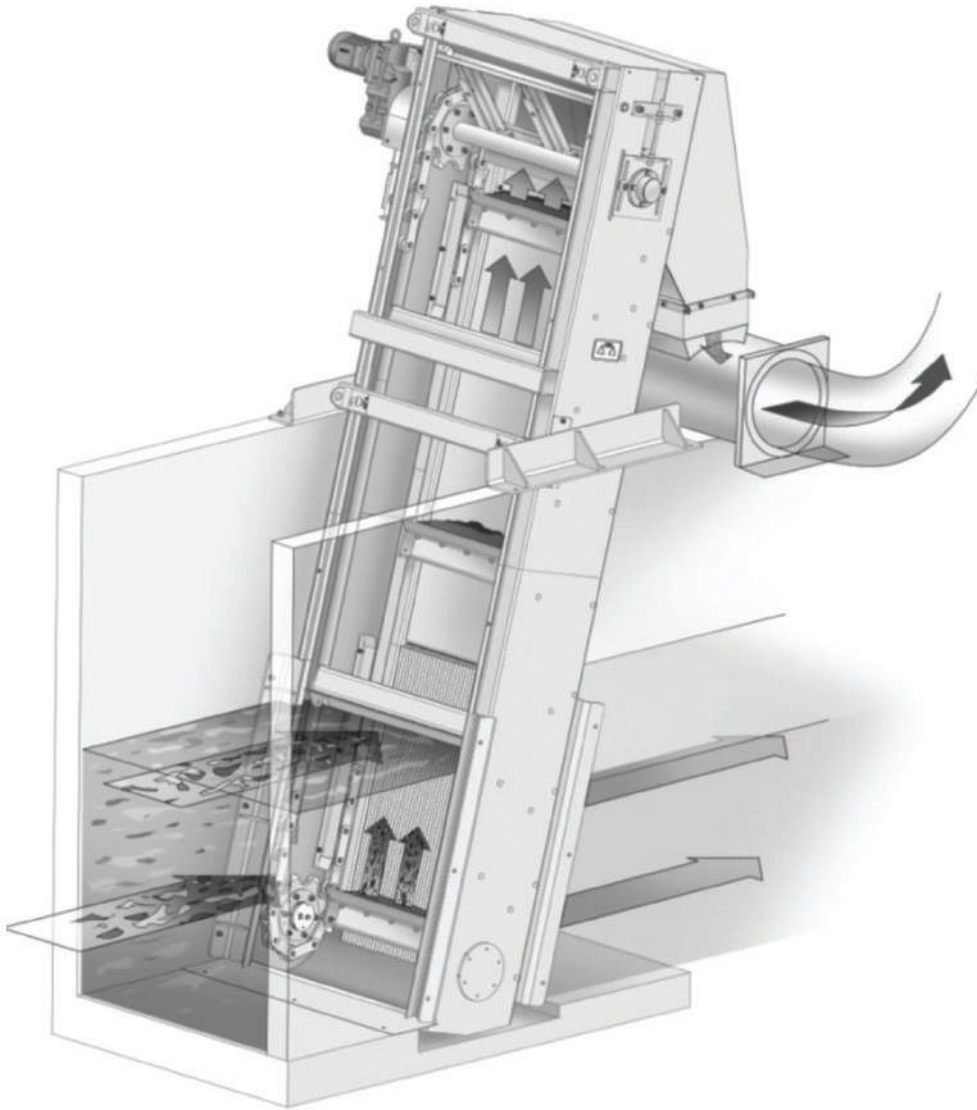
Mechanically cleaned racks are generally erected almost vertically. Additional provision should be made for manual raking in case the mechanical rakes are temporarily out of order. Plants using mechanically cleaned screens have controls for:

- a. Manual start and stop
- b. Automatic start and stop by clock control
- c. High level switch
- d. High level alarm
- e. Starting switch or overload switch actuated by loss of head and
- f. Overload alarm.

There are various types of mechanisms in use, the more common being traveling rakes that bring the screenings up out of the channel and drop them into hoppers or other debris containers. A typical mechanically cleaned bar screen is shown in Figure 3.11 overleaf. The rotary drum screen otherwise known as arc screen by United Nations Industrial Development Organization (UNIDO) is shown in Figure 3.12 overleaf.

In the drawing, the screening rods are in the form of arc. The cleaning takes place when the meshing teeth at both ends of a diametrical rotating arm plough through the screen openings and push the screenings upwards. Upon exiting the upper end of the screen, which is well above the operating sewage level, a built in spring loaded arrangement in the diametrical rods jacks out the meshing teeth gently, which pushes the screenings gently into a collection trough.

The screenings can be manually removed or a conveyor belt can collect the screenings and drop them into a container on the ground through a drop chute.



Source: WEF,2010

Figure 3.11 Mechanically-cleaned bar screen

Refer to Sec.5.6 of Part A of the manual for details of screens.

