CHAPTER - 10

ANCILLARY EQUIPMENT

10.1 BLOWERS

Blowers are required to obtain the required volume of air at required pressure for the back washing of filters in water treatment plants. They should be designed to produce oil-free air. Blowers employ two balanced specially profiled rotating impellers driven by a shaft extension from one of the impellers. As each lobe of an impeller passes the blower inlet, it traps a quantity of air and sweeps it round the case to the blower outlet. Timing gears accurately position the impellers in relation to each other maintaining the correct clearance vital to the volumetric efficiency. Blowers are generally coupled to electric motors through a Vee-Belt drive.

The blower capacity is generally specified in m^3/h at the required discharge pressure above atmospheric pressure.

For filter washing in water treatment plants a rate between 0.015 to 0.025 $m^3/m^2/sec$ of air at a discharge gauge pressure between 200 to 300 mbar is being used.

The following points are important when specifying air blowers;

* **Oil free air**
* **Guarding of belts**
* **Heavy duty bearings for long life.**
* **Silencing**
* **Pressure gauges and relief valves**
* **Non return valves and flexible connections.**

Packaged type air blower units are available where blower unit with the drive motor and other accessories are mounted on steel channel base.

10.2 LIME AND ALUM PUMPS

10.2.1 INTRODUCTION

Most of our Lime and Alum pumps fall into the positive displacement category. The diaphragm, Piston or the plunger is moved forwards and backwards at a controlled rate. These pumps which can displace a predictable quantity of liquid in discrete strokes, the desired control being applied by varying the stroke length and or the stroking speed are also called metering pumps.

10.2.2 PUMP HEADS

These pumps come with three different pump heads. They have their own advantages and disadvantages depending on the application.

10.2.2.1 PLUNGER HEADS

Plunger type pumps give the best accuracy at a price. Its disadvantage being the gland also and very vulnerable when liquids with fine abrasive particles are dosed. There have been many failures of this plunger type lime dosing pump due to presence of fine sand particles in lime.

10.2.2.2 MECHANICALLY ACTUATED DIAPHRAGM HEADS

Mechanically actuated diaphragm pumps can be easily maintained but they are not so accurate as the plunger type. Nowadays the manufacturers give a 5 year guarantee for the diaphragm and also an alarm signal is given in case of a diaphragm leakage. It is the author's view that this type of pump heads are the most suitable for our applications.

10.2.2.3 HYDRAULICALLY ACTUATED DIAPHRAGM HEADS

Hydraulically Actuated diaphragm heads give very good accuracy and also can produce high working pressures.

10.2.3 PERFORMANCE

A plunger pumphead efficiency will be virtually unaffected by increased delivery pressure and will be around 95%. A mechanically actuated diaphragm head has similar performance but over a very much smaller pressure range. (Typically 0-5 bar). In the case of plungerheads the variation of flow rate is linear with stroke length but the mechanically actuated diaphragm heads are not quite linear in this respect, but is sufficiently good enough for may duties. The stroke length is adjustable from 0-100%.

10.2.4 SAMPLE CALCULATION

Raw water flow rate = 75 m^3/hr.

Jar Test Analysis requirement of Alum = 30 ppm

Strength of Alum dosing solution = 10%

Let X be the flow rate of Alum Solution in m^3/hr.

$$X \times 10/100 = 30 \times 75/10^6$$

$$X = 22.5 \text{ l/hr.}$$

Keeping a margin of safely 3.3 approximately

Alum dosage would be 75 l/hr. at the existing head at full stroke length.

Under these conditions the required dosage could be obtained at 30% of the stroke length leaving sufficient adjustment for increasing demands.

10.2.5 COMPARISON OF DIFFERENT TYPES

	Plunger	Mech. Act. Diaphragm	Hydraulic Diaphragm	Solenoid Diaphram
Accuracy	High ± 1%	Moderate ± 3%	High ± 1%	Low ± 10%
Linearity	Excellent	Moderate	Excellent	Non-Linear
Pressure Range	High 0-500 bar	Low 0-10 bar	High 0-500 bar	Low 0-10 bar
Capacity Range	Widest 0-5000 l/hr	Small to very high	Medium Range 1-1000 l/hr	Low 1-100 l/hr
Comparative Cost	Average	Low cost for high capacity	Highest	Lowest
Main Advantages		Glandless	Glandless & high pressure.	Low cost

Table 10.1 - Comparison of different heads

(Source : Horgan, Metering Pumps Ltd. 1986)

10.2.6 INSTALLATION

It is of utmost importance that the selected pump is installed properly according to manufacturers instructions with all necessary accessories for proper operation. The important features are summarized below;

* The solution tank should be as close as possible to the pump and the liquid level should be always slightly above the pump centre line. Electric stirrers should be provided to the solution tanks to provide adequate agitation.

