I. CLASSIFICATION OF PUMPS

- Pumps
  - Turbo
    - Centrifugal
      - Volute
        - Single suction
          - Single stage
            - Non self-priming ...... S, FS, IBL, IFW, LPD, LPS, FSD, 3M
            - Self-priming .... SQ, SQD, FQ, FQD
            - Submersible .... P717, DS, DN, DVS, DL, DV, DML
          - Multi stage
            - Non self-priming ...... MS, SP, P121
            - Self-priming .... FMQ, MSQ
            - Submersible .... P727, BMS, BMSP
        - Double suction
          - Single stage
            - Non-submersible ...... CSA/CNA
            - Submersible
          - Multi stage
            - Non-submersible ...... SPD
            - Submersible
      - Diffuser
        - Single suction
          - Single stage
            - Non self-priming
            - Self-priming
          - Multi stage .... SS, BHS, EVM
        - Double suction
          - Single stage
          - Multi stage .... SSD
    - Mixed flow
      - Volute
        - Single stage .... SZ, VL
        - Multi stage
      - Diffuser
        - Single stage .... HX, VX
        - Multi stage VX
    - Axial flow .... HS, VS
  - Others
    - Regenerative
      - Non self-priming .... RK
      - Self-priming .... RQ, RQD
    - Reciprocating
    - Rotary
      - Gear .... GP, GPA
      - Vane
      - Screw
    - Vacuum .... NV, NVD, NVE
    - Jet .... JE, JES
    - Air lift

II CLASSIFICATION OF TURBO PUMPS

Turbo pumps are loosely grouped into the following three types.

Centrifugal Pump
Pump head caused primarily by the centrifugal force of impeller rotation. This type pump is widely used for its high head capability.

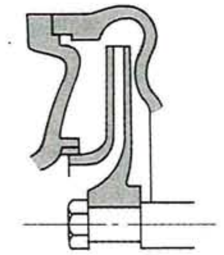


Fig. 1 Centrifugal

Mixed Flow Pump
Here pump head is derived partly from rotation of the impeller, partly from impeller lift.

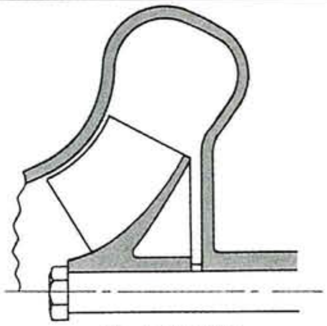


Fig. 2 Mixed Flow

Axial Flow Pump
Head produced by this pump is primarily a result of impeller action on water. It is used extensively when a large flow with low head is required.

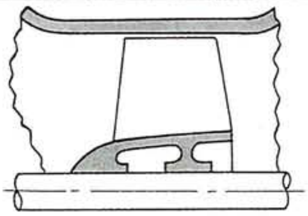


Fig. 3 Axial Flow

These three kinds of pumps are also classified according to types of casing and impellers.

CASING

Volute Pump & Diffuser Pump
Water flows from impeller at high speed, which must be efficiently converted into pressure. In a diffuser pump, this conversion is performed by a guide vane installed in contact with the impeller. In a volute pump, conversion is by a volute casing not provided with a guide vane. Because of its high efficiency in handling a wide flow of water, simplicity of construction and compactness a volute pump is universally used, except for such special use, as with a deep well.

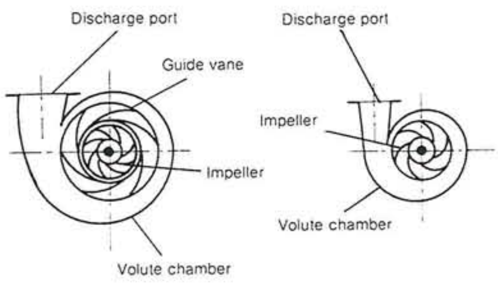


Fig. 4 Diffuser　Fig. 5 Volute

SUCTION TYPES

Single Suction & Double Suction
When single suction is insufficient to move a large volume of water, two impellers are used back to back, and suction occurs on both sides. This, then, is the double suction type. Double suction improves efficiency, and the axial thrust is, in theory, balanced. However, because of structural complications, double suction is not used in other volute type pumps.

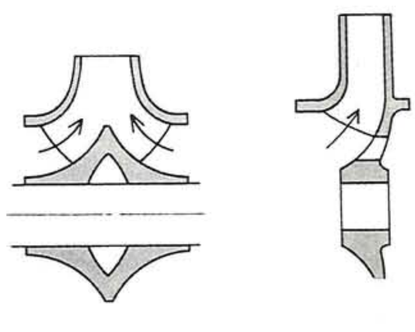


Fig. 6 Double suction　Fig. 7 Single Suction

MULTI-STAGES

When a single impeller fails to produce the required head, several impellers are arranged on as many stages on the principle of series operation of pumps. Most high-head pumps are multi-stage type.

