(c) Instruments

For flow and pressure measurements, location and alignment of pipes and detection of underground leaks through pipes, the following instruments are used and any water undertaking should possess some of the simple and a few of the sophisticated instruments.

(1) Pitometer Assembly

It consists of pitot tube with two orifices immersed in the flow of water and a differential manometer with scale along with special type of pitot-cock for fitting into the pipe. It is calibrated with reference to the pipe and single point velocity measurements are taken at the centre line of pipe.

(2) Pressure Gauge (With Recorder)

Spring type pressure gauge is used to measure pressures at the inlet and various points on the zone. Recorder permits the continuous record of pressure with time.

(3) Integrating Type Water Meter

Normal integrating turbine type meter measures the flows between two hydrants connected by pressure hose serving as bypass before feeding into the zone or subzone. Normally 25 mm and 80 mm diametre are used.

(4) Mobile Waste Water Flow Meter

The integrating rate of flow type meter that can be mounted on a trailer is used for measuring the waste flow in a subzone. The rate of flow with reference to time is recorded on a drum chart.

(5) Hydrants and Hose Pipes.

These are required for bypassing the water in the feed pipe to the zone through the integrating of waste meter.

(6) Electronic Valve Box Locator

This is to locate buried metals underground upto a depth of about 0.25 to 0.5 m below the surface.

(7) Electronic Pipe Line Locator

By means of electromagnetic induction and wireless signals, the existence and exact alignment of underground metallic pipelines can be found.

(8) Sounding Rod

It is a 1.2 m long, 12 mm diameter hollow mild steel rod, flat or pointed at one end and fixed with cup shape brass cap of 50 mm diametre at the other. Bamboo canes can also be used. The rod is traversed over the surface along the centre line of pipe and the noises due to water leaking are picked up by the human ear thus locating the possible leaks.

(9) Electronic Leak Detector

It consists of a pickup, amplifier and headphone. The sound vibrations created by water escaping through leaks in pipes are selected and magnified by a magnetic pickup and converted to electrical impulses. These are sensitive and can pinpoint the position of the leaks.

(10) Road Measurer

This is a single wheeled integrating type roller facilitating the measurement of the length traversed as it moves along the road.

(d) Corrective Action

After location of the leaks in the pipes prompt repairs to pipes and valves are to be undertaken and 'Flow Test' of the sub-zones run to determine the extent and efficacy of the corrective measures. If re-testing proves that there are further leakages, they have to be attended to, until the losses in the zone are reduced to the minimum. The experience of waste assessment surveys indicates that a few major leaks in a zone or subzone contribute to about 75% of the total loss. Sizeable reduction in wastage can be brought about by locating and remedying promptly all such leaks first. Sometimes, it is prudent in a zone to go in for the sounding of probable leaks in pipes without being preceded by waste assessment.

The leaks are usually noticed at or near ferrule connections and in corroded G.I. house service pipes or in the joints of mains and house service pipes. The savings in water resulting from this programme more than offsets the investments. In addition to the favourable direct cost benefit analysis due to saving of water, the secondary benefits accruing out of such surveys are easy updating of distribution system drawings, maintaining valves, hydrants and stop cocks, the improved quality of water in the system due to prevention of back flow of pollution into the mains in non-supply hours and above all, the public goodwill earned due to the improved supply. Some of these cannot be exactly quantified.

10.10.3 CLEANING OF PIPES

The necessity for systematic and periodic cleaning of pipelines is borne out by the fact that the carrying capacity of the pipes gets reduced due to growth of slimes, incrustations or deposits. Flushing and swabbing of pipes, which are simple and inexpensive can go a long way in maintaining the capacity.

The old cast iron and steel pipes which are cleaned can be protected from further incrustations or corrosion by cement lining. Insertion of a plastic pipes has also been practiced with success.

Disinfection of the mains has been discussed in Appendix 5.8. This can be done at site specially for large diameter pipelines.

(a) Flushing

Water at high velocity is allowed to flow in the pipe and finally escape through a scour valve or hydrant. The minimum velocity to be induced varies from 90 to 120 cm/s and it is to be ensured that the flows are in one direction and the dirty water does not enter the cleaned sections. Flushing can only remove loose deposits of small size and not the slimy layers, large sized deposits and hard incrustations. Flushing also disentangles microscopic biological growths which, if left unattended, are likely to grow further and create problems. The period of flushing is determined by the quality of outgoing water in hydrants or valves. Usually this amounts to the flushing out of a volume of water equal to twice the capacity of the pipe length under consideration. About 100 to 300 m length of pipe can be flushed in one operation.

(b) Swabbing

The swab used is made of polyurethene foam of cylindrical shape and 30 to 60 cm long with varying diameters. It is soft and flexible, highly compressible and can retain the original shape when released from compression. Two varieties are available, one soft and the other relatively hard.

This swab is pushed into the pipe by the momentum of the flowing water. As the swab moves, it sweeps out the loose and slimy layer adhering to the inside of the pipelines and the deposits are carried away by the flowing water. Swabbing is not successful for dealing with hard deposits.

Swabs are slightly larger in diameter than the pipe to be cleaned. In certain cases with heavily incrusted pipes, swabs of the same diameter as the pipe are used initially. For pipe diameters of 75 to 100 mm, the swab diameter is usually 25 mm larger in size while for larger diameter pipe it is 50 to 75 mm larger.

For cleaning pipelines of 150 mm diametre or less, the following procedure is adopted. In distribution systems, where hydrants are connected vertically above a main without a duck-foot bend, the insertion of swab and its expulsion from the pipe are carried out at the hydrants. In situations, where the hydrants are laterally connected to the main, insertion of the swab has to be either through an existing valve in the line or by pumping water under pressure through the hydrant. The exit can be through another hydrant or a tee connected to the other end of the pipe and kept open.

The length of the main to be cleaned is isolated by valves. The swab is dipped in bleaching powder solution of strength 50 mg/l of chlorine prior to insertion. After insertion, the hydrant valve is closed or the valve body is covered. Water is allowed into the pipe by opening the valve near the hydrant and keeping the exit hydrant valve open, while the valve on the other side of pipe is kept closed. This ensures water flows in one reach only between the point of insertion and point of exist of the swab.

The movement of swab depends on the rate of flow or velocity of flush in the pipe which usually should not be less than 30 cm/s. If swab gets stuck or blocked in the pipe, water can be passed from the opposite direction in the pipe to release it.