* It is essential that the discharge head exceed the suction head by at least 0.5 bar or more. Otherwise siphoning will occur. If the delivery head is not sufficient, a pressure retention valve of the spring type should be installed immediately after the pump.

* The system and the pump should be always protected. A relief valve should always be installed in the system.

* In the case of long pipe lines the friction and acceleration effects can produce unacceptable back pressure. In such situations pulsation dampers should be incorporated in the system.

10.2.7 PACKAGED TYPE DOSING SYSTEM

Now packaged type dosing systems are available from various metering pump manufacturers. This eliminates the construction of concrete tanks and the provision of other accessories under separate contracts.

The packaged unit comprises of solution tank complete with stirrer, pump with driver, all piping, fittings and accessories etc. It is worthwhile going for a packaged type system rather than following the old system.

One should keep in mind that all necessary information regarding the system should be provided to the manufacturer in order to design and manufacture the packaged unit to suit the system.

10.3 FLOW METERS

Measurement flow rate is one of the prime important factors in controlling the pumping station efficiency. There are a large variety of flow meters available and the most common ones used in the water industry are discussed in this chapter. Flow meter selection has become somewhat difficult due to various reasons like;

* **Availability of large variety.**
* **Cost and accuracy.**
* **Performance.**
* **Installation and maintenance.**

10.3.1 DIFFERENTIAL PRESSURE TYPE FLOWMETERS

Differential pressure (DP) meters are available in a wide variety of shapes and sizes. As a group they form the majority of flowmeters currently sold, and within the group the orifice plate is the most accepted and most widely used whatever their design, they all infer flow rate from the pressure drop across a restriction. For many years orifice plate meters were the only reliable way of measuring flows with reasonable performance.

In these meters there are two basic parts, the primary element which generates the pressure difference and a secondary element which sences the differential, and transmit either an analoge or a digital single which is proportional to flow. Differential pressure devices all make use of Bernoulli's equation.

Different differential pressure types are;

* **Orifice meters.**
* **Venturi tubes.**
* **Dall tubes.**

10.3.1.1 **ORIFICE METERS**

This is the most simplest and commonly used inexpensive flow meter. It consists of a stainless steel disc bored to a size calculated to produce a pre-determined pressure difference at a specific flow. The accuracy of the orifice plate is about ± 1.5% but the head loss is higher. The output is not linear related to flow rate and the performance changes with plate damage.

10.3.1.2 **VENTURI TUBES**

The venturi meter is used in water distribution systems. It has a tapered inlet and outlet with a central parallel section where the low pressure tapping is located. This gives a discharge coefficient of 0.99 instead of 0.6 for the orifice and gives a lower head loss but lower differential than the same area ratio orifice plate. The main function of the divergent outlet section is to decelerate the flow with maximum pressure recovery. This is the best choice of DP meter over 1000 mm bore and is less affected by internal erosion. However, they occupy much longer lengths in the line and are more expensive to manufacture and install.

The advantages are zero head loss and obstructionless no moving parts, wide size range from 3 mm to 3m, liner output relationship with flow rate.

10.3.1.2 **DALL TUBES**

The dall tube is an advanced development of the venturi tube with the exception that the curves of the venturi tube are replaced by coned angles and the throat is replaced by an annulus. It is shorter lighter and has a lesser head loss than venturi tubes and also gives about 80 per cent more differential than for an equivalent area ratio venturi and as a result they are widely used in water distribution systems.

10.3.2 **DISPLACEMENT FLOWMETERS**

Displacement meters are sometimes called positive displacement or simply PD meters. They operate on a basic principle of dividing the flow into a number of precisely known volumes. Counting the number of volumes gives the volume passed and counting the number of volumes at a given time gives the flow rate. Registration can be either by mechanical gearing or by an electrical pulse unit. This type is exclusively used to meter the domestic water consumers and also to meter small commercial consumers. These meters have a very high accuracy but are not suitable for dirty or two phase flows.

