Conveyance System

Introduction:
Whenever the water is withdrawn from a surface source such as lake or a river or a reservoir, and the entrance of the withdrawn conduit is not a part of an integrated part of a dam or any other related structure, when an intake structure must be constructed at the entrance of the conduit.

The basic function of the intake structure is to help in safely withdrawing water from the source over a predetermined range of pool levels and then to discharge this water into the withdrawal conduit.

Intake Structure:
An intake structure constructed at the entrance of the conduit and thereby helping in protecting the conduit from being damaged or clogged by ice, trash, debris etc. can vary from a simple concrete block.
Supporting the end of he conduit pipe to huge concrete towers housing:

(i) Aerobic bacteria - those which require oxygen for their survival.

(ii) Anaerobic bacteria - those which flourish and in the absence of oxygen.

(iii) Facultative bacteria - those which can survive with or without free oxygen.

**Water Quality Standards**:


2nd set - 1984 (Revised).

**India**:

1949 - Environment Hygiene Committee (1949).

Intake Structures:

Whenever the water is withdrawn from a surface source such as a lake or a river or reservoir and the entrance of the conduit is not an integral part of a dam or any other related structure, then an intake structure was constructed at the entrance of the conduit.

The basic function of the intake structure is to help in safe withdrawing water from the source over a predetermined range or point levels and then to discharge this water into the withdrawal conduit, through which it flows up to the water treatment plant.

The site for locating the intake should be selected by keeping the following points in mind.

1) The site should be near to the treatment plant so that the cost of conveying water to the city is less.
(i) It should be located in the pure zone of the source so that the best possible quality of water is withdrawn from the source.

(ii) Never be located at the downstream or point of disposal of wastewater when it becomes necessary, it is advisable to construct a weir or a barrage upstream of the disposal point and install the intake upstream of the barrage.

(iii) Never be located near navigation channels.

(iv) Site should be such as to permit greater withdrawal of water, if required at a future date.

(v) Must be located at a place from where it can draw water even during the driest period of the year.

(vi) The intake site should remain easily accessible during floods and should not get flooded.
(viii) In mean during rivers, the intakes should not be located on curves or almost on sharp curves.

Types of Intakes:

Intakes are used to collect water or water works from various sources. The sources may be lakes, rivers, reservoirs or canals.

Depending upon the source of water, the intake works are classified as:

1. Lake Intake.
2. Reservoir Intake.
3. River Intake.
4. Canal Intake.

Lake Intake:

For obtaining water from lakes, mostly submersible intakes are used. These intakes are constructed in the bed of the lake below the slow water level so as to draw water in dry season.
It is essentially consists of a pipe laid in the bed of a river. The middle of the lake is fitted with a mesh and protected by timber or concrete block. The water enters in pipe through the bell mouth opening and flows under gravity to the river bank where it is collected in a sump well and then pumped to the treatment plant for necessary treatments.

These intakes have some advantages such as no obstruction to navigation, no danger from floating bodies, no trouble due to ice.

If one pipe is not sufficient two or more pipes are laid to get required quantity of water.

These type of intakes draw small quantity of water, these are not used in big water supply schemes or on rivers or reservoirs.
River Intake:

Water from the river is always drawn from the upstream, because it is free from the contamination caused by the disposal of sewage in it.

It is a circular masonry tower of 4 to 7 m in diameter constructed along the bank of the river at such places where required.

The required quantity of water can be obtained even in dry periods. The water enters the lower portion of the intake known as sump-well from penstocks.

The penstocks are fitted with a screen, check the entry of floating solids and are placed on the downstream side so that water free from most of SS may only enter.

The water from the sumpwell of the intake in upra portion of the intake are shown in Fig (i).
No. of penstocks openings are provided in the intake tower to admit water at different levels.

The opening and closing of penstock valve is done with the help of wheels provided at the pump house floor.

![Diagram of River Intake and Reservoir Intake with labeled parts: HFL, Pump, Screen, etc.]

