For a smaller size of pipe, the pump head curve will be steeper.

Paradoxical reduction in the pump head due to increase in pipe size is due to the air pressure in the pipe system. Yields the pump head curve, less discharging.

The reduction loss being very in series production of the pump, to the pump head due to flow and change in the flow rate, a change in the pump's operation.

The pump's running and the discharge of the pumps more than the level.

This makes the head reduction.

Lastly, the pump head in the head is needed to compensate for the suction head to be used.

The pressure is reduced by the pump head is reduced by the pump.

3.7.5.1 System Head

The suction head is the total head of the pump.
9.75.3 Parallel Operation

9.75.3.1 Operating Point of a Generator

From the system feed curves, one knows what the load head will be for the most

9.75.3.2 Operating Point of a Water Turbine

9.75.3.3 Calibrating a Generator

9.75.3.4 Reducing a Generator to Specification

9.75.3.5 Adjusting a Generator

9.75.3.6 Testing a Generator

9.75.3.7 Maintenance of a Generator

9.75.3.8 Storage of a Generator

9.75.3.9 Disposal of a Generator

9.75.3.10 Recycling of a Generator

9.75.3.11 Reconditioning of a Generator

9.75.3.12 Replacement of a Generator

9.75.3.13 Repair of a Generator

9.75.3.14 Calibration of a Generator

9.75.3.15 Inspection of a Generator

9.75.3.16 Overhaul of a Generator

9.75.3.17 Refurbishment of a Generator

9.75.3.18 Modernization of a Generator

9.75.3.19 Upgrading of a Generator

9.75.3.20 Retrofit of a Generator

9.75.3.21 Upgrading of a Generator

9.75.3.22 Retrofit of a Generator

9.75.3.23 Upgrading of a Generator

9.75.3.24 Retrofit of a Generator

9.75.3.25 Upgrading of a Generator

9.75.3.26 Retrofit of a Generator
FIG. 9.6: OPERATION OF PUMPS IN PARALLEL

<table>
<thead>
<tr>
<th>No. of Pumps</th>
<th>Flow of Each Pump</th>
<th>In Open Pumps</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

FIG. 9.5: CHANGE IN OPERATING POINT BY OPERATION OF DELIVERY VALVE

Open Delivery Valve

Partially Open Delivery Valve
The progress curve of the pump has a typical form and under some conditions the performance of the pump is limited by the discharge of the pump. This characteristic is very important because it shows the discharge curve of the pump.

The progression curve of the pump is a good example of the design of the pump. The progression curve is a graphical representation of the discharge curve of the pump. The curve shows the relationship between the discharge of the pump and the head of the pump.

The progression curve of the pump is useful in the design and operation of the pump. It can be used to determine the discharge of the pump at different heads.

The progression curve of the pump is also useful in the selection of the pump for a particular application. It can be used to determine the discharge of the pump for a given head and to determine the head of the pump for a given discharge.

The progression curve of the pump is also useful in the operation of the pump. It can be used to determine the discharge of the pump at different heads and to determine the head of the pump for a given discharge.

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The progression curve of the pump is also useful in the selection of the pump for a particular application. It can be used to determine the discharge of the pump for a given head and to determine the head of the pump for a given discharge.
FIG. 8: TYPICAL FOUNDATION FOR A PUMP

1/2 TO 1 1/2 ALLOWANCE FOR GROUT

FIG. 87: STABLE & UNSTABLE CHARACTERISTICS OF CENTRIFUGAL PUMPS

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FIG. 9.9: FOUNDATION FORVERTICAL PUMPS

Foundations form for vertical pump sole plate

Top of foundation

Sole plate, grout, shims, and wedges

Round type curb ring for above ground discharge vertical pump

Bolt foundation

Grout

Foundation

Wedges and shims

Curb ring

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9.7 9 DAILY OBSERVATION

Maintenance of Pumps

The pumps are to be checked before starting the day. Daily inspection of the pressure gauge and switch is essential.

Cleaning:

(1) Whether any undue noise of vibration is heard during the operation of the pump.
(2) Whether any leakage through the pipes or valves is present.
(3) Whether any apparent mechanical defects or maladjustments are present.

Operation of the Pumps

(1) Start the pump and observe the pressure gauge and switch.
(2) Check the condition of the lubrication system.
(3) Check the temperature of the motor and bearings.
(4) Check the discharge pressure and flow rate.

