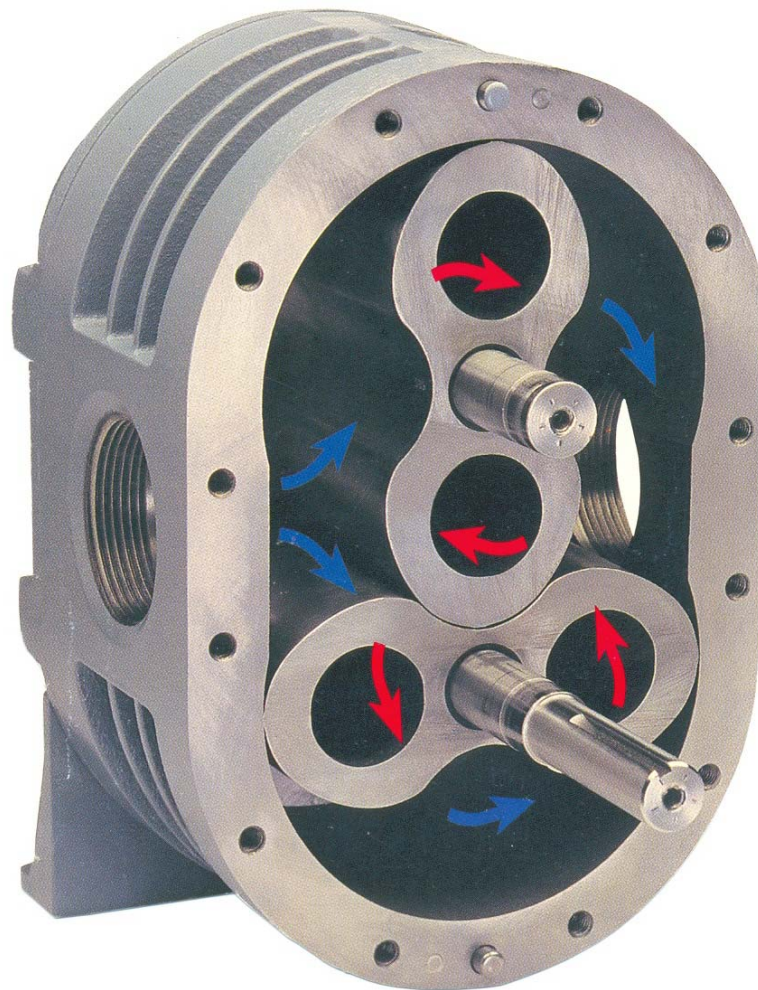# Understanding Twin Lobe Blowers Roots Blowers

Compressors and Fans are essentially pumps for gases. Although they differ in construction from liquid handling machines, the principles of operations are similar. Gases being compressible, a large portion of the energy of compression is dissipated in form of heat to the gas. This limits the operation of the compressor unless suitable cooling is effected. Various gas machines can be classified depending upon their compression ratio i.e. ratio of final pressure P_2 to suction pressure P_1.

CENTRIFUGAL BLOWERS & FANS

This Range covers various types of Centrifugal and Axial Flow Fans, which have relatively high air displacement but low compression ratios. They are either of Centrifugal type, axial flow types or regenerative types. As their internal clearances are relatively high, the discharge pressures are limited to few inches of water only. These types are generally used for applications requiring high volumes but low pressures such as in air-conditioning, furnaces, low pressure cooling, dust or fume extraction systems, lean phase pneumatic conveying etc.

BASIC FAN LAWS

1. Volume $\propto$ Operating Speed

$$\frac{V_1}{rpm_1} = \frac{V_2}{rpm_2}$$

Volume flow changes directly with speed. Change in density has no effect.

2. a) Pressure Changes $\propto (Speed)^2$

$$\frac{P_2}{P_1} = \left(\frac{rpm_2}{rpm_1}\right)^2$$

Pressure changes as square of speed ratio.

   b) $$\frac{P_2}{P_1} = \frac{D_2}{D_1}$$

Pressure changes with density ratio.