As a permanent measure, tee-branches can be provided near the junction points of the pipe network preceded by the valves. (Fig. 10.2). These tee connections are covered by blank flanges. The tee can be vertical or horizontal and the outlet end with blank flanges can be enclosed in a chamber. Whenever swabbing or flushing is desired, the blank flange can be opened after closing the downstream valve and allowing the water and swab to escape through the tee.

For large diameter pipelines particularly greater than 300 mm, the existing valves have to be used for removal of the swab. Providing a tee-connection in important large diameter mains may be a problem apart from being costly. To take out swab from such mains while used for cleaning, the top half of the valve is opened, and the water is allowed to escape through a grating provided. The swab gets stuck at the grating which can be then taken out conveniently.

10.11 PROTECTION AGAINST POLLUTON NEAR SEWERS AND DRAINS

10.11.1 Horizontal Separation

A water main should be laid such that there is at least 3 m separation, horizontally, from any existing or proposed drain or sewer line. If local conditions prevent this lateral separation, a water main may be laid closer to a storm or sanitary sewer, provided that the main is laid in a separate trench, or on an undisturbed earth shelf located on one side of the sewer at such an elevation that the bottom of the water main is at least 0.5 m above the top of the sewer.

10.11.2 Vertical Separation

In situations where water mains have to cross house sewer, storm drain, or sanitary sewer, it should be laid at such an elevation that the bottom of the water main is 0.5 m above the top of the drain or sewer with the joints as remote from the sewer as possible. This vertical separation should be maintained for a distance of 3 m on both sides measured normal to the sewer or drain it crosses.

10.11.3 Unusual Conditions

Where conditions prevent the minimum vertical separation set forth above from being maintained, or when it is necessary for the water main to pass under a sewer or drain, the water main should be laid with flanged cast iron pipe, with rubber gasket joints for a length on either side of the crossing to satisfy the lateral separation of 3 m. A vertical separation of 0.5 m between the bottom of the water main and the top of the sewer should be maintained, with adequate support for the larger sized sewer lines, to prevent them from settling on or breaking the water main. In making such crossings, it is preferable to have the sewer also of cast iron flanged pipe with rubber gasket joints and both the water and sewer mains pressure tested to assure water tightness before back filling.

Where a water main has already been laid and where a new sewer is to be laid, the above aspects may also be taken into consideration and the water main may be realigned to the extent necessary, when it is not possible to lay the sewer consistent with the above recommendations.

10.12 PROTECTION AGAINST FREEZING

Since water expands nearly about 10% in volume with an irresistible pressure, freezing solid conditions should not be allowed in any pipe system to avoid interruption of service and prevent damage to the pipes. Keeping water flowing is one of the simplest methods of preventing freezing. Keeping reasonable amount of flow in and out of an overhead reservoir with a stand-pipe riser of 0.5 to 1 m diametre to prevent freezing solid in the riser pipe, may be resorted to in very cold climates. Water flowing at a velocity of 1.3 mps will not freeze

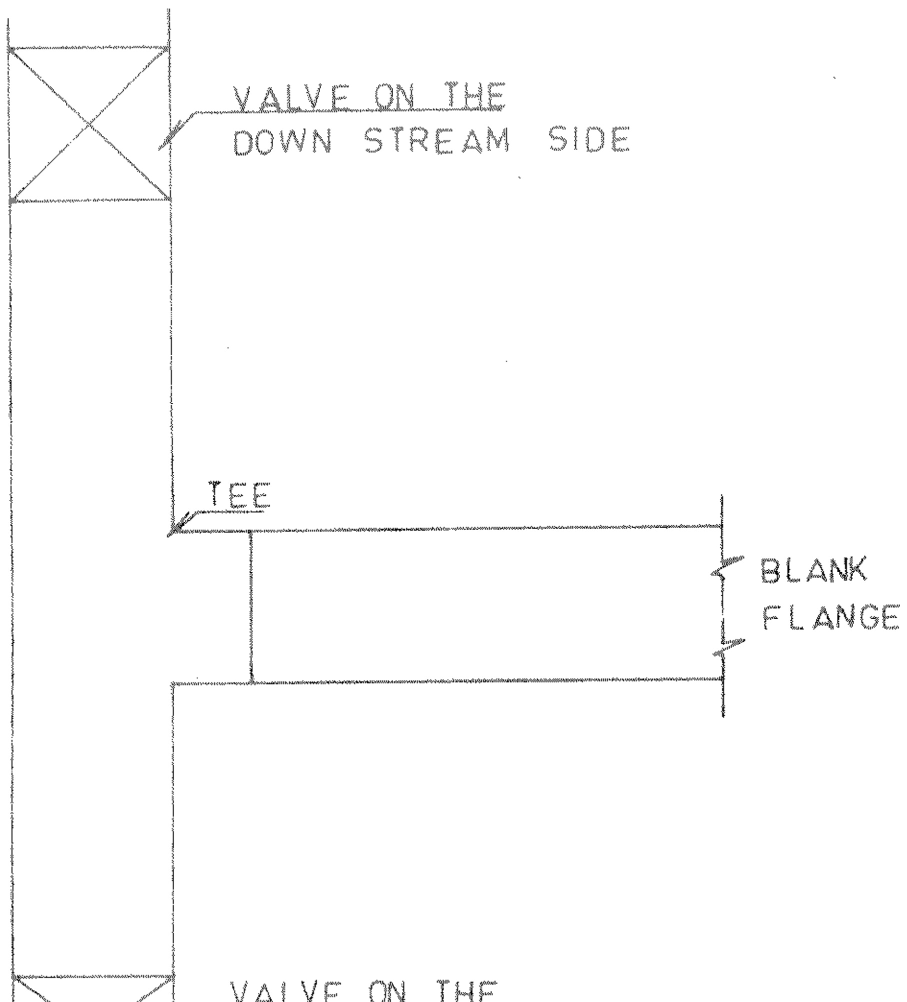

FIGURE 10.2 : THE BRANCHES TO ENABLE SWABBING

even in an unprotected welded steel pipe at 0^0C. With lower outside temperatures water is likely to freeze irrespective of the velocity in long main unless they are laid below the frost line. In Indian conditions, frost does not penetrate more than 2 m even in extreme cold areas. The cover of 1 to 1.5 m needed from the structural and traffic considerations should be adequate to take care of freezing also. Where water pipes are exposed to air temperatures below 0^0C, they are kept at a minimum size of 50 mm diametre and usually insulated, the common specification being three layers of standard hairfelt (total nominal thickness 75 mm) protected by means of weather proof wrapping of tarred roofing jacket lapped and sealed at all joints. This specification is suitable where water circulation is maintained continuously or where circulation is interrupted for only brief periods.

