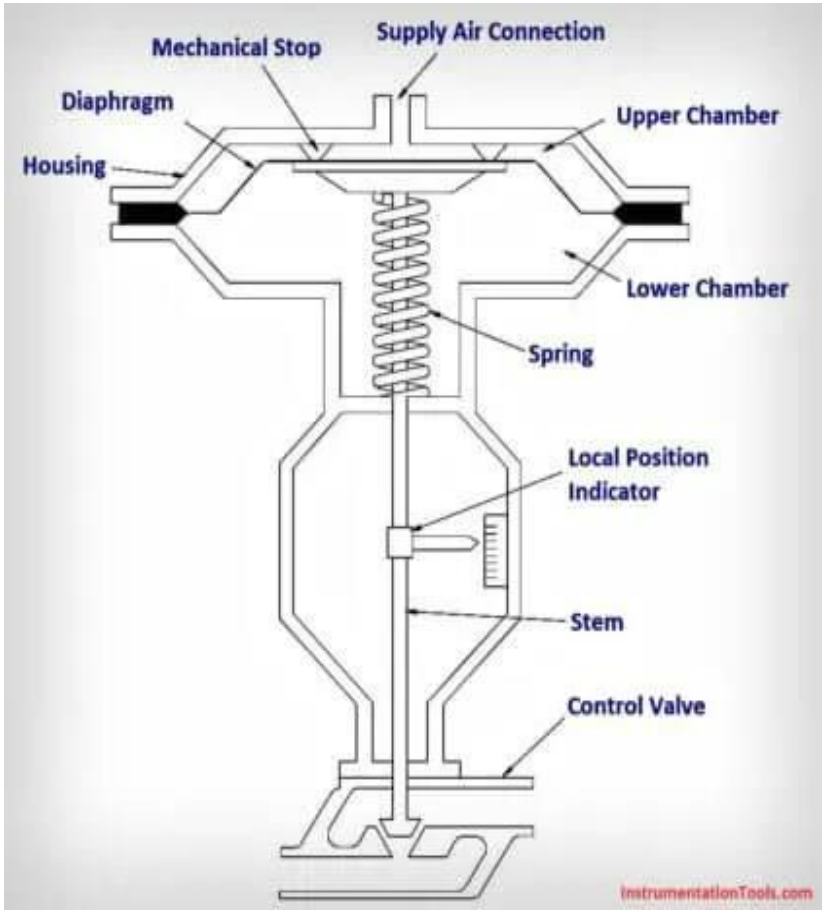
UNIT-IV
Pneumatic Systems 06 Hours

- Introduction to Pneumatic an Actuators
- Physical Components of a Pneumatic Systems
- Pneumatic Cylinders
- Pneumatic Actuators (e.g. Spring Actuator and Spring Actuator with positioner)
- Air compressor
- Air Receiver
- Air Dryer Air Service Treatment: Air Filter, air regulator and Gauge
- Air Lubricator and Pressure regulation
- Intake and Air Filter.
- Case study of Robotic Pick and Place robot

Pneumatic Actuators

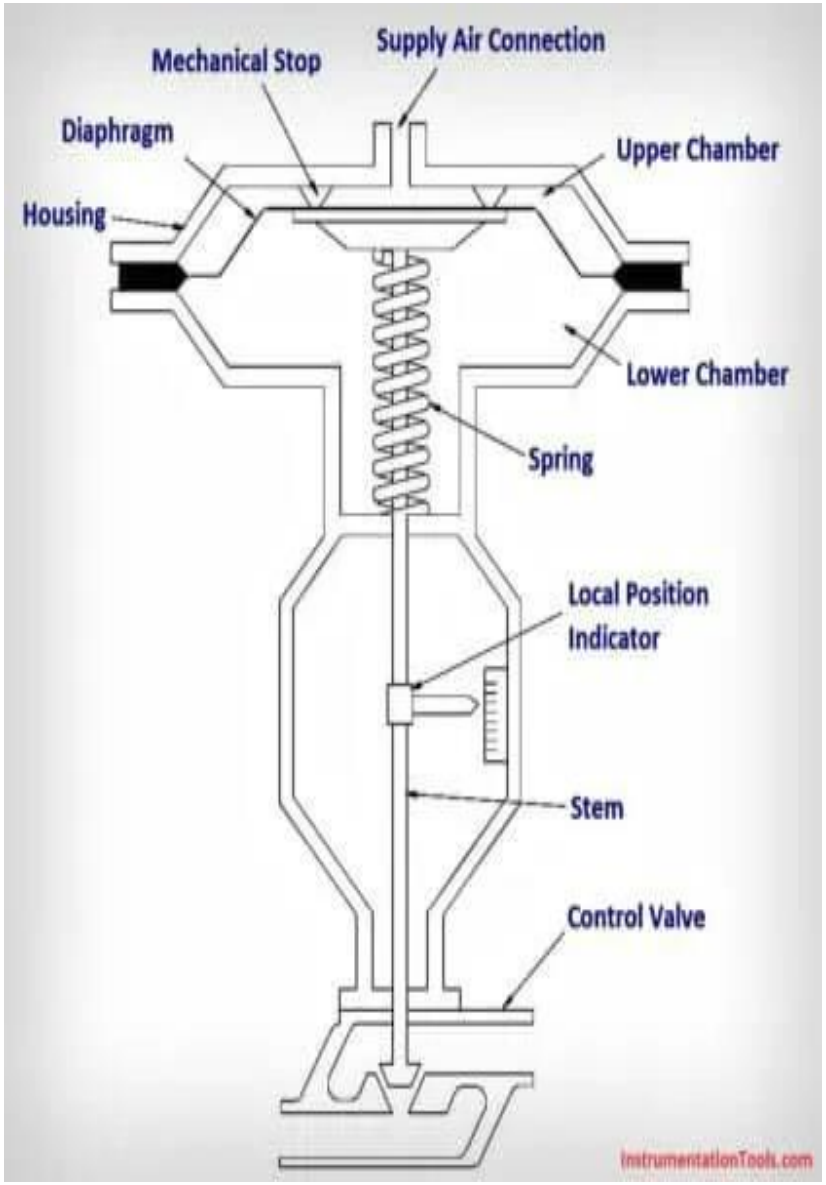
Pneumatic actuators are devices that **convert the energy of compressed air or gas into a mechanical motion** that regulates one or more final control elements.

They are used as a form of automation control to reduce mandatory human interaction with a system's internal mechanisms, which is particularly beneficial for automatic modulation and emergency shutdowns.



Working

- The actuator positions a control valve by transmitting its motion through the stem.
- It operates by a combination of force created by **air and spring force.**
- **A rubber diaphragm separates the actuator housing into two air chambers.**
- The upper chamber receives supply air through an opening in the top of the housing.
- The bottom chamber contains a spring that forces the diaphragm against mechanical stops in the upper chamber.

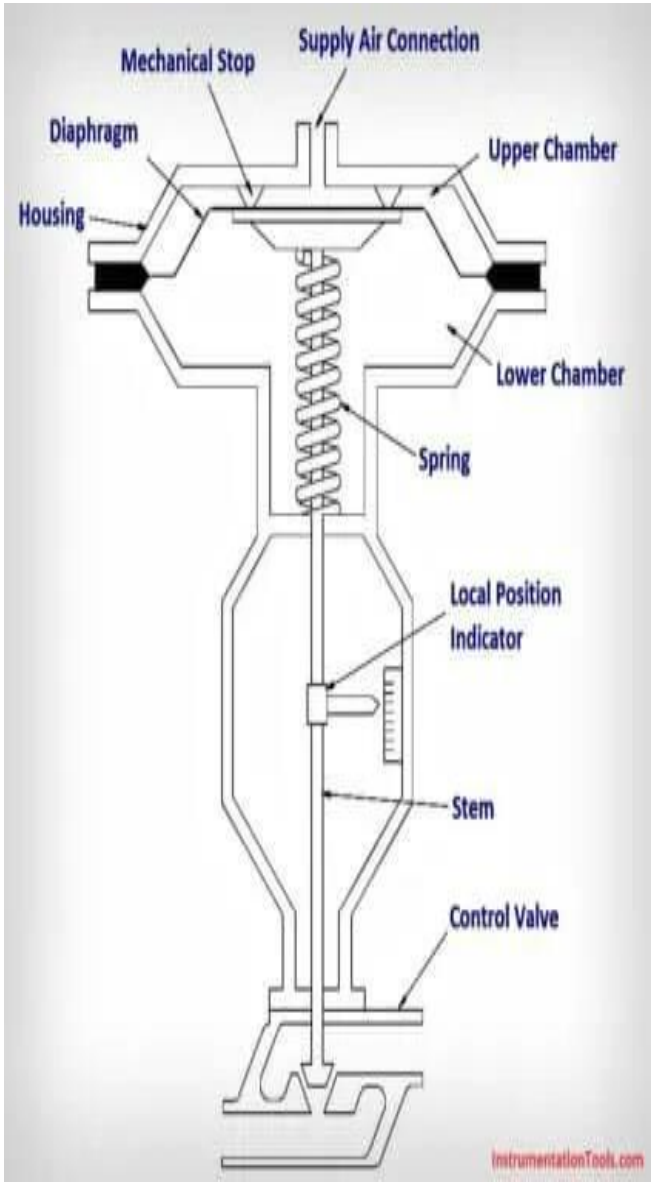


Finally, a local indicator is connected to the stem **to indicate the position of the valve.**

The position of the valve is controlled by varying supply air pressure in the upper chamber.

This results in a varying force on the top of the diaphragm.

Case 1- Initially, with no supply air, the spring forces the diaphragm upward against the mechanical stops and holds the valve fully open.



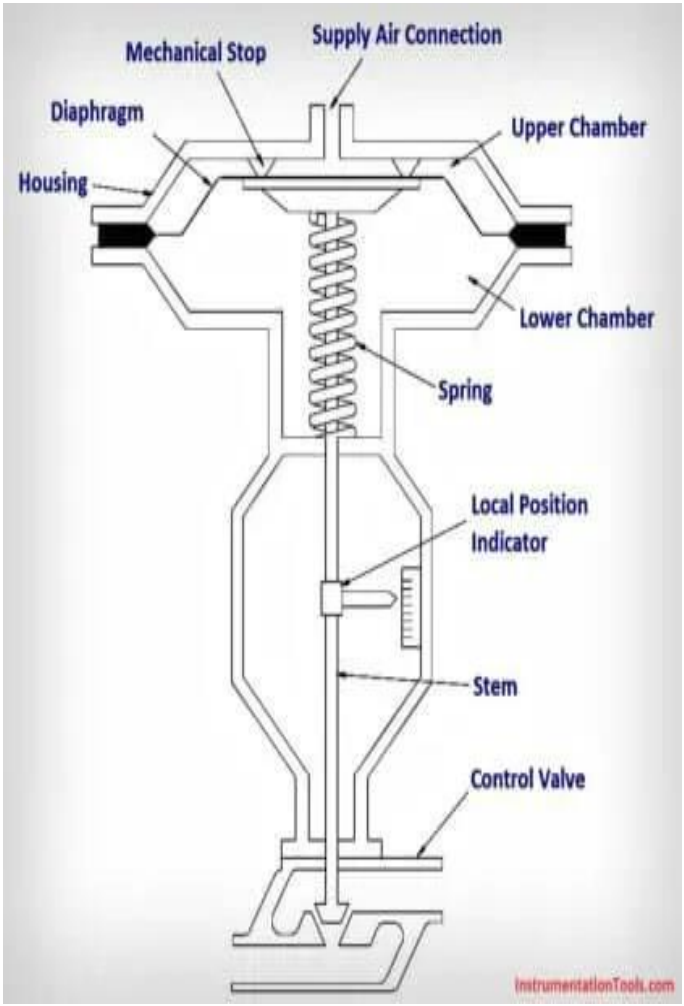
Case 2. As supply air pressure is increased from zero, its force on top of the diaphragm begins to overcome the opposing force of the spring.

This causes the diaphragm to move downward and the control valve to close.

With increasing supply air pressure, the diaphragm will continue to move downward and compress the spring until the control valve is fully closed.

