Vertical Turbine Pumps

Prepared by :

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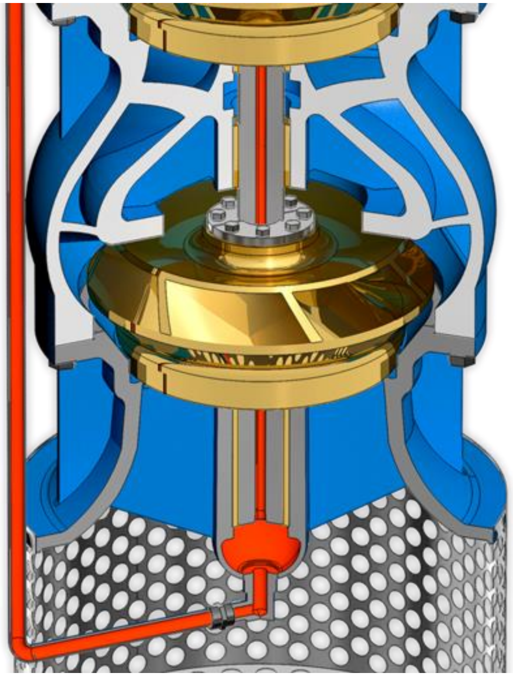
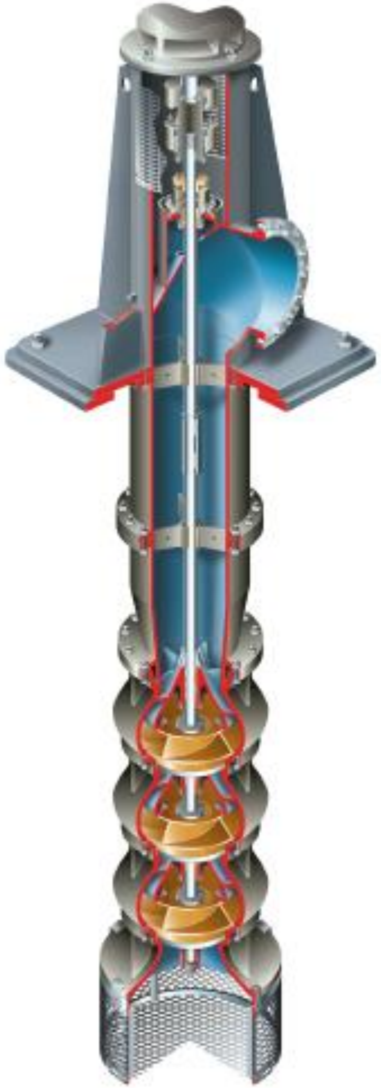
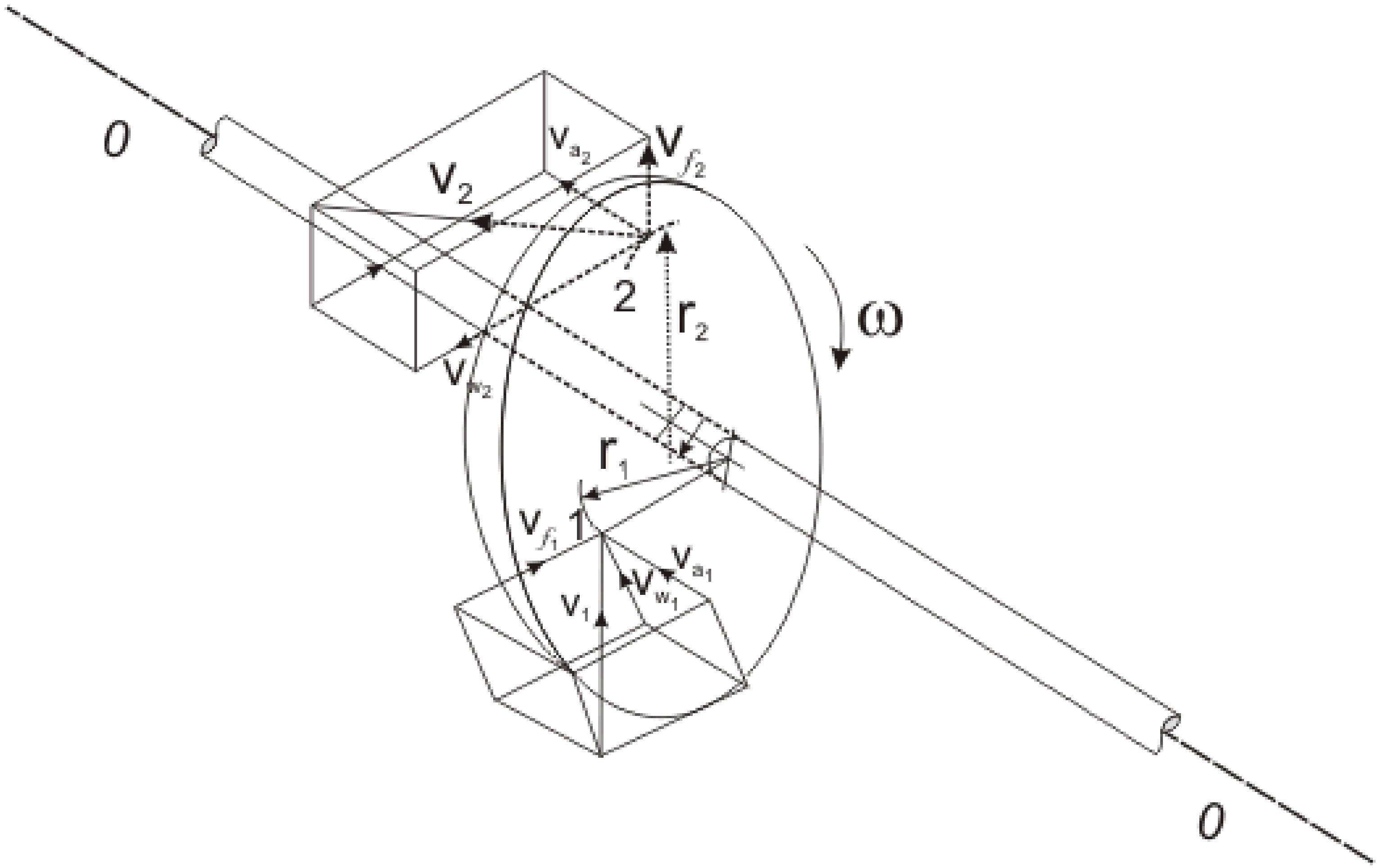





0
V
V
2
ω
0

Euler's Equation for Turbomachines:

$$\boxed{H = \frac{Vw2 - Vw1}{g}}$$

$$\boxed{H = \frac{V1^2 - V2^2}{g} + \frac{U1^2 - U2^2}{g} + \frac{Vr2^2 - Vr1^2}{g}}$$

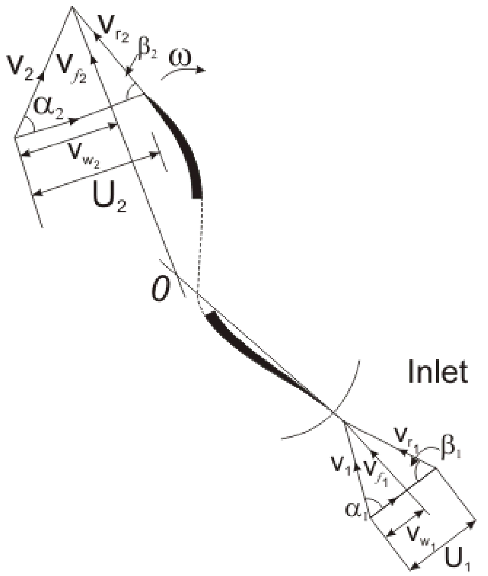
For Turbines:

H > 0 i.e. $V_1 > V_2$ $U_1 > U_2$ $V_{r2} > V_{r1}$

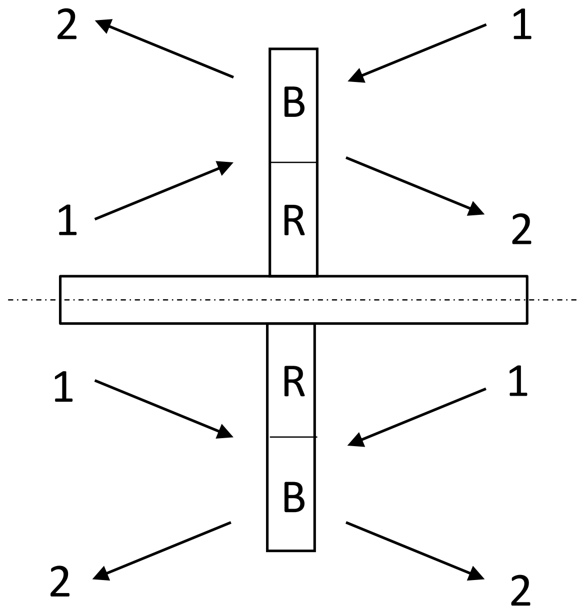
For Pumps & Compressor:

H < 0 i.e. $V_1 < V_2$ $U_1 < U_2$ $V_{r2} < V_{r1}$

Note : Head delivered by the fluid to Machine is taken as +Ve while head delivered to the fluid is taken as -Ve

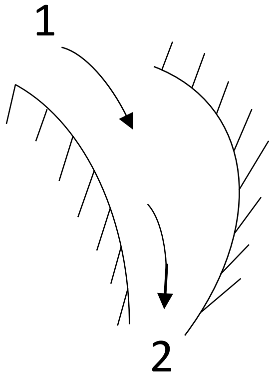


Radially outward flow

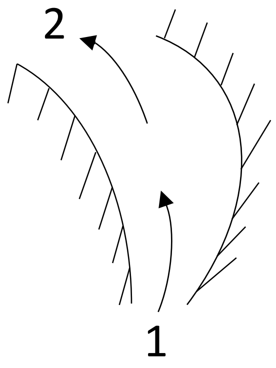


Radially Inward flow

Converging blade passage $V_{r2} > V_{r1}$



Diverging blade passage $V_{r2} < V_{r1}$

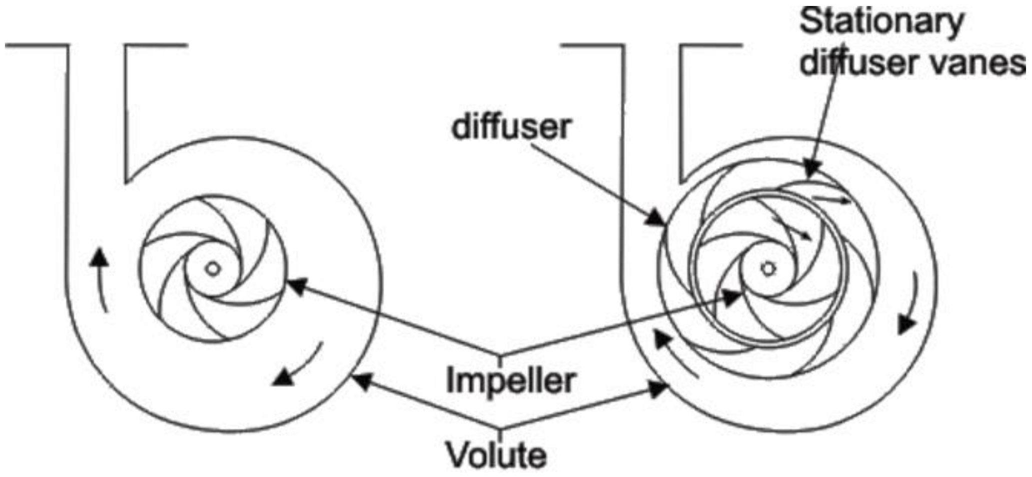


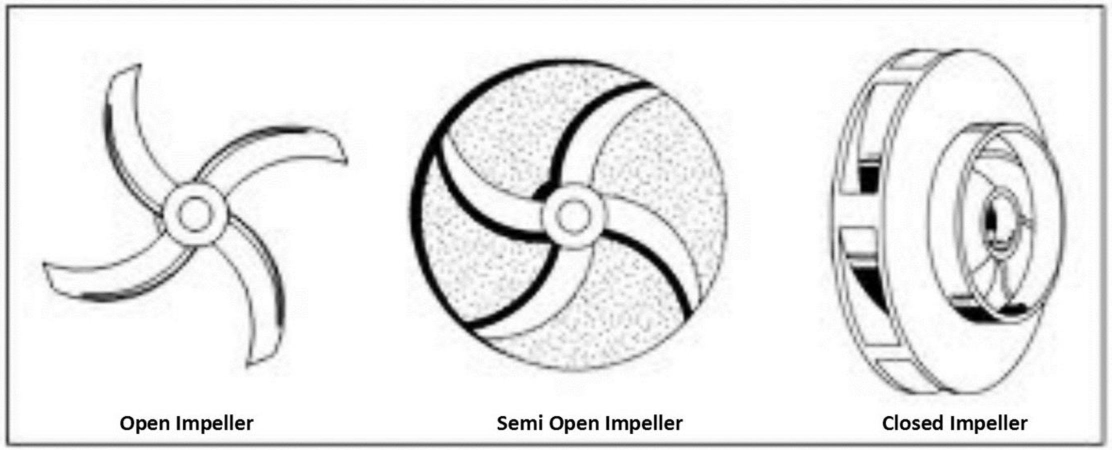
Pumps ➡ Radially outward flow with diverging blade passage