CHAPTER 11
PUMPING STATIONS AND MACHINERY

11.1 REQUIREMENTS

Planning and operation of a pumping station embraces considerations of the following points:

(i) Selection of the pump/s

(ii) Intake design

(iii) Piping layout

(iv) Providing space, equipment and facilities for

(a) Substation, if needed, for receiving and distributing the power supply

(b) Auxiliary power unit, generally diesel

(c) Control panel

(d) Bays for loading and unloading

(e) Overhauling, repairs and maintenance of pumps and all other equipments

(f) Head room and material handling tackle

(g) Ventilation

(h) Lighting

(i) Safety from fire

(j) Railings, ladders and passages for safe, easy and efficient movement of people.

(k) Office and administrative areas, including room for lockers, dress change and utilities for sanitary and hygienic needs of the working staff.

(v) Installation of pumps

(vi) Operation of pumps

(vii) Maintenance of pumps

(viii) Trouble shooting of pumps

(ix) Selection of motors

(x) Selection of starters

(xi) Provisions in control panel

(xii) Selection of cables

(xiii) Planning of transformer substation

(xiv) Maintenance and repairs of the electrical equipments

(xv) Trouble shooting of the electrical equipments

Guidelines on the above are detailed in the following paragraphs.

11.1.1 SELECTION OF PUMPS

In a water supply system, pumping machinery serves the following purposes:

(a) lifting water from the source (surface or ground) to purification works or to the service reservoir;

(b) boosting water from source to low service areas and to the upper floors of multi storied buildings; and

(c) transporting water through treatment works, draining of settling tanks and of other treatment units, withdrawing sludge, supplying water especially water under pressure to operating equipment and pumping chemical solutions to treatment units.

While deciding the type of pump for the specific requirements, it is necessary to analyse different type of pumps and their suitability to meet the requirements.

11.1.2 TYPES AND CONSTRUCTIONS OF PUMPS

There are various ways of classifying pumps.

11.1.2.1 Pump Types Based On The Underlying Operating Principle

This analysis develops into a chain of classes and sub-classes. However, broadly there are four classes, viz.

(a) Velocity (kinetic energy) adaptations as in centrifugal types, regenerative types and jet centrifugal combinations,

(b) Positive displacement pumps either reciprocating, such as simplex, duplex, triplex, etc., in piston, plunger and diaphragm-types or rotodynamic, such as gear pumps, screw pumps, jobe pumps, vane pumps and peristaltic pumps, etc.,

(c) Buoyancy operated (air lift) pumps,

(d) Impulse operated, such as hydraulic rams,

Of these, the centrifugal pumps and the reciprocating type positive displacement pumps are more popular. Prominently, the reciprocating pumps are good on high head (high pressure) duties and for metering/dosing requirements. Centrifugal pumps, on the other hand are of mechanically simpler construction and give non-pulsating continuous flow.

11.1.2.2 Pump Types Based On The Type Of Energy Input

Pumps need external energy to be input. It can be manual, as for hand pumps, from engines or from electric motors.

11.1.2.3 Pump Types Based On The Method Of Coupling The Drive

Pumps are coupled to the drives, direct through flexible couplings or are close coupled or are distantly driven through belt and pulley arrangement, sometimes with gearing arrangement or even with infinitely variable speed arrangement.

11.1.2.4 Pump Types Based On The Position Of The Pump Axis

Pumps normally work with their axis horizontal. Vertical turbine pumps, bore-well submersible pumps and volute type sump pumps have their axis vertical. Dry pit pumps are often arranged to work with their axis vertical. In specific situation, pumps of the Archimedian screw-type are arranged with inclined axis also.

11.1.2.5 Pumps of Types Based On Constructional Features

For ease of maintenance, pumps are made with axially split casing or with back pull out arrangement. Pumps for high heads are built with multi staging. Pumps to handle solids and sewage are provided with access for inspection and cleaning the choking and also with the provision for flushing and draining. Submersible pumps to handle raw water should be with mechanical seals. In this manner, a large variety of constructional features are provided in pumps for different purposes in different situations.

Pumps are also made in a variety of materials, to withstand corrosion, erosion, abrasion and for longer life under wear and tear.

11.1.3 Criteria for Pump Selection

Prior to the selection of a pump for a pumping station, detailed consideration has to be given to various aspects, viz.:

(a) Nature of liquid, may be chemicals or if water, then whether raw or treated

(b) Type of duty required, i.e. Whether continuous, intermittent or cyclic

(c) Present and projected demand and pattern of change in demand

(d) The details of head and flow rate required

(e) Type and duration of the availability of the power supply

(f) Selecting the operating speed of the pump and suitable drive/driving gear

(g) The efficiency of the pump/s and consequent influence on power consumption and the running costs

(h) Various options possible by permuting the parameters of the pumping system, including the capacity and number of pumps including standbyes, combining them in series or in parallel,

(i) Options of different modes of installation, their influence on the costs of civil structural constructions, on the ease of operation and maintenance and on the overall economics

11.1.4 CONSIDERATIONS OF THE PARAMETERS OF HEAD, DISCHARGE AND SPEED IN THE SELECTION OF A PUMP

These parameters are combined together in the term Specific Speed of a pump, which is calculated by the following formula

$$n_q = \frac{3.65NQ^{0.5}}{H^{0.75}} \tag{11.1}$$

Where,

n_q	=	Specific speed
N	=	The operating speed of the pump in rpm
Q	=	The rate of flow in cubic meters per second
H	=	The rated head per stage of the pump in meters

Most aspects of the performance characteristics of the different types of pumps can be compared, based on their specific speed. Some useful observations are summarized below.

(a) Positive displacement pumps are prominently used when high pressures high heads are to be developed or for metering/dosing duties as also handling sludge

(b) Centrifugal pumps are made with specific speeds above 36. Fig. 11.1 illustrates the relationships amongst the pump-efficiency, the shape of the impeller and the nature of the curves of Head (H) versus Discharge (Q), Power versus Q and Efficiency versus Q as influenced by the specific speed of the pump. The figure also helps in obtaining estimates of pump efficiency, which are useful in planning a pumping plant.