When the pump is in operation, the pressure gauge should be observed regularly. Any increase in pressure should be noted immediately.

Operation:

(1) Start the pump and observe the pressure gauge and switch.
(2) Check the condition of the lubrication system.
(3) Check the temperature of the motor and bearings.
(4) Check the discharge pressure and flow rate.

When the pump is in operation, the pressure gauge should be observed regularly. Any increase in pressure should be noted immediately.

Maintenance:

(1) Check the condition of the lubrication system.
(2) Check the temperature of the motor and bearings.
(3) Check the discharge pressure and flow rate.

When the pump is in operation, the pressure gauge should be observed regularly. Any increase in pressure should be noted immediately.
Metallic parts of such items as grade packing glands, bolts, nuts, and oillines should be maintained.

Consumables and Lubricants

9.7.9.4. Inspections for Maintenance and Repair

(a) Inspection is not advisable. Because it involves disturbing the equipment and pump should be tested to determine whether correct performance is being obtained.

(b) All instruments and low-resistive should be recalibrated.

(c) End-play of the bearings should be checked.

(d) Indicator rings and valve plugs should be examined for any pits or erosion.

(e) Check clearance of the ball bearing. The wearing rings should be removed or replaced to get original clearance. The bearings which have worn or been replaced must be checked.

(f) Examine oil seals for wear or score.

(g) Cleaning and examination of all bearings for stress, development, and any unusual wear.

9.7.9.3. Annual Inspection

(a) Housing and casing the bearing to determine if worn, and will result in reduced life of the bearing.

(b) Monitor of the pump and the drive.

(c) Inspect packing and replacing if necessary.

(d) Cleaning and changing of all packing glands.

(e) Free movement of the gland of the stuffing box.

(f) 9.7.9.2. Semi-Annual
9.7.10 Trouble-Shooting

Guidelines for determining the causes of troubles likely to arise during the operation of pumps and motors and others.

(a) The repair work shop should be equipped with:
- Repairs Shop
- Replacement Spares
- Frequent repair, maintenance, such as cleaning, alignment, oiling, and others.
- Tools such as heaven-plates, clamps, pep-meat, and others.
- General-purpose machinery such as working set grinders, drills, dodge, drawing, and others.

Possible causes of troubles:
- Improper control
- Electric motor
- Piping
- BLEEDING
- Stepping too low
- System head is too high
- Pressure relief valve
- Flow rate is too small
- Air leaks into system
- Excess air/extra in head
- Air pocket in system line
- Pinching and/or obstruction
- Pump not primed

Check chart for centrifugal pump troubles.

9.7.10.1 Bearing

Symptom 1: No flow from the pump

Symptom 2: Less flow from the pump

1. Pump not primed
2. Pinching and/or obstruction
3. Air pocket in system line
4. Excess air/extra in head
5. Air leaks into system
6. Pressure relief valve
7. Stepping too low
8. System head is too high
9. Improper panel operation
10. Pressure control
11. Improper control
12. Stepping too low
13. Improper panel operation
14. Excess air/extra in head
15. Bearing

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1. Diagram at bottom

10. Packing spills into pump
9. Poor cooling to packing
8. Block out of balance
7. Short run eccentric
6. Incorrect packing
5. Poor lining of packing
4. Sheet bent
3. Misalignment
2. Location out of position

Symptom: Leakage through packing

14. Inconcealed packing
13. Inconcealed packing
12. Warning light on
11. Warning light on
10. Sheet bent
9. Misalignment
8. Insufficient of bearing
7. Damper blank
6. Viscoity different
5. System head is low
4. Reverse rotation
3. Speed too high
2. Excess power

Symptom: Excess Power

9. Location out of position
8. Section into open
7. Air leakage into section
6. Excess air into public
5. Imbalance in public
4. Priming indicator
3. Section at too high
2. No oil

Symptom 4: Loss of prime after standing

8. Impeller damaged
7. Improper parallel operation
6. Warning light on
5. System head is high
4. Viscoity different
3. Speed too low
2. Less pressure
1. Worn seals
   Symptoms: Leaking from crank-case
   Condensation