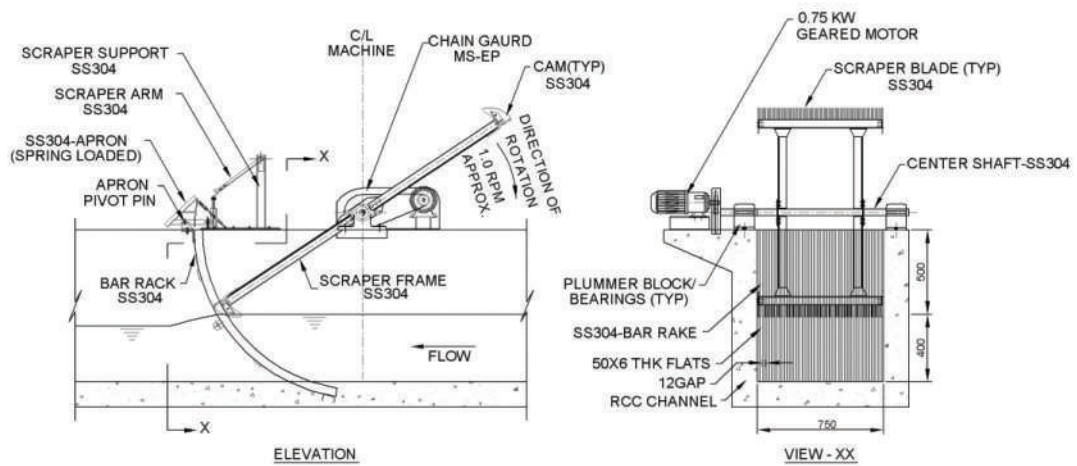
#### A. Preventive Maintenance

- Verify the equipment manufacturer's manual for preventive maintenance instructions and carry out the same (if permitted to be done by the operator).
- Switch off electrical power before doing any work on the mechanical screen.

#### B. Regular maintenance on a daily basis and repairs

- Before start of the day's work, check for any friction between metal parts. If friction exists and the sound is disturbing, disconnect the electric supply and divert all sewage to manual screens. Enter this action in the site register. Do not perform repairs by unauthorized personnel because it is dangerous.





Source: TWAD, 2012

Figure 3.12 UNIDO type arc screen

- Check the alignment of the tipper plates. If the screenings are slipping back and are not going up, allow the machine to work and do not stop it. Enter the abnormality in the site register and request for visit by the manufacturer’s engineer. Do not perform repairs by unauthorized personnel because it is dangerous.

C. Operation

- Before start of the day’s work, do not approach the mechanical screen unless you are wearing, electrical gloves, safety helmet and safety boots.
- Before start of the day’s work, switch off the mechanical screen and restart it. Watch for any friction or sparks. If you notice sparks, disconnect the electric supply and divert all sewage to manual screens. Enter the abnormality in the site register. Sometimes, these sparks can be dangerous and may cause electrocution.
- Follow the procedure for disposing screenings as described earlier.

### **3.4.3 Accessories (Conveyors)**

Belt conveyors are used in conveying the screenings to the trolley parked by the side of the screen chamber. Generally, these are meant only for mechanical screens. For manually operated screens, the water content has to first drip out fully before the screenings can be put on the conveyor. In the case of mechanical screens, the angle is close to vertical, the height is more and dewatering is automatic, but this is not the case with manual screens. If it is to be used, then the conveyor belt has to be behind the operator. The operator first picks up the screenings, drops it on the slotted platform and allows four hours for the screenings to drip fully. Thereafter, he can lift it by the same fork and turn it around 180 degrees and place it on the conveyor belt behind him. On the other hand, in smaller plants he can directly push the screenings to the slotted platform and into the trolley on the ground after the sidewall. All the guidelines for preventive maintenance, regular day-to-day maintenance and operation, and site register entries by the operator are the same as before.

### **3.4.4 Disposal of Screenings**

Screenings generally consist of non-bio degradable stuff like plastic sachets, milk packets, shampoo packets, etc., with very little organic content. Hence, it is best disposed of as a secure landfill, which should be prevented from direct rainfall and flow of overland rainwater. The procedure specified by the pollution control authority should be adhered to without fail.

## **3.5 GRIT REMOVAL**

The different types of grit removal equipment are given in chapter 5 of Part-A of the manual. These are velocity controlled channels, detritors, aerated grit chambers, vortex type, etc.

### **3.5.1 Preventive Maintenance**

Almost all these equipment are patented. Each manufacturer has proprietary schedules for preventive maintenance. These schedules should be followed. Preventive maintenance should be done only by the manufacturer or the erection contractor who has installed the equipment, and not by the operators.

### **3.5.2 Regular Day to Day Maintenance**

The operator should hose the mechanical parts using the high-pressure hose, and pump the final treated sewage so that slime does not accumulate. Where flap gates or turnstiles are provided, the operator should necessarily “exercise” these once a day.

The operator should not enter the chambers unless the sewage entry is blocked, the chamber has been dry for at least two hours and the operator is wearing an oxygen mask. In the case of velocity-controlled channels, the trip switch controlled traveling bridge with suspended suction hoses for each channel connected to a vacuum pump set are standard items. If this system fails and grit accumulates in the channel, each channel should be taken out of sewage flow. The scour valve should be opened below the chamber and the sewage after filtering through the in-built filter port should be allowed to drain to the site drain. Thereafter, the chamber should be allowed to air dry for at least two hours, high pressure water jetting, draining and air drying cycle carried out at least three times.