The discharge of some rivers in summer remains sufficient to meet up the demand, but some rivers dry up partly or fully and cannot meet the hot weather demand. In such cases, reservoirs are constructed by constructing weir or dam across the river.
Figure shows a reservoir intake which is mainly used to draw water from an earthen dam reservoir.

It is essentially consists of an intake tower constructed on the slope of the dam at such place from where intake can draw sufficient quantity of water in drier period.

Intake pipes are fix at different levels, so as to draw water near the surface in all variations of water level. Screens are provided at the mouth of the all intake pipes to prevent the entrance of floating and suspended matter in them.

The water which enters the vertical pipe is taken in to the other side of the dam by means of an outlet pipe. At the top of the intake tower, sluice valves are provided to control the flow of water. The valve tower is connected to the top of the dam by means of a foot bridge - very way for reaching it.
In case of earthen dam intake towers are separately constructed by but in RCC or masonry dams it is constructed inside the dam itself and only pipes or intake pipes are provided at various levels as shown in figure.
Canal intake is very simple structure constructed on the bank. It essentially consists of a pipe placed in a brick masonry chamber constructed partially in the canal bank.

On one side of the chamber an opening is provided with coarse screen for the entrance of water. The end of the pipe in side chamber is provided with a bell mouth fitted with a hemispherical fine screen as shown.

The outlet pipe carries the water to the other side of the canal bank from where it is taken to the treatment plants.

One sluice valve which is operated by a wheel from the top of the masonry chamber is provided to control the flow of water in pipe.
Conveyance of water:

Water is drawn from the source by intakes. After its drawing the next problem is to carry it to the treatment places which are located usually within the city limits.

After collection the water is conveyed to the city by means of conduits. If the source is at higher elevation than the treatment plant, the water can flow under gravitational force.
for the conveyance of water at such places we can use open channel, aqueduct or pipe line mostly it has been seen that water level in the source is at lower elevation than the treatment plant. In such cases water can be conveyed by means of closed pipe under pressure.

Open Channel:

Open channels are occasionally used to convey the water from the source to the treatment plant. These can be easily and cheaply constructed by cutting in high grounds, and banking in low grounds.

The channel should be lined properly to prevent the seepage and contamination of water; flows only due to gravitational force, a uniform longitudinal slope should be given. The level of water in channels
Should not exceed the permissible limit otherwise scouling will start in the bed and water will get dirty.

In channel there is always a loss of water by seepage & evaporation.

Aqueduct:

An aqueduct is the name given to the closed conduit constructed with masonry used for conveying water from source to the treatment plant or point of distribution.

An aqueduct may be constructed with bricks, stones or reinforced cement concrete. In older days rectangular aqueducts were used, but now a days horse-shoe or circular section are used. The aqueduct are masonry constructed with cement concrete. The avg velocity should be 1.0m/s.
Tunnels! (Long passage made under the ground).

This is also gravity conduit in which water flows under gravitational force. But sometimes water flows under pressure and in such cases, these are called pressure tunnels.

Ceramic tunnels are mostly constructed in horse-shoe c/s but pressure tunnels are circular c/s.

In pressure tunnels, the depth of the overlay material will be sufficient to check bursting pressure.

Tunnels should be water tight and there should be no loss of water.

Corrosion Control:

1. Protective Coating:
   The inner surfaces are coated with coatings of paint, galvanizing, bituminous compounds, cement lining etc. so as to protect the metal pipe itself from corrosion. Red lead paint was commonly used.
Selection of Proper Pipe Materials:

The pipe metal may be so chosen as to be more resistant to corrosion. Certain alloys of iron or steel with chromium, copper or nickel have been found to be better than the pure iron or steel.

Quality of Water:

The water passing through the pipe should be made as less corrosive as possible. This can be accomplished by raising PH of water by adding certain chemicals that reduce corrosion.

Cathode Protection:

Electrolytic corrosion can be prevented by connecting the pipe with the positive terminal of DC generator and connecting the negative terminal with blocks of zinc or magnesium buried near the pipe. This ensures the flow of a current from the buried block towards the pipe which is in opposition to the corrosion process of electrolysis.
Testing of Pipe lines

Pressure Testing

(i) The pipe line is tested from section to section. Thus at a time only one particular section lying btw two sluice value is taken for testing.