Pumps → Positive Displacement Pumps

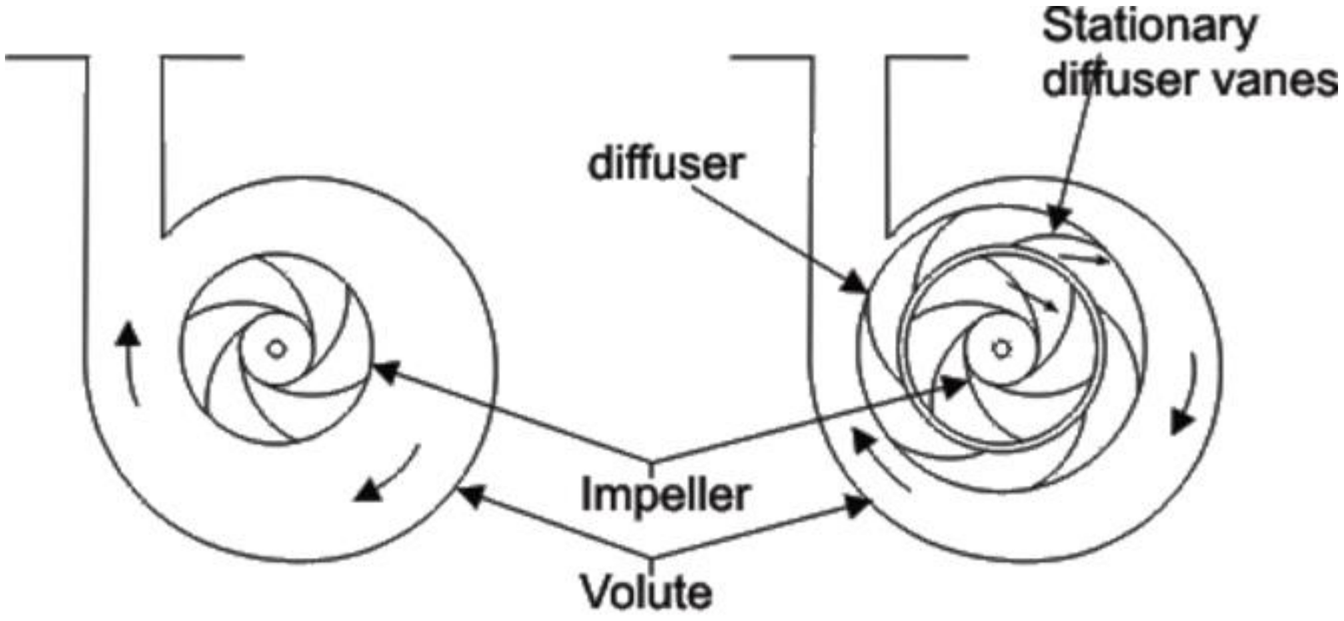
Pumps → Rotodynamic Pumps

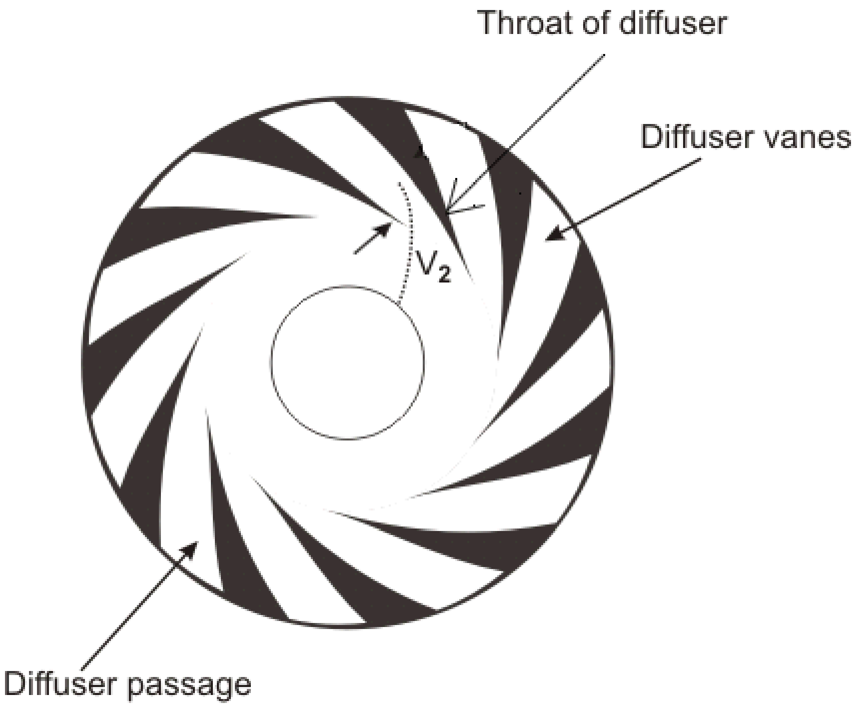
Centrifugal Pumps ➡ employing centrifugal effects for increasing fluid pressure





Pump with Diffuser vanes





Usually 10% of head generated is lost in the volute casing because of the viscous action of the fluid.

To have better/efficient diffusion (↓ Velocity & ↑ Pressure) we use vane diffuser (fixed blades/vanes). Hence before going to volute casing fluid passes through vane diffuser which has diverging type of fluid passage.

Hence Pump becomes more compact with efficient conversion of kinetic energy into pressure energy.

Turbine Pumps

similarity in appearance to a turbine

Turbine Pump → **a vane diffuser pump** → **for lifting water from small-diameter wells especially from deep levels for Irrigation & water supply**

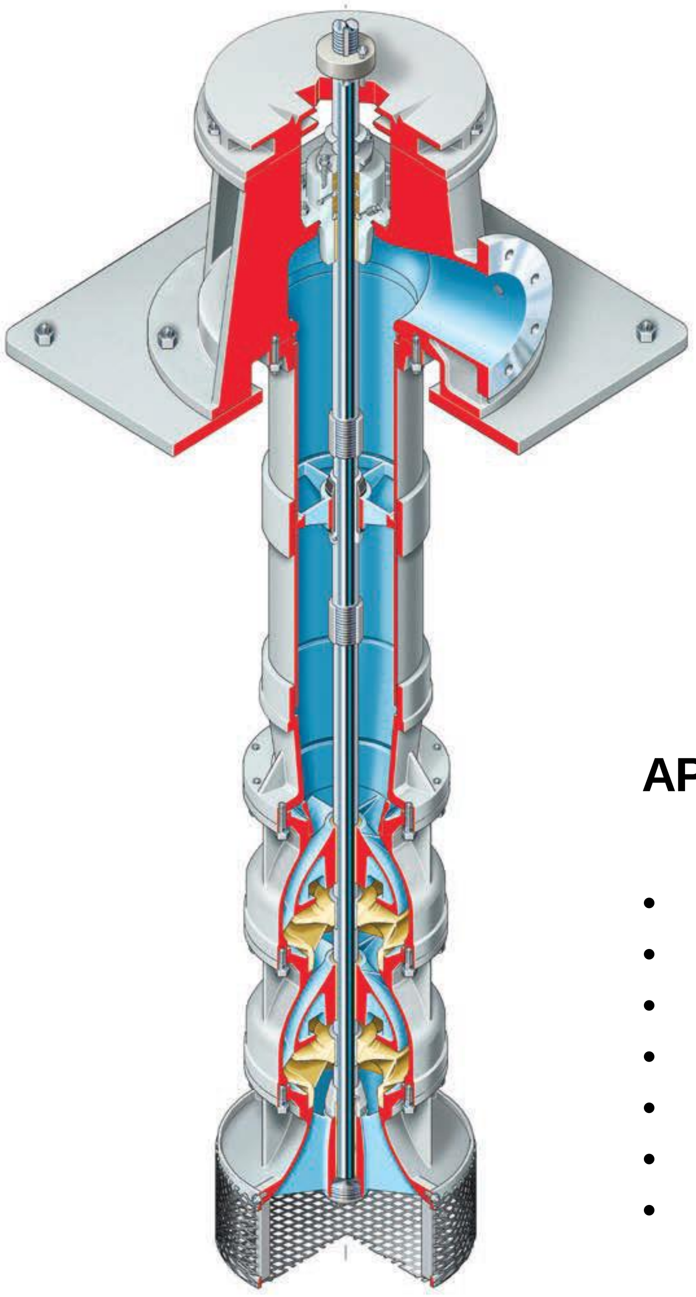
(Deep-well turbine pump)

Multi stage arrangement – was developed to meet the increase in the requirement of head & limitation concerning small impeller diameters

Diffuser-type vertical centrifugal pumps

- Deep well turbine
- submersible pumps

- Best suited to situations where seasonal fluctuations in water level (in the well) are encountered.
- Adapted **to high lifts, and possess high efficiencies**.
- However, these pumps involve **higher initial costs**, and are **more difficult to install** and **get repaired**, as compared to volute pumps.



APPLICATIONS

- Agriculture & Irrigation
- Power Generation
- Oil & Gas
- Municipal
- General Industry
- Chemical
- Mining

Vertical Turbine Pumps Vs Submersible Pumps

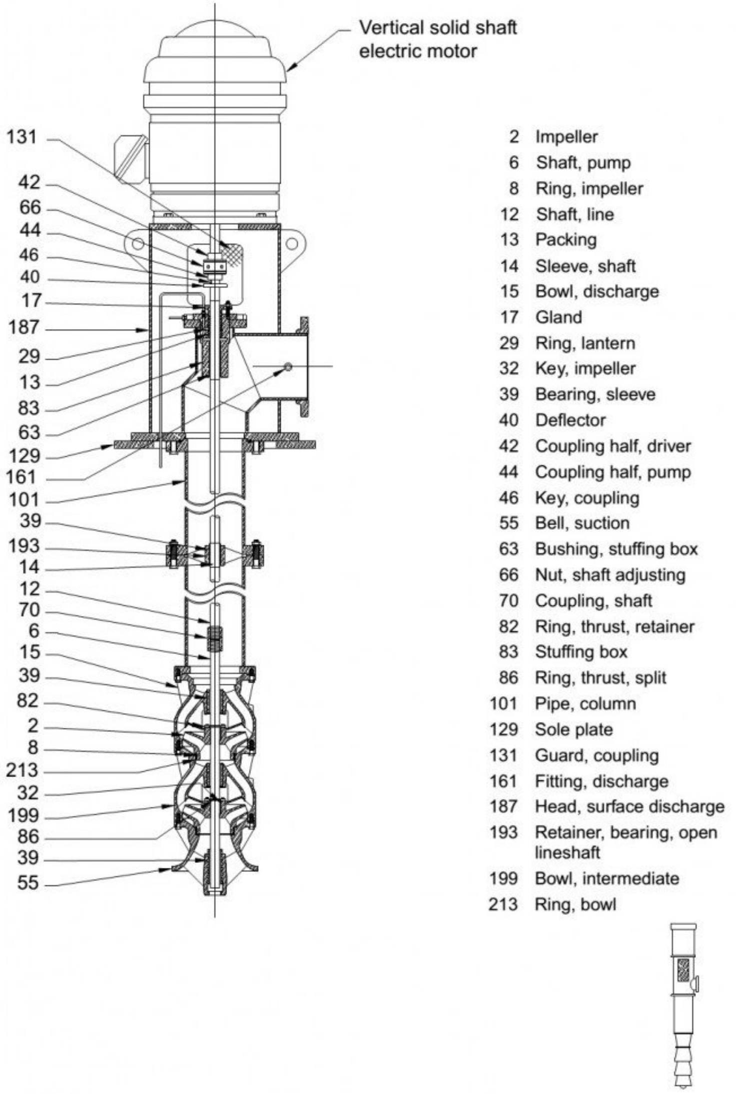


Figure 2.1.3.2a — Vertical single or multistage, short setting, open lineshaft (VS1)