Subsequently, labourers can be deployed to scrap the grit, provided the labourers wear goggles, gloves, safety shoes and oxygen masks.

In general the vacuum pump is the main source of failure and these types of channels are to be used only in large STPs where other such equipments are also functioning and qualified operators are available in all the shifts.

The vortex type grit separators described in chapter 5 of part A manual are simpler devices to lift and clean the grit and discharge at a convenient elevation above the ground level.

### 3.5.3 Disposal of Grit

The grit is usually pre-rinsed in the grit removal chamber itself before it is evacuated from it. Figure 3.13 shows a typical grit chamber.



Figure 3.13 Typical grit chamber

Clean grit is characterized by the lack of odour. Washed grit may resemble particles of sand and gravel, interspersed with inert materials from households. Grit washing mechanism has to be included whenever the detention time is more and flow through velocity is less. Unless washed, it may contain considerable amount of organic matter. This becomes an attraction to rodents and insects and is also unsightly and odorous. The grit should be contained in a secure landfill as directed by the local pollution control authority or disposed along with the municipal solid wastes, if permitted.

## 3.6 PUMP EQUIPMENT

The types of pumps are dealt with in chapter 4 of Part-A of the manual. These are horizontal centrifugal, vertical shaft centrifugal, dry submersible and wet submersible pumps.

### 3.6.1 Preventive Maintenance

This shall be done only by the manufacturer / his authorized service agency / properly trained staff. The operator shall not carry out preventive maintenance.

### 3.6.2 Regular Day-to-Day Maintenance

This should include the tasks as given in Table 3.1.

Table 3.1 Tasks to be addressed in day-to-day regular maintenance

Description	Comments	Maintenance Interval			
		D	W	M	Y
Earthing	Check whether earthing is proper	yes			
Visual Appraisal	Check that safety aids and first aid are in place		yes		
Gland packing	Check for leaks & condition of mechanical seals			yes	
Alignment	Check alignment using computerized monitor				yes
Oil & Grease	Check for lubrication as per manufacturer			yes	
Motors	Check vibration and temperature		yes		
Mountings	Check for vibrations from foundation bolts			yes	
Bearings	Check for unusual sounds			yes	
Pump sequence	Start & stop the pumps as per duty condition	yes			
Foundation	Check for spalling or cracking			yes	

Note: D: Daily, W: Weekly, M: Monthly, Y: Yearly

Proper operation of submersible pump systems requires that minimum submergence should always be maintained. This is for two primary reasons:

- Prevention of motor overheating
- Prevention of “vortex” and associated problems

The following should be inspected:

- Inspect seal for wear or leakage and repair, if required.
- Visually inspect the oil in the motor housing.
  - Remove pipe plug from housing.
  - Make sure oil is clean and clear, light amber in colour and free from suspended particles.
  - Milky white oil indicates the presence of water.

If the system fails to operate properly, carefully read the instructions supplied during the time of purchase and perform maintenance recommendations.

### 3.6.3 Operation and Maintenance

Before starting the pump, check the following:

- Check insulation resistance by megger at free end of cable and verify with pump manual.

- Check continuity between ends of motor in the same phase and in all phases.
- Check resistance across moisture sensing wires and verify with pump manual.
- Physically rotate the coupling joint and verify smooth movement.
- Check for leaky oil plug and fix it before starting.
- Check for the bulbs indicating the on–off status of the pump and replace fused bulbs.
- Look for warning lamps for alerting the pumped liquid entering the oil chamber.
- Close the discharge valve before starting the pump. This is also taken care by check valve.
- Open the discharge valve gradually and not all of a sudden.
- While the pump is running at full flow, check the power consumed to be within the duty point.
- If the power consumed is very high, stop the pump and inform the manufacturer.
- Switch off the pump only after the discharge valve is closed.

### **3.6.4 Accessories**

#### **3.6.4.1 Oil and Grease**

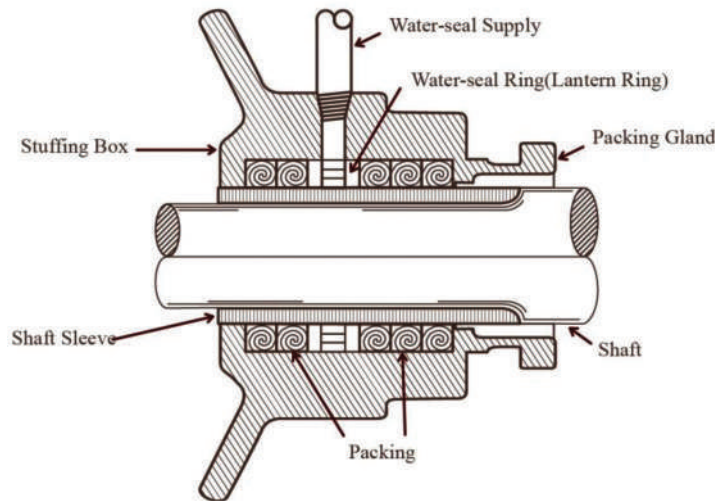
- Pumps, motors and drives should be oiled and greased strictly in accordance with the recommendations of the manufacturer. Cheap lubricants may often become the most expensive in the end.
- Oil should not be put in the housing while the pump shaft is rotating because a considerable amount of oil will be picked up and retained due to the rotary action of the ball bearings. When the unit comes to rest, an overflow of oil will occur around the shaft or oil will flow out of the oil cup.