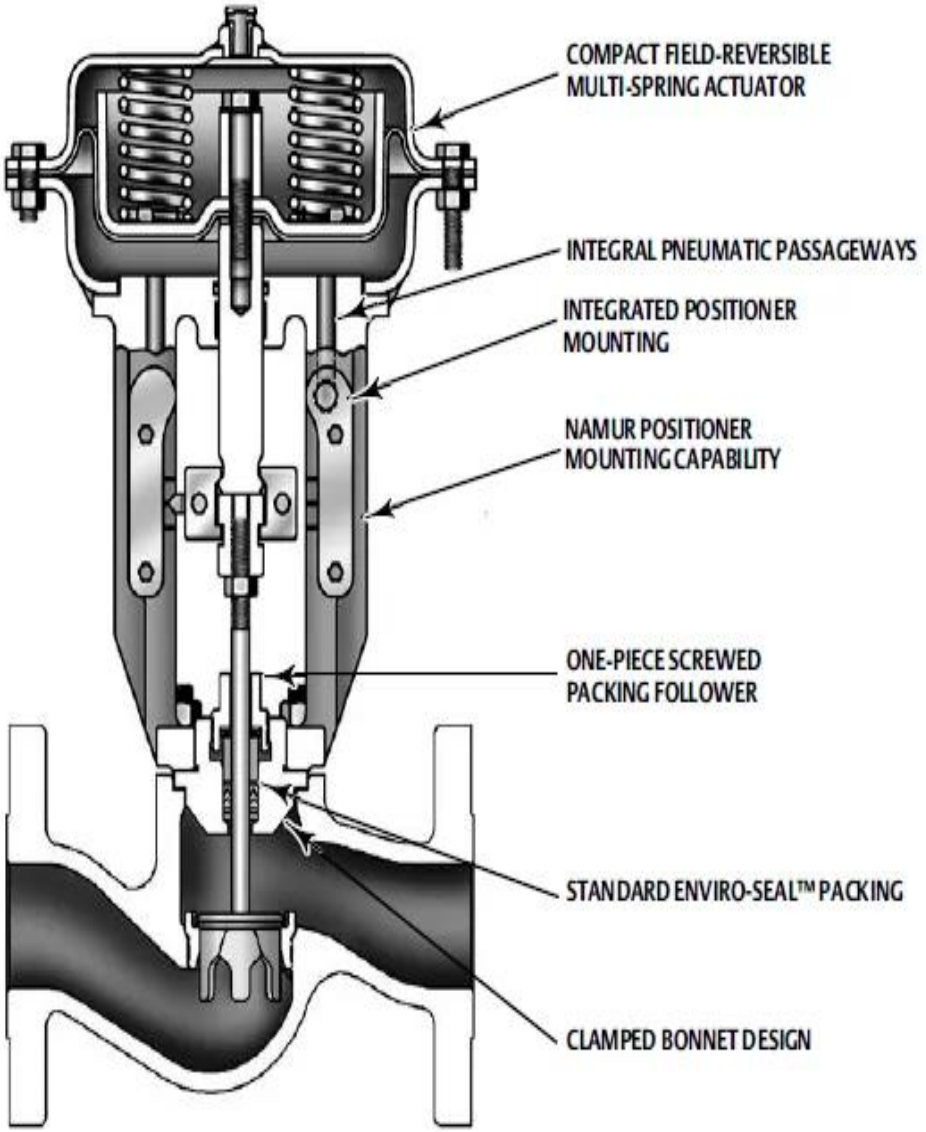
Case 3.

Conversely, if supply air pressure is decreased, the spring will begin to force the diaphragm upward and open the control valve. Additionally, if supply pressure is held constant at some value between zero and maximum, the valve will position at an intermediate position.



Therefore,

the valve can be positioned anywhere between fully open and fully closed in response to changes in supply air pressure.

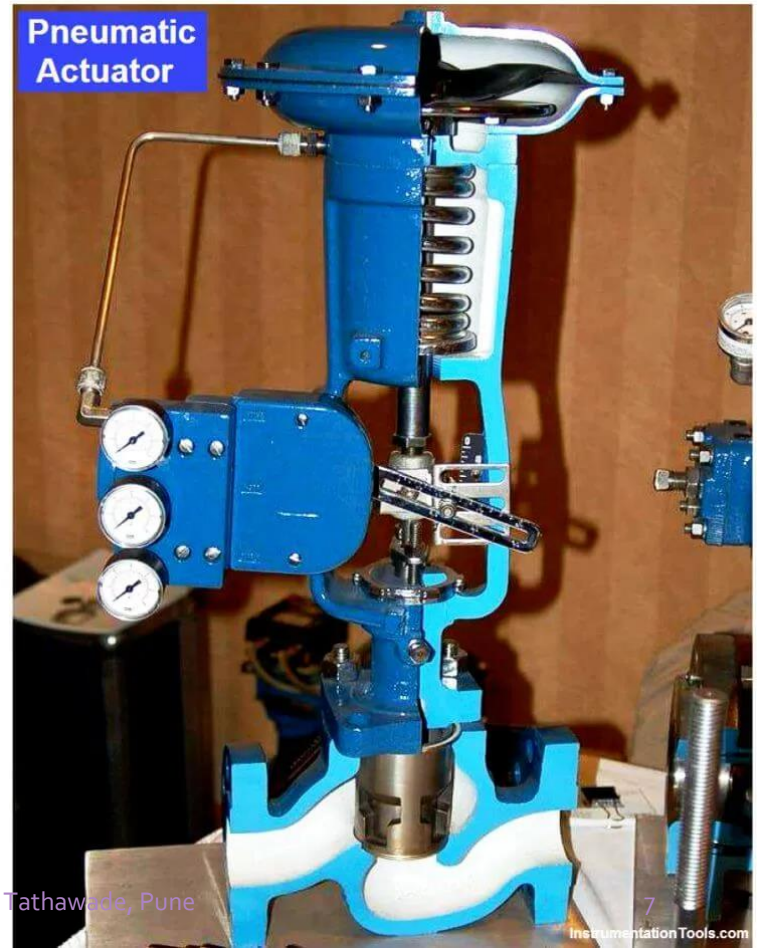


Introduction to Pneumatic an Actuators

Pneumatic actuators use instrument air pressure to apply force on the diaphragm to move the valve actuator and then to position valve stem.

You can see **the large coil spring providing default positioning of the valve** (air pressure acting against the diaphragm moves the valve against the spring) and the rubber diaphragm at the very top.

Air pressure applied to the bottom side of the diaphragm lifts the sliding stem of the valve in the upward direction, against the spring's force which tries to push the stem down.



The amount of force (F) in units of pounds generated by any fluid pressing against any surface is equal to the fluid's pressure (P) in units of PSI multiplied by the surface area (A) in units of square inches ($F = PA$).

In the case of a circular diaphragm, with area equal to πr^2, the complete formula for force is $F = P\pi r^2$.

For example,

A control valve diaphragm 14 inches in diameter (radius = 7 inches) with an applied air pressure of 15 PSI generates a linear force of 2309 pounds.

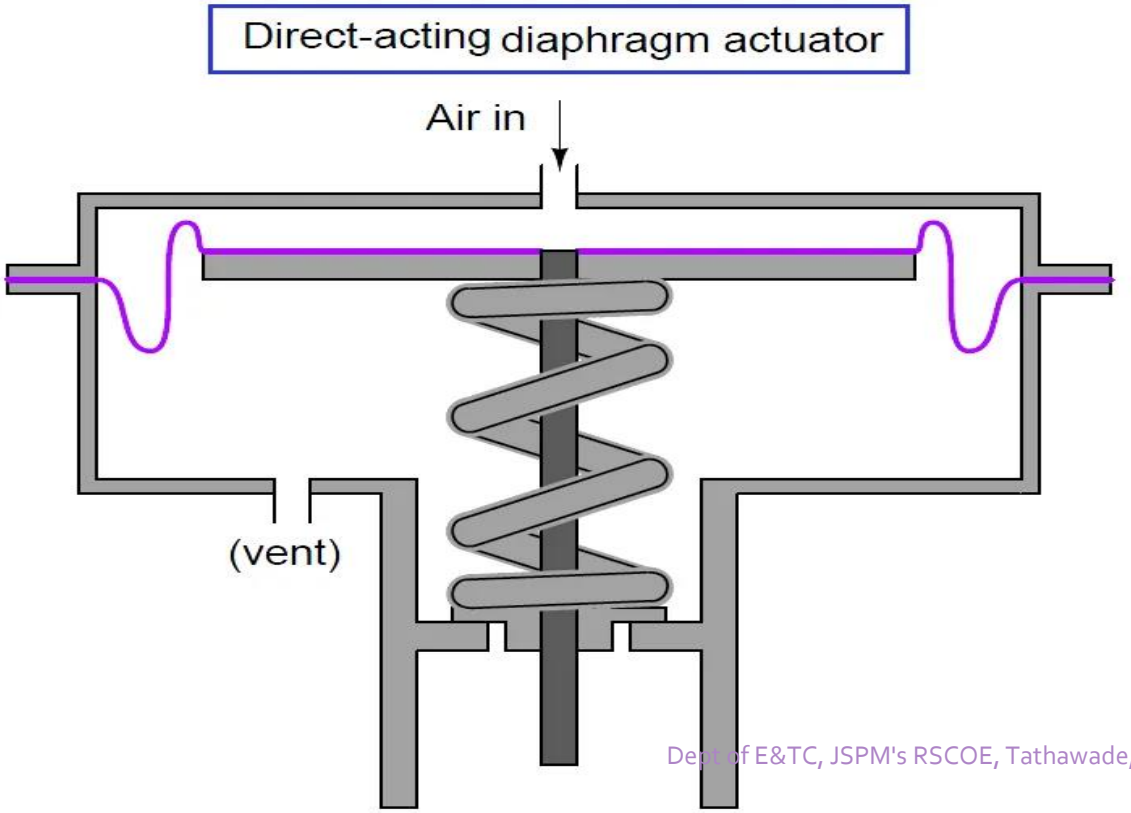
- Air pressure required to motivate a pneumatic actuator may come
- 1. directly from the output of a pneumatic process controller,
- 2. from a signal transducer (or converter) translating an electrical signal into an air pressure signal.

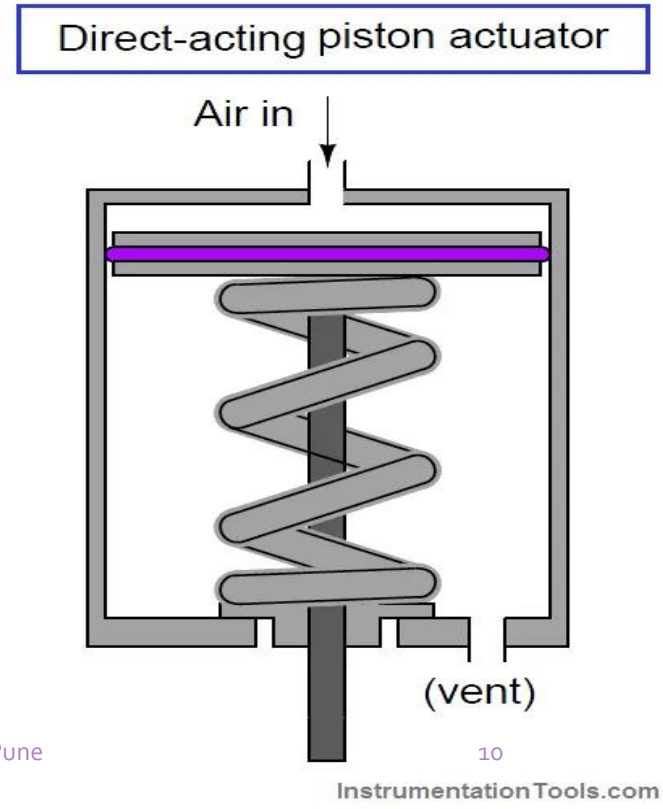
- Such transducers are commonly known as **I/P or "I to P"** converters, since they **typically translate an electric current signal (I) of 4 to 20 mA DC into an air pressure signal (P) of 3 to 15 PSI.**

- Some pneumatic valve actuators are equipped with handwheels which are used to manually position the valve in the event of air pressure failure.