(c) For high discharges, by which specific speed becomes high the corresponding Net Positive Suction Head required (NPSHr see 11.1.4.1) also becomes high, it can be arranged that the discharge be shared by two impellers or by two sides of an impeller as in a double suction pump. While estimating the attainable efficiency for such pumps, only half of the total Q should be considered.

(d) Similarly, for high heads, by which the specific speed becomes low, and hence the attainable efficiency becomes low, it can be arranged that the head be distributed amongst a number of impellers as in multi stage pumps, thus improving the specific speed of each stage and consequently the attainable efficiency.

11.1.5 CONSIDERATION OF THE SUCTION LIFT CAPACITY IN PUMP SELECTION

11.1.5.1 The Meaning Of NPSHr

The suction lift capacity of a pump depends upon its NPSHr characteristics. The meaning of NPSHr can be explained by considering an installation of a pump working under suction lift as illustrated in Fig. 11.2

When a pump, installed as shown is primed and started, it throws away the priming water and has vacuum developed at its suction. The atmospheric pressure acting on the water in the suction sump then pushes the water through the foot valve, into the suction line, raising

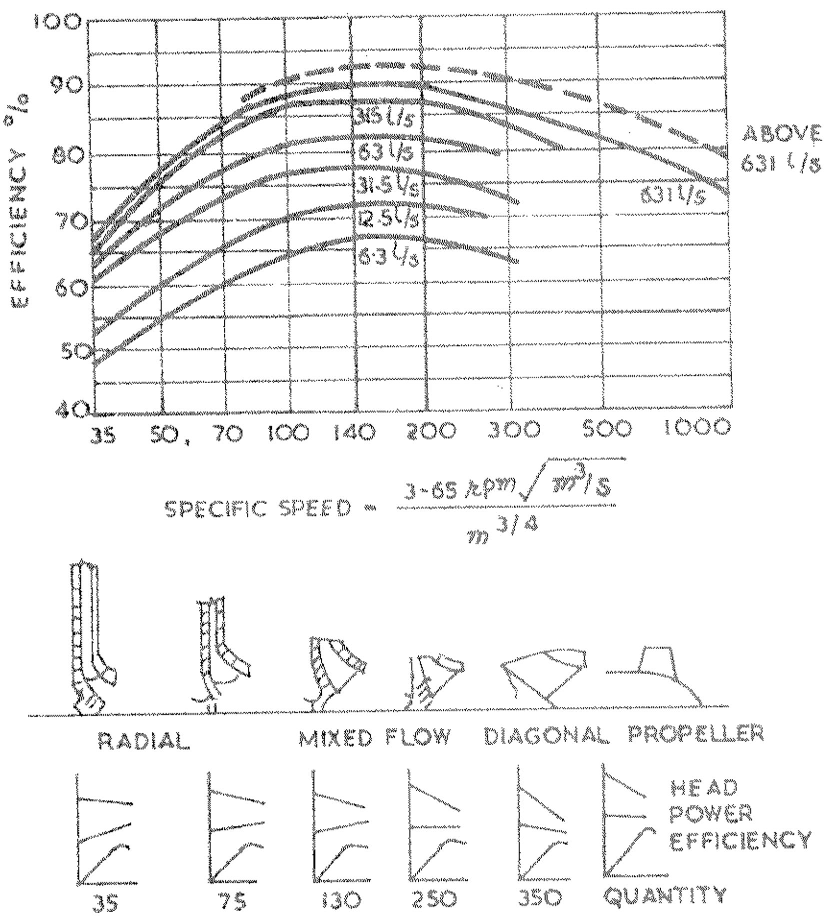

FIG. 11.1 SPEED AND EFFICIENCY CHARACTERISTICS

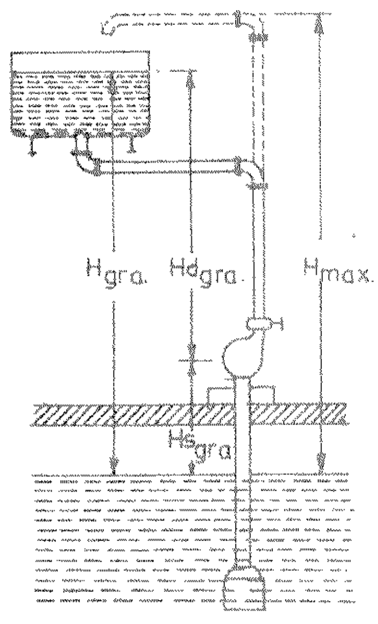

FIG. 11.2 SCHEMATIC REPRESENTATION OF NPSHr

2962 UA&E/97—28A

it upto the suction of the pump. While reaching upto the suction of the pump, the energy content of the water, which was one atmosphere when it was pushed through the foot valve would have reduced, partly in overcoming the friction through the foot valve and the piping and the pipe fittings, partly in achieving the kinetic energy appropriate to the velocity in the suction pipe and partly in rising up the static suction lift. The energy content left over in the water at the suction face of the pump is thus less than one atmosphere until here the flow is a fairly streamlined flow. But with the impeller rotating at the pump suction, the flow suffers turbulances and shocks and will have to lose more energy in the process. This tax on the energy of the water demanded by the pump, before the pump would impart its energy, is called the NPSHr of the pump.

The NPSHr characteristics of a pump is parabolic, increasing with flow rate.

Pumps of high specific speed have high NPSHr.

11.1.5.2 Vapour Pressure And Cavitation

The energy of the water at the pump suction, even after deducting the NPSHr should be more than the vapour pressure Vp, corresponding to the pumping temperature. The vapour pressures in meters of water column (mWC), for water at different temperatures in degrees Celsius are given in Table 11. 1.

TABLE 11.1
VAPOUR PRESSURE OF WATER

^{0}C	(mWC)
0	0.054
5	0.092
10	0.125
15	0.177
20	0.238
25	0.329
30	0.427
35	0.579
40	0.762
45	1.006
50	1.281

If the energy of the water at the pump suction would be less than the vapour pressure, the water would tend to evaporate. Vapour bubbles so formed will travel entrained in the flow until they collapse. This phenomenon is known as cavitation. In badly devised pumping systems, cavitation can cause extensive damage due to cavitation erosion or due to the vibration and noise associated with the collapsing of the vapour bubbles.