#### **3.6.4.2 Bearing**

- Pump bearings should usually last for many years if serviced properly and used correctly.
- There are several types of bearings used in pumps such as ball bearings, roller bearings and sleeve bearings. Each bearing has a special purpose, such as thrust load, radial load and speed. The type of bearing used in each pump depends on the manufacturer's design and application.
- Whenever a bearing failure occurs, the bearing should be examined to determine the cause and, if possible, to eliminate the problem.

#### **3.6.4.3 Packing Gland**

- Check packing gland, which is usually neglected and is a troublesome part as shown in Figure 3.14 overleaf.
- If the stuffing box leaks excessively when gland is pulled up with mild pressure, remove the packing and examine the shaft sleeve carefully.
- Replace grooved or scored shaft sleeve because packing cannot be held in stuffing box with roughened shaft or shaft sleeve.
- Replace the packing a strip at a time, tamping each strip thoroughly and staggering the joints. Position the lantern ring (water sealing) properly.



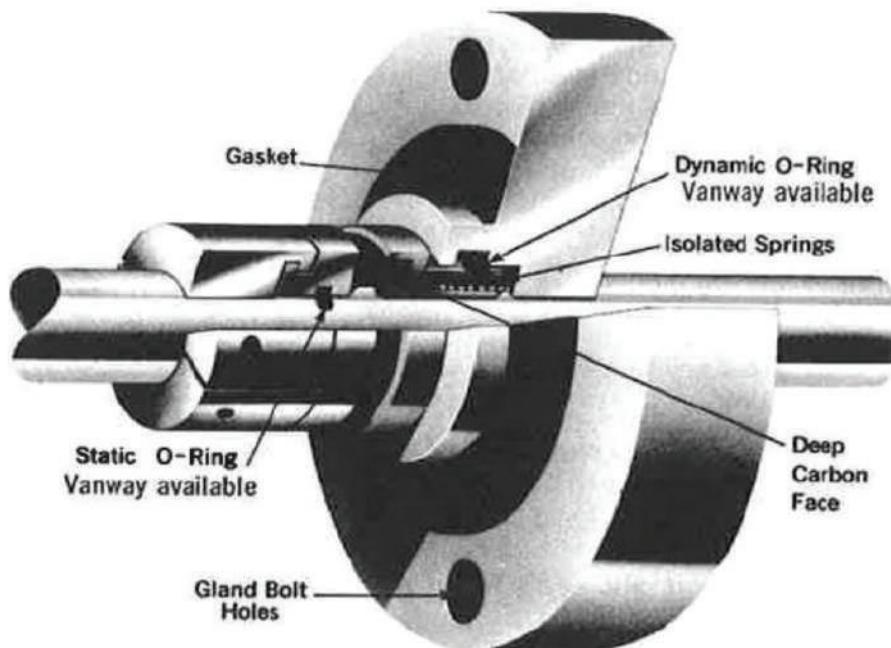
Source: EPA, 2008

Figure 3.14 Packing gland

- If grease sealing is used, completely fill the lantern ring with grease before placing remaining rings of packing in place.
- The proper size of packing should be available in the plant's equipment files.

#### 3.6.4.4 Mechanical Seal

Many pumps use mechanical seals instead of packing as shown in Figure 3.15.



Source: EPA,2008

Figure 3.15 Mechanical seal

- Mechanical seals serve the same purpose as packing; that is, they prevent leakage between the pump casing and shaft. The seals have two faces that close tightly and prevent the sewage from passing through them.
- The different materials are selected for their best application. Some of the factors for selection of material are:
  - Liquid and solids being pumped
  - Shaft speed
  - Temperature
  - Corrosion resistance
  - Abrasives
- Initially, mechanical seals are more expensive than packing when installed in a pump. This cost is recovered through maintenance savings over a period of time.
- Some of the advantages of mechanical seals are as follows:
  - They last from three to four years without any maintenance, resulting in labour savings.
  - Usually, there is no damage to the shaft sleeve at the time of their replacement.
  - Continual adjusting, cleaning, or repacking is not required.

The construction of a mechanical seal is shown below.