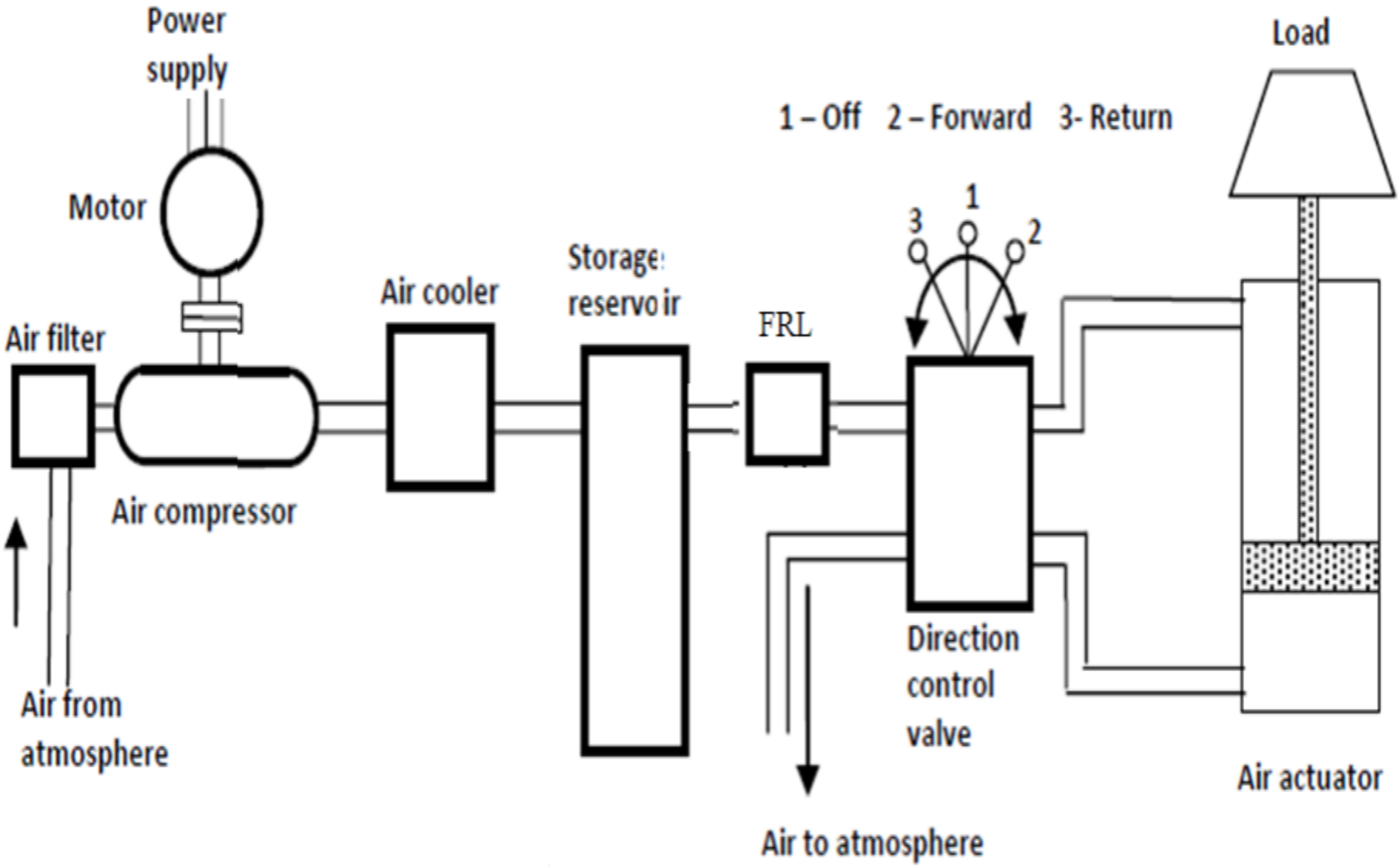
In **direct-acting actuators**, the air enters the top area of the diaphragm/ piston and pushes the diaphragm/piston down.

The air pressure, given to the diaphragm/piston overcomes the spring torque located under the diaphragm/piston, so it pushes the valve stem down and closes the valve.





Physical Components of a Pneumatic Systems



Basic Components of Pneumatic System

Air filters: These are used to filter out the contaminants from the air.

Compressor: Compressed air is generated by using air compressors.

Air cooler: During compression operation, air temperature increases. Therefore coolers are used to reduce the temperature of the compressed air.

Control Valves: Control valves are used to regulate, control and monitor for control of direction flow, pressure etc.

Air Actuator: Cylinders and motors are used to obtain the required movements of mechanical elements of pneumatic system.

Electric Motor: Transforms electrical energy into mechanical energy. It is used to drive the compressor.

Receiver tank: The compressed air coming from the compressor is stored in the air receiver.

The functions of basic components :

1. The **pneumatic actuator** converts the fluid power into mechanical power to perform useful work.

2. **The compressor** is used to compress the fresh air drawn from the atmosphere.

3. **The storage reservoir** is used to store a given volume of compressed air.

4. **The valves** are used to control the direction, flow rate and pressure of compressed air

5. External power supply (**motor**) is used to drive the compressor.

6. The **piping system** carries the pressurized air from one location to another.

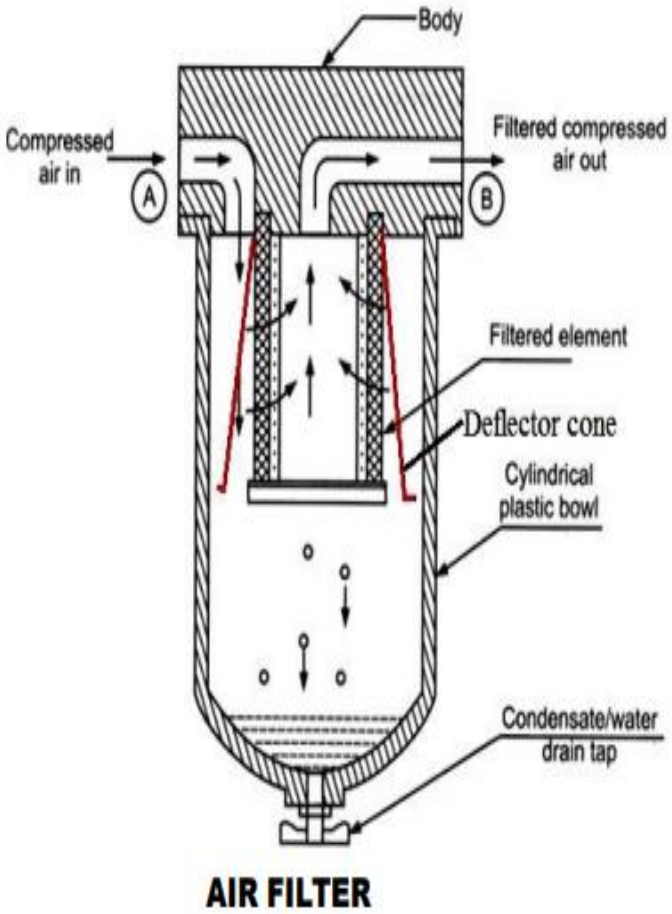
Air Filter

Air contains various impurities such as **pollen grains, dust particulate, soot**, etc.

The **air filter is a fibrous or porous material** that traps the solid particulate and allows air to move in.

It may also contain some absorbent material such as **charcoal that absorbs pollutant gas particles and soot** (a deep powdery material produced by incomplete burning of organic matter).

These impurities need to be removed from the air before it enters a pneumatic circuit.



AIR FILTER

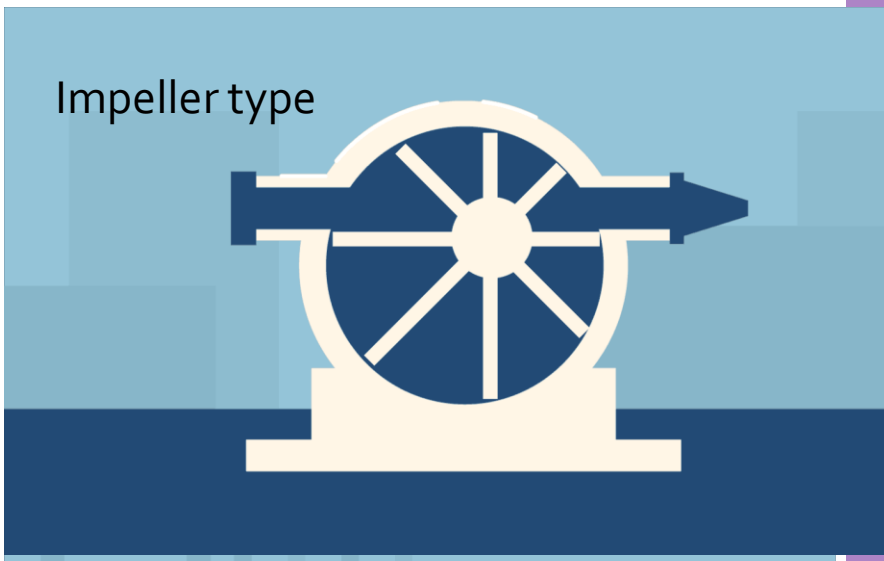
Air compressor

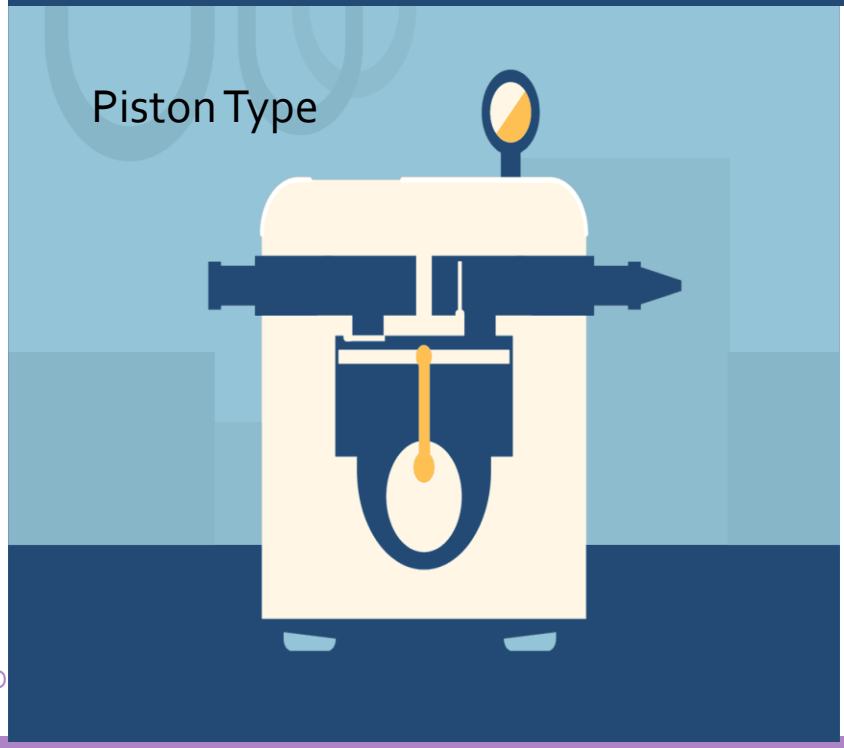
The device used to compress the air is called an air compressor.

These compressors have rotating blades called **impellers** that rotate with the help of a motor.

The impeller creates a vacuum that sucks the air via an air filter.

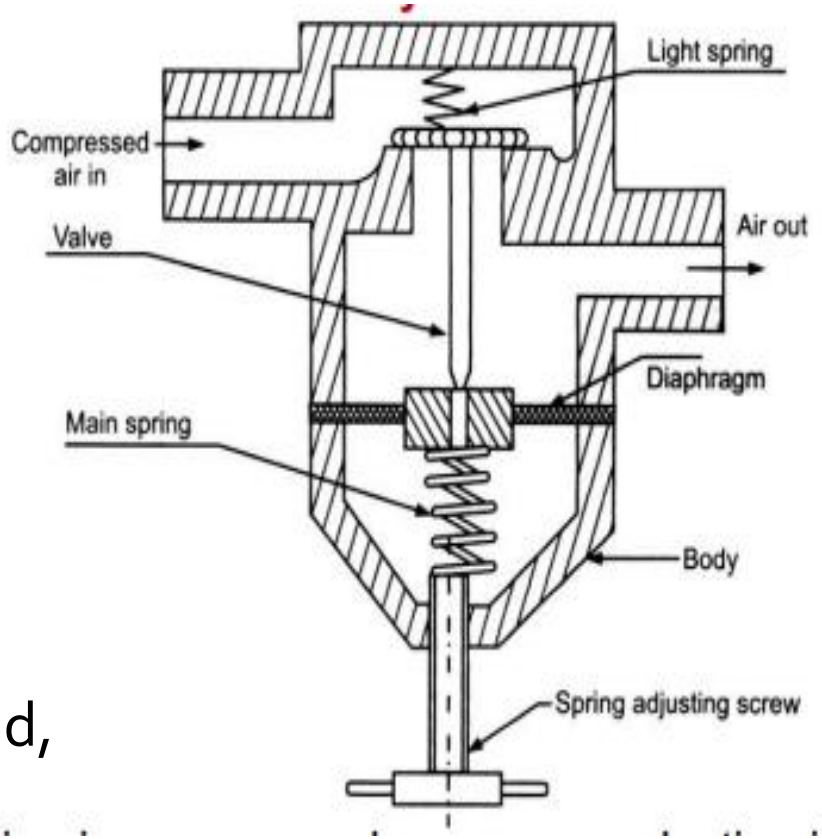
The pressure of air at the outlet of the impeller is more than the atmospheric





The ratio of outlet pressure to the inlet pressure of the compressor is called the compression ratio.

The compression ratio is different for different purposes. Generally, axial flow air compressors are used in pneumatic systems.