11.1.5.3 Calculating NPSHa

To insure against cavitation, the pumping system has to be so devised that the water at the pump suction will have adequate energy. Providing for this is called as providing adequate Net Positive Suction Head available (NPSHa). The formula for NPSHa hence becomes as follows.

NPSHa = Pressure on the water in the suction sump.

$$= P_s - Hf_s - \frac{Vs^2}{2g} - Z_s - V_p$$

P_s	=	suction pressure
Hf_s	=	friction losses across the foot valve, piping and pipe fittings
V_s	=	velocity-head at the suction face
Z_s	=	the potential energy corresponding to the difference between the levels of the pump-centre line and of the water in the suction-pump
V_p	=	the vapour pressure

While calculating NPSHa, the atmospheric pressure at the site should be considered, as the atmospheric pressure is influenced by the altitude of the place from the mean sea level (MSL). Data on the atmospheric pressure in mWC for different altitudes from MSL is given in Table 11.2.

TABLE 11.2

ATMOSPHERIC PRESSURE IN mWC AT DIFFERENT ALTITUDES ABOVE MSL

altitude above MSL in m	mWC
upto 500	10.3
1000	9.8
1500	9.3
2000	8.8
2500	8.3
3000	7.8
3500	7.3
4000	6.8

11.1.5.4 Guidelines On NPSHr

The NPSHa has to be so provided in the systems that it would be higher than the NPSHr of the pump. The characteristics of the pump's NPSHr are to be obtained from the pump-manufacturers. However some general guidelines for max. suction lift or min. NPSHa based on the type of a pump and based on the range of head and the specific speed are compiled in Figs. 11.3, 11.4 and 11.5.

11.1.5.5 General Observations

(a) Horizontal centrifugal pumps are installed with suction-lift.