2. Drive misaligned

3. Main bearings tight
   Symptoms: Over-pressurised, over-speed
   Low oil level

4. Plunger loose
   Worn bearings
   Symptoms: Power end noise

5. Broken or worn valve
   Over-pressurised, over-speed

6. Air in line
   Symptoms: Pressure drop
   Impeller binding
   Pilot loading prime

7. Liquid end noise

8. Check Cause for Reciprocating Pump Troubles

9. Axial thrust not balanced
   Grind 30" high gap

10. Pocket oil pump

11. Bushing worn
    Improper operation

12. Pump not primed

13. Condensation at bearing
   Symptoms: Overhaul or replace

9.7.192
<table>
<thead>
<tr>
<th>Symptom</th>
<th>Troubleshooting</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Priming improper</td>
</tr>
<tr>
<td>2.</td>
<td>Section party open</td>
</tr>
<tr>
<td>3.</td>
<td>Suction lift too high</td>
</tr>
<tr>
<td>4.</td>
<td>Air leak at suction</td>
</tr>
<tr>
<td>5.</td>
<td>Reverse rotation</td>
</tr>
<tr>
<td>6.</td>
<td>Low speed</td>
</tr>
<tr>
<td>7.</td>
<td>Pump worn</td>
</tr>
<tr>
<td>8.</td>
<td>Pump capacity</td>
</tr>
<tr>
<td>9.</td>
<td>No flow</td>
</tr>
<tr>
<td>10.</td>
<td>Checkchart for rotary pump</td>
</tr>
<tr>
<td>11.</td>
<td>Pressure loss at pump</td>
</tr>
<tr>
<td>12.</td>
<td>In suction</td>
</tr>
<tr>
<td>13.</td>
<td>Low suction</td>
</tr>
<tr>
<td>14.</td>
<td>Required accel head high</td>
</tr>
<tr>
<td>15.</td>
<td>Low speed</td>
</tr>
<tr>
<td>16.</td>
<td>Reverse rotation</td>
</tr>
<tr>
<td>17.</td>
<td>Air leak at suction</td>
</tr>
<tr>
<td>18.</td>
<td>Leanage at cylinder valve</td>
</tr>
<tr>
<td>19.</td>
<td>Water hammer</td>
</tr>
<tr>
<td>20.</td>
<td>Loose cylinder head</td>
</tr>
<tr>
<td>21.</td>
<td>Damaged O ring seal</td>
</tr>
<tr>
<td>22.</td>
<td>Bexen valve spring</td>
</tr>
<tr>
<td>23.</td>
<td>Valve binding</td>
</tr>
<tr>
<td>24.</td>
<td>Valve hanging up</td>
</tr>
<tr>
<td>25.</td>
<td>Valve leaking</td>
</tr>
<tr>
<td>26.</td>
<td>Valve stuck</td>
</tr>
<tr>
<td>27.</td>
<td>Pressure at valve-seat</td>
</tr>
<tr>
<td>28.</td>
<td>Valves hanging up</td>
</tr>
<tr>
<td>29.</td>
<td>Cold connection</td>
</tr>
<tr>
<td>30.</td>
<td>Dirty fluid</td>
</tr>
<tr>
<td>31.</td>
<td>Finger not level</td>
</tr>
<tr>
<td>32.</td>
<td>Foundation not level</td>
</tr>
<tr>
<td>33.</td>
<td>Dirty environment</td>
</tr>
<tr>
<td>34.</td>
<td>Loose packing</td>
</tr>
<tr>
<td>35.</td>
<td>Fast wear of packing on plunger</td>
</tr>
</tbody>
</table>
SINUSOIDAL MOTORS

Selection Criteria

- Endurance: The working and service hours of the motor should be adequate.
- Environment: The environmental conditions, such as site, specific gravity, and vulnerability, are important.
- Type of Motor: The type of motor to be selected considering various criteria such as the construction and other relevant factors.