(ii) The d/s value is closed, water is admitted into the pipe through the upstream sluice value. The air valves will be properly operated during filling up of the pipe.

(iii) The u/s value, through which water was admitted is closed, so as to completely isolate the pipe section from the rest of the pipe.

(iv) Pressure gauges are then fitted along the length of the pipe section at suitable intervals on the crown known holes.

(v) The pipe is connected to the delivery side of a pump through a small by pass valve, & the pump is started so as to develop pressure in pipe.
(vi) The by-pass valve is then closed and the pumping is discontinued.

(vii) The pipe is thus kept under pressure for 24 hrs and inspected for possible defects, leakages at the joints etc.

*Disinfection of pipe lines before use*

When the pipe lines are carrying treated water, they must be disinfected before use. The pipes are disinfected by keeping them full with water and adding chlorine in amounts as to maintain a residue of 0.5 mg/l.

This residue is maintained for 12 hrs and the pipe is emptied and flushed with fresh treated water, thus making the pipe ready for carrying potable water to the consumers or for storage tanks.
Factors Considering the Selection of Particular Pipe Materials:

1. Carrying Capacity of Pipe
2. Length + Weight of Pipe
3. Nature of Soil
4. Quality of Water

Stress in Pipes:

(i) Internal Water Pressure:
- Causes hoop tension in the pipe shell. Causes flow of water.

(ii) Stresses due to External Loads:
- When water supply pipes are buried underground, they are subjected to weight of the backfill and the external loads if the pipe is under a road.

(iii) Temperature Stresses:
- Temperature stresses are caused in metal pipes when they are laid above ground.
Stresses at Bends:

When water flows through a pipe bend, an outward thrust is exerted on the pipe due to the combined action of the pipe's unbalanced internal pressure ($P_i$) contributed by the moving water.

Water Hammer:

Water hammer effect is produced when the velocity of water in the pipe is checked suddenly by sudden closure of a valve. Suddenly, by sudden closure of a valve, there will be a sudden rise in pressure due to the momentum of the moving water being destroyed.

$$P_{\text{max}} = \frac{W}{g} \cdot U_p \cdot V_0$$

$U_p$ → Velocity of pressure wave generated.

$$P_{\text{max}} = \frac{W}{g} \cdot \frac{V_2}{\sqrt{1 + \frac{Kw}{E_p}}} \cdot \frac{d}{L}$$
\[ V_s = \sqrt{\frac{Kw}{e}} \quad \text{m/s} \]

\[ P = \frac{W}{g} \]

- \( Kw \) = Bulk modulus of water (2.07 x 10^9 N/m²)
- \( E_p \) = Modulus of elasticity of Pipe material (kg/m²)
- \( d \) = Diameter of Pipe (m)
- \( t \) = Thickness of Pipe (m)
- \( V_o \) = Normal velocity of flow in the pipeline before sudden closure.

Disinfection of pipe lines before use:

When new pipe lines are coming treated water, they must be disinfected before use.

The pipes are disinfected by keeping them full with water and adding chlorine in amounts as to maintain a residue of 50 mg/l.

This residue is maintained in 12 hrs. Then pipe is emptied and flushed with fresh heated water.
Thus making the pipe ready for carrying potable water to the consumers or for storage tank.

Factors considering in selection of particular pipe materials:

1. Carrying capacity of pipe
2. Length & weight of pipe
3. Nature of soil
4. Quality of water.

Pipe is a circular closed conduit through which the water may flow either under gravity or under pressure. When pipes do not run full, they run under gravity, such as in sewer lines, however in supply mains, pipes mostly run under pressure. Pipes may be made of the following materials.
Cast iron pipes are used in great majority of water distribution mains because of centuries of satisfactory experience with it. Cast iron pipe is resistant to corrosion and accordingly a longer lived. These are manufactured by two methods.