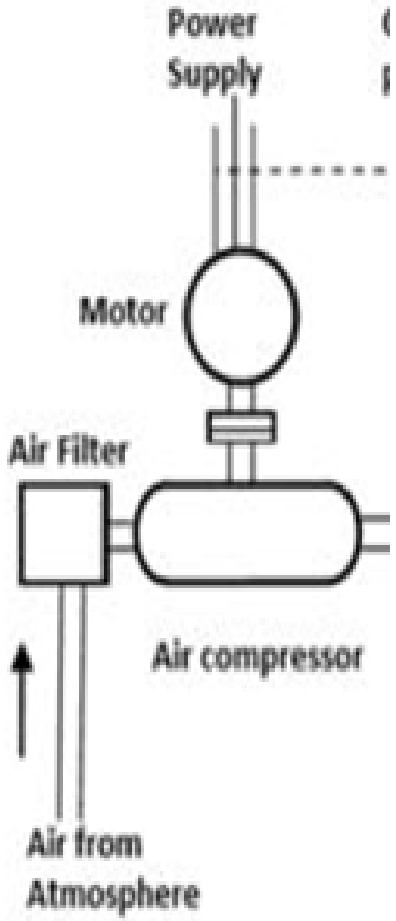
- When light spring is compressed, pressure reduction is less.
- If light spring compression is more, pressure reduction is more.

Motor

A **suitable motor** is used to run the compressor in a pneumatic system.

The capacity of the motor depends on the size of the compressor and the power required to run the compressor.

The motor is directly connected to the power supply.



Air cooler

Air temperature increases when the air is compressed in the compressor.

This hot air is not suitable for further operation.

Hence it is important to cool down the hot air coming out of the air compressor.

The cooling of air is done by an air cooler.

The main objective of an air cooler is to reduce the temperature and moisture content in the air coming out from the air compressor.

There are two types of commonly used air coolers

- Air-cooled air cooler.
- Water-cooled air cooler.

In an **air-cooled air cooler**, the hot air is enclosed in pipes and cool air is forced on it with the help of a fan this cool air carries away heat from the hot air without decreasing the pressure.

While in **water-cooled air cooler** the heat is exchanged by indirect contact between the hot air from the compressor and cold water.

Much lower temperature can be obtained by a water-cooled air cooler than the air-cooled air-cooler.

As cold water is available in large quantities, water-cooled air coolers are cost-effective and quick.

Storage Reservoir

A storage reservoir is an air pressure vessel used **to store compressed air under high pressure.**

This storage device **ensures a smooth supply of pressurized air and eliminates fluctuations caused due to loading and unloading of air demand. (example balloon)**

Storage reservoirs play an important role in pneumatic systems as they ensure quick response to user demand.

Storage reservoirs can store both dry and wet air depending on demand.

Requirements of reservoir:

A storage reservoir must be **strong, high tensile strength, and must be durable.**

Hence the commonly used materials for storage reservoirs are **Mild steel, Aluminum, Carbon steel, and Stainless steel.**

Filter, Regulator, and Lubricator (FRL) unit

These three are generally used as one unit in a pneumatic system, but can also be used as different individual units.

FRL is an important component of a pneumatic system as it reduces losses and increases the efficiency of the system.

The three basic functions of an FRL unit are as follows.

1. **Filter:** To filter out the wastewater, contaminants, and debris (broken pieces of rocks) from the air coming out of the storage reservoir.

This is done by filers and is generally the first step in an FRL unit.

2. Regulator To regulate the pressure and restrict it from crossing the upper limit the damage to the system and also reduces unwanted losses due to high pressure.

3. Lubricator The last stage of the FRL.

In the air, lubrication is done by mixing a thin mist of oil or other lubricants into compressed air.

This is generally done after filtration and regulation.

This lubricated air **reduces the friction** between the moving parts of a pneumatic system and thus **reduces the loss of energy** and **increases the life of the equipment**.

If an FRL unit is not present in a pneumatic system it would decrease the life of the system, increase the energy consumption and reduce the efficiency of the system.

Directional control valve (DCVs)

Directional control valves are the most important device used in a pneumatic system.

The directional control valves or DVCs **are used to control the direction and the amount of air entering the actuators.**

The valves transfer the pressure energy of air to the actuators as per the command given by the operator.

The generally used valve in a pneumatic system is a solenoid valve, also sometimes known as a spool valve.

These valves are operated by the action of a solenoid coil coupled with an electromagnet.

Actuators

Actuators are devices that convert the pressure energy of fluid (air) into mechanical movement (motion).

There are many types of actuators used in the industry.

The actuators are classified based on the motion achieved by them.

- Linear actuators
  - Single-acting cylinders
  - Double-acting cylinders
- Rotary actuators
  - Vane type
  - Rack and pinion type

Pneumatic System Working

The air **comes into the compressor** through an **air filter** due to the vacuum generated by the blades of the compressor

The air is filtered out in the air filter and then goes into the **compressor**.

The compressed air then enters the **air cooler** where the temperature of the air is reduced to improve the efficiency of the system.

This compressed cold air is then stored in the **storage reservoir** to make the air readily available.

The air then enters **the FRL unit** where it is filtered again, pressure is regulated and some oil is added to lubricate the air.
From the FRL unit, the air goes into the **direction control valve** where the air is sent according to the user's action.

Difference betⁿ the Hydraulic System and the Pneumatic System

Pneumatic system	Hydraulic system
The pneumatic system uses air as the working fluid.	The Hydraulic system uses oil as the working fluid.
This is an open-loop system.	This is a closed-loop system.
The construction of pneumatic systems is simple.	The construction of the hydraulic system is complex.
The cost of a pneumatic system is low	The cost of a hydraulic system is high
Pressure in the system is low hence the size is small.	The system's internal pressure is high, hence the size is bigger.
Accuracy is less.	Accuracy is high.
The air inside the system is not flammable.	The oil inside the system is flammable.
The system does not corrode easily.	The system corrodes easily.
The power to size ratio is less.	The power to size ratio is more.

Precautions of Pneumatics

1. We must take care to monitor **for air leaks and corrosion in pipelines to avoid breakdowns**.

2. **The quality of the compressed air** must be high enough to ensure efficient operation.

3. Air preparation in pneumatics is essential. Therefore, there should be **a removal system for moisture, unwanted dust particles, and oils**. Otherwise, they can **clog or corrode** certain components such as valves and seals.

4. The application of a filtration system and monitoring of the air supply will also ensure that the pneumatic system is working as it should.

Advantages of Pneumatics

1. The elements that make up a pneumatic system are **simple and easy** to understand.

2. Air in the atmosphere is abundant, that is, we can dispose of it in **an unlimited way**.

3. The **maintenance cost** of pneumatic circuits is generally **low.**

4. The pneumatic system is **intrinsically safe and best suitable in explosive and hazardous atmospheres**.

5. It is **easily transportable**.

Disadvantages of Pneumatic system

1. Pneumatic systems are **sensitive to vibration**.

Therefore, system installation must be away from sources of vibration.

2. Compared to other types of energy sources, it needs preparation before use (**removal of impurities and moisture**).
3. It has **limited working forces**. (from 20 to 30,000 N).
4. It is **noisy, due to air leaks after use**.
5. It is **expensive energy**, which can be offset to a certain extent by good performance and ease of implementation.
6. The pneumatic **system occupies a huge space** inside the panel with tubing, indicators, recorders, controllers, square root extractors, and air headers.
7. On the other hand, panels with electronic instrumentation are not cumbersome, and easy to fix problems related to wiring.

The applications of the pneumatic system

- Used in manufacturing industries like machine tools, automotive, domestic appliances & commercial appliances.
- These systems are used in processing industries like food processing, chemical, textiles, paper, petrochemical, etc.
- These are used in railway coaches, automobile braking systems, wagons & printing presses.
- These are used in industrial robots for different purposes like packing, filling, drilling, stamping, punching, hosting, clamping, etc.
- Assembly systems.
- Plastics machinery.
- Car washes.
- Test systems.
- Used to drive both rotary & linear and actuators.
- Coolant systems.
- Opening & closing the doors.
- Petroleum markets.
- These are used in different types of equipment for material handling.
- Medical equipment & logic controlling operations.
- In nut runners & power hammers.
- Used in machine tools operations.

Pneumatic Cylinders

Pneumatic cylinders also called **Pneumatic drives / air cylinders** are the final component of the pneumatic or compressed air control mechanical device.

Air or pneumatic cylinders are devices that transform compressed air power into mechanical energy.

The mechanical energy produces **linear or rotary motion**.

The pneumatic air cylinder functions as the actuator in the pneumatic system.

Hence it is called a pneumatic linear actuator.

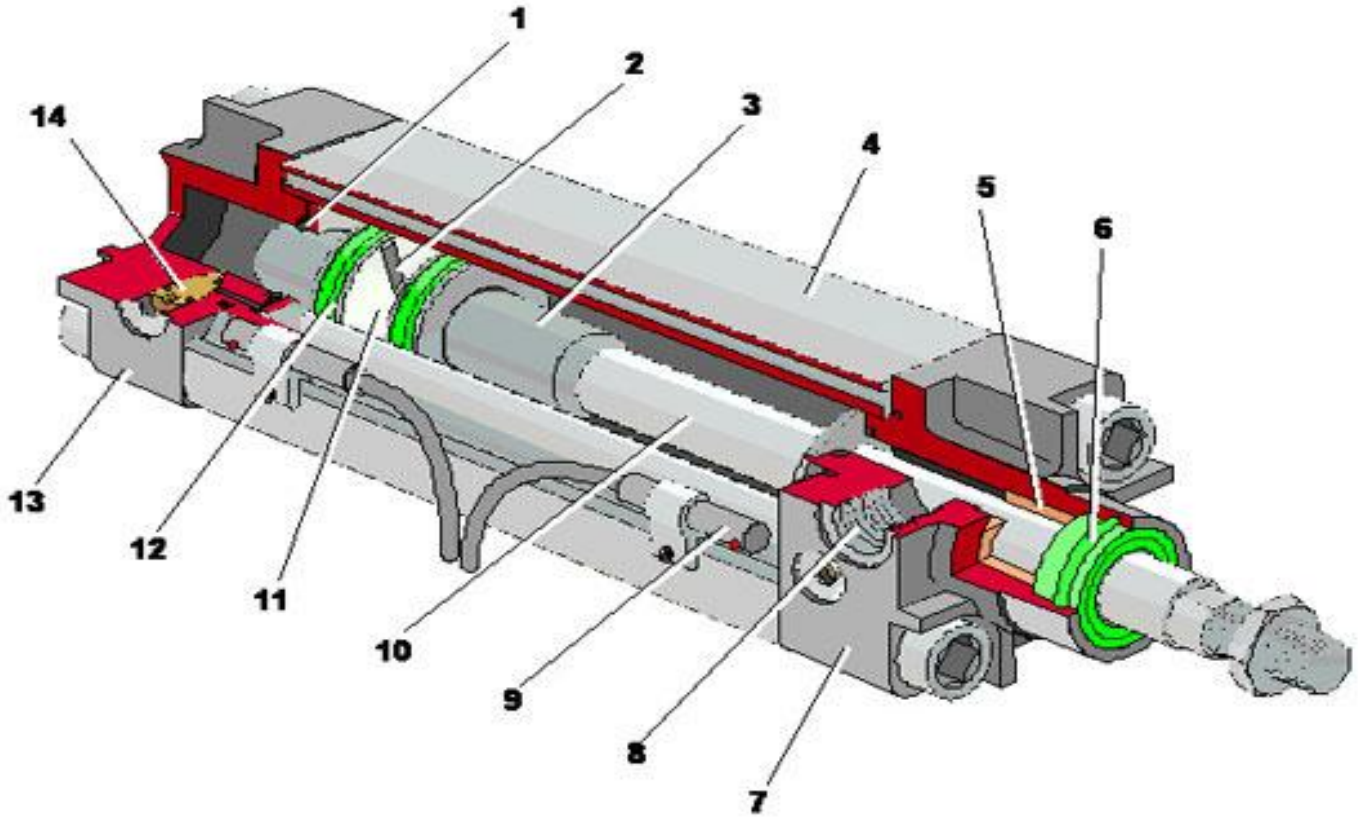
Advantages:

Selecting the right pneumatic cylinder **can ensure the long-term success** of an application and improves the proper overall performance of the machine.

They are mechanical components that are used to produce power or movement from the air or compressed gas.