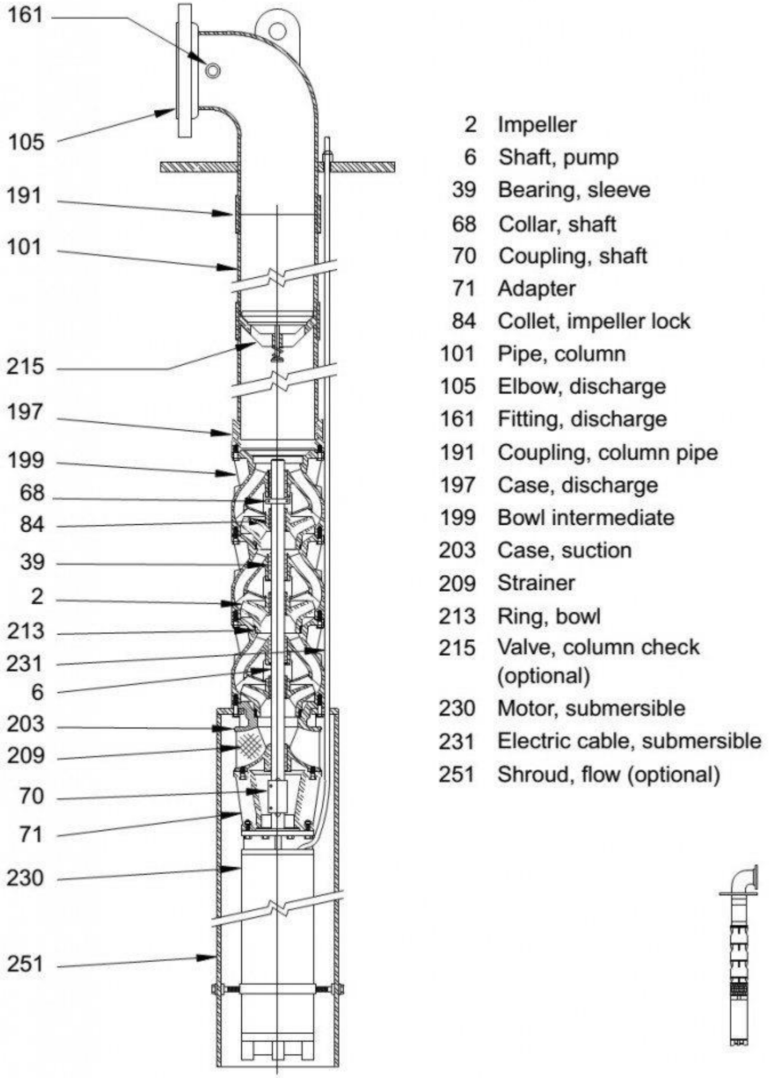


Figure 2.1.3.5 — Vertical, multistage, submersible pump (VS0)