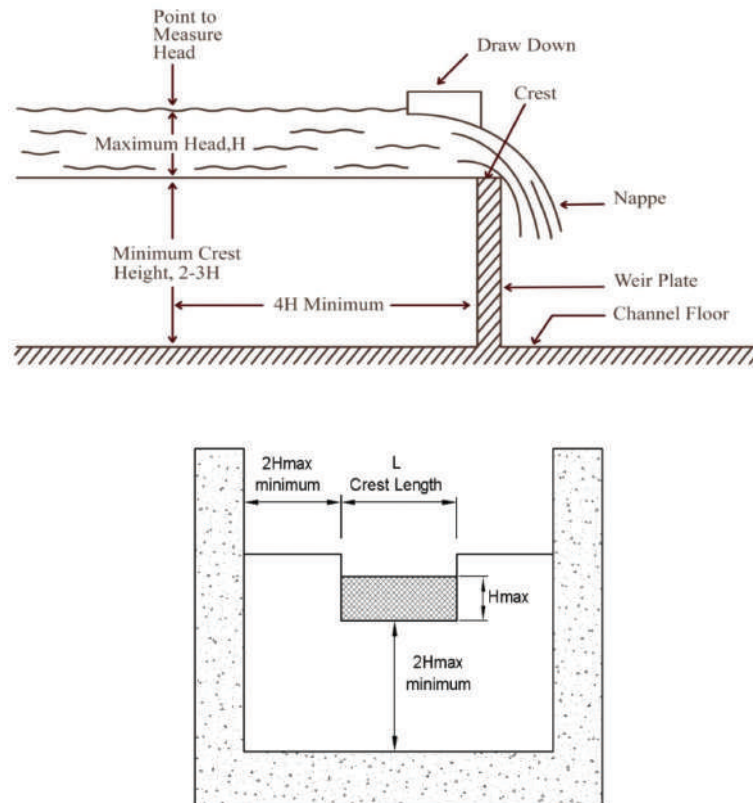
- Whatever be the method used, the mechanical seal must be inspected frequently.
- Grease cups must be kept full at all times and inspected to make sure they are operating properly. When a pump is fitted with a mechanical seal, it must never run dry or the seal faces will be heated up and ruined.
- Mechanical seals should not leak from the gland. If a leak develops, the seal may require resurfacing or it may have to be replaced.
- Repair or replacement of mechanical seal requires the pump to be removed and dismantled.
- Seals are quite delicate and special care must be taken when installing them. Mechanical seals differ widely in their construction and installation, and the manufacturer's instructions must be followed.

### **3.7 FLOW MEASURING DEVICES**

Flow, similar to water level (Refer to Sec.6.5.2 "Level Measuring Equipment"), is one of the most important parameters to be measured. The various types of flow-measuring devices have three basic criteria that determine their performance namely: area, velocity, and device characteristics. The two basic types of flow measurements are open-channel and closed-pipe. For good measuring device performance, both types require approach conditions free of obstructions and abrupt changes in size and direction. Obstructions and abrupt changes produce velocity-profile distortions that lead to inaccuracies.

### 3.7.1 Weir Flow-Meter

A weir measures the liquid flowing in open channels or partially filled pipes under atmospheric pressure as shown in Figure 3.16.



Source: WEF,2008

Figure 3.16 Typical weir section and elevation

This device causes the flow to take on certain characteristics (such as shape and size) depending on the device used.

Changes in flow-rate produce a measurable change in the liquid level near or at the device.

This level is related to flow-rate by an appropriate mathematical formula. The specific device determines the location and accuracy of level measurements and is extremely important for accurate performance.

Measurement errors occur if the actual crest height differs from the designed height due to accumulated matter on the channel floor.

The sediments must be removed.

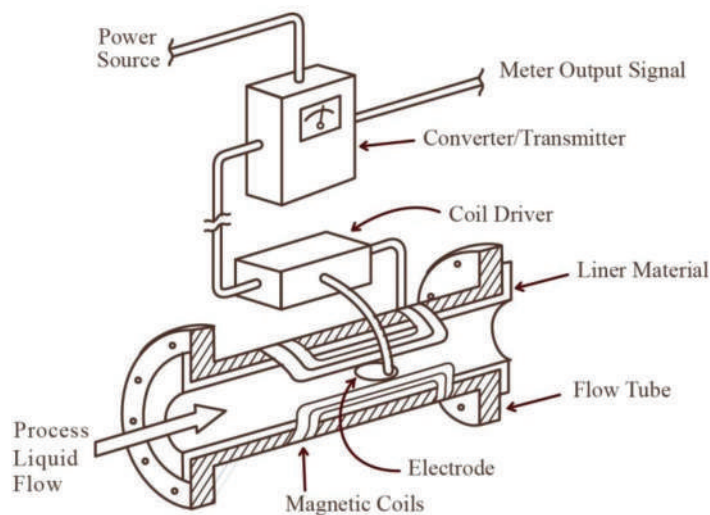
Floating matter or surface wave may cause incorrect level measurements and lead to errors in flow measurements. Therefore, floating matter should be removed immediately.

Section 3.10 of Part A of the manual provides the equations to calculate flow rates of weirs.



### 3.7.2 Electromagnetic Flow-Meter

Magnetic flow meters are used extensively in applications ranging from filtered sewage to thickened or digested solids. They function by electromagnetic induction, in which the induced voltage generated by a conductor moving through a magnetic field is linearly proportional to the conductor's velocity. As the sewage (the conductor) moves through the meter (generating the magnetic field), the voltage produced is measured and converted to a velocity and, thus, a flow-rate. Magnetic meters require a full pipe flow for proper operation. Proper grounding is important for certain brands. In applications where greasing of electrodes is likely, additional equipment for degreasing the electrode may be required. Magnetic flow meters provide no obstructions and are manufactured with abrasion-and corrosion-resistant liners, which is why they are frequently used in solids metering. Repairs should be done only by the manufacturer's representatives. Electromagnetic flow meters rarely break down because they have no moving parts. Dirt on sensors should be cleaned because that may cause error in measurements. The working principle is shown in Figure 3.17.