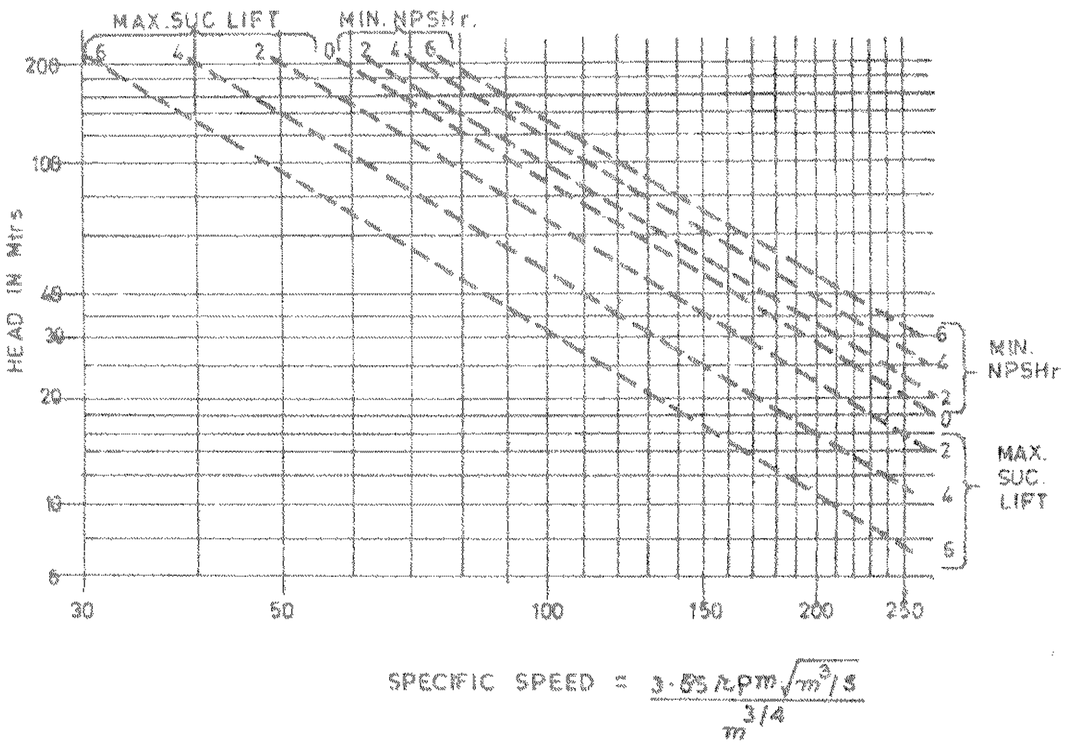

FIG. 11.3 NPSHr FOR SINGLE SUCTION PUMPS WITH OVERHUNG IMPELLER

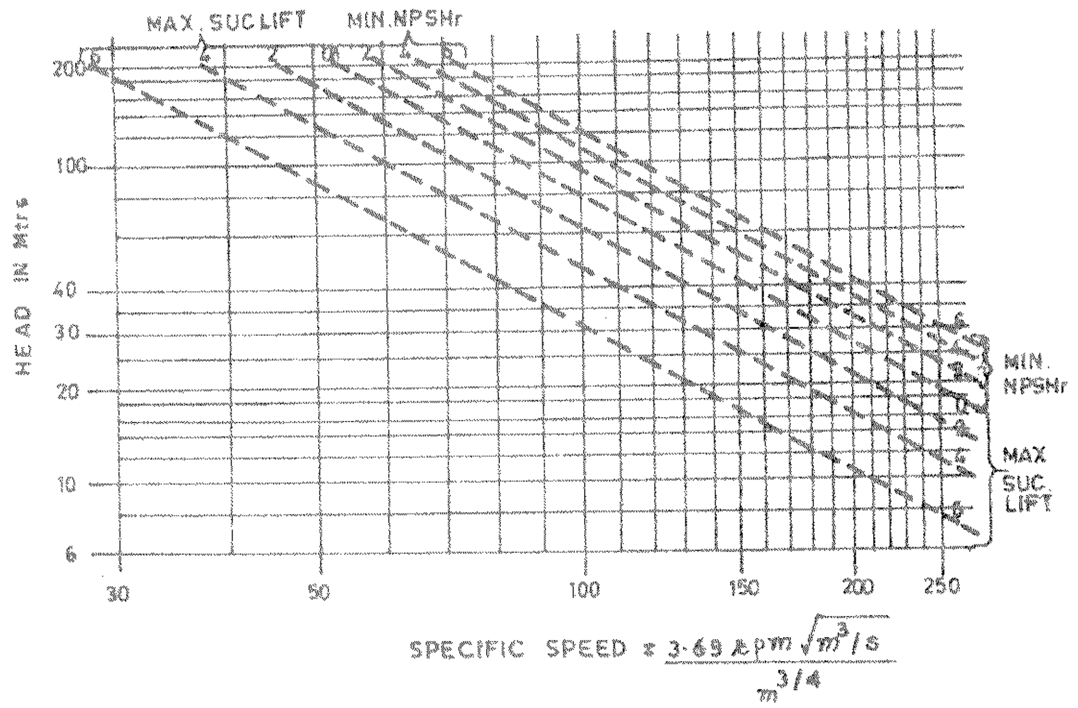

FIG. 11.4 NPSHr FOR SINGLE SUCTION PUMPS WITH SHAFT THROUGH EYE OF IMPELLER

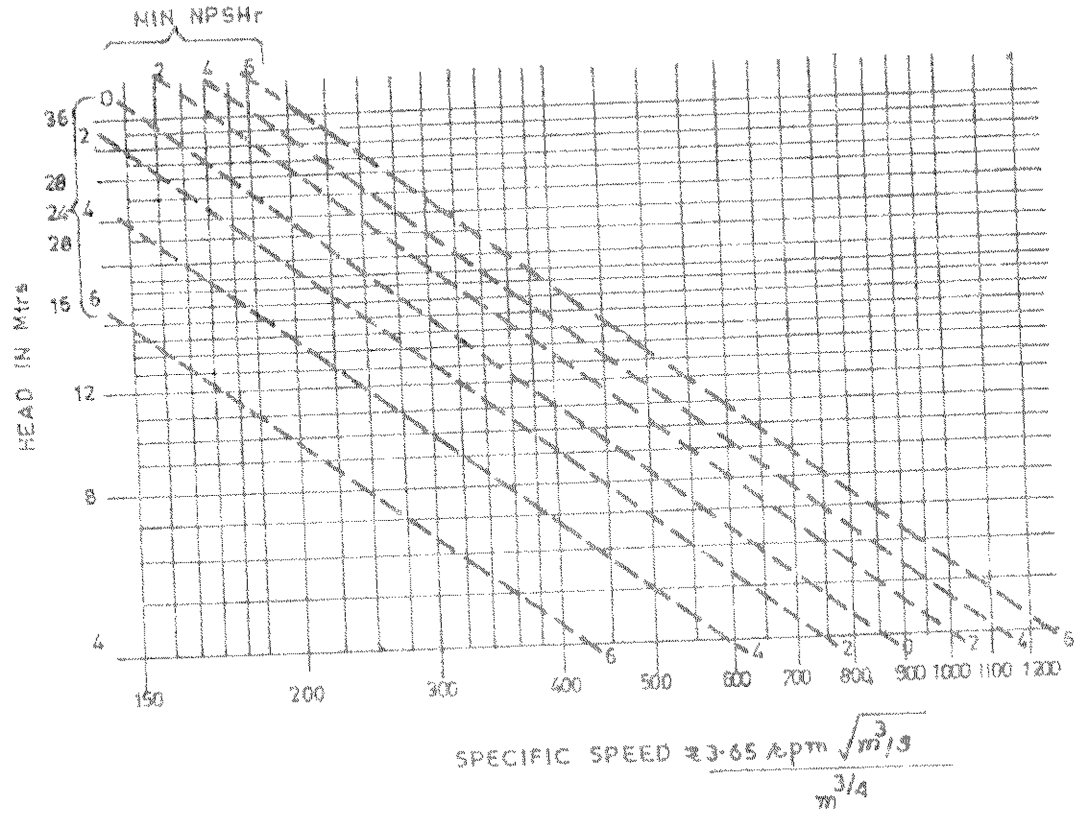

FIG. 11.5 NPSHr FOR SINGLE SUCTION, MIXED FLOW AND AXIAL FLOW PUMPS

(b) For vertical pumps, mainly of the vertical turbine type and of the bore-well submersible type, suction lift has to be totally avoided. Even for these pumps, when the discharge required is high, they have to be installed providing the minimum submergence. The minimum submergence required may at times demand submerging more than the first stage of the pump. It should also be checked whether the submergence would be adequate for vortex-free operation (see Table 11-3).

(c) Jet centrifugal combinations can work for lifting from depths upto 70m. However, the efficiency of the pumps is very low.

(d) Positive displacement pumps are normally self-priming. However this should not be confused with the NPSHr. Even if the NPSHa is not adequate, the pump may prime itself and run, but would cavitate.

11.1.6 Considerations of the System Head Curve in Pump Selection

A pump or a set of pumps has to satisfy the needs of the pumping system. Hence one has to first evaluate the head needed to be developed by the pump for delivering different values of flow-rate. A plot of these values is called as the System Head Curve. Each point on the System Head Curve denotes the head comprised of the following:

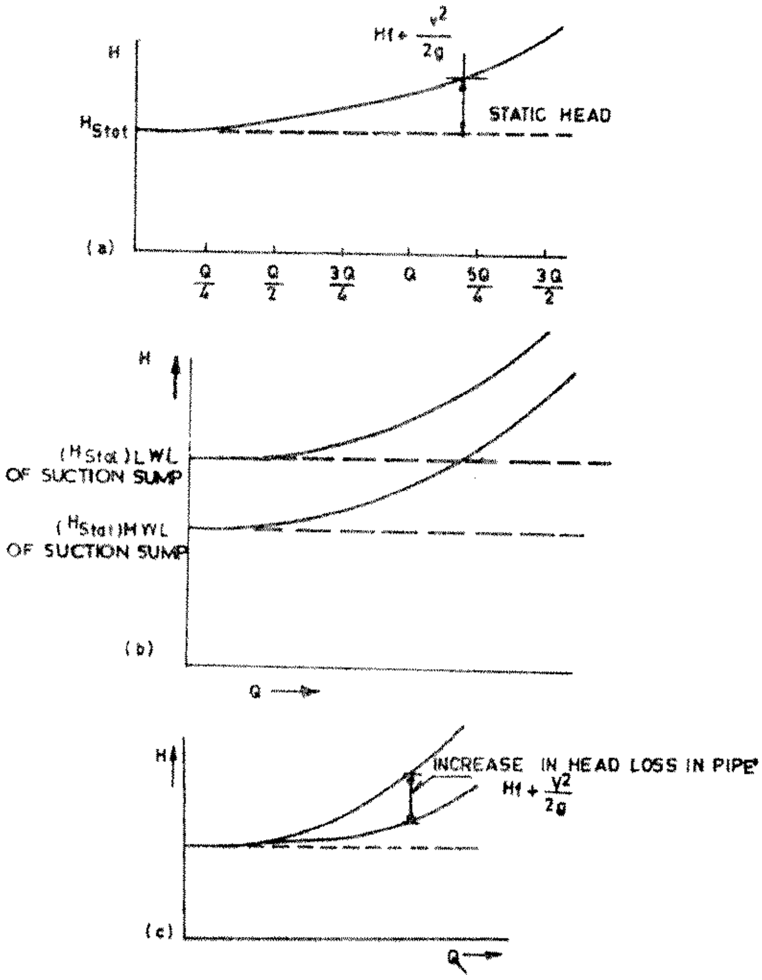

FIG. 11.6 SYSTEM HEAD CURVE

(a) Static Head

This is the difference between the level of the liquid in the suction-sump and the level of the highest point on the delivery piping, obviously the static head is more at the low water level (LWL) and less at the high-water level (HWL).

(b) Friction Head

This is sum of the head-losses in the entire length of the piping, from the foot valve to the final point of delivery piping, also the losses in all the valves i.e. the foot valve, the non-return (reflux) valve and the isolating (generally, sluice or butterfly) valves, and the losses in all pipe-fittings such as the bends, tees, elbows, reducers, etc. The friction head varies particularly with the rate of flow. Details for calculating the friction heads are given in Chapter 6.

(c) Velocity Head

At the final point of delivery, the kinetic energy is lost to the atmosphere. To recover part of this loss, a bell-mouth is often provided at the final point of delivery. The kinetic energy at the final point of delivery has also to be a part of the velocity head. Figs. 11.6 (a, b & c) show typical System Head Curves. As shown in Fig. 11.6(b) the System Head Curves for HWL and LWL are parallel to each other.

The system head curve will change by any changes made in the system, such as change in the length or size of the pipings, change in size and/or number of pipe fittings, changes in the size, number and type of valves by operating the valves semi-open or fully open. These changes can cause the System Head Curve to be steep or flat as shown in Fig. 11. 6 (c).

11.1.7 Summary View of Application Parameters and Suitability of Pump

Based on the considerations in 11.1.4 and 11.1.5, a summary view is compiled of the application-parameters and suitability of pumps of various types and presented in Table 11.3. However, these are general guidelines. Specific designs may either not satisfy the limits or certain designs may exceed the limits.

TABLE 11.3

APPLICATION OF PUMPS

Pump type	Suction-capacity to lift			Head range			Discharge range		
	Low 3.5m	Medium 6m	High 8.5m	Low Upto 10m	Medium 10- 40m	High Above 40m	Low Upto 30L/s	Medium Upto 500L/s	High Above 500L/s
Centrifugal, horizontal end-suction	Ok	Ok	Ok	Ok	Ok	No	Ok	Ok	No
Centrifugal horizontal axial split casing	Ok	No	No	Ok	Ok	No	No	Ok	Ok
Centrifugal, horizontal multistage	Ok	Ok	No	No	Ok	Ok	Ok	Ok	No
Jet-centrifugal, combinations	When limitations of suction lift are to be overcome			Ok	Ok	No	Ok	No	No
Centrifugal, vertical turbine	when suction lift is to be avoided			Ok	Ok	Ok	Ok	Ok	Ok
Centrifugal, vertical submersible	when suction lift is to be avoided			Ok	Ok	Ok	Ok	Ok	Ok
Positive displacement pumps	Normally self priming			Limited only by the pressure which casing can withstand			Ok Ok No Easy adaptation for dosing or metering		

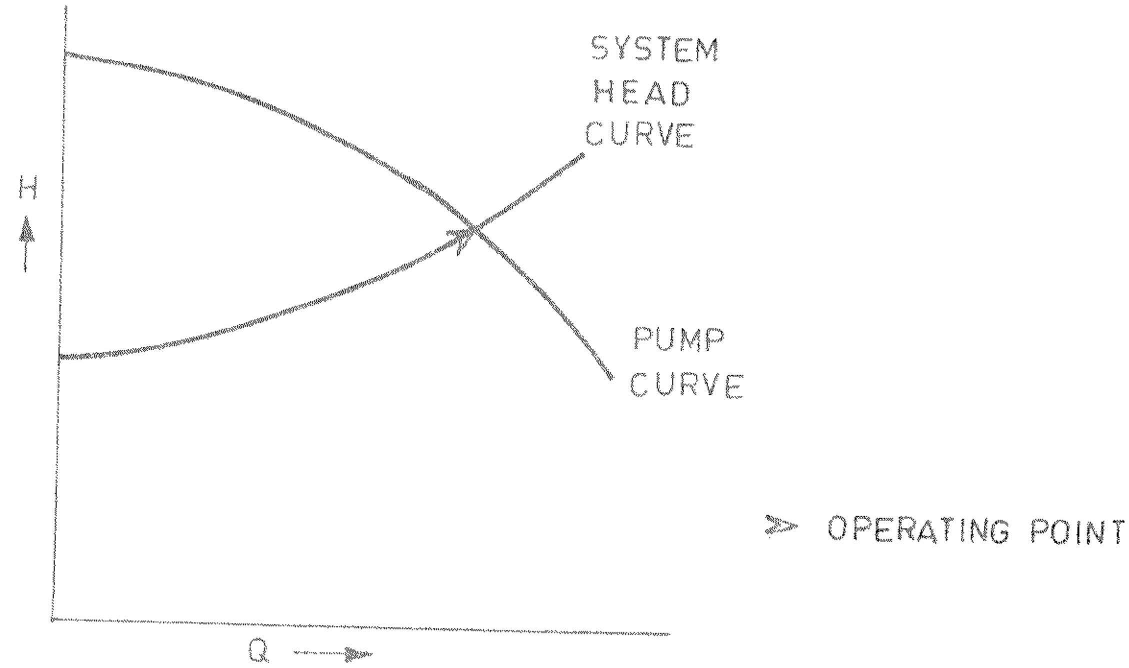

FIG. 11.7(A) OPERATING POINT OF THE PUMP

11.1.8 Defining the Operating Point or the Operating Range of a Pump

The operating point of a pump is the point of intersection of the System-Head Curve with the H versus Q characteristics of the pump. See Fig. 11.7 (A). Shifting of the System-Head Curve will cause a change in the operating point of the pump. Hence, the following points are worth noting;

(a) If the level of water in the suction sump would deplete during pumping from HWL to LWL, the operating point of the pump would vary from a low-head-high discharge point to a high-head low-discharge point. See Fig. 11.7 (B).