3. a) Power Changes $\propto (Speed)^3$

$$\frac{HP_2}{HP_1} = \left(\frac{rpm_2}{rpm}\right)^3$$

HP varies with cube of speed ratio

   b) Power changes $\propto$ Density Ratio

$$\frac{HP_2}{HP_1} = \frac{D_2}{D_1}$$

H.P. varies with density ratio.

POSITIVE DISPLACEMENT BLOWERS (ROOTS BLOWERS)

Twin Lobes and Three Lobes type Blowers fall under this category. They have higher efficiency at moderate compression ratios and are most efficient in the compression ratios of 1.1 to 2. They find use in applications, which require relatively constant flow rate at varying discharge pressures. These are generally available for capacities $10m^3$/hr – $10,000m^3$/hr for pressures up to $1Kg/cm^2$ (g) in single stage construction. They are extensively used in applications such as pneumatic conveying, aeration in ETP, cement plants, water treatment plants for filter backwash, aquaculture aeration etc.

BASIC LAWS FOR ROOTS BLOWERS (EVEREST TWIN LOBE TYPE)

1. Inlet Capacity = V_{rev} * (N- Slip * $\sqrt{\Delta P}$)
    V_{rev} = Blower design constant, displacement per revolution
    N   = Operating Speed
    Slip = Blower design constant – due to internal clearance
    ΔP = Total differential pressure across blower (P2-P1)

    | For a given blower, working at a fixed Delta P, **Inlet Capacity $\propto$ Speed** |

2. Power: Power at blower shaft (BHP)

    Input Power=   0.00436* Vrev * N * ΔP + FHP

    FHP = Frictional loss

    | For a given blower operating, at a specified speed, **input power $\propto$ Delta P** |

3. Temperature rise of Discharge air.
    Delta t $\propto$ P_2/P_1 P_2 = discharge abs. Pressure
 P_1 = discharge abs. Pressure

    | Rise in temperature is proportional to **compression ratio.** |

COMPRESSORS

Reciprocating, Vane or Screw Type Compressors are the machines in which compression ratios are high – generally more than 2.5. These are generally required for applications requiring low airflow but high pressures such as Pneumatic Tools, Solenoid Valves, Paint shops, Drilling rigs etc.

BASIC TWIN LOBE ROTARY AIR BLOWER PRINCIPLE

This article is focused on Twin Lobe Blowers also popularly know as Roots Blowers-on the name of its inventors. TWIN Lobe Rotary Air Blowers belong to the category of Positive Displacement Blowers. They consist of a pair of involute profiled (shape of 8) lobes/rotors rotating inside an oval shaped casing, closed at ends by side plates. One lobe is the driving lobe, which is driven by the external power while the driven lobe is driven by a pair of equal ratio gears. Both the lobes thus, rotate at same speed but in opposite direction.