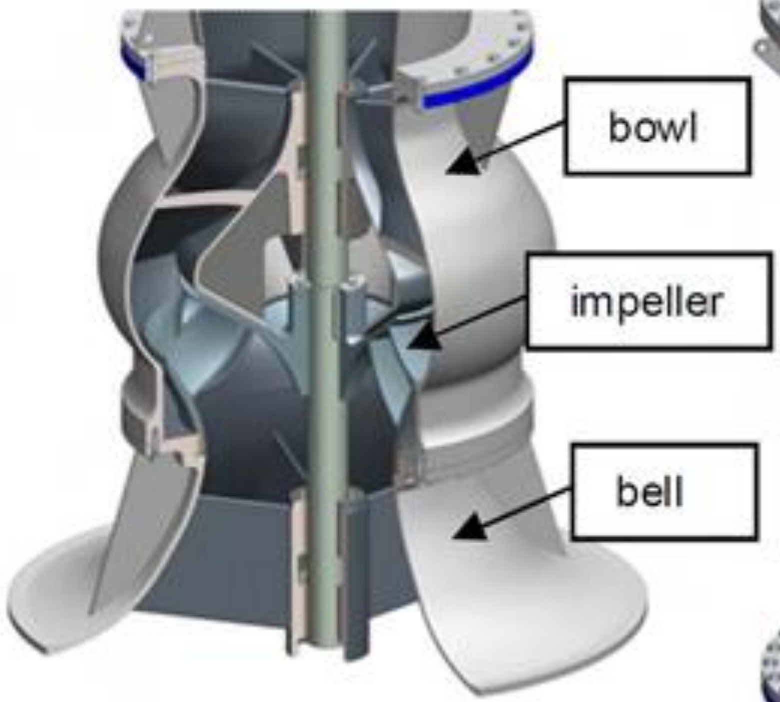

TT
Engineered for

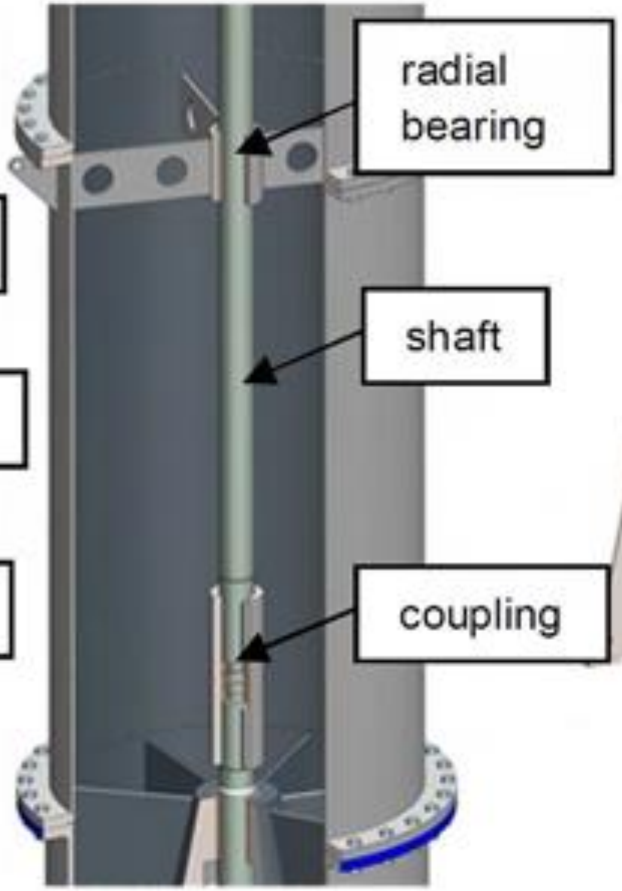

3
4
6
5
8
7
6
1
2

Elements of Vertical Turbine Pumps

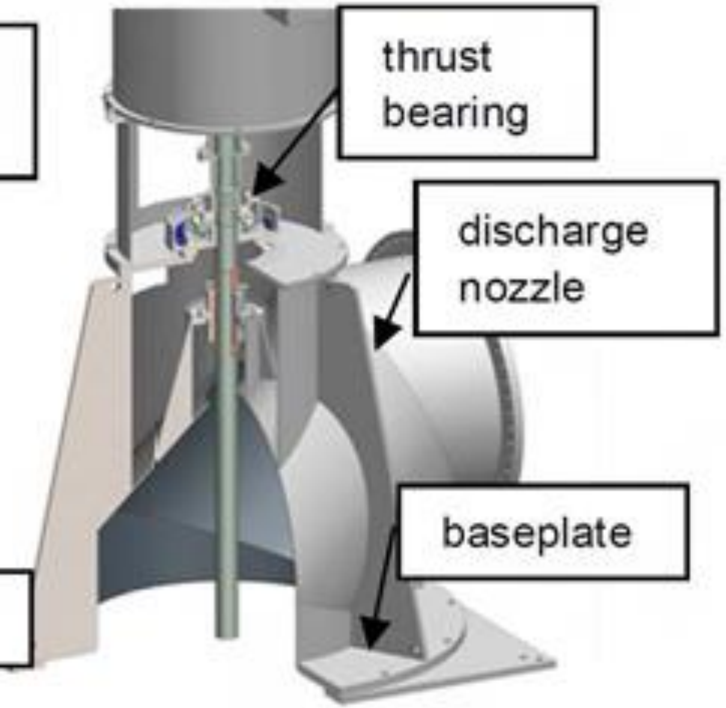
Pump element	It consists of one or more bowls (or stages); and, each bowl assembly consists of an impeller and diffuser and a bearing. The bowl assembly remains under the water surface. It carries a screen (or a strainer) fixed to its bottom to keep away coarse sand gravel from entering the pump. A semi-open impeller can handle suspended solids with a minimum of clogging. Impeller are generally made of bronze, cast iron or cast iron coated with porcelain enamel
The discharge column	comprises the delivery pipe and the shaft including its couplings and bearings. Construction of the column assembly depends on the mode of lubrication of the pump-oil or water-lubricated. Column pipes and shaft are usually supplied in 3 m lengths. The drive shaft is located at the centre of the discharge pipe
Discharge Head	The pump column assembly is fixed to the discharge head which is located at the ground surface. The base of the discharge head is bolted to the pump foundations. Electric motors, gear drives belt pulleys may be used on the same discharge head. The discharge elbow is provided with a flange to which the discharge pipe may be fixed.

SUCTION - BOWL

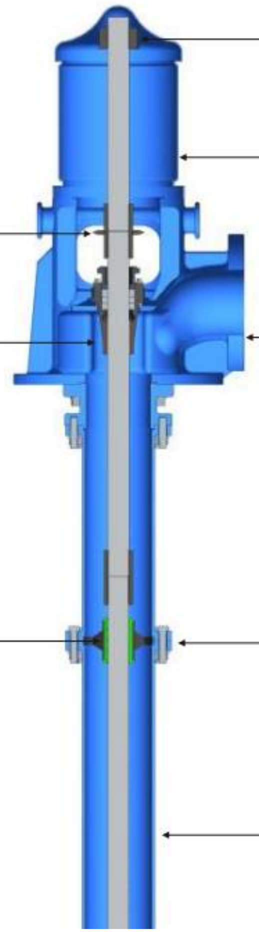




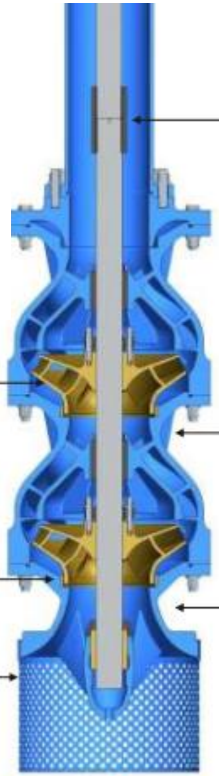
COLUMN



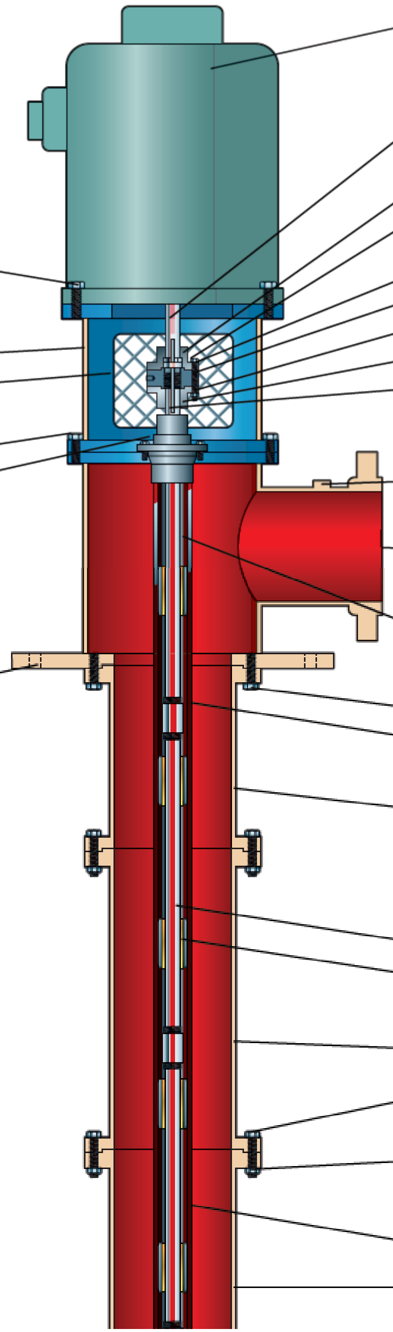
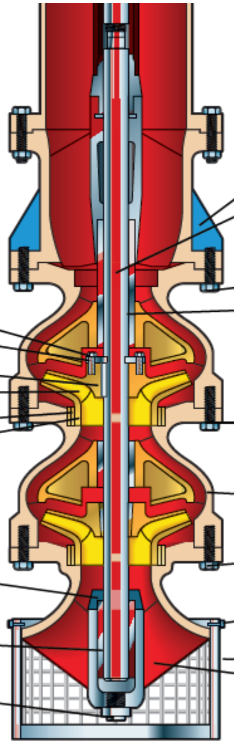
DISCHARGE HEAD



Coupling Nut
Hollow Shaft Motor
Deflector
Stuffing Box with packing and support bush
Cast Discharge Head provides
more rigidity & stability to the pump
Bearing Insert. Fluted bearing restricts movement
of suspended solid particles of moderate size
to avoid damage to shaft and bearing.
Bearing Retainer sandwiched within column
spigot ensures perfect alignment with shaft
Fabricated Column Pipe with flanged ends



Screwed Coupling
Enclosed Impeller.
Fixed to shaft with collet and key.
Bowl-Diffuser design eliminates radial
loading and provides down thrust only.
This design reduces shaft deflection and
vibration. It increases bearing life.
Serrated Wear Rings reduce
metal to metal contact and helps
increase & maintain pump efficiency.
Each suction bell includes anti-vortex ribs and
bottom bearing. Bell mouths are available with
replaceable wear rings.
Basket type strainer
avoids entry of undesired
size of solids in the pump.


Motor
Motor Key
(Supplied By Motor Vendor)
Hub - Motor
Ring - Retaining
Soc HD Capscrew
Plate - Adjusting
Hex Nut
Hub - Pump
Pump Key
Capscrew
Motor / Support
Motor Support
Coupling Guard
Capscrew Support / Head
Tension Plate
Oil Lube
Water Flush
Pipe Plug
Head
Tube Nipple
Mounting Holes
Capscrew Col / HD
Headshaft
Column - Top
Tube - Encl.
Bearing - Tube
Column - Intermediate
Capscrew - Col / Col
Hex Nut
Lineshaft
Column - Bottom

Dish Bowl
Pumpshaft
Capscrew - Bowl / Disch Bowl
Bearing - Throttle
Soc HD Capscrew
Thrust Ring
Key - Impeller
Impeller
Wear Ring - Bowl
Wear Ring - Imp
Capscrew - Bowl / Bowl
Bowl
Capscrew - Bowl / Bell
Capscrew - Strainer
Sand Collar
Bearing - Suction
Pipe Plug
Strainer (Basket Type)
Suction Bell

Main Features of Turbine Pumps

(a) Specific Speed and Type Numbers for Different Setting

Setting	Range of Ns (US customary)	Range of Type Number
Two stage vertical turbine pump	1200-4000	0.44-1.46
Two Stage Mixed Flow (enclosed)	4000 - 5500	1.46 - 2.01
Single Stage Mixed Flow	6000 - 10000	2.19 - 3.66
Single Stage Propeller	10000 - 14000	3.66 - 5.12

$$N_S = \frac{N\sqrt{Q}}{H^{3/4}}$$

$$Type\ Number\ -\ N_T = \frac{2\,N\sqrt{Q}}{g\,H^{3/4}}$$

Ns are metric units, in which

- impeller speed N (rpm)
- the discharge Q (m^3/hour)
- head H (metres).

Note: Type Number = (Ns in US. customary Unit) x 3.656 x 10^{-4}

Main Features of Turbine Pumps

(b) Size and Diameter

Sizes were adapted to common installations.

For example, a 300 mm turbine pump might have a maximum outer bowl diameter of 285 mm, and could be used in a well of 300 mm well casing pipe.