(b) If in a pumping system, the discharge is re-circulated to the suction sump, as is often the case at the testing setups at the manufacturers' works, the throttling of the delivery valve from full open to close, shifts the system-head curve from a flat curve, intersecting the pump's H-Q curve at high flow initially to a steep system-head curve intersecting the pump's H-Q curve at high head. See Fig. 11.7 (C).

Similarly, a pumping system can be devised with flat or steep system-head curve. Alternatively, throttling the delivery valve would shift the system-head curve from flat to steep.

The most average water level in the suction sump and the most average system-head curve would define the operating point of the pump. For such operating point of the pump, the pump should have its point of maximum efficiency at or nearest to it. To provide for marginal changes in the operating point, e.g. between HWL and LWL, the nature of the efficiency-characteristics of the pump should be as flat as possible in the vicinity of the point of its best efficiency, often called as the BEP.

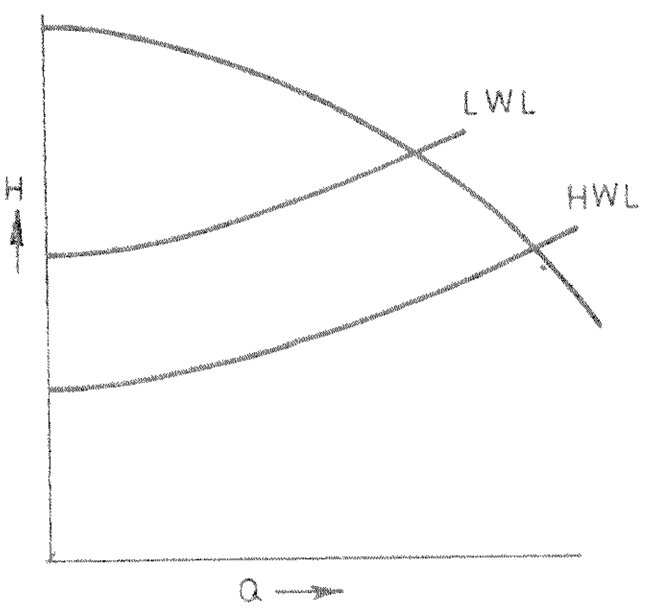

FIG. 11.7(B) CHANGE IN OPERATING POINT OF PUMP WITH CHANGE IN WATER LEVEL IN SUCTION SUMP

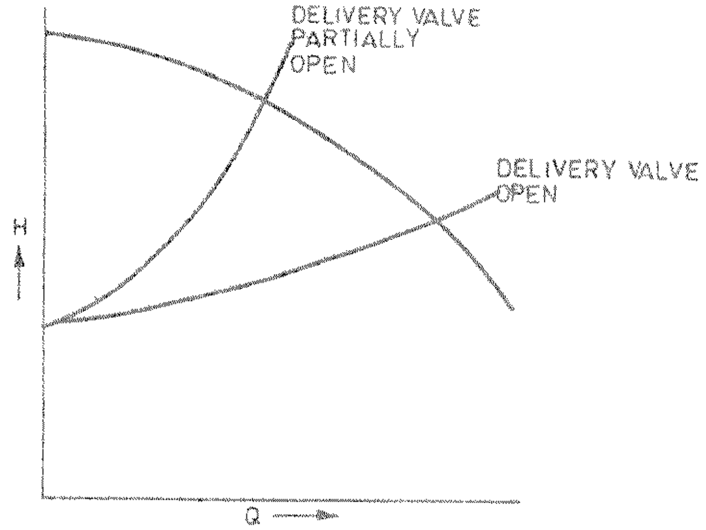

FIGURE 11.7(C) : CHANGE IN OPERATING POINT OF PUMP BY OPERATION OF DELIVRY VALVE

(c) When specifying the operating point of the pump, margins and safety factors, especially in specifying head should be avoided. On providing margins and safety factors, the rated head for the pump would work out high. In actual running the pump would work at a head less than the rated head and yield high discharge. From Fig. 11. 1, it would be noted that the Power versus Q characteristics of pumps of specific speeds upto 300 is with positive gradient, hence demanding more power at higher discharge. By such higher power demand, the drive may get over loaded.

By working at high discharge, the NPSHr demanded by the pump would be higher. If NPSHa is not adequate for this higher NPSHr, the pump may cavitate.

Due to the high discharge included, the pump may vibrate. Sometimes this may result in serious damage to the shaft and bearings.

11.1.9 Drive Rating

After the operating point of a pump is decided as discussed in 11.1.7, the efficiency of the pump can be estimated from Fig. 11. 1. The rating of the drive should be such that it would not get overloaded when the pump would be delivering the high discharge, as with HWL in the suction-sump. Also, the drive rating should be adequate to provide for the negative tolerance on efficiency and the positive tolerance on discharge, applicable for variations in actual Pump-performance from the rated performance.

The power needed to be input to the pump is the power to be output by the drive, i.e. at the pump-shaft. Since, most drives are coupled direct to the pump, the power at the pump-shaft denotes the brake power of the drive. All drives are rated only as per their brake power capacity, often quoted in Brake Kilowatts (BKW).

To provide margins over the BKW required at the operating point, so that the overloading would not happen at HWL, the following margins are recommended.

TABLE 11.4

MARGINS TO DECIDE DRIVE RATING

BKW required at the operating point	Multiplying factor to decide drive rating
upto 1.5	1.5
1.5 to 3.7	1.4
3.7 to 7.5	1.3
7.5 to 15	1.2
15 to 75	1.15
above 75	1.1

11.1.10 Stability of Pump Characteristics

In the H-Q characteristic of the centrifugal pump, the flow reduces as the head increases. If the head increases continuously until zero flow or until full close i.e., shutoff of the delivery valve, as shown in Fig. 11.8 (a) the H-Q characteristic is said to be stable. However, it is also probable that the shut off head of a pump may be less than the maximum head, as