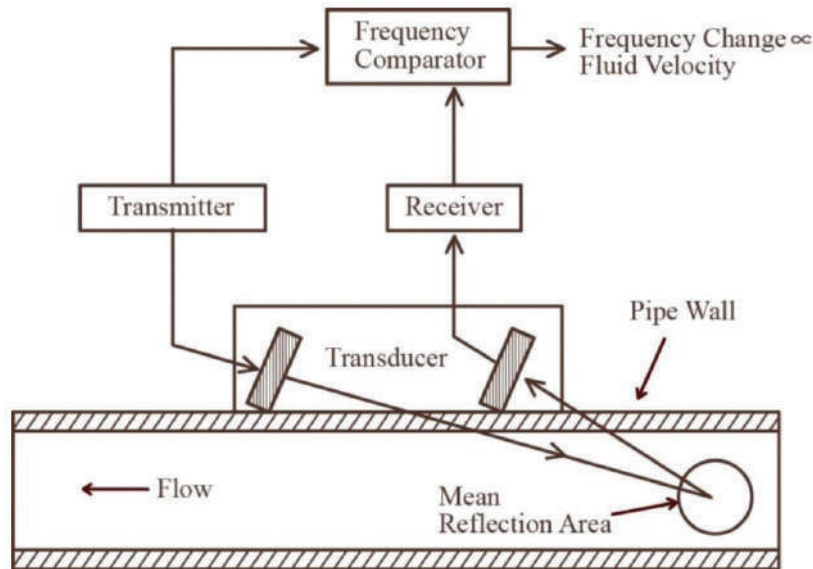
Source: WEF,2008

Figure 3.17 Magnetic flow meter

### 3.7.3 Ultrasonic Flow-Meter

Ultrasonic flow meters are based on the measurement of ultrasonic wave transit time or frequency shift caused by the flowing fluid. An instrument that measures wave-transit time is called a time-of-flight or counter-propagation ultrasonic flow meter.

Ultrasonic waves of known frequency and duration are beamed across the pipe at known angles. The waves are sensed either directly by an opposing receiver or indirectly as reflected waves. The changes in wave transit time or frequency caused by the flowing liquid are linearly proportional to the liquid velocity. This velocity is converted from flow and output to a display by conversion electronics. The presence or absence of air bubbles and density of solids in the fluid being metered affect the meters. Operators should follow the manufacturer's specifications and carefully match the meters to the application. The working principle is shown in Figure 3.18.



Source: WEF,2008

Figure 3.18 Reflecting ultrasonic flow meter

### 3.7.4 Fluorescent Tracers

Fluorescent tracer method requires the use of a tracer like Rhodamine B Dye, which is injected using a peristaltic pump from a small volume of a known concentration of dye solution. The dye is injected into the gravity or pumping main. After traveling and getting mixed, the dye concentration is measured at a distance away. The mass of the dye is the same in the beginning and after traveling. The instrument used is called Fluorometer. The dye will automatically degrade and it does not affect the water body.

## 3.8 PREVENTIVE MAINTENANCE

Equipment has become more complex with the application of advanced technologies and automation systems in recent years. Thus, high technical knowledge is required and technicians, technical tools and special instruments are necessary for implementing preventive maintenance of the equipment. Unlike O&M contractors, manufacturers can provide such skilled staff and special tools. The manufacturers can provide safe and secure maintenance based on their long experience and abundant information on their products. Preventive maintenance after expiry of warranty period should be availed from the manufacturers continuously.

A good maintenance programme is essential for a pumping station to operate continuously at peak design efficiency. A successful maintenance programme will cover everything from mechanical equipment, such as pumps, valves, scrapers and other moving equipment, to the care of the plant grounds, buildings and structures. For preventive maintenance, it is advisable to follow a schedule for the maintenance of the equipment.

The schedule covers recommendations for checks and remedial actions to be observed at different intervals such as daily, monthly, quarterly, bi-annually and annually.

Operators should receive training to obtain more knowledge of characteristics and structure of machinery and to improve their maintenance skill.

#### A. Mechanical Maintenance

Mechanical maintenance is of prime importance, as the equipment must be kept in good operating condition for the plant to maintain peak performance. Manufacturers provide information on the mechanical maintenance of their equipment. Operators should thoroughly read manuals on the plant equipment, understand the procedures, and contact the manufacturer or the local representative if there are any questions. The instructions should be followed very carefully when performing maintenance on equipment. Operators also must recognise tasks that maybe beyond their capabilities or repair facilities, and should request assistance when needed.