Operation of Twin Lobe Blower
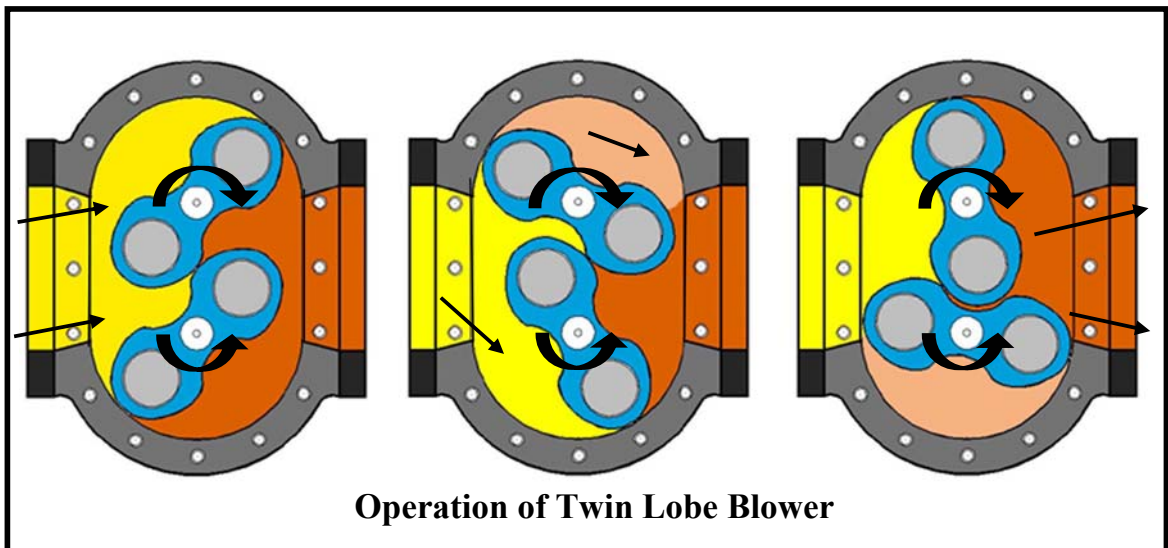
As the rotors rotate, air is drawn into inlet side of the cylinder and forced out the outlet side against the system pressure. With each revolution, four such volumes are displaced. The air, which is forced out, is not allowed to come back due to the small internal clearance within the internals of the machine except a very small amount called 'SLIP'. There is no change in the volume of the air within the machine but it merely displaces the air from the suction end to the discharge end, against the discharge system resistance i.e. no compression takes place in the machine. Since the lobes run within the casing with finite clearances, no internal lubrication is required. The air, thus, delivered is **100% Oil Free**. These blowers deliver, practically, a constant flow rate independent of the discharge pressure conditions. The flow rate is dependent, largely on the operating speed.

Due to these constructional features it has the following distinct characteristics:
- The flow is largely dependent on the operating speed.
- The input power is largely dependent on the total pressure across the machine.
- The suction & Discharge pressures are determined by the system conditions.
- The temperature rise of the discharge air & machine is largely dependent on the differential pressures across it.