Nearly all mixed flow and propeller pump bowl assemblies are numbered by the upper flange diameter.

(c) Length, Capacity and Head

Turbine pumps are built for capacities starting from 4.5 m3/h at multistage heads of 450 m.

The upper hits of capacity are determined by shaft size, length and power capability.

Many deep well turbine pumps of **300** m column length exist.

Many single stage mixed flow pumps with capacity of **225 m^3/hr at 18 m head**, and propellers pumps with **45,000 m^3/hr**, having **6m** head, are known to be in service.

As an illustration let there be a requirement of 114 m3/hour (500 gallon per min) of pumping at a total bowl head of 80.8 m (265 ft).

One choice of the suitable system specific speed with 3500 rpm drive is

$$N_S = \frac{3500\sqrt{500}}{265^{\,3/4}} = 1200$$

The bowl efficiency (using Figure 14.5) is 78.5 %.

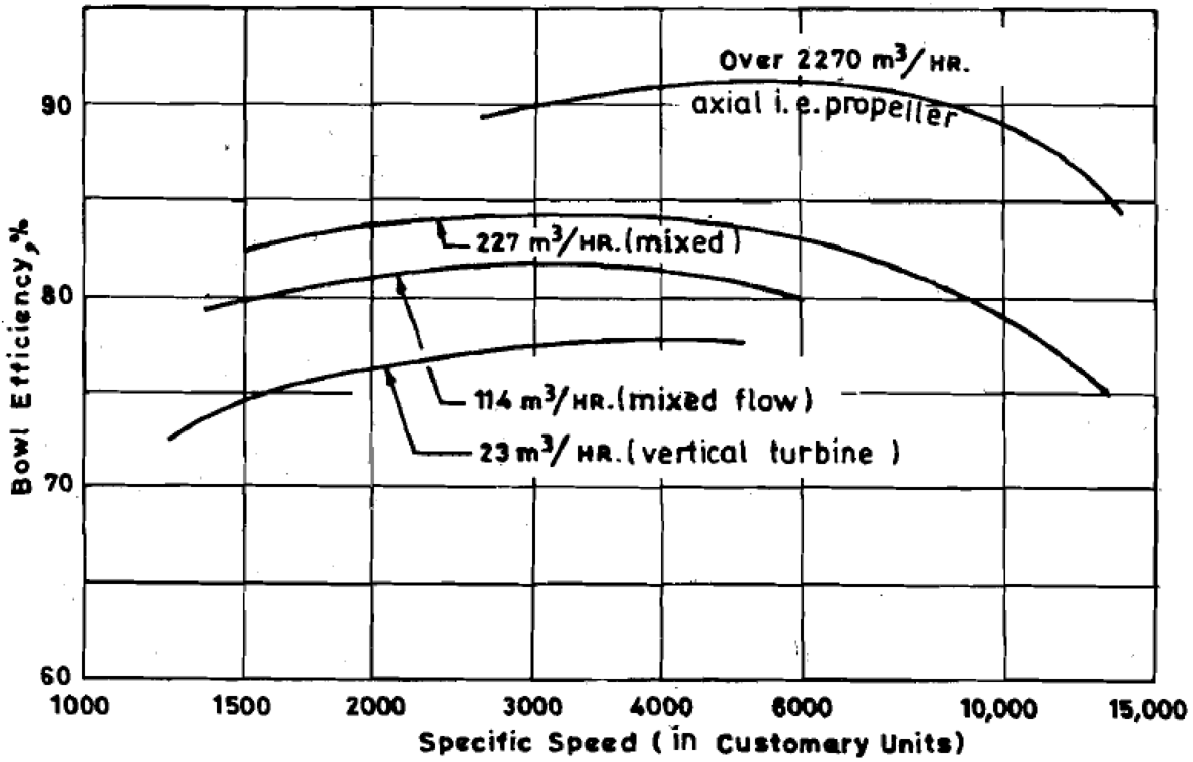


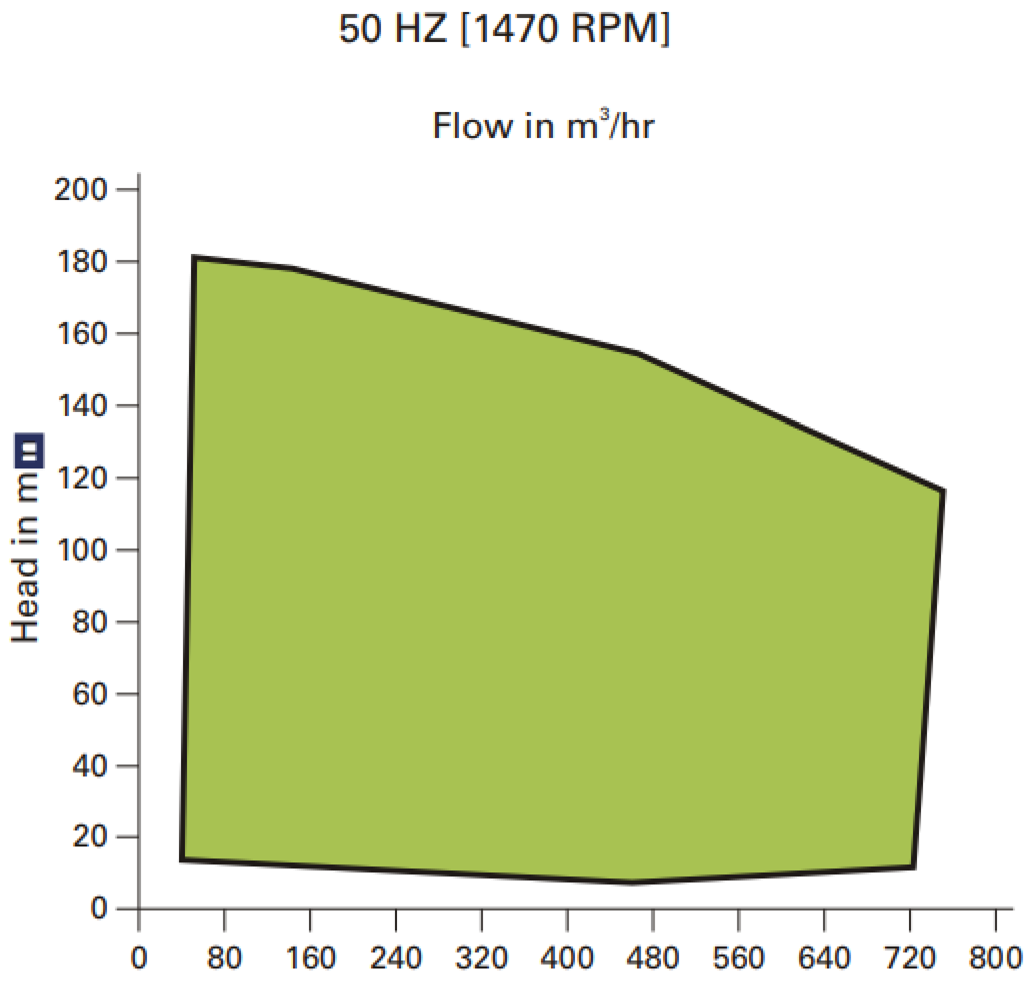
Figure 14.5: Maximum Expected Bowl Efficiency for Vertical Turbine, Mixed Flow and Propeller Pumps