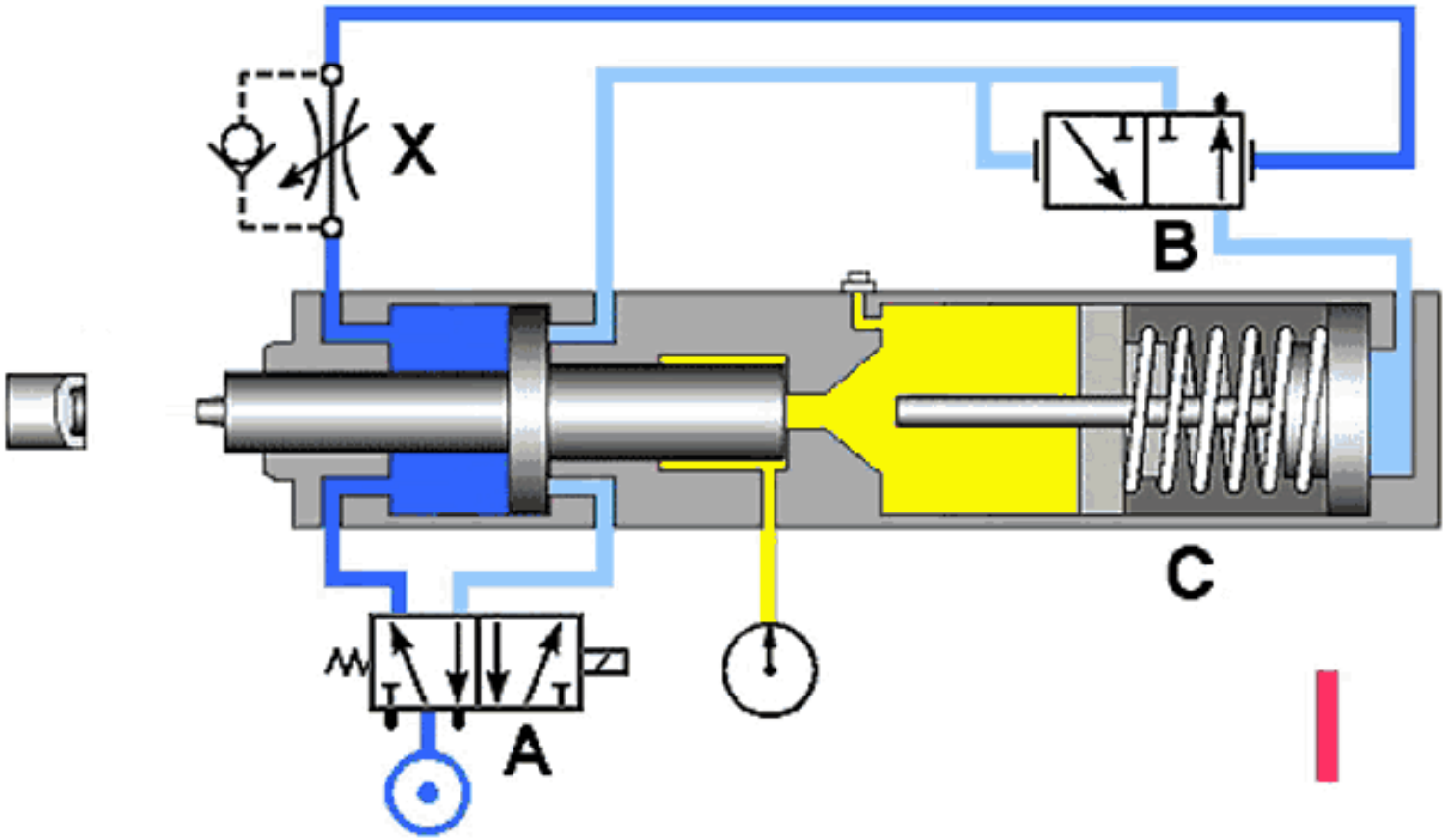
They are a cheap, cost-effective way to produce linear- or rotary motion.

Basic Components of a Pneumatic Cylinder



1 and 3 is buffer plunger 2-piston 4-cylinder 5-guide sleeve
6-dust ring 7-front end cover 8-air port, 9-sensor
10-piston rod 11-wear ring 12-seal ring
13-rear end cover 14-buffer throttle valve.

Pneumatic cylinders can be used for pressure ranges between 5 bar to 20 bar.



A Pneumatic Cylinder

1 and 3 is buffer plunger, 2-piston, 4-cylinder, 5-guide sleeve, 6-dust ring, 7-front end cover, 8-air port, 9-sensor, 10-piston rod, 11-wear ring, 12-seal ring, 13-rear end cover, 14-buffer throttle valve.

1. The pneumatic cylinder bore

The inner diameter of the cylinder represents the output force of the cylinder. The piston shall make smooth reciprocating sliding in the cylinder, and the surface roughness of the cylinder shall reach ra 0.8um. Pneumatic Cylinder material in addition to the use of high carbon steel tube, or with high strength aluminum alloy and brass.

2. The end cover

The end cover is provided with an inlet and exhaust port, and some are also provided with a buffer mechanism inside the end cover. A sealing ring and a dustproof ring 6 are arranged on the end cover of the rod side to prevent air leakage from the piston rod and prevent external dust from mixing into the pneumatic cylinder. A guide sleeve 5 is arranged on the end cover of the rod side to improve the guiding accuracy of the cylinder.

3. The piston

A piston is a pressurized part of a cylinder. In order to prevent the piston from gas channeling between the left and right Chambers, a piston sealing ring 12 is arranged. The wear-resisting ring 11 is also provided to improve the orientation of the cylinder.

4. The piston rod

Piston rod is the most important stressed part of cylinder. High carbon steel is usually used, with a hard chrome finish, or stainless steel **to prevent corrosion and improve the wear resistance of the sealing ring**.

5. Buffer plunger and buffer throttle valve

The piston is equipped with buffer plunger 1 and 3 on both sides along the axis direction, and buffer throttle valve 14 and buffer sleeve 15 are on the cylinder head. When the air cylinder moves to the end, buffer plunger enters the buffer sleeve, and the pneumatic cylinder exhaust needs to pass through the buffer throttle valve. The exhaust resistance increases, and the exhaust back pressure is generated to form buffer cushion, which plays a buffer role.

Principle

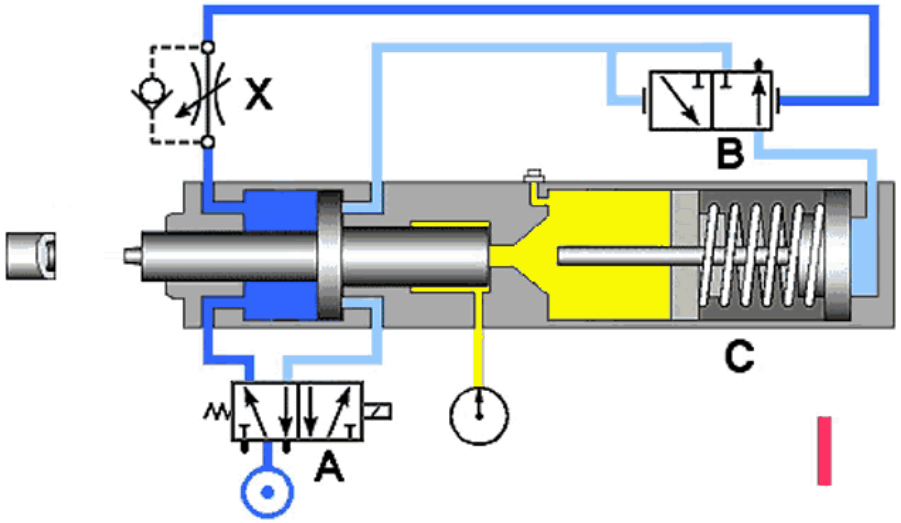
The pneumatic cylinder converts the pressure energy of a compressed air medium into mechanical energy in the form of linear or rotary motion.

Single Acting Cylinder

Only one side of the piston is supplied with certain working pressure.

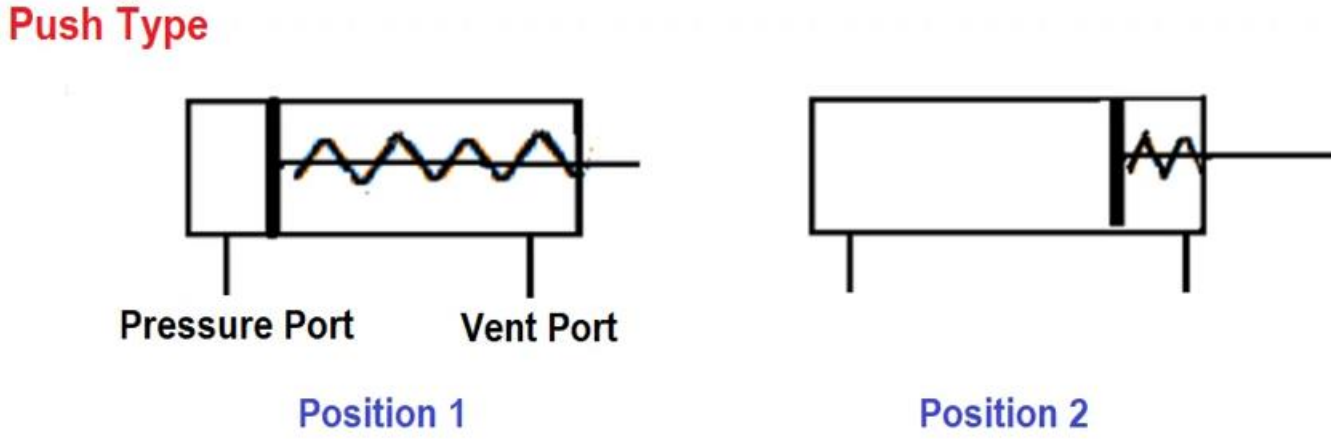
Force acts in one direction to control the movement, returns to normal state by an external force such as a spring inside.

Based on the operation the Single-acting cylinders are classified as Push type and Pull type.



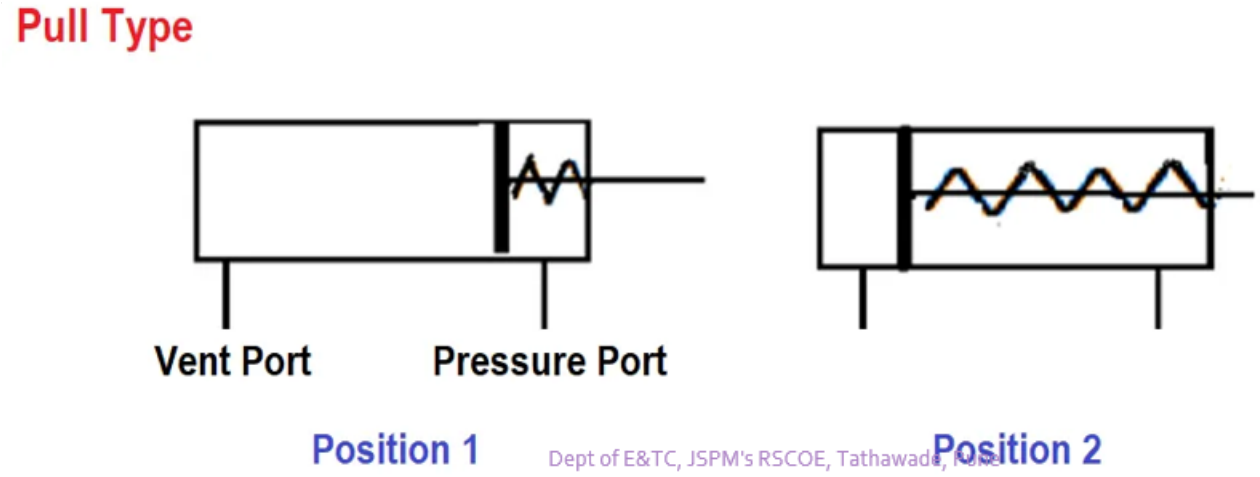
Push type Single-acting Cylinder

Compressed air enters to push the piston out of the cylinder. The spring automatically retracts the piston to its home position when the pressure is removed.