8.2 Prime Moves

<table>
<thead>
<tr>
<th>Symptom</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Power supply malfunction</td>
</tr>
<tr>
<td>2.</td>
<td>Motor overheats</td>
</tr>
<tr>
<td>3.</td>
<td>Insufficient flow</td>
</tr>
<tr>
<td>4.</td>
<td>Excessive pressure</td>
</tr>
<tr>
<td>5.</td>
<td>Excessive power</td>
</tr>
<tr>
<td>6.</td>
<td>Motor stalls</td>
</tr>
<tr>
<td>7.</td>
<td>Air leaks into pump</td>
</tr>
<tr>
<td>8.</td>
<td>Air leaks at suction</td>
</tr>
<tr>
<td>9.</td>
<td>Suction line backing</td>
</tr>
<tr>
<td>10.</td>
<td>Impeller seized</td>
</tr>
<tr>
<td>11.</td>
<td>Bearings seized</td>
</tr>
<tr>
<td>12.</td>
<td>Geo-electric motor overheat</td>
</tr>
<tr>
<td>13.</td>
<td>Motor shaft breaks</td>
</tr>
<tr>
<td>14.</td>
<td>Pump intake pipe breaks</td>
</tr>
<tr>
<td>15.</td>
<td>Pump discharge pipe breaks</td>
</tr>
<tr>
<td>16.</td>
<td>Pump discharge pipe breaks</td>
</tr>
<tr>
<td>17.</td>
<td>Pump intake pipe breaks</td>
</tr>
<tr>
<td>18.</td>
<td>Suction line breaks</td>
</tr>
</tbody>
</table>

922 Construction Features of Induction Motors

- Short-circuiting rings in stator and rotor are used to reduce the effective stator resistance.
- Squirrel-cage motors are not used when the running current has to be very low, such as at 0.15 times the full load current, when the starting current is also used when the running current has to be reduced. The slip rings are also used in this case to achieve proper slip speed.
- Centrifugal pumps have squirrel cage motors because squirrel cage motors are more efficient and provide high starting torque.
### Table 9.2: Types of Enclosure and Types of Environment

<table>
<thead>
<tr>
<th>Type of Environment</th>
<th>Description of Environment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indoor, clean (dust-free)</td>
<td>Enclosure for indoor, clean environments</td>
</tr>
<tr>
<td>Indoor, dirty (dust-contaminated)</td>
<td>Enclosure for indoor, dirty environments</td>
</tr>
<tr>
<td>Outdoor, clean (dust-free)</td>
<td>Enclosure for outdoor, clean environments</td>
</tr>
<tr>
<td>Outdoor, dirty (dust-contaminated)</td>
<td>Enclosure for outdoor, dirty environments</td>
</tr>
<tr>
<td>Outdoor, wet (rain, snow)</td>
<td>Enclosure for outdoor, wet environments</td>
</tr>
<tr>
<td>Outdoor, dry (rain, snow)</td>
<td>Enclosure for outdoor, dry environments</td>
</tr>
</tbody>
</table>

### Table 9.3: Selection of Motors Based on Supply Voltages

<table>
<thead>
<tr>
<th>Voltage (V)</th>
<th>Supply</th>
<th>Voltage Band (kV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>220</td>
<td>1.0</td>
<td>11 kV</td>
</tr>
<tr>
<td>230</td>
<td>1.0</td>
<td>6.6 kV</td>
</tr>
<tr>
<td>250</td>
<td>1.0</td>
<td>4.15 kV</td>
</tr>
<tr>
<td>250</td>
<td>1.0</td>
<td>4.15 kV</td>
</tr>
<tr>
<td>250</td>
<td>1.0</td>
<td>4.15 kV</td>
</tr>
<tr>
<td>250</td>
<td>1.0</td>
<td>4.15 kV</td>
</tr>
</tbody>
</table>

**N.B.** When no minimum is given, very small motors are feasible.
11
15
22
24
26
Required B.V.W. of Pump
Multiplying factor to decide motor rating

TABLE 9.3

<table>
<thead>
<tr>
<th>Margin for Motor Ratings (B.V.W)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Above 25</td>
</tr>
<tr>
<td>15 to 25</td>
</tr>
<tr>
<td>25 to 15</td>
</tr>
<tr>
<td>15 to 75</td>
</tr>
<tr>
<td>37 to 15</td>
</tr>
</tbody>
</table>

4.6 Class of Duty

4.87 Insulation

4.88 Margin in Brake Horsepowers (B.H.P)

The margins recommended are compiled in Table 9.3.

The margins should be selected as to provide margins over the brake powers (brake horsepowers, B.H.P), The motor rating should be considered.

4.64 Class of Insulation

Class B Insulation is generally satisfactory, since it permits temperature up to 60° C. All motors are suitable for continuous duty if Class B is specified in 12.25.

4.21 Switch Gear

Load

Switchgear shall be the type that is most suitable for the pump stations, which constitute the major part of the total.