SYSTEM PRESSURES / BACK PRESSURE ON BLOWER
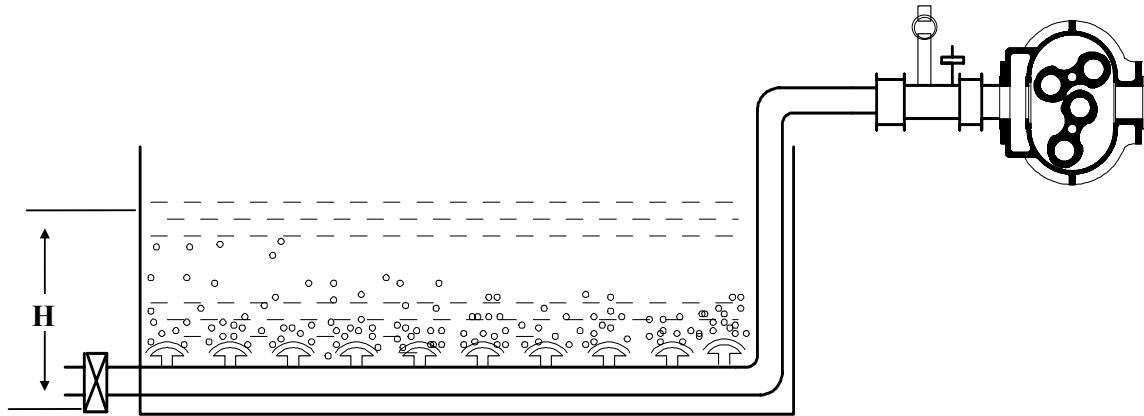
THERE is no compression or change in volume within the machine but the Blower works under system back pressure conditions. To illustrate further, let us consider a case when the discharge of a Blower is connected to the bottom of a tank, having water to a depth of 'H' mm. The air-discharged accumulates in the discharge line until sufficient pressure is built (slightly over 'H' mm of WG), when it starts to escape out. The system resistance or the static load on the Blower is thus 'H' mm WG. The power consumed by the blower depends upon the flow rate and the total pressure head on the Blower.
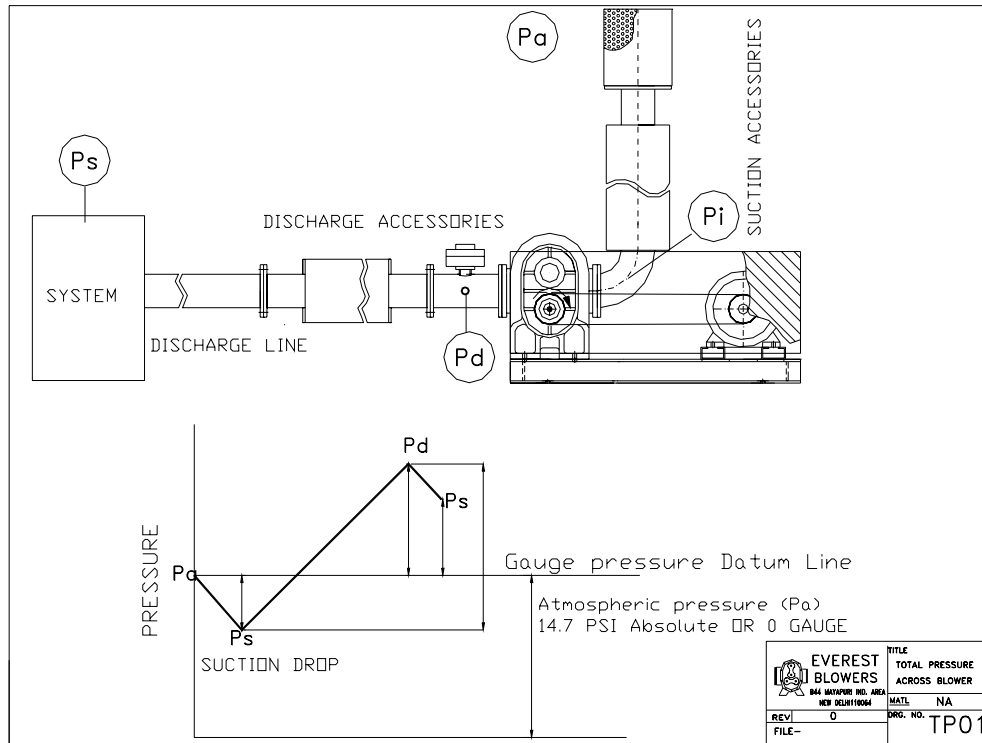
The total pressure across the Blower is taken as the pressure across the inlet and the discharge port of the Blower. The pressure drop through inlet accessories and discharge accessories are a part of system drop. The figure above indicates Pa as the ambient pressure. Ps is the pressure at the suction port which is slightly below the ambient due to suction filter and silencer drop. Pressure Pd is the pressure at the discharge port of the Blower and Ps is the actual system back pressure. As seen from the curve the total work done by the Blower is to raise the pressure of inlet volume from Ps to Pd. Ideally, the blower is capable of resisting high pressures but the mechanical limitations, increased power intake, temperature rise and increase in 'SLIP' restrict the working pressure head to about 7000mm WG for Air cooled Blowers and 10,000mm WG for Water Cooled Blowers in single stage operation.

It is therefore, important to ensure that the drop between Pa and Ps (Inlet drop) and Pd and Ps (outlet drop) should be as low as possible. This can be achieved by using adequate size piping and large radius bends wherever possible.

The Blowers are generally selected for the maximum system pressure, which they may encounter during operation and the prime mover is selected accordingly. When in operation, the Blower offers a considerable power saving since the power consumed by it depends upon the actual working pressure under which it operates and not the rated pressure.

Typical performance curve below shows the characteristics of roots blower.