Pull type Single-acting Cylinder

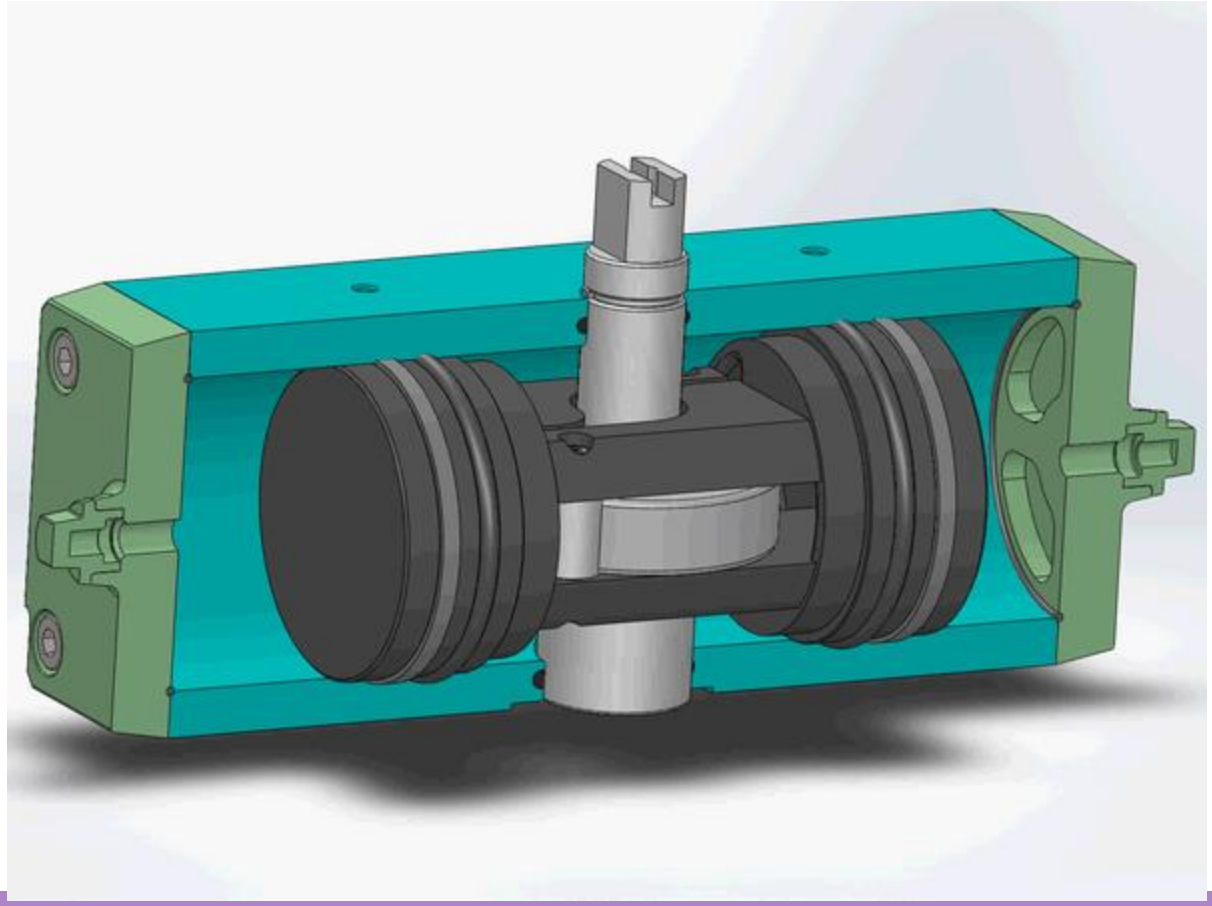
Compressed air enters to pull the piston inside of the cylinder. When the compressed air passed through the port, the piston in the cylinder starts retracting. The pressure port is located at the cylinder end.



Double Acting Cylinder

Both sides of the cylinder are supplied with certain working pressure.

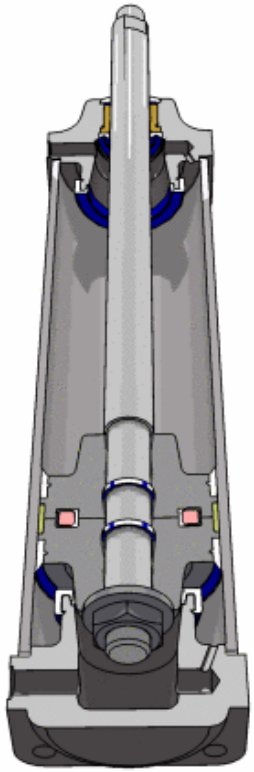
Force exerted by the compressed air moves the cylinder piston rod in two directions.



Double-acting Cylinders

According to the operational principle, the double-acting cylinders are

- Through rod Cylinder
- Cushion end Cylinder
- Tandem Cylinder
- Impact Cylinder
- Cable Cylinder
- Rotary or turn cylinder



1. Through rod Cylinder

In this case, the piston rod is extended on both ends of the piston.
This will make sure equal force and speed on both sides of the cylinder.

2. Cushion End Cylinder

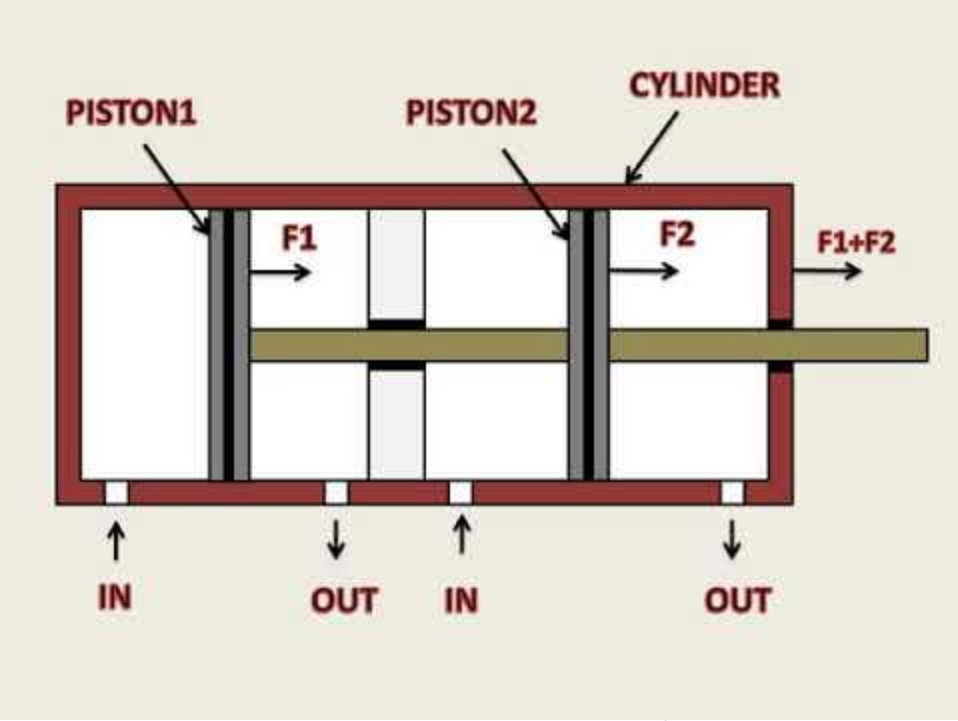
In this case, the piston has a cushioned nose at one or both ends of the piston deceleration of position near the ends of the stroke.

Cushioning may be of rubber buffers to absorb shock and to prevent the impact of the piston on end covers can be avoided.

3. Tandem Cylinder

In this case, two cylinders are arranged in series so that the force obtained from the cylinder becomes double.

https://www.youtube.com/watch?v=AeicfOrmeTw



4.Impact Cylinder

In this case, the piston rod of the cylinder is specially designed for accelerating high force or impact.

5. Cable Cylinder (rodless cylinder)

In this case, a cable is attached on both ends of the cylinder eliminating the piston rod. This is called a rodless cylinder also. Cable-type cylinders are used in applications requiring long strokes

The benefit of the Cylinder

- Space-saving when installing the cylinder.
- Relatively low cost per inch of stroke.
- Rotary or Turn Cylinder
- In this case, the piston rod having a rotary profile against a worm wheel and provides a linear movement.

Cylinder Specifications:

Following are a few specifications to be checked while ordering a pneumatic cylinder.

- Cylinder Bore
- Piston rod diameter
- Stroke length
- Mounting style
- Pressure range
- Force output at maximum pressure
- Cushioning (at one end or both the ends of cylinder)
- Standard operating temperature

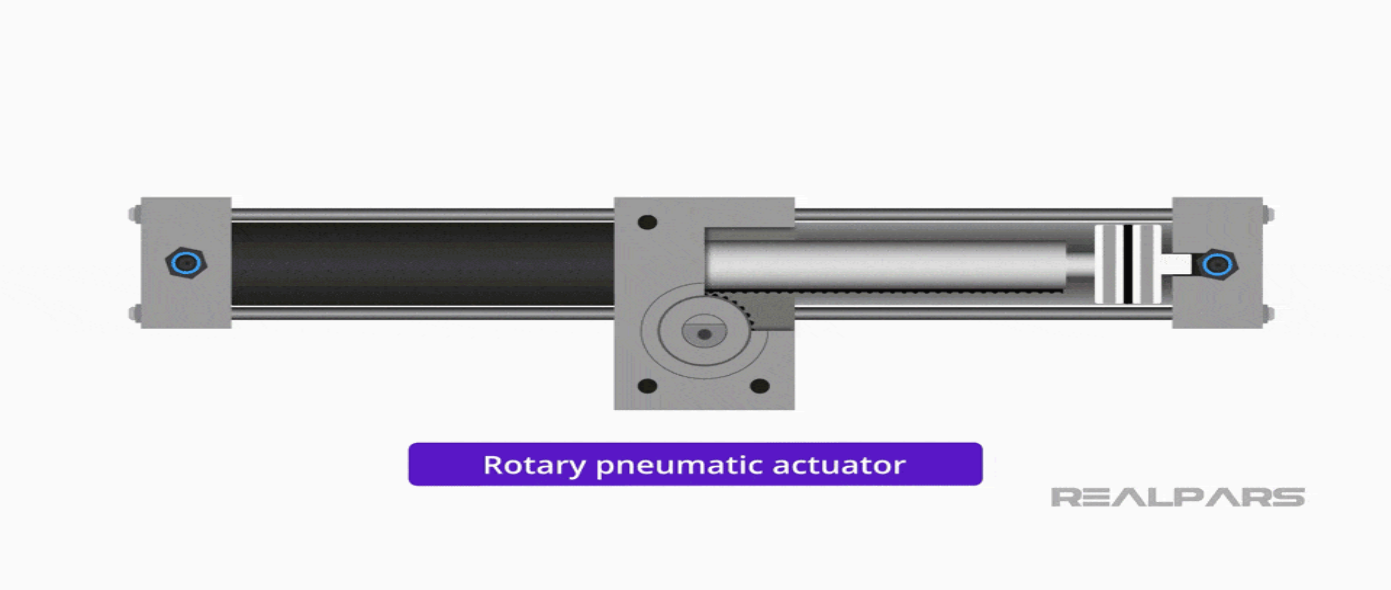
According to type of motion:

A. Pneumatic Actuators (e.g. Spring Actuator and Spring Actuator with positioner)

Pneumatic actuators are categorized by their type of motion. They are either Linear or Rotary.

A linear pneumatic actuator can move something in a straight line.
For example, a rod is moved in and out of a cylinder in a linear motion by a pneumatic energy source

B. Rotary pneumatic actuator



A rotary pneumatic actuator can make something move in a circular motion.
For example, a rod in a **rack and pinion** drive system is used to produce rotary motion.

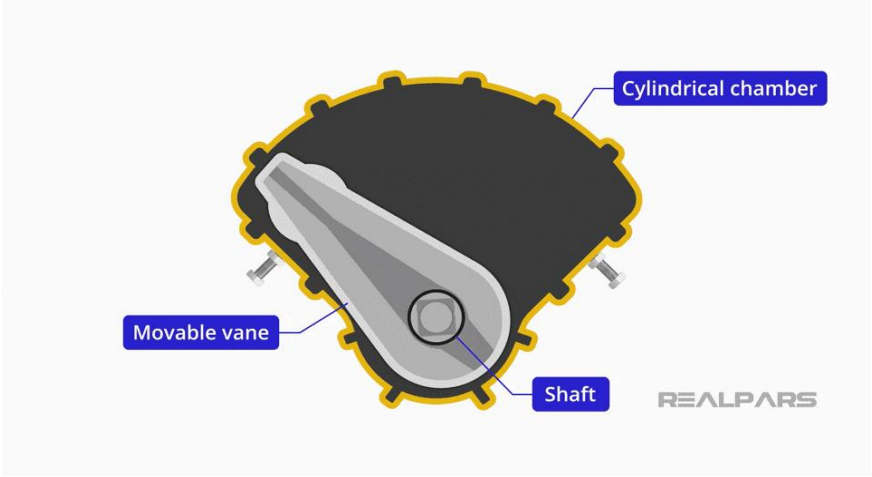
Rotary pneumatic actuator

In the Rotary pneumatic actuator category, the Vane style and the Rack and Pinion style are very common.

i. Vane Actuator

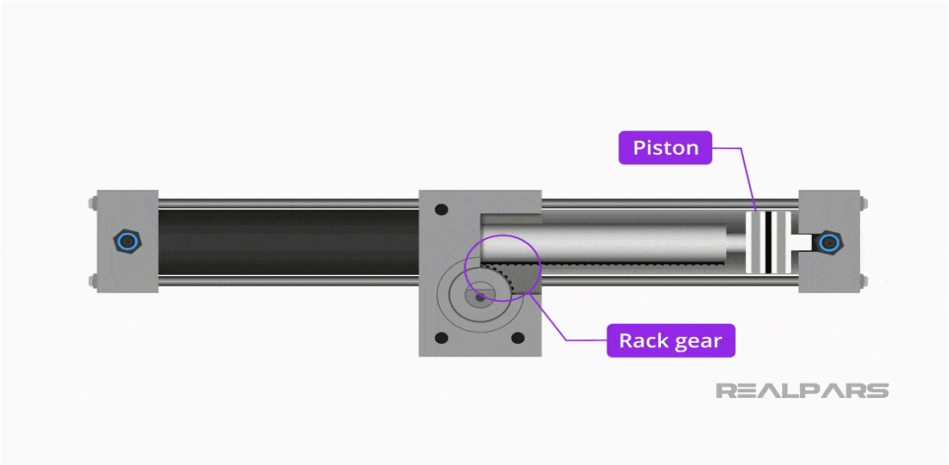
Vane Actuators have a cylindrical chamber in which a movable vane is mounted on a shaft.