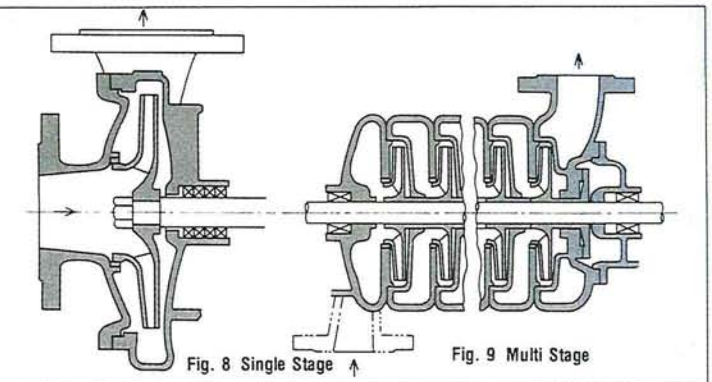


Fig. 8 Single Stage

Fig. 9 Multi Stage

NON-SELF-PRIMING & SELF-PRIMING PUMPS

It is necessary to prime a conventional pump prior to operation to create a water channel from the pump through the suction piping. A self-priming pump can be started without the need for this drudgery, if there is water in the pump, without the need for water in the suction pipe. Self-priming pumps work as follows:

i) Prior to operation, water is in the casing and the impeller is immersed in water.

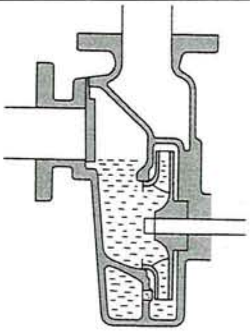


Fig. 10

ii) With the start of operation, the impeller creates a vacuum in the pump, and air in the suction pipe is gradually drawn into the pump. On the outlet side, air alone is discharged and water circulates within the impeller.

iii) With the complete removal of air from the suction pipe, the pump commences regular watering.

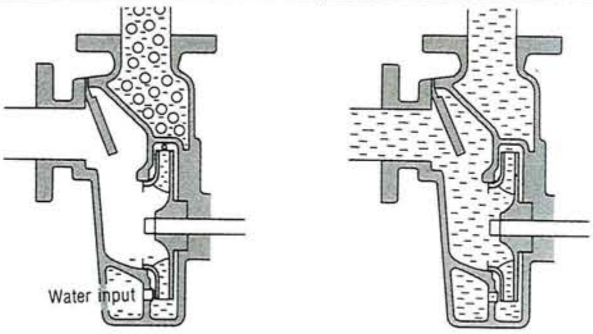


Fig. 11

Fig. 12

SUBMERSIBLE PUMPS

Submersible pumps have enjoyed fast progress in recent years because:

1) No installation space is necessary.
2) Priming is not required.
3) There is no worry about cavitation.

Another reason for the popularity of submersible pumps is the new reliability of submersible motors and their mechanical seals, plus the availability of these pumps at moderate cost.

OTHER PUMPS

In addition to the various types of turbo pumps mentioned above, there are others such as regenerative, reciprocating, rotary, vacuum, jet and air lift pumps. These pumps, however, have special applications. Most widely used among pumps are turbo pumps, and, particularly, centrifugal volute pumps.

HEAD LOSS FOR WATER FEED PIPE

(1) Head Loss for Straight Pipe

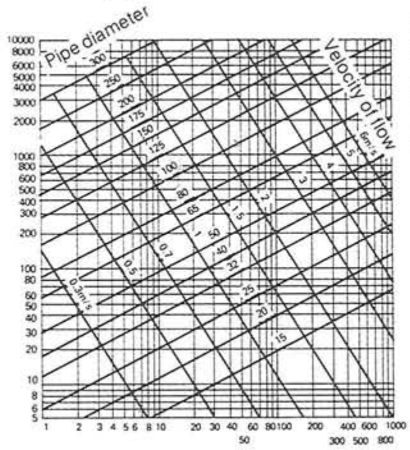
a. To find head loss by calculation:
Calculate using the following equation:

$$Hf\,(m) = \lambda \cdot \frac{L}{D} \cdot \frac{v^2}{2g}$$

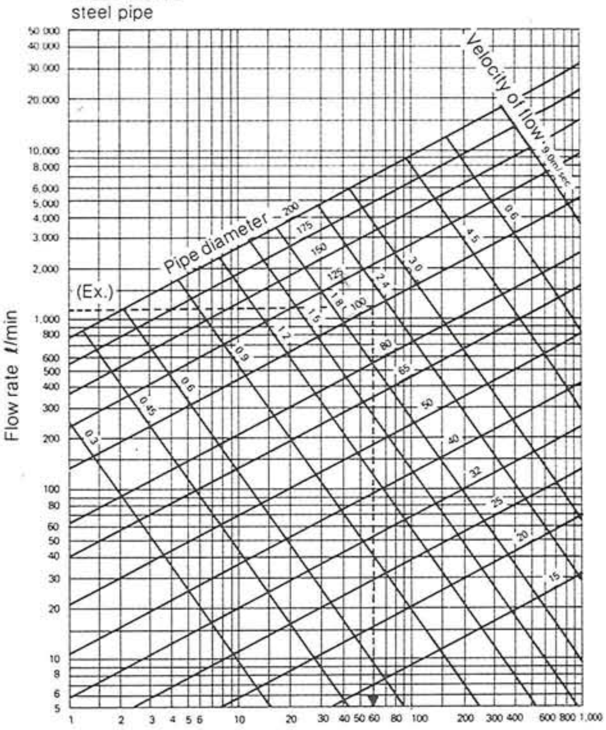
Where:
L: Overall length of pipe (m)
D: Diameter of pipe (m)
v: Velocity of flow in pipe (m/s)
G: Gravity acceleration ($9.8 m/s^2$)
λ: Value variable with fluid viscosity and flow velocity, pipe diameter and inside roughness, being found, in the case of water, by the following formula:

$$\lambda = 0.02 + \frac{1}{2000D}$$

Loss of head for vinyl chloride pipe



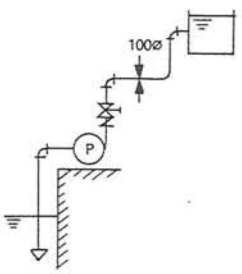
Head loss for steel pipe



b. To find head loss from graph:
The head loss for a vinyl chloride pipe and that for a steel pipe (the head loss for a cast iron pipe being 1.3 times that for a steel pipe) are as shown above. These graphs however, indicate the head loss per meter for a new pipe, and therefore the results obtained must be translated into the length as desired. Moreover, from a practical vewpoint, the resultant length must be multiplied by 1.5, allowing for aging.
Example:
To find the head loss of a straight steel pipe measuring 100mm in diameter and 80m in length designed to feed water at $1.2m^3$/min., see the figure above and you will get 60mm (=0.06m), and Hf=0.06m 80 1.5 (design coefficient)=7.2 (m)

(2) Head Loss for Piping Elements
The table below shows the length of a straight pipe which produces the same head loss as the friction head loss produced by a pipe joint or valve. (For example, the head loss produced by a single 90° elbow of 40mm equals that produced by a straight pipe of 0.7m. The values calculated on the basis of the following table is added to the actual length of a straight pipe, so that the overall head loss for the piping may be found from the graphs above.

Example:
The piping system as shown below is designed to feed water of $1.2m^3$/min. through a steel pipe of 100mm in diameter with straight section totaling 80m long, one foot valve, four elbows, one check valve, and one gate valve. Find the gross friction loss.



Length of Piping Elements in Terms of Straight Pipe (m)

Piping element \ Pipe diameter (mm)	25	32	40	50	65	80	120	125	150	200	250
90° elbow	0.5	0.6	0.7	0.9	1.1	1.3	1.8	1.2	2.7	3.7	4.3
90° bend	0.5	0.6	0.7	0.8	0.9	1.1	1.3	1.5	1.7	2.1	2.4
Globe valve	13.7	16.5	18.0	21.3	23.5	28.6	36.5	—	—	—	—
Gate valve	—	—	—	0.8	0.8	0.9	0.9	1.0	1.0	1.0	1.0
Check valve or foot valve	2.2	3.1	3.7	5.2	6.4	8.2	11.6	15.2	19.4	27.4	36.6

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Solution:
Length of straight sections 80m
Length of piping element in terms of straight pipe .... About 32m

Breakdown
- Foot valve............. 11.6
- Check valve 11.6
- Gate valve 0.9
- Elbow 1.8x4 = 7.2

Total: 112m

In effect, find the head loss for a straight pipe of 112m in length. From the graphs above which show the head loss for a gas pipe to be 60mm (=0.06m) per meter, Hf=0.06 112m 1.5 (design coefficient)=10m is obtained.