Typical Performance Curve for Roots Blower
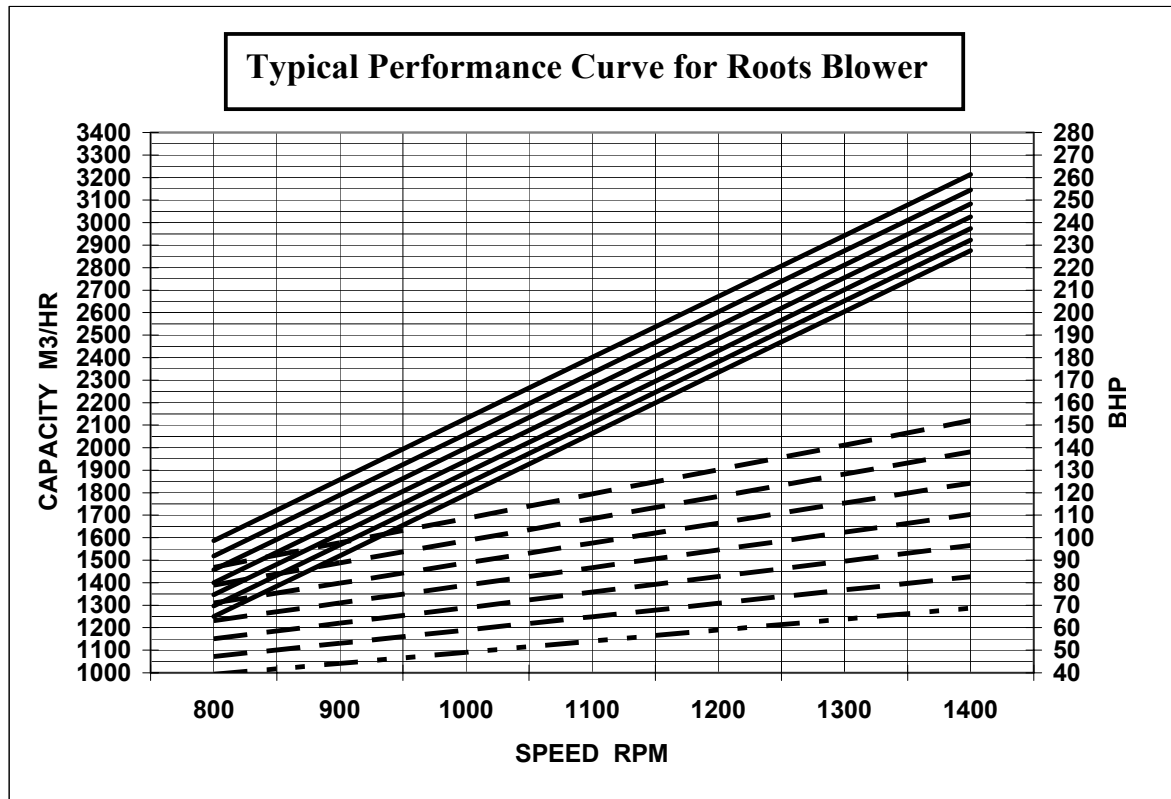
In a Reciprocating or Vane type compressor the compression ratio is fixed and the suction air is compressed, according to the compression ratio, irrespective of the load conditions. A fixed power, is therefore, consumed by for these type of compressors.

GENERALLY USED TERMS

Ambient Pressure: Absolute pressure of the atmospheric air in the vicinity of the blower.

Absolute Pressure: Is the pressure measured from absolute zero i.e. from an absolute vacuum. It is the algebraic sum of the atmospheric pressure and gauge pressure.

Gauge Pressure: Pressure measured above the atmospheric pressure.

Static Pressure: Is the pressure of the gas measured in a manner that no effect due to velocity of gas stream is recorded.

Velocity Pressure: Is the pressure solely due to velocity head.

Total pressure: Is the total system pressure i.e. sum of static pressure and velocity pressure.

Pressure Ratio/Compression Ratio: Is the ratio of absolute discharge pressure to absolute inlet pressure.

Swept Volume of Blower: Volume swept by one revolution of the blower.

Actual volume flow rate: Actual volume flow rate of gas compressed and delivered at the standard discharge point, referred to conditions of total temperature, total pressure and composition, prevailing at the standard inlet point. Also referred as FAD (Free air delivery),inlet conditions.

Standard volume flow rate: Volume flow rate of compressed gas as delivered at the discharge point but referred to standard inlet condition of total pressure, total temperature, and composition (1 bar, 20 °C, R.H. 36%).