Pneumatic air under pressure applied on one side of the vane causes it to rotate through it stroke.



ii. Rack and pinion

Rack and Pinion actuators use a piston attached to rack gear. When pneumatic pressure is applied, the piston and rack move linearly rotating the pinion gear and driveshaft.



The piston-style pneumatic actuator

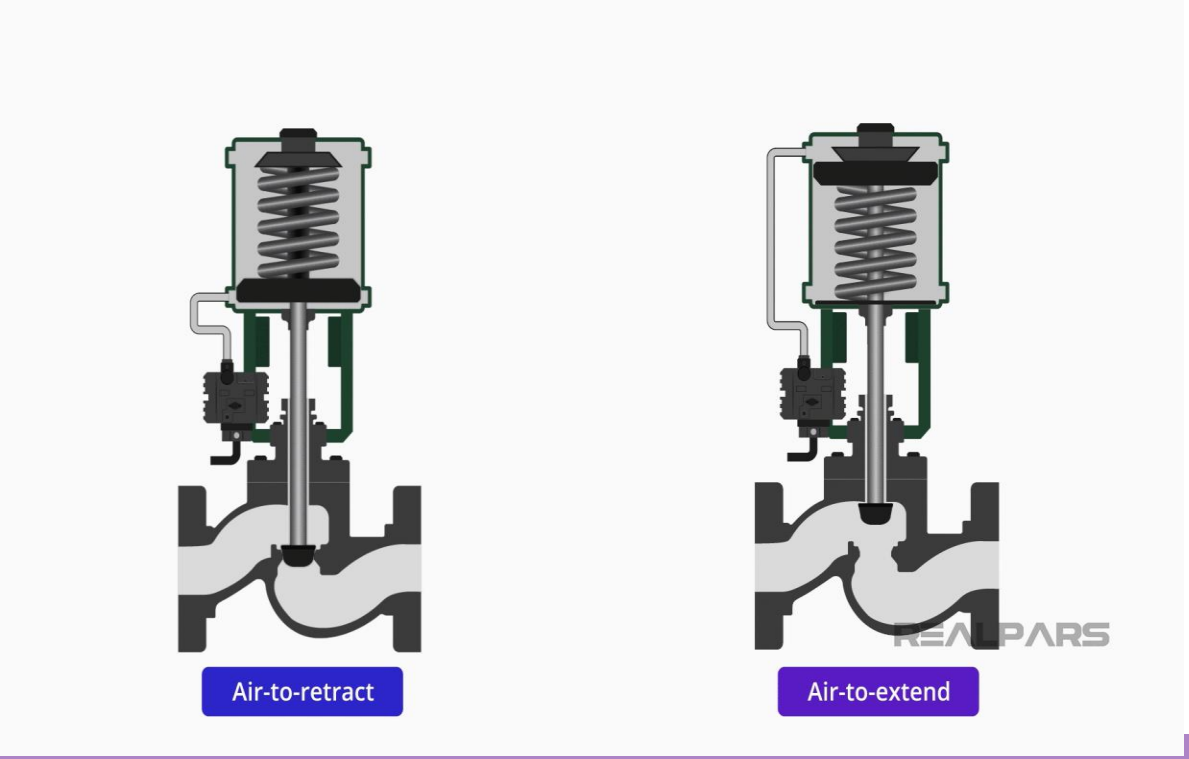
The piston-style pneumatic actuator utilizes a piston inside a cylinder.

a. The movement of the piston is caused by applying pneumatic pressure thereby moving the piston upwards.

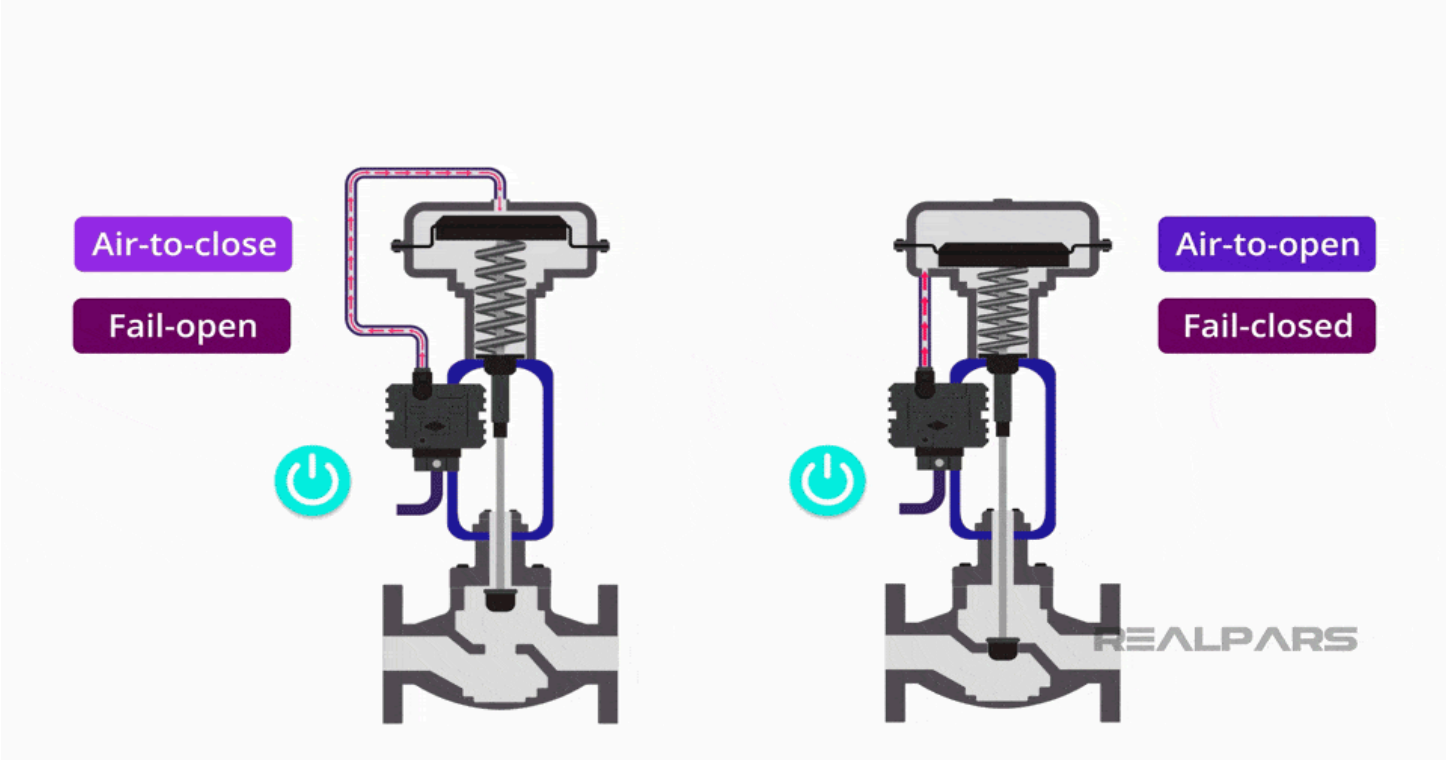
b. Removing the pneumatic pressure causes the piston to move downward due to the pressure of the spring.

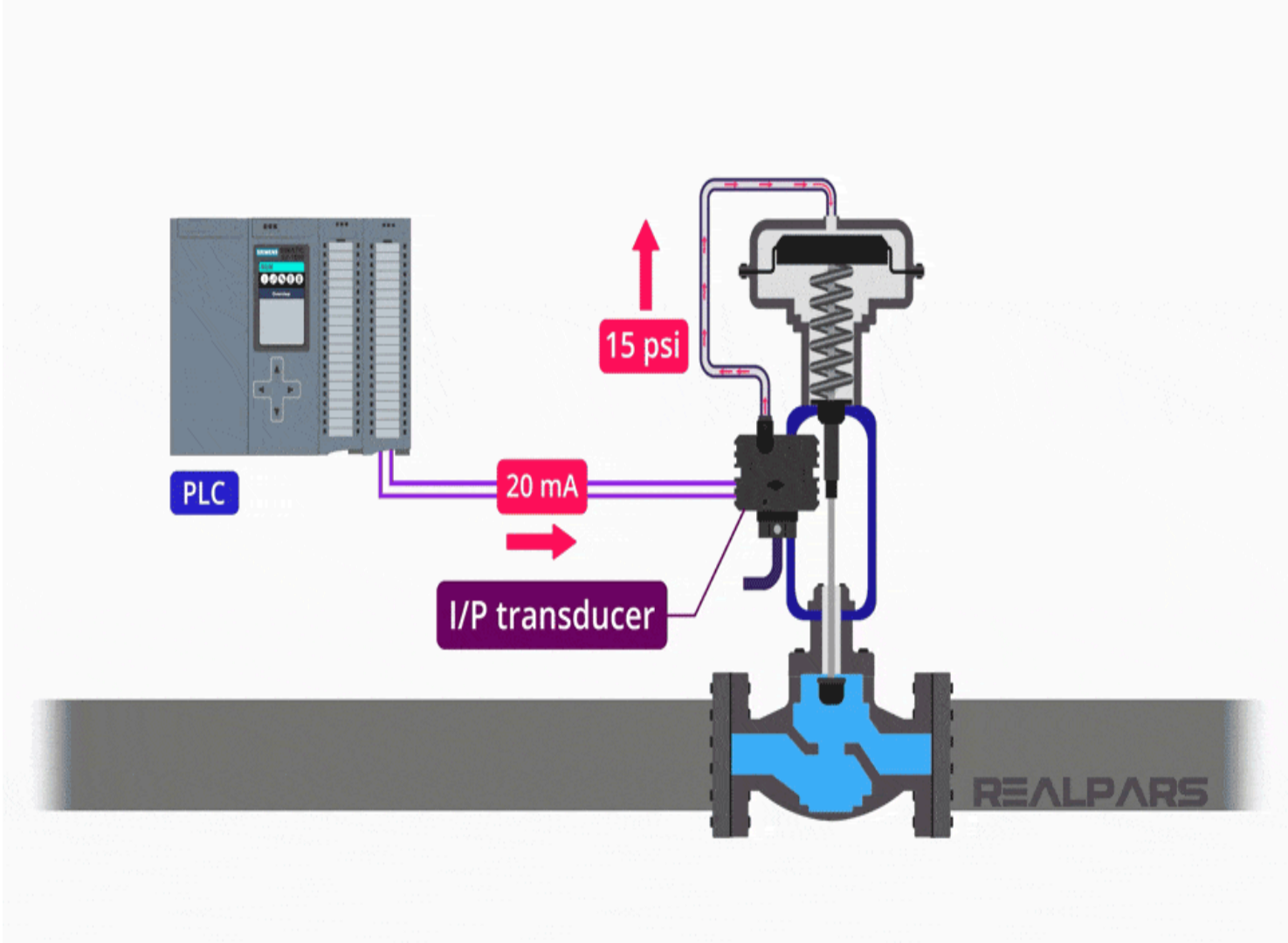
This motion is referred to as **Air-to-Retract (Withdraw)**.

Similarly, an **Air-to-Extend** motion can be also be achieved by rearranging the spring, piston, and pneumatic supply.



In an **air-to-open** operating condition, the spring forces the valve closed.
The air pressure on the diaphragm creates a force that overcomes the force of the spring and opens the valve.
By rearranging the spring pneumatic supply, this type of actuator can **fail-open** or **fail-closed** when air pressure is lost.




15 psi
PLC
20 mA
I/P transducer
REALPARS

Air compressor

An air compressor is a pneumatic device that converts power (using an electric motor, diesel, or gasoline engine, etc.) into potential energy stored in pressurized air (i.e., compressed air)

- An air compressor, as the name indicates, is a machine to compress the air and to raise its pressure.
- The air compressor sucks air from the atmosphere, compresses it and then delivers the same under a high pressure to a storage vessel.
- From the storage vessel, it may be conveyed by the pipeline to a place where the supply of compressed air is required.
- The compressed air is used for many purposes such as for operating pneumatic drills, riveters road drills, paint spraying, in starting and supercharging of internal combustion engines, in gas turbine plants, jet engines and air motors, etc.
- It is also utilised in the operation of lifts, rams, pumps and a variety of other devices.

Working

Air compressors work by forcing air into a container and pressurizing it.
Then, the air is forced through an opening in the tank, where pressure builds up.

They're powered by an engine that turns electrical energy into kinetic energy.

From there, the pressurized air can be used to power a variety of tools.

Note: Think of it as an open balloon: the compressed air can be used as energy as it's released.