(i) Ordinary sand moulding process, (ii) Centrifugal process.

In sand casting molten metal is poured into sand lined moulds that are set in either a vertical or horizontal position. Horizontally cast pipes are more prevalent than pipes. In centrifugal process, pipes may be cast either in a sand mould or in a water cooled metal mould.

Cast iron pipes are generally cast in length of 3-6M.
Wrought Iron and Galvanized Iron Pipes:

Wrought iron pipes are manufactured by rolling a flat plate of wrought iron to the proper diameter and welding the edges. Such pipes are much cheaper than CI pipes and can be easily cut, screwed, or welded. They corrode easily and hence are used principally for installation within buildings protected by coating them with a thin film of molten zinc. Such coated pipes are known as cast iron pipes and are commonly jointed by screwing or socketed joint.

Steel Pipes:

Steel pipes of small diameter can be made from the solid, but the larger size are made by riveting or welding together the edges of suitably curved plates. The socket being formed as shown in fig. Steel pipes cannot be easily made to resist high external pressures.
Concrete pipes:

CC pipes may be either plain or reinforced and are best made by the spiling process. They may be either precast or may be prepared at the site. The plain cc pipes are used for heads up to 7 m, while reinforced cement concrete pipes are normally used for heads up to 60 m.

For heads higher than this, prestressed concrete pipes are used, whereas pipes are used only for large water supply lines but they are not suitable for distribution systems. Water treatment in low pressure reinforced concrete pipe is obtained by providing sufficient thickness of good concrete.

Asbestos cement pipes:

Asbestos cement pipes are manufactured from asbestos fibre and Portland cement combined under pressure to form a dense homogeneous structure having strong bond with asphalt.
Copper and lead pipes:

Copper pipes are very costly and their use is restricted for conveyance of hot water in the interior of buildings and for making gooseneck in the service connections. They are also resistant to corrosion by acidic bend due to hot water.

Lead pipes are very soft and can be easily bent due to this property. They are extensively used in service connections and for internal plumbing. Due to the cumulative poisoning effect of lead, these are not suitable for conveying acidic water. They are used for apparatus requiring for alum and chlorine doses.

Wood stove pipes:

Wood stove pipes are prepared by steves or planks of wood held together by steel bands. They have been used for many years, for wood pipes though they were replaced due to lack of capacity.
Plastic pipes:

Plastic pipes are of recent origin. They are made of synthetic resins of high molecular weight, polymerized from simple molecular compounds by heat, pressure, and catalytic action. Plastic pipes and tubes are manufactured from a number of polymerization products such as polythene, polypropylene, polyvinyl chloride, and cellulose acetate butyrate.

Pipe Appurtenances:

Create values or sluice values:

Introduction:

In order to isolate or drain the pipe line sections for tests, inspections, cleaning or repairs a number of appurtenances such as gates, valves, manholes, insulation, joints, expansion joints, anchorages etc are provided at various suitable places along the pipe lines.
Gates and valves in pipe lines \(\text{or} \) sluice valves.

Valves are used to regulate the flow of water through pipes. They are similar to gate valves in dams but not so large. They are generally located along the pipe line at intervals of about 3-5 values usually placed at the points nearer to the hydraulic gradient line.

Air valves

A special kind of valves which are generally placed along the pipe line at summits or both sides of the sluice valves and also on the sides of all other sluice valves. These valves are ensured the safety of the pipe against collapse. They will protect against the
negative pressure which may develop when the steady flow is suddenly closed.

Air inlet valve → allowing air to enter the pipe.

Air relief valve → To remove accumulated air.

Blow off or Drain or Scour valves:

In order to remove the entire water.

In order to remove the entire water from within a pipe, small gated off-takes are provided at low points.

These valves are necessary at low level points for completely emptying the pipe for inspection, repairs etc.

Pressure relief valves:

Water hammer pressure in pressure pipe can be reduced by using pressure relief valves.