10.3.3 ROTARY INFERENTIAL METERS

This group of meters, include turbine meters, single and multi jet, helical meters. They have a rotary element whose speed is proportional to the flow rate. The speed is monitored by magnetic or by means of a mechanical gear train to a readout. Poor installation conditions can lead to large systematic errors in output.

10.3.3.1 MECHANICAL FLOW METERS (WOLTMANN)

In this type of meters, helical vane fitted parallel to the flow axis is driven by the water and it revolves in direct proportion to the quantity of water passing through the meter. These type of meters are suitable for bulk metering. They have low head loss characteristics due to minimum restriction and no change in flow direction as water passes through the meter. For maintenance purposes the complete measuring mechanism can be quickly replaced with a pre-calibrated measuring mechanism. An adjustable regulating vane is used to adjust the meter linearity.

10.3.3.2 TURBINE AND PROPELLER METERS

All types of axial flow turbine meters have a bladed rotor assembly running on bearings which are supported by a central shaft. The whole assembly is mounted concentrically within the housing. The shape and number of blades varies between various manufacturers.

Propeller meters are modifications of conventional axial turbine meters. These can be single jet or multi jet type and the blade axis perpendicular to the flow axis. These types of meters are used to meter domestic consumers.

10.3.4 COMBINATION METERS

A combination meter is a combination of a large diameter and a small diameter meter to give consistent accuracy over an extended range of flow rates. They are particularly suited to bulk flow metering in areas such as hospitals and factories etc. where large variations in flow rate can be expected.

10.3.5 ELECTRO MAGNETIC FLOW METERS

The principle it works is based on Faraday's law of electro magnetic induction in that the induced voltage in a conductor as it moves across a magnetic field is proportional to the velocity in that conductor. The induced voltage is proportional to the vector product of the flux density and the velocity. Therefore induced voltage varies as flux density velocity. Therefore induced voltage is proportional to the length of the conductor, i.e. the distance between the two measuring electrodes. The measuring fluid must be conductive and should have a conductivity of 1 micro mho/cm. This type of flow meters are suitable for water and untreated sewage. In the absence of moving parts these meters are maintenance free and have a higher accuracy.

10.3.6 ULTRASONIC FLOW METERS

There are two types of ultrasonic flow meters namely.

* **Doppler meter.**
* **Sing around meter.**

The doppler meter is basically a clamp-on device bonded to the pipe and ultrasonic sound is transmitted into the fluid and rejected back by the travelling fluid.

The "sing around" system is a flanged self-contained unit where ultrasonic pulses are emitted in paths in the direction of and against the direction of flow. The difference in transit time is computed as fluid velocity.

10.3.7 FLOW TESTS

Meters are tested for accuracy in a test bench. The three flows recommended for meter testing are;

* **Maximum flow.**
* **Transitional flow.**
* **Minimum flow.**

Percentage error can be calculated from the formula;

Percentage Error = [(Quantity Registered - Quantity Passed)/(Quantity Passed)] x 100

10.3.8 METER INSTALLATION

It is recommended that a straight length of pipe of the same diameter as the meter and equivalent in length to 10 times the meter diameter is fitted immediately prior to the meter inlet. The meter should be installed in such a way that the water will flow always full with no air present inside meter body for accurate measurement of flow.