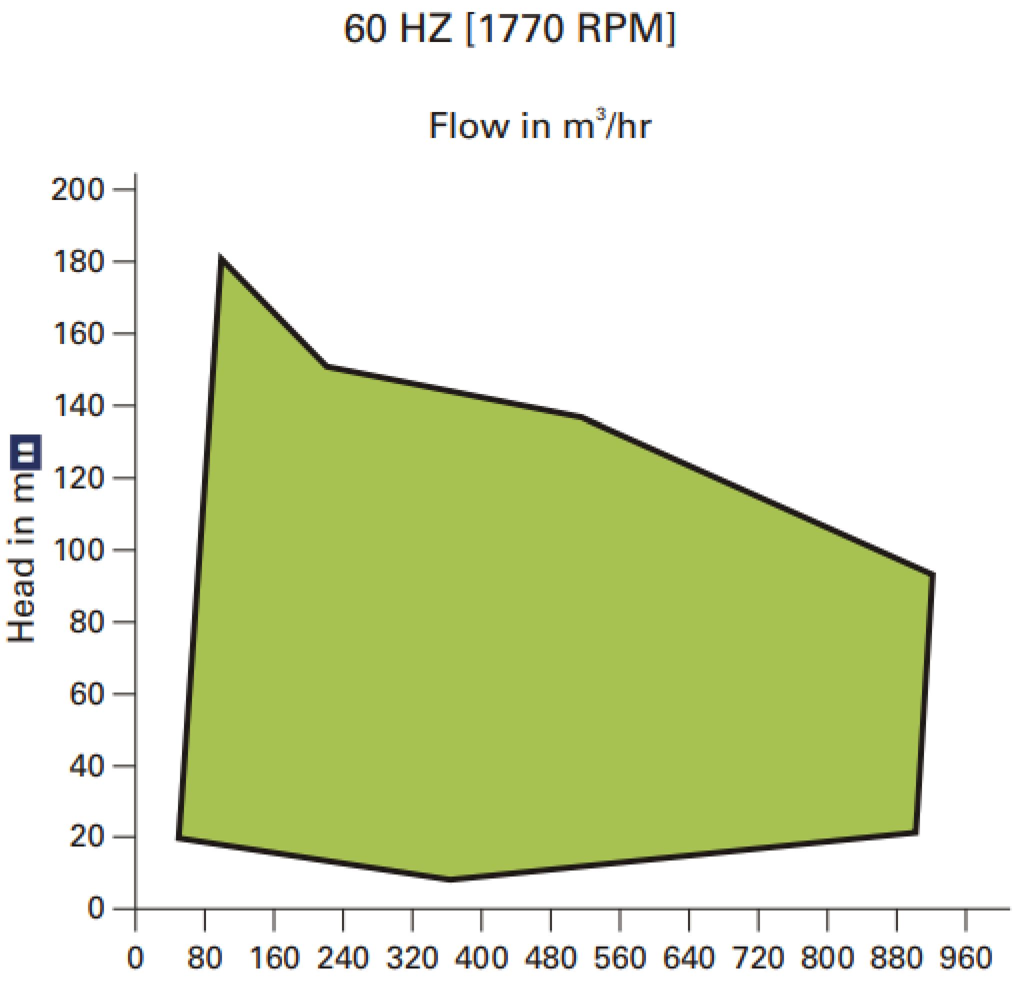
Table 14.2: Optimum Number of Stages

No. of Stages	Head/Stage ft. (m)	Pump N_S	Efficiency %
1	265 (80.8)	1,200	78.5
2	132.5 (40.4)	2,018	81.0
3	88.3 (26.9)	2,736	81.6
4	66.3 (20.2)	3,392	81.6
5	53.0 (16.2)	4,012	81.5

RANGE CHART

General operating range of pumps is indicated below:





Essential Data Required for Making a Selection

- depth of well,
- inside diameter of well casing,
- dimensions of well pit (if any),
- depth to static water level at the required capacity,
- required capacity of the pump,
- discharge curve of the well,
- information about the seasonal fluctuation in the water table,
- preference for oil or water-lubricated pump design,
- available source of power and its statistics, mode as:

  a) electricity -voltage, phase and cycle,
  b) stationary engine : diesel / petrol,
  c) belt pulley size and speed,

- quality of water to be pumped, and
- condition and alignment of the well bore

Grey iron / grey cast iron

- Weak & brittle in tension.
- Stronger in compression.
- Excellent damping capacity, wear resistance.
- Casting shrinkage is low.
- Corrosion resistance.
- Maximum temperature limit.
- Coefficient of thermal expansion is low.

Bronze

- Very good wear resistance.
- Stronger than brass
- Good tensile properties.
- Corrosion resistance
- can be cast hot worked and cold worked

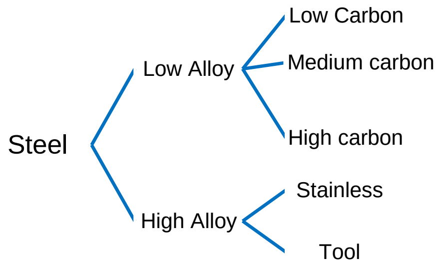
Bismuth Bronze (developed to hold similar properties to leaded bronzes)

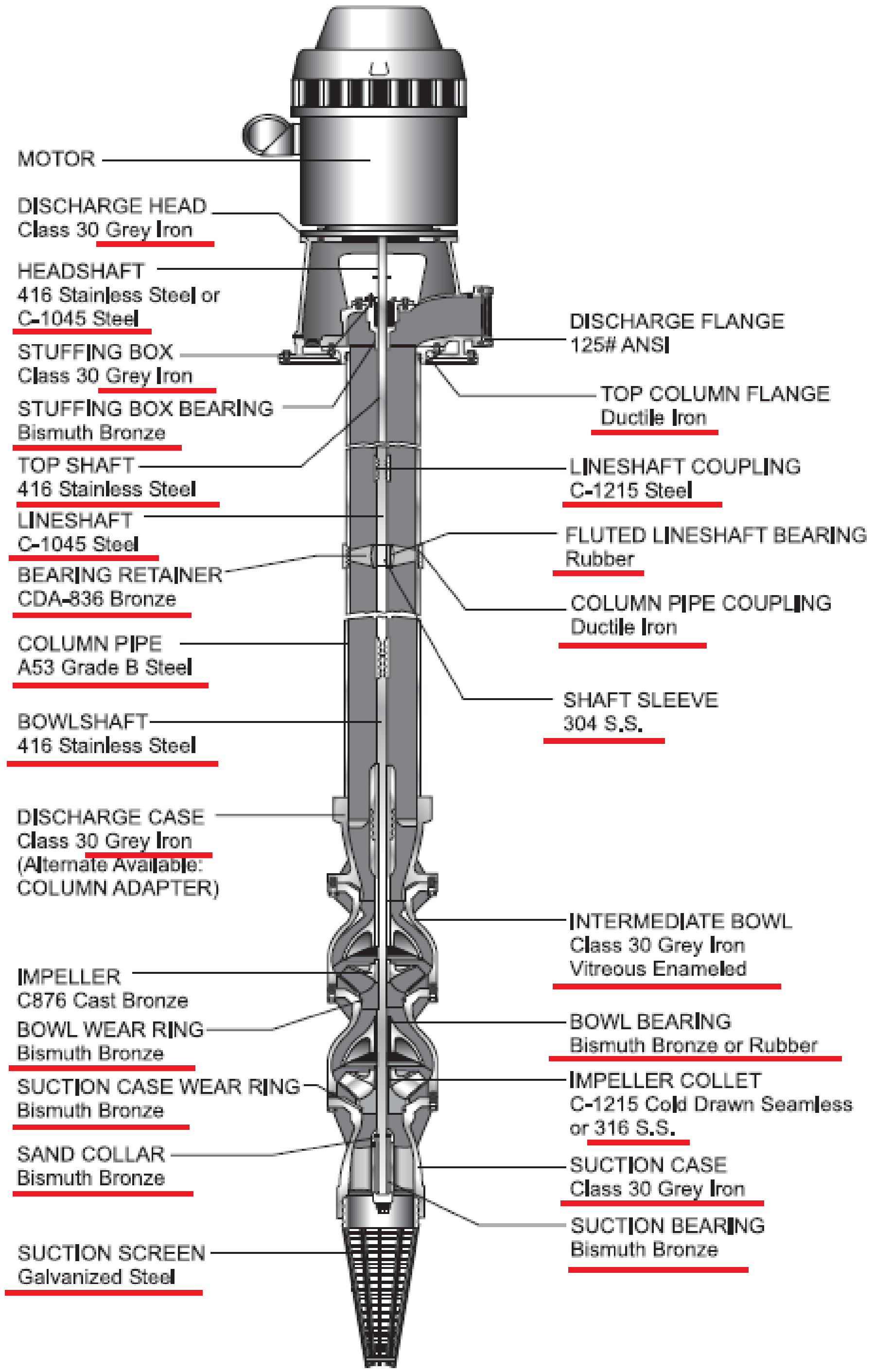
- Lead is added to improve machinability
- Bismuth acts very much like lead in many respects. It is lead's neighbour on the Periodic Table of Elements.