Such a value is adjusted to open.
automatically as soon as the pressure in the pipe exceeds a certain fixed predetermined value. Due to the opening of this valve, water will get out of the pipe and the pressure in the pipe will reduce. As soon as the water hammer pressure reduces at the pump, the valve will close automatically.

Check or Reflex Valves:
They prevent water to flow back in the opposite direction. They may be installed on the delivery side of the pumping set, so to prevent the back flow of stored or pumped water, when the pump is stopped. Check valves are also known as non-return valves.

Manholes:
Manholes are provided at suitable intervals along the pipe lines at suitable intervals, so as to help in laying and repairing of the pipes at the intervals of 300-600 m.
Insulation Joints:
Insulation joints are provided along the pipeline at suitable intervals, so as to
protect the pipe against the flow of stray electric currents. This is to check electrolysis.
Rubber gaskets or rings can be provided as insulators in between the length of pipe.

Anchorages: (To maintain pressure)
The pipes try to pull apart and get out of the alignment at bends or other points of unbalanced pressure. At such places, the forces exerted on the joints due to longitudinal shearing stresses caused by these unbalanced pressure are enormous and the joints may get opened, ultimately leading to excessive leakage or failure of the pipe.

In order to prevent the pipes from being thrown open, the pipes are anchored by
massive anchorage.
Pumps & Pumping

Necessity of Pumps:

In majority of cases, pumping is required to lift the water from the river, lake, or reservoir to the treatment plant. The pumping is therefore required for the following purposes:

(i) To lift the raw water from the source of supply, such as lake, reservoir, river or well.

(ii) To lift the treated water to overhead tanks or reservoirs.

(iii) To deliver treated water to the consumer at reasonable pressure.

(iv) To boost the line pressure.

(v) To supply water under pressure for fire hydrants.

(vi) For miscellaneous operations at the water treatment plant, such as (i) for back washing of filters, (ii) for pumping chemicals, (iii) for de-watering of tanks, basins, sumps etc.
Types of pumps:

Pumps can be classified on the basis of the following:

(i) Mechanical principle of operation.
   (ii) Type of power required.
   (iii) Type of service called for.

a) Classification based on mechanical principle of operation:

   (i) Displacement pumps.
   (ii) Centrifugal pumps.
   (iii) Air lift pumps.
   (iv) Miscellaneous pumps.

b) Classification based on type of power required

   (i) Steam engine pump
   (ii) Diesel engine pump
   (iii) Electrically driven pump

   (iv) Classify based on type of service:

   (i) Low lift pumps.
   (ii) High lift pumps.
   (iii) Deep well pumps.
   (iv) Booster pumps.
The selection of particular type of pump depends upon the following factors:

(i) Capacity of pump
(ii) No of pump units required.
(iii) Suction condition.
(iv) Lift (Total head).
(v) Discharge condition or variation in head.
(vi) Flow space requirement.
(vii) Flexibility of operation.
(viii) Starting & priming characteristics.
(ix) Type of drive required.
(x) Initial cost & running costs.

Types of Centrifugal Pumps:

A radial or a mixed flow impeller which constitutes or centrifugal pump may be either be open or closed.

The open impeller consists of a hub to which the vanes are attached, which closed impeller is having plates on each side of the vanes.
In a turbine type or diffuser type of pump, the impeller is surrounded by stationary guide vanes which reduce the velocity of water before the water enters the casing, thus converting the velocity head into pressure head in the casing itself.

The casing surrounding the guide vanes is generally circular with the impeller.

The velocity of the water thus more completely converted into pressure head, resulting in higher efficiency than is possible in a vane pump.

- One impeller = single stage pump.
- Two or more impellers = double stage pump.
- Multistage Pump.

There are various types of pumps, but the two types which the hydraulic engineers generally encounter are:

1. Roto dynamic pumps.
2. Displacement pumps.

The roto dynamic pump has a wheel or a rotating element which rotates the water in a casing, thus imparting energy to the water.
There are two types:

(i) Centrifugal pump.

(ii) Axial flow pump.