Normal volume flow rate: Volume flow rate of compressed gas as delivered at the discharge point but referred to NTP condition of total pressure, total temperature and composition (1 bar, 0 °C).

Compressed Volume flow rate: Volume flow rate of gas at the discharge referred to conditions of total temperature, total pressure and composition, prevailing at the discharge point. This is generally not used.

Rotary Air Blowers are widely used in applications demanding medium pressures and relatively large flow rates.

- ❑ **Water Treatment Plants:** For backwashing of filter beds.

- ❑ **Effluent Treatment Plants:** For diffused aeration and agitation of effluent.

- ❑ **Cement Plants:** For Blending, Aeration, Fluidisation, and Conveying.

- ❑ **Slurry Agitation:** For maintaining the B.O.D. / C.O.D

- ❑ **Aquaculture:** For Maintaining the dissolved oxygen level.

- ❑ **Biogas Boosting:** Transferring of Biogas from gasholder to boiler.

- ❑ **Flocculation:** To increase the removal of suspended solids in primary setting facility.

- ❑ **Chemical Plants:** For supplying of process air.

- ❑ **Electroplating Plants:** For Oil free air agitation of electrolyte to maintain uniform density.

- ❑ **Paper Plants:** For Coating of paper/Knife edge

- ❑ **Yarn Drying:** Vacuum/Pressure Drying of yarn.

- ❑ **Polyester Chip Conveying & Drying:** For transfer of polyester Chips

- ❑ **Reverse Jet Filters:** For reverse cleaning of Filter bags.

- ❑ **Pneumatic Conveying:** Vacuum, Pressure and Combination Conveying of cereals, cement, husk, baggage, granules, powders and other similar material.

PIPING SELECTION

It is important to ensure that the system back pressure across the blower i.e. the sum of all the pressures such as drop across the filter, silencer, discharge pipeline and the final system drop do not exceed the specified limits. The power consumed by the blower is directly proportional to the discharge pressure / system back pressure. A good system layout would offer power saving and higher efficiency. It is, therefore, important to ensure that proper care is taken during piping design and installation.

Pressure losses in ducting are caused by skin friction, flow separation, change in flow direction due to bends, turbulence, and restrictions to flow caused by valves etc. Any saving in the pressure loss is a direct saving on the power consumed.

While duct designing the following should be taken care of:

❑ Size the pipeline to maintain average air velocity of 15-20 m/sec. High velocity results in higher Skin Friction loss and higher Dynamic Velocity head.

❑ The Frictional losses are a function of velocity and pipe surface conditions so ensure that smooth pipes are used.

❑ Dynamic losses occur due to sudden changes in the direction and the magnitude in the path of flow. Avoid Bends and sudden changes in cross sectional areas to minimise losses.

❑ Dynamic losses, apart from the normal frictional losses, result when a fast moving air stream suddenly expands or contracts due to change in the cross sectional area. The impact on dynamic loss for sudden contraction is less than sudden expansion. In sudden expansion the flow is separated giving rise to turbulence and an additional pressure drop. Sudden contractions cause acceleration in flow, which tends to prevent flow separation. Use of transition pieces of correct angles.

❑ The diffuser transition piece should have angle between 8 to 10 Deg. and the nozzle-transition piece should have 30-35 Deg.

❑ Dynamic losses caused by changes in flow direction can be significant. If the flow cannot adjust quickly enough to follow a sharp pipe turn, flow separation & turbulence occurs giving rise to additional pressure drop. Keep the ratio of mean radius of the bend to pipe diameter at least 1.5-2.