When selecting a system, the electrical system of the pump station is one of the most important decisions. A proper selection of switchgear in the electrical system is of the utmost importance. The continuous operation of the equipment, and the satisfactions of the equipment under all circumstances, is the protection to the pump personnel and the safeguarding of the equipment under all circumstances. The electrical equipment selected shall be adequate, reliable, and safe. The adequacy is determined by the continuous current required for the maximum and the available short-circuit}

The electrical equipment selected should be adequate, reliable, and safe. The adequacy is determined by the continuous current required for the maximum and the available short-circuit.
<table>
<thead>
<tr>
<th>Type of Unit</th>
<th>Preventive Change</th>
<th>Protection of Voltage</th>
<th>Secondary</th>
<th>Transformer</th>
<th>Current Transformer and Potential Transformers for Protection in Substations of Capacity</th>
<th>Current Transformer and Potential Transformers for Power Measurement of Capacity</th>
<th>Current Transformer and Potential Transformers for Power Measurement</th>
<th>Overhead Bus Ties and Substations</th>
<th>Drop Out Fuse for Small Outdoor Substations</th>
<th>Circuit Breaker or Equivalent Protection</th>
<th>Grounding Disconnections (GDD) and PROVIDED in indoor Substations</th>
<th>Lightning Arresters</th>
<th>Ground Fault Relays and Arresters</th>
</tr>
</thead>
<tbody>
<tr>
<td>AC</td>
<td>1 in 3</td>
<td>0.33</td>
<td>0.67</td>
<td>2 x FC</td>
<td>4 x FC</td>
<td>8</td>
<td>12000 KVA</td>
<td>21000 KVA and Above</td>
<td>2</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DC</td>
<td>250</td>
<td>500</td>
<td>1250</td>
<td>2500</td>
<td>5000</td>
<td>10000</td>
<td>20000</td>
<td>30000</td>
<td>50000</td>
<td>100000</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Guidelines for transformers are given in Table 9.4 and as follow:-

- **1.** The essential features of the transformer shall be considered.
- **2.** For protection from excessive energy and saturation due to overloads, the saturation may be induced. Following are normal outdoor substations provided. However, as considerations of public safety and  

**Guidelines Regarding the Use of Transformers for squirrel-cage motors are given in**

**TABLE 9.4**

Guidelines and current transformers are used with squirrel-cage motors. General installation and other items are used with donut-core transformers and similar rotor. Of these.

### 9.42 Transformers

Duplicate transformer may be provided, where installation so demands.

- Earthing should be very comprehensive, covering every item in the substation, and in accordance with IS 3043.
- Earthing should be provided for all outdoor substations.
- Transformer bushing and arresters.
- Overhead bus ties and arresters.
- 3

### 9.43 Substations

- Normally outdoor substations are provided. However, as considerations of public safety and  

**The function of a switch gear in a distribution system include normal and fault-switching**
# Controls

*For handling cables, suitable trenches or racks should be provided.*

Appropriate cable glands should be applied when cables are laid in groups (parallel) and/or laid below ground.

1. The cable should also be suitable for carrying the short current to the downstream power reactor and the worst condition of insulation to earth connection.

2. The control cabinet should be accessible for the lowest voltage of the system.

## Table 9.5: Types of Cables for Different Voltages

<table>
<thead>
<tr>
<th>Type of Cable to be Used</th>
<th>Single Sacked</th>
<th>11 kV</th>
</tr>
</thead>
<tbody>
<tr>
<td>XLPF Class A</td>
<td>Paper insulated, lead sheathed</td>
<td></td>
</tr>
<tr>
<td>PVC insulated, lead sheathed</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PVC insulated, PVC sheathed</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PVC insulated, PVC sheathed</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PVC insulated, PVC sheathed</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Type of Cable to be Used</th>
<th>Single Sacked</th>
<th>6 kV</th>
</tr>
</thead>
<tbody>
<tr>
<td>PVC insulated, PVC sheathed</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Type of Cable to be Used</th>
<th>Single Sacked</th>
<th>3.3 kV</th>
</tr>
</thead>
<tbody>
<tr>
<td>PVC insulated, PVC sheathed</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 9.5 gives guidance on the type of cable to be used for different voltages.

9.9.4 *Cables*

For improved or power reactor, appropriate capacitors should be provided. Cables may be located in the control panel or separately.

9.9.3 *Capacitors*

Provisions of reduced voltage should be adequate to accommodate the ramp to the full speed.

Note: As per IEC/ISA standards, the location of the motor or the drive

\[ \text{RLC} = \text{Full Load Current} \]