A displacement pump works on the principle of mechanically including vacuum in a chamber, hence by drawing in a volume of water, which is then mechanically displaced and forced out of the chamber.

(iii) Reciprocating pump.

(iv) Rotary type pump.

The rotary dynamic pumps do have a wheel type rotating element called impeller. The shape of the impeller may be such as to force the water outward in a direction at right angles to its axis or to give water an axial as well as a radial velocity (mixed flow), or to force the water in the axial direction alone (axial).

Radial & mixed flow machines → Centrifugal pumps.
Axial flow machines → axial flow pumps.
A centrifugal pump may have to be primed before it started. The priming consists of filling the pump casing with water, so that the air trapped in the pump does not hinder its operation to reduce its efficiency.

To fill the pump with water from an outside source, while permitting the displaced air to escape through an exhaust valve.

Certain pumps are provided with vacuum pumps to remove the air from the casing.

Advantages & Disadvantages:

1. Initial cost as well as maintenance cost are comparatively low.
2. Size is compact and can be installed in limited space.
3. Mechanism is simple.
4. Discharge obtained is steady.
5. It can be used for pumping water containing silt, sand etc.
6. Durable & safe against high pressure.
Reciprocating Pumps

The simplest type of a reciprocating pump, which is still widely used in rural areas, is a hand-operated well pump. In such a pump, a piston or plunger reciprocates in a closed vertical cylinder. This is moved up and down by hand. On the upper side, a vacuum gets created below the piston, thereby opening the check valve. On the next stroke, the water above the piston value gets opened, permitting water to enter the cylinder above the piston. The cycle is then continued, and a continuous supply of water can be obtained.
Advantages:

(i) Very useful for very high and variable heads with low discharge.
(ii) They are durable and flexible.
(iii) High efficiency is possible.

Disadvantages:

(i) Initial cost of installing the pump is high.
(ii) It is occupy large space.
(iii) Unsuitable to pump water with sediments.
(iv) Maintenance charges are high.

Rotary Pump:

A rotary displacement pump, that rotary motion is used in place of a reciprocating motion as is used in reciprocating type.

The rotary motion is obtained by using two cams or two gears, which mesh together in opposition direction.

These hit the casing closely. The water enters through the suction pipe and is trapped between the cams and gears.

It is then forced out through the discharge pipe, as the cams or the gears rotate.
Advantages:
(i) Not require any priming.
(ii) Flow in pump is free from pulsation.
(iii) Simple to construct & easy to repair.
(iv) Efficiency is high @ low moderate head.

Disadvantages:
(i) Initial cost is high
(ii) They are not durable
(iii) Water containing sediments are very injurious to such pumps.

Air Lift Pump:

Air lift pumps are generally used for pumping water from deep wells for lifts of about 60-80m.

A typical arrangement of an air lift pump is shown in figure. In such pump, compressed air is forced into the well through a small air pipe & is released through a diffuser into the suction pipe at the bottom of the well.

The air rises small bubbles in the suction pipe thus forming a mixture of air & water. This resulting mixture of air & water inside the suction pipe is
Lighter than the water outside the pipe, hence is forced upward by hydrostatic pressure, finally coming out through the outlet at the top.

Advantages:

1. Generally cheaper, simple + reliable in operation.
2. No moving part in pump.

Disadvantages:

1. Generally not adopted for raising water much above the ground level.
2. Efficiency is low.
3. Flow obtained is not continuous but intermittent.
4. They are less flexible in fulfilling variable demands.

Jet Pumps:

Jet pumps are often used for pumping water from small wells. They are portable + sometimes used in construction works for dewatering trenches.

In this pump compressed air or steam or water is made to enter the pipe A, which is nozzled at its discharging...
end, thus forcing out through the nozzle. The jet of compressed air thus comes out of the nozzle at high velocity & discharge into the throat of another pipe (b) as shown. This high velocity jet creates a suction which draws the water up the pipe & finally discharge through the discharge end.

Advantages:
(i) It can also handle sediment water.
(ii) They are compact & light in weight

Disadvantages:
(i) Efficiency is low.