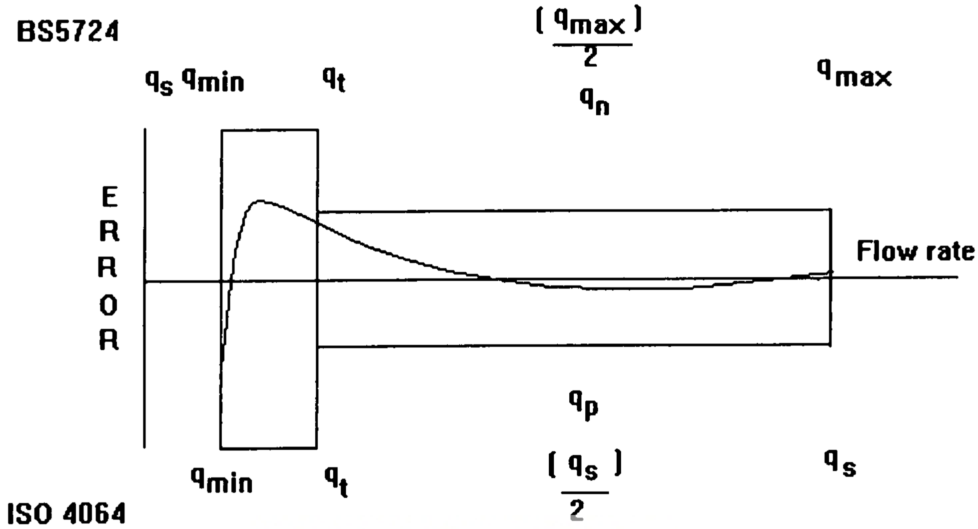
10.3.9 STANDARDS OF FLOW MEASUREMENT

ISO 4064 - 1 1977 and BS 5728-1 1986 have been in use regarding the aspects of flow measurement.

The second edition ISO 4064-1 1993 cancels and replaces the first edition (ISO 4064-1 1977). BS 5728-1 1986 is currently under review to fall inline with ISO 4064-1 1993.

The main differences of the BS and the latest ISO are given on page 167 diagramatically.

ERROR/FLOW RATE ENVELOPE COMPARING BS 5728 AND THE NEW ISO 4064 TERMINOLOGY



BS 5728 1986	ISO 4064 1993
Normal flow rate, q_n. Half the Maximum flow rate, q_{max} Expressed in cubic meters per hour, the nominal flow rate is used for the purpose of designating the water meter. At the nominal flow rate, q_n a water meter is expected to operate in a satisfactory manner under normal conditions of use, i.e. under steady or intermittent flow conditions.	**Permanent flow rate, q_p.** Flow rate at which the meter is required to operate in a satisfactory manner under normal conditions of use, eg. under steady and/or intermittent flow conditions.
Maximum flow rate, q_{max} The highest flow rate at which the meter is required to operate in a satisfactory manner for a short period of time without deteriorating.	**Overload flow rate, q_s** Flow rate at which meter is required to operate in a satisfactory manner for a short period of time without deteriorating; its value is twice the value of q_p.
Minimum flow rate, q_{min} The lowest flow rate at which the meter is required to give indications within the maximum permissible error tolerance. It is determined in terms of q_n	**Minimum floor rate q_{min}** Lowest flow rate at which the meter is required to give indications within the maximum permissible error tolerance. It is determined in relation with the numerical value of the meter designation.
Flow rate range. The range limited by the maximum and the minimum flow rates (q_{max} and q_{min}). This range is divided into two zones known as the 'upper zone' and 'lower zone', separated by the transitional flow rate.	**Flow rate range.** Range limited by the overload flow rate, q_s, and the minimum flow rate q_{min}, in which the meter indications must not be subject to an error in excess of the maximum permissible errors. This range is divided into two zones called "upper" and "lower" zones, separated by the transitional flow rate.
Transitional flow rate, q_t. The flow rate at which the maximum permissible error of the water meter changes in value.	**Transitional flow rate, q_t** Flow rate value, occurring between overload and minimum flow rates, at which the flow rate range is divided into two zones, the "upper zone" and "lower zone", each characterized by a maximum permissible error in this zone.
Starting flow rate, q_t The flow rate at which a water meter commences registration.	No equivalent definition in this standard.
No equivalent definition in this standard. Usually quoted as q_n followed by figures and m^3/h.	Meter designation No. Numerical value, preceded by the capital letter N, to designate the meter in relation to tabulated values of dimension.

Flow rates in both specifications are expressed in cubic meters per hour.

Table 10.2 - Comparison of Standards

Metrological characteristics
BS 5728 1986

Maximum permissible errors

The maximum permissible error in the lower zone from q_{min} inclusive up to but excluding q_t is ±5%.

The maximum permissible error in the upper zone from q_t inclusive up to and including q_{max} is ±2%.

Metrological Classes

Water meters are divided into four metrological classes according to the values of q_{min} and q_t (please see table overleaf).

Metrological characteristics
ISO 4064 1993

Maximum permissible errors

The maximum permissible error in the lower zone from q_{min} inclusive up to but excluding q_t is ± 5%.

The maximum permissible error in the upper zone from q_t inclusive up to and including q_{max} is ±2%.