Recommended line size
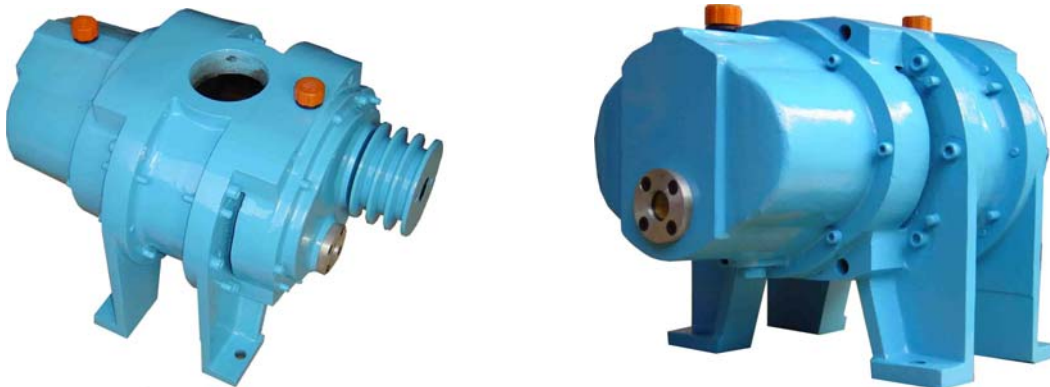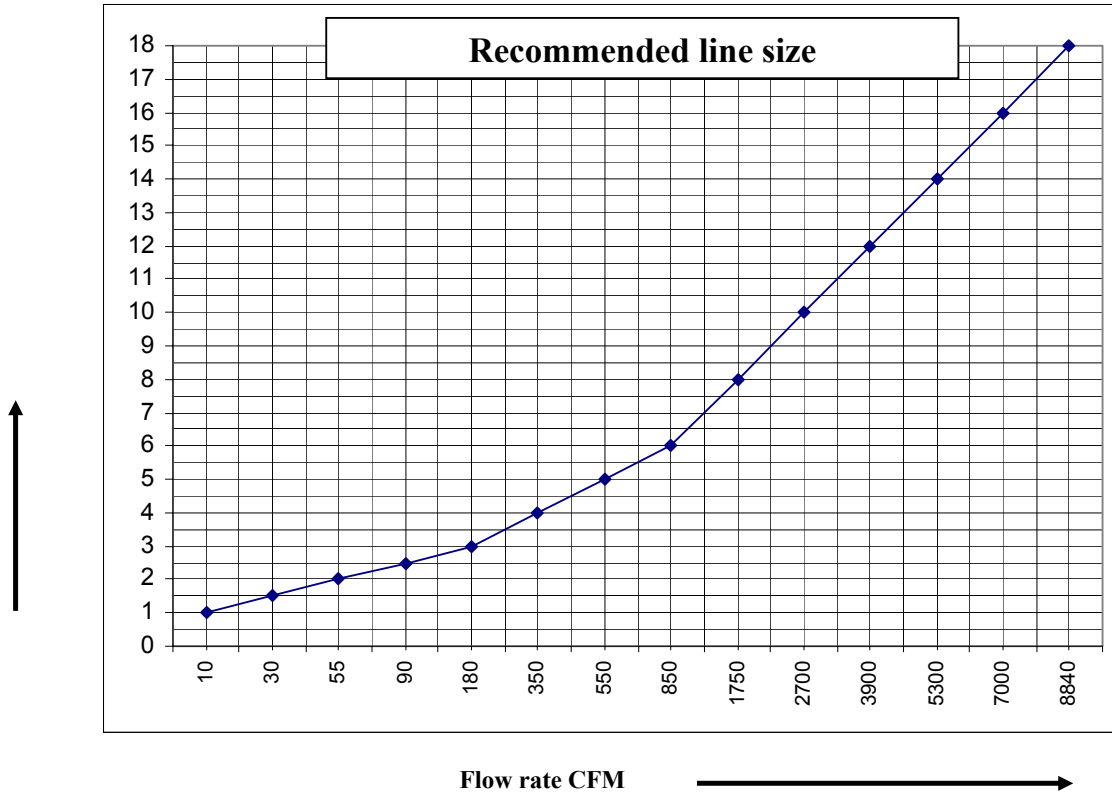
Flow rate CFM

X Axis: Flow rate CFM ; **Y Axis:** Pipe Line size NB Inches. The graph is calculated on friction loss of 0.25 PSI per 100 ft of line. For bends / valves add 5 – 7 times "D" to find equivalent length.

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