#### B. Maintenance of Civil Structures

Building maintenance is another programme that should be maintained on a regular schedule. Buildings in a treatment plant are usually built of sturdy materials to last for many years. Buildings must be kept in good condition by repairs. For selecting paint for a treatment plant, it is always a good idea to have a painting expert help the operator select the types of paint needed to protect the buildings from deterioration. The expert also will have some good ideas as to colour schemes to help blend the plant in with the surrounding area. Consideration should also be given to the quality of paint. A good quality, more expensive material will usually give better service over a longer period of time than the economy-type products.

Building maintenance programmes depend on the age, type and use of a building. New buildings require a thorough check to ensure that essential items are available and are working properly. Older buildings require careful observation and prompt attention to detect leaks, breakdowns and replacements beforehand. Attention must be given to the maintenance requirements of many items in all plant buildings, such as electrical systems, plumbing, heating, cooling, ventilating, floors, windows, roofs, and drainage around the buildings. Regularly scheduled examinations and necessary maintenance of these items can prevent many costly and time-consuming problems in the future.

In each plant building, periodically check all stairways, ladders, catwalks and platforms for adequate lighting, head clearance, and sturdy and convenient guardrails. Protective devices should be around all moving equipment.

Whenever any repairs, alterations or additions are made, avoid building accident traps such as pipes laid on top of floors or hung from the ceiling at head height, which could create serious safety hazards.

Keep all buildings clean and orderly. Supervisory work should be done on a regular schedule.

All tools and plant equipment should be kept clean and in their proper place. Floors, walls and windows should be cleaned at regular intervals to maintain a neat appearance.

### C. Valve Maintenance

Valves should be lubricated regularly (according to the manufacturer's instructions), and valve stems should be rotated regularly to ensure ease of operation. These activities should be part of a regular pump-maintenance programme.

### D. Electric Actuator Maintenance

- Declutch and operate the manual hand wheel.
- Check oil level and top up, if required.
- Re-grease the grease lubricated bearing and gear trains, as applicable.
- Check the insulation resistance of the motor.
- Check for undue noise and vibration and take necessary rectification measures.
- Tighten limit switch cam ends. Check for setting and re-adjust, if necessary.
- Examine all components and wiring thoroughly and rectify as necessary.
- Change oil or grease in the gearbox and thrust bearing.
- Check the condition of the gears and replace them if teeth are worn out.

### E. Flow Meter Maintenance

Each individual sensing meter will have its own maintenance requirements.

The single most important item to be considered in sensor maintenance is good housekeeping. Always keep sensors and all instrumentation very clean. Good housekeeping and the act of providing preventive maintenance for each of the various sensors, includes ensuring that foreign bodies do not interfere with the measuring device. Check for and remove deposits that will build up from normal use. Repair the sensor or measuring device whenever it is damaged.

External connections between the sensing and conversion and readout devices should be checked to ensure such connections are clean and connections are firm. Be sure no foreign obstruction will interfere or promote wear. On mechanical connections, grease as directed; on hydraulic or pneumatic connections, disconnect and ensure free flow in the internal passage.

### F. Maintenance of Pumps

The maintenance schedule should list out items to be attended to at different periods, such as daily, semi-annually, annually and as needed.

#### i. Daily Observations

- Leakage through packing
- Bearing temperature
- Undue noise or vibration
- Pressure, voltage and current readings

## ii. Semi-annual Inspection

- Free movement of the gland of the stuffing box
- Cleaning and oiling of the gland bolts
- Inspection of packing and repacking, if necessary
- Alignment of the pump and the drive
- Cleaning of oil-lubricated bearings and replenishing fresh oil.
- If bearings are grease-lubricated, the condition of the grease should be checked and replaced with correct quantity, if necessary.
- An anti-friction bearing should have its housing packed with grease so that the void spaces in the bearings and the housing are 1/2 to 2/3 filled with grease. A fully packed housing will cause the bearing to overheat and will result in reduced life of the bearing.

## iii. Annual Inspection

- Cleaning and examination of all bearings for flaws developed, if any
- Examination of shaft-sleeves for wear or scour.
- Checking clearances

Clearances at the wearing rings should be within the limits recommended by the manufacturer. Excessive clearances indicate a drop in the efficiency of the pump. If the wear is only on one side, it means misalignment. Not only should the misalignment be corrected, but also the causes of the misalignment should be investigated and the clearances reset to the values recommended by the manufacturers. If the clearance on wear is seen to be 0.2 or 0.25mm more than the original clearance, the wearing ring should be renewed or replaced to obtain the original clearance.

These are to be done by the equipment representative.

- Impeller-hubs and vane-tips should be examined for any pitting or erosion.
- End-play of the bearings should be checked.
- All instruments and flow-meters should be re-calibrated.
- Pump should be tested to ensure proper performance is being obtained.
- In the case of vertical turbine pumps, the inspection can be bi-annual. Annual inspection is not advisable because it involves disturbing the alignment and clearances.

## iv. Annual Maintenance and Repairs

- Consumables and lubricants

Adequate stock of items as packing glands, belts, lubricating oils, greases should be maintained.

- Replacement of spares

To avoid downtime, a stock of fast-moving spares should be maintained. A set of recommended spares for two years of trouble-free operation should be ordered along with the pump.