Metrological classes

Water meters are divided into four metrological classes according to the values of q_{min} and q_t (please see table overleaf).

BS 5728 1986

Classes	Nominal flow rate q_n of meter	
	<15 m^3/h	>15 m^3/h
Class A Value of q_{min} Value of q_t	 0.04 q_n 0.10 q_n	 0.08 q_n 0.30 q_n
Class B Value of q_{min} Value of q_t	 0.02 q_n 0.08 q_n	 0.03 q_n 0.20 q_n
Class C Value of q_{min} Value of q_t	 0.01 q_n 0.015 q_n	 0.006 q_n 0.015 q_n
Class D Value of q_{min} Value of q_t	 0.0075 q_n 0.0115 q_n	 -------- --------

Table 10.3 - Flow rates

ISO 4064 1993

Classes	Nominal flow rate qn of meter	
	N < 15	N > 15
Class A q_{min} q_t	 0.04 N 0.10 N	 0.08 N 0.30 N
Class B q_{min} q_t	 0.02 N 0.08 N	 0.03 N 0.20 N
Class C q_{min} q_t	 0.01 N 0.015 N	 0.006 N 0.015 N
Class D q_{min} q_t	 0.0075 N 0.0115 N	 -------- --------

Table 10.4 - Flow rates

10.4 CHLORINATORS

10.4.1 INTRODUCTION

Chlorinators come in three different forms viz;

* **Cabinet mounted**
* **Wall mounted**
* **Cylinder mounted**

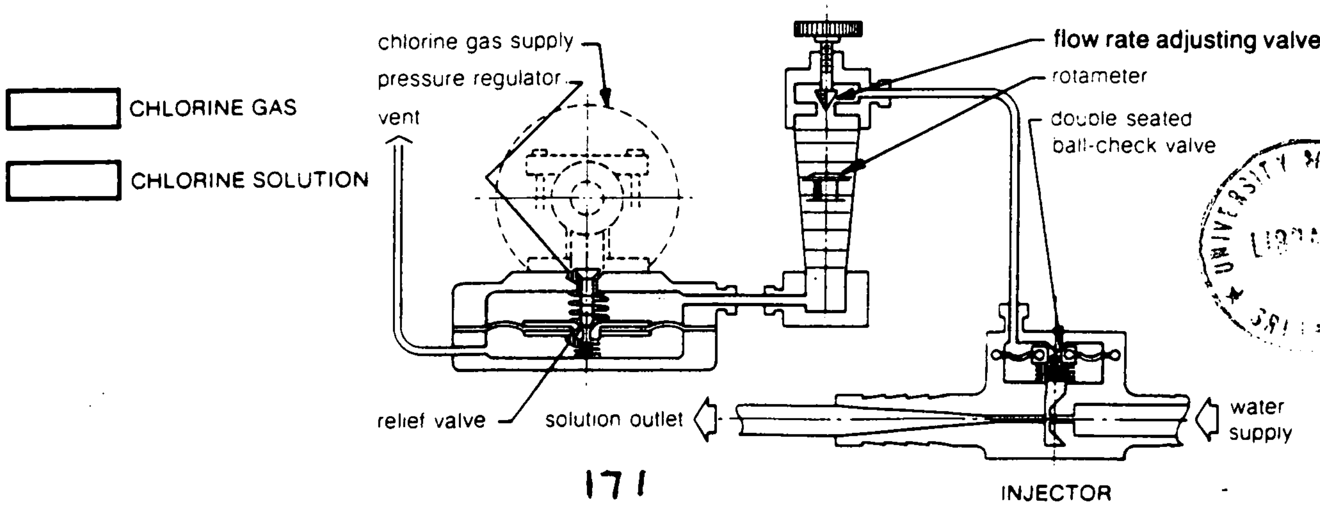
Wall mounted and cylinder mounted forms are the improved versions of cabinet mounted models. They are simple and versatile. They can handle about 225 (275 combined) kilograms per day of chlorine gas.

Vacuum operated, solution feed type chlorinators are by far the most commonly used because of their safe working feature. The other type being pressure operated, dry gas feed type.