Ductile iron / Nodular Iron

- Addition of Mg and/or Cerium to grey iron converts the graphite flakes to nodules.
- Castings are stronger and much more ductile than grey iron as the stress concentration points existing at the flake tips are eliminated

Steel (Alloy of Iron & Carbon)





Types of Vertical Turbine Pumps

2 Impeller
6 Shaft, pump
8 Ring, impeller
10 Shaft, head
12 Shaft, line
13 Packing
17 Gland
29 Ring, lantern
39 Bearning, sleeve
40 Deflector
55 Bell, suction
63 Bushing, stuffing box
64 Collar, protecting
66 Nut, shaft-adjusting
70 Coupling, shaft
77 Lubricator
79 Bracket, lubricator
83 Stuffing box
84 Collet, impeller lock
85 Tube, shaft-enclosing
91 Stablizer, tube
101 Pipe, column
102 Bearing, throttle
103 Bearing, lineshaft, enclosed
129 Plate, sole
131 Guard, coupling
183 Nut, tubing
185 Plate, tension, tube
187 Head, surface discharge
189 Flange, top column
191 Coupling, column pipe
193 Retainer, bearing, open line shaft
195 Adapter, tube
197 Case, discharge
199 Bowl, intermediate
203 Case, suction
209 Strainer (optional)
211 Pipe, suction (optional)
213 Ring, bowl

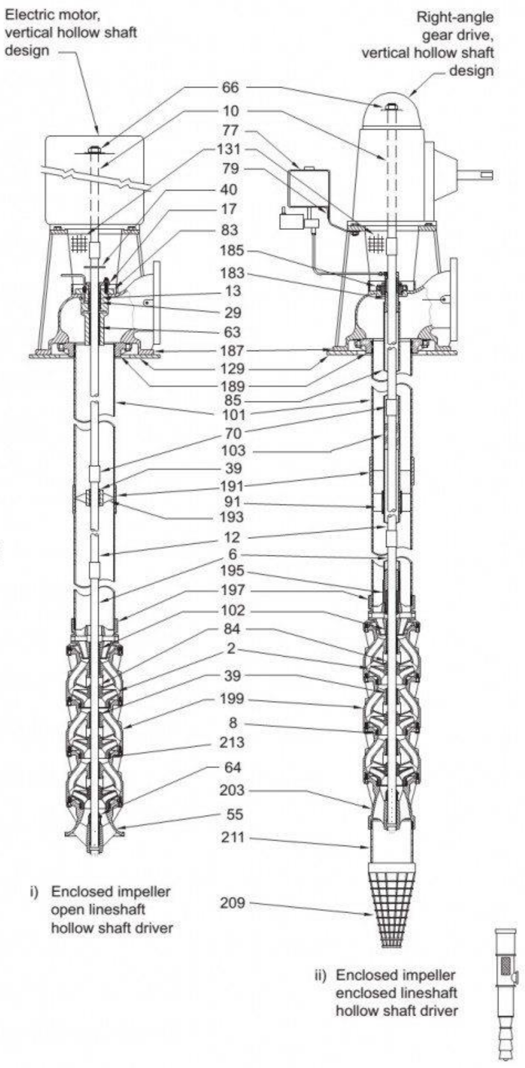
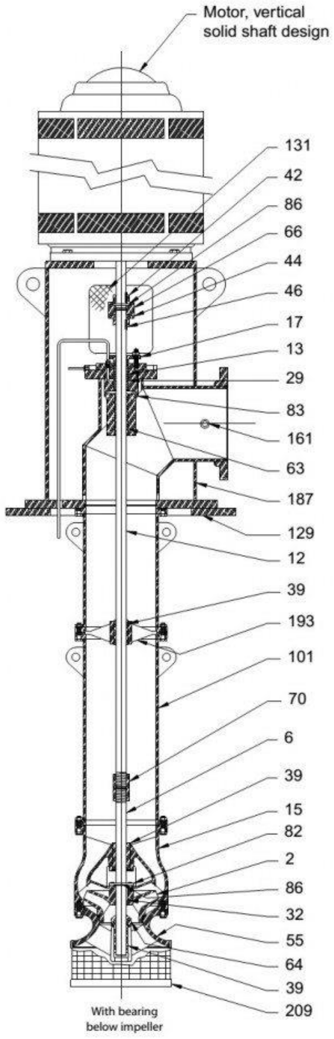


Figure 2.1.3.1 — Deep well pumps (VS1)



2 Impeller
6 Shaft, pump
12 Shaft, line
13 Packing
15 Bowl, discharge
17 Gland
24 Nut, impeller
29 Ring, lantern
32 Key, impeller
39 Bearing, sleeve
42 Coupling half, driver
44 Coupling half, pump
46 Key, coupling
55 Bell, suction
63 Bushing, stuffing box
64 Collar, protecting
66 Nut, shaft, adjusting
70 Coupling shaft
82 Ring, thrust, retainer
83 Stuffing box
86 Ring, thrust, split
101 Pipe, column
129 Sole plate
131 Guard, coupling
161 Fitting, discharge
187 Head, surface discharge
193 Retainer, bearing, open lineshaft
209 Strainer (optional)

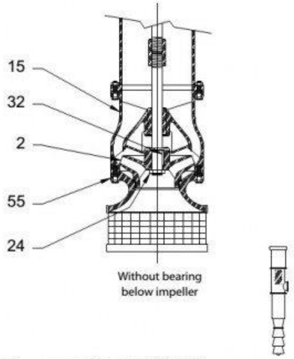
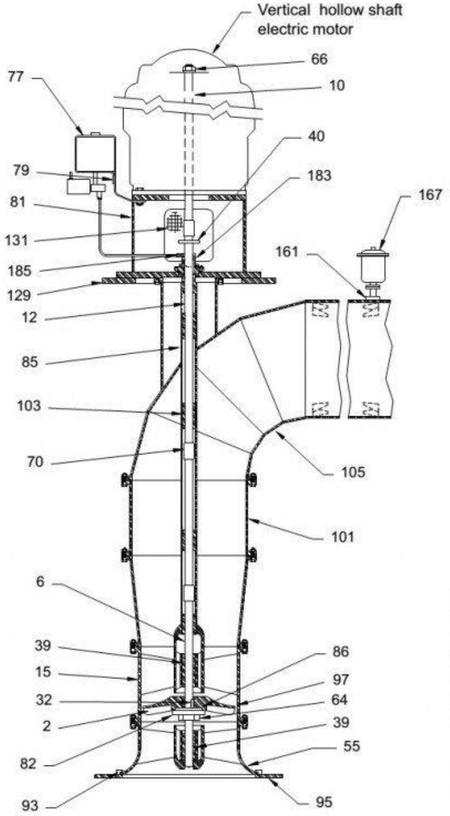


Figure 2.1.3.2b — Mixed flow vertical — open lineshaft (VS1)



2 Impeller
6 Shaft, pump
10 Shaft, head
12 Shaft, line
15 Bowl, discharge
32 Key, impeller
39 Bearing, sleeve
40 Deflector
55 Bell, section
64 Collar, protecting
66 Nut, shaft-adjusting
70 Coupling, shaft
77 Lubricator
79 Bracket, lubricator
81 Pedestal, driver
82 Ring, thrust, retainer
85 Tube, shaft-enclosing
86 Ring, thrust, split
93 Clamp, umbrella (optional)
95 Umbrella, suction (optional)
97 Liner, bowl
101 Pipe, column
103 Bearing, lineshaft, enclosed
105 Elbow, discharge
129 Sole plate
131 Guard, coupling
161 Fitting, discharge
167 Valve, air and vacuum release (optional)
183 Nut, tubing
185 Plate, tension, tube

Figure 2.1.3.2d — Vertical, axial flow impeller (propeller) type (enclosed lineshaft) below floor discharge configuration (VS3)

REGULATORY REQUIREMENTS:

1. National Fire Protection Association (NFPA 20)
2. Factory Mutual (FM)
3. Institute of Electrical and Electronic Engineers (IEEE)
4. National Electrical Manufacturers Association (NEMA)
5. American Society for Testing and Materials (ASTM)
6. National Electric Code (NEC)
7. Occupational Safety and Health Administration (OSHA)
8. ANSI/HI standards
9. Underwriters Laboratories, Inc.

NFPA 20 - Standard for the Installation of Stationary Pumps for Fire Protection

ANSI-HI 2.6-2000 - American National Standards for Vertical Pump Tests

THANK YOU