- Repair workshop

The repair workshop should be equipped with tools such as bearing-pullers, clamps, pipe-wrenches, and other general-purpose machinery such as welding set grinder, blower, drilling machine, etc.

### **3.9 TROUBLESHOOTING**

Refer to Appendix B.3.1 to Appendix B.3.3.

### **3.10 RECORD KEEPING**

The purpose of recording data is to track operational information that will identify and avoid duplicating optimum operating conditions.

A record of equipment performance and repairs allow O&M personnel to properly evaluate equipment's effectiveness and determine if the equipment meets the objectives to justify its purchase and installation.

As a minimum, the following basic information should be maintained for each equipment in the pumping station:

- Plant equipment identification number
- Manufacturer
- Model number and serial number
- Type
- Dates of installation and removal from service
- Reasons for removal
- Location when installed
- Calibration data and procedures
- Hours required to perform maintenance
- Cost of replacement parts
- O&M manuals, references and their locations
- Apparatus failure history

Inspection reports should be prepared for each sewage pumping station according to the equipment installed.

An example of an annual inspection report for pumping station is shown in Table 3.2 overleaf.

Table 3.2 Annual inspection report for pumping station

Pumping station annual inspection report					
Date					
Mechanical	General condition of equipment				
	Sewage pump			Sump pump	Remarks
	No.1	No.2	No.3		
1. Pump					
Bearings					
2. Gates					
Gate operator (manual)					
Gate operator (motor)					
Stems					
3. Crane and hoist					
4. Siphon breaker					
5. Trash racks					
Drive chain					
Bearings					
Gear reducers					
Electrical		Date			
1. Motors					
2. Motor bearing					
3. Switchgear controls					
4. Control panels					
General		Date			
1. Water levels	Elevation			Remarks	
Forebay					
Sumps					
Building and grounds		Date			
					Remarks
1. Sump					
2. Forebay					
3. Discharge chamber					
4. Gatewell to river outlet					
5. Structure					
6. Fire extinguishers					
7. Tools and cabinets					
8. Painting					
9. Caulking					
10. Grating, rails and ladders					
11. Water system and plumbing					
12. Louvers and ventilators					
13. Windows					
14. Doors					
Remarks					

Source: JICA,2011

Recommended maintenance/inspection tasks for equipment in pumping stations are summarised by frequencies and are listed in Table 3.3. Because the required maintenance / inspection and their frequencies may differ depending on the equipment installed, maintenance plans should be prepared according to manufacturer's instruction manuals of related equipment.

Table 3.3 Recommended maintenance for pumping equipment

	start up	monthly	3 month	6 month	1 year	5 year	Oper hrs
Trash rake		GI,O,CL			CL		
Motors				AL	PG	CL	
Heaters	GI						
Gear reducers		GI		CH			
Drive chain	PG						PG
Pillow blocks				PG			
Torque limit coupling					PG		
Shear pin & sprocket		GI					
Trip cam		GI					
Control panel					GI,CL		
Sub-station drainage					GI		
Building structure			GI				
Trash-rack				GI			
Toilet facility				GI			
Domestic water				GI			
Holding tank			GI		PO		
Siphon breakers			GI				
Unit heaters					GI		
Fire extinguishers		GI		GI			
Switch gear	GI						
Bus & connections					GI,CL		
Instruments & lamps	GI				GI,CL		
Heaters					GI		
Lighting panel	GI				GI		
Control panel	GI				GI		
Grounding					GRT		
Float control	GI				GI		
Main pump motors							
Entrance channel						GI,RS	
Sump					GI,RS		
Gates				GI,O,CL			
Stem	GI			CL,SG			
Thrust nut	GI			CL,SG			
Manual operators					PG		
Motor operators					GI,CL		

## Legend

O	Operate	GRT	Ground resistance test	MR	Megger and record
CH	Change	TO	Test oil	PG	Pressure grease
CL	Clean	GI	General inspection	SG	Surface grease
AL	Add lubricant	PO	Pump out	TS	Test
RS	Remove silt	RC	Remove condensate		

Source: JICA,2011



### **3.11 DUTIES OF SITE ENGINEER IN CHARGE AND HIGHER UPS**

The site engineer should first check the entries of the operator in the previous three shifts and take corrective action, or alert the supervisor by e-mail and make an entry in the site register. If the site engineer cannot correct the problem within two weeks, he should directly send an e-mail message to the plant incharge. If no action is taken even after two weeks, the complete responsibility will rest with the plant incharge from then onwards, including the responsibility for any accidents/fatalities caused by not taking the requisite action.

### **3.12 IF THE PUMPING STATION IS UNDER O&M BY THE CONTRACTOR**

The references to operator, site engineer and plant incharge inevitably apply to the staff of the contractor also. The engineer in charge of supervising the contractor's work should review the site register once a fortnight and institute such remedies as available under the contract.

### **3.13 SUMMARY**

The most important thing for O&M of pumping stations is to minimize suspension time due to equipment failures and to maximize the life of pumps. For accomplishing these targets, the following causes of breakdown of pumps should be eliminated:

- Inflow of screenings into pumping stations
- Overloading of pumps

Preventive maintenance is also essential for detecting abnormalities in their early stages.