The vacuum operated solution feed type system consists of a water operated injector and a vacuum controller. The injector when fed with water creates a vacuum and draws chlorine gas from the controller and mixes with chlorine gas to form a chlorine solution. Chlorine enters through a spring loaded vacuum operated pressure regulator which serves as a check valve in the event of injector vacuum loss. The relief valve prevents any build-up of chlorine pressure in the system. The chlorine gas passes through the rotameter which indicates the flow rate is an integral part of the vacuum regulator. The regulator can indicate flows upto 1/20 of the maximum feed with an accuracy of ± 4%.

A simplified flow diagram is given below:

Simplified Flow Diagram



As far as possible the chlorine solution should be fed to the delivery line of the system as chlorine can attack the metallic parts of the pumps.

To boost the chlorine solution to the delivery line or in instances where the available supply pressure is less than the minimum required value, a booster pump must be installed to supply the water at correct flow rate and head. Booster pump capacity and head will depend on the total back pressure. This back pressure must include all losses after the injector.

Annex 10.1 gives the required capacity and heads for booster pumps (Note flow is in US Gallons - Source Modern Chlorinators USA).

10.4.2 EVAPORATORS

When the gas feed rate requirement exceed the practicality of using multi-container gas withdrawal type, evaporators will have to be used. An evaporator consists of a sealed pressure vessel having an inlet tube to bring the liquid into the bottom of the evaporator. The pressure vessel is housed within a chamber which contains the heat transfer medium used to supply heat necessary to convert the liquid chlorine into gaseous state. The heat transfer medium may be water heated by an electric immersion heater or an immersed steam coil or circulating hot water or steam obtained from an external source. The capacity of an evaporator is limited by its heat transfer rating. Any attempt to force an evaporator to operate above its capacity is dangerous.

The withdrawal rates of chlorine from the containers without evaporators depends on heat of vaporization container size quantity of chlorine, temperature dimensions and the piping system of the container and the type of withdrawal (intermittent or continuous).

The table below gives the maximum chlorine withdrawal rate in kg per day without evaporators. (Source : Instruction Bulletin 70-9001 Fischer Porter, Pennsylvania, USA 1977)

Size of container	Withdrawal rate kg/day
68 kg.	22.7
900 kg.	181.8

Table 10.5 - Cl_2 Withdrawal Rates

However higher withdrawal rates can be achieved with cylinder mounted chlorinators.

10.4.3 **SAFETY**

Chlorine causes irritation of eyes, nose throat and lungs, and exposure to a sufficiently high concentration will be fatal. The physiological effects of chlorine are listed below. (Source : National Water Supply and Drainage Board O & M manual, Vol - 1, Kirindi Oya Water Supply Scheme 1993)

Effect	**Parts Gas per Million Parts of Air**
Detectable Odor	3.5
Throat Irritation	15.1
Coughing	30.2
Dangerous in 30 - 60 min.	40 - 60

Table 10.6 - Effects of Cl_2

Therefore adequate safety precautions should be taken in handling, storing and using chlorine. The following points should be taken into consideration.

* **Personnel handling chlorine should be trained.**
* **Protective clothing, gas masks, gloves boots etc. must be available at site.**
* **Storage room and chlorinator room must be equipped with exhaust fans.**
* **Gas detectors must be provided.**
* **Facilities should be provided for the safe disposal of the gas in the event that a container develops a leak - Caustic Soda Bath.**

10.4.4 CHLORINATOR SIZING

When the flow rate of water and the required dosage (PPM) of chlorine is known the general sizing formula can be written in the following form;

Kg/Hr. = $1x\ 10^{-3}$ x Dosage in PPM x m^3/Hr

Typical dosages for different applications and sizing chart are given in Annexures 10.2, 10.3 and 10.4 respectively. (Source : Modern Chlorinators 1994).

10.5 OVERHEAD CRANES

Different types of overhead cranes are used to install, disassemble, assemble and service equipment in pumping stations. Overhead cranes used in pumping stations can be classified into three types according to the rated load namely;

* **Manual chain block - for 5 Tons or less**
* **Manual trolley - for > 5 Tons and < 10 Tons**
* **Motorised trolley - for > 10 Tons**

It should be noted that suitable lifting facilities are provided within pumping stations especially in order to facilitate easy maintenance work.

10.6 TRASH REMOVAL

Since clogging with trash can cause problems to pumps, installing trash removal equipment in intakes is very important if the water way is not clean.

Thrash removal equipment consists of;

* **Screens**
* **Trash rakes**
* **Conveyors**

Spacing of screens depend on the pump type and impeller passage area.