Classification of air compressor -

1.According to working

(a) Reciprocating compressors, and (b) Rotary compressors

2. According to action

(a) Single acting compressors, and (b) Double acting compressors

3. According to number of stages

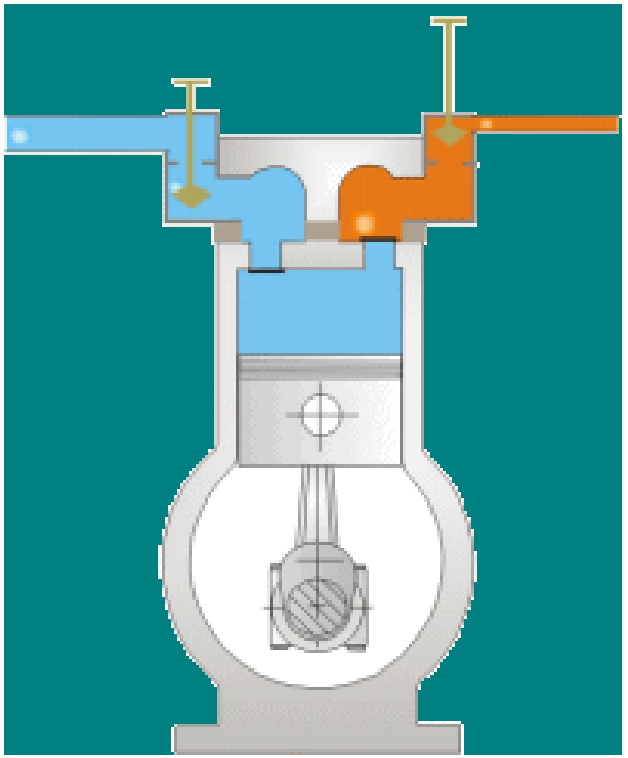
(a) Single stage compressors, and (b) Multi-stage compressors.

This type of compressor uses piston-cylinder arrangement to compress the air.

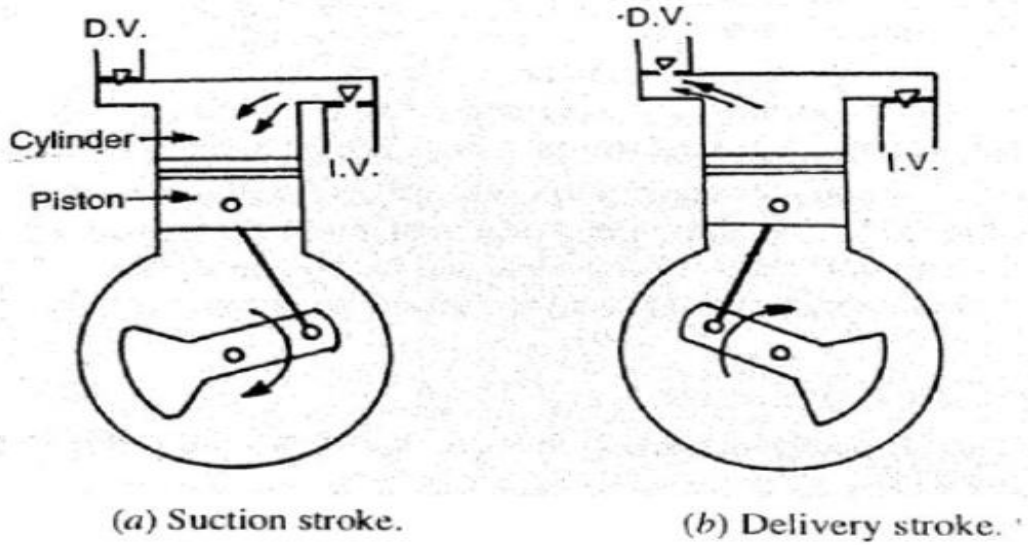
Whenever something moves back and forth it is considered as moving in reciprocating motion.

Similarly in this type piston move back and forth inside the cylinder and compress the air.

There are two sets of valves that take care of air intake and exhaust(working is shown in image).



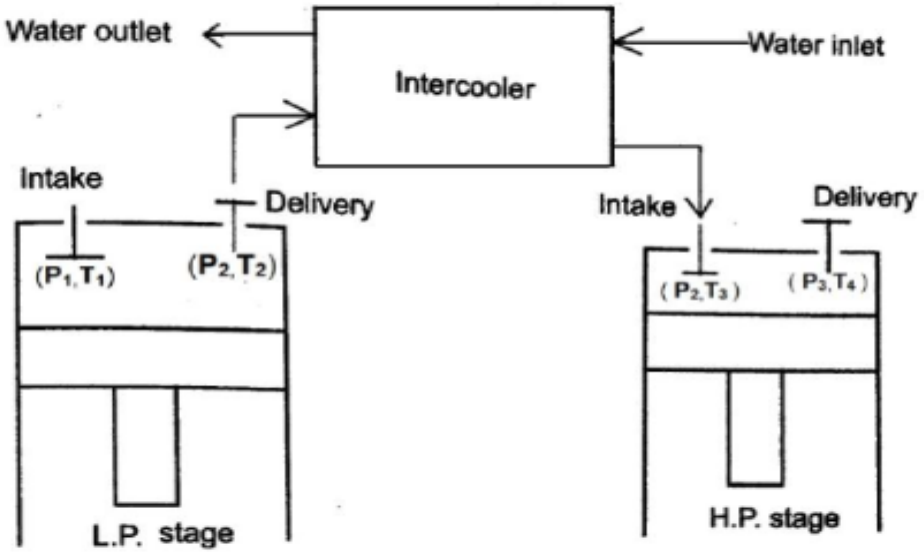
Single Stage Reciprocating Air Compressor –



(*a*) Suction stroke. (*b*) Delivery stroke.

- It consists of the following main components as shown in Fig.
  - Cylinder
  - Piston
  - Suction valve
  - Delivery valve
- In single stage reciprocating air compressor, there are three main strokes .
- When the piston moves downwards, the pressure inside the cylinder falls below the atmospheric pressure.
- Due to this pressure difference, the suction valve gets opened and air Sucked into the cylinder.
- When the compression stroke is taking place both suction and delivery valves are close.
- When the piston moves upwards the pressure inside the cylinder increasing till it reaches the discharge pressure.
- At this stage delivery valve opened and air is delivered to container.
- When the compression stroke is taking place both suction and delivery valve are closed.
- When the pressure of air increases automatically volume of air decreases and temperature of air increases.
- In single stage, compression and delivery of air takes place in two strokes of the piston or one revolution of crankshaft.

Two stage reciprocating air compressor –



- A schematic arrangement for a two-stage reciprocating air compressor with water cool intercooler is shown in Fig.
- First of all, the fresh air is sucked from the atmosphere in the low pressure (L.P.)cylinder during its suction stroke at intake pressure P_1 , and temperature T_1 .
- The air, after compression in the L.P. cylinder (i.e. first stage) from 1 to 2, is delivered to the intercooler at pressure P_2 and temperature T_2.
- Now the air is cooled in the intercooler from 2 to 3 at constant pressure P_2 and from temperature T_2 to T_3.
- After that, the air is sucked in the high pressure (H.P.) cylinder during its suction stroke.
- Finally the air, after further compression in H.P. cylinder (second stage) from 3 to 4, is delivered by the compressor at pressure P_3 and temperature T_4.

https://www.youtube.com/watch?v=E6_jw841vKE

ROTARY COMPRESSOER

- In reciprocating air compressor the pressure of air increases in its cylinder with the help of moving piston.
- In a rotary compressor, the air is entrapped between two sets of engaging surface and the pressure of air increases by squeezing action or back flow of air.

Types of rotary air compressor are:

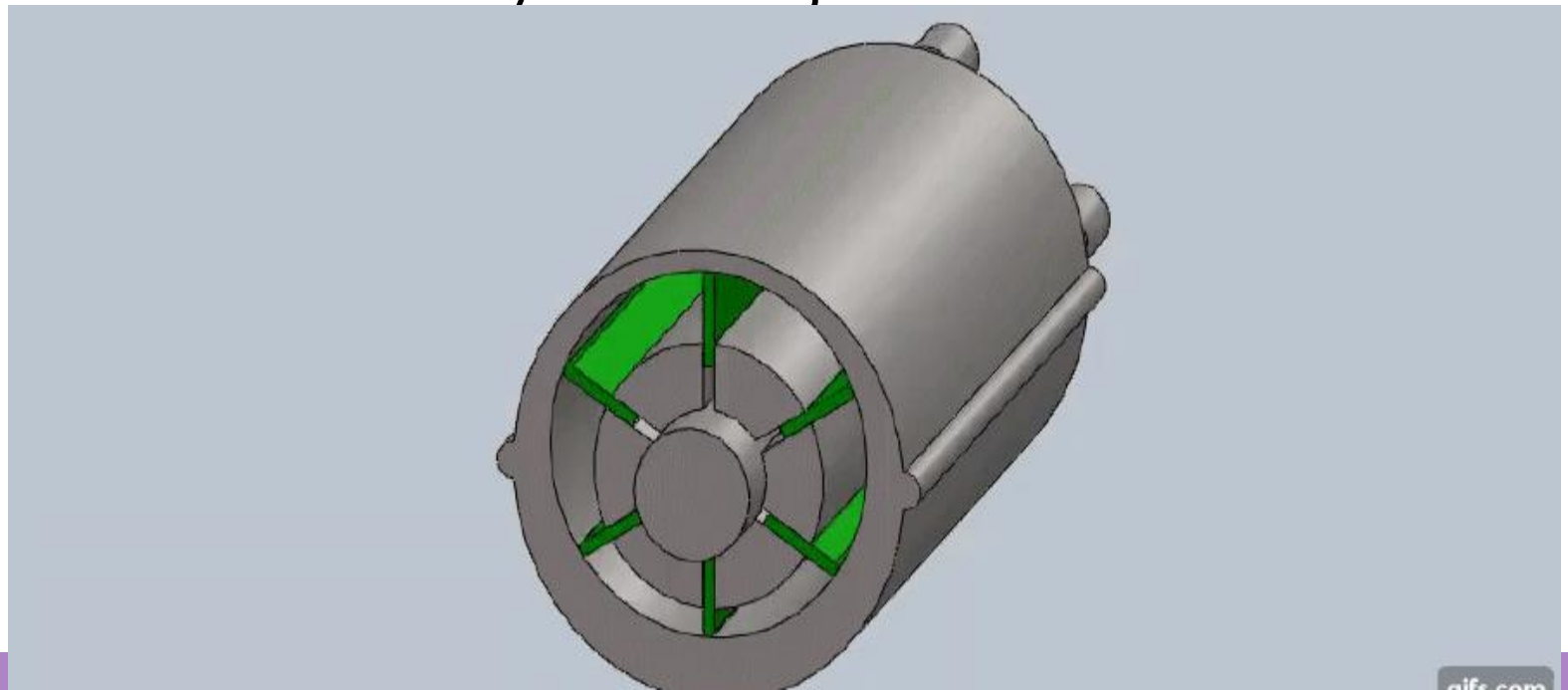
- Centrifugal compressor
- Axial flow compressor
- Screw compressor
- Roots blower or Lobe compressor
- Vane compressor

Above types roots blower, vane and screw are positive displacement Compressor and centrifugal and axial are non-positive displacement compressor.

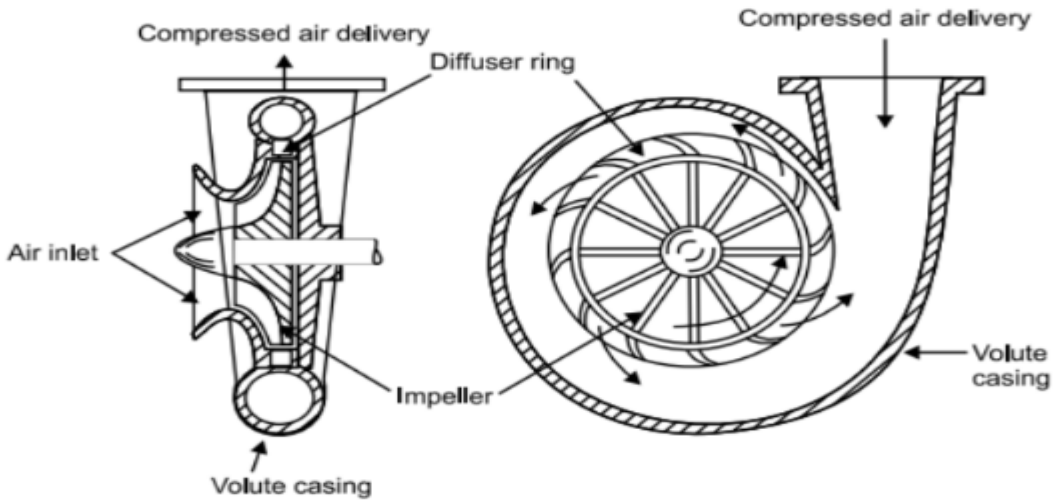
Rotary compressors contain two helical, interlocking rotors within the housing.

Ambient air enters the compressor through the inlet valve.

This air is then trapped between the two rotors. Here, the screws turn, and this increases the pressure of the air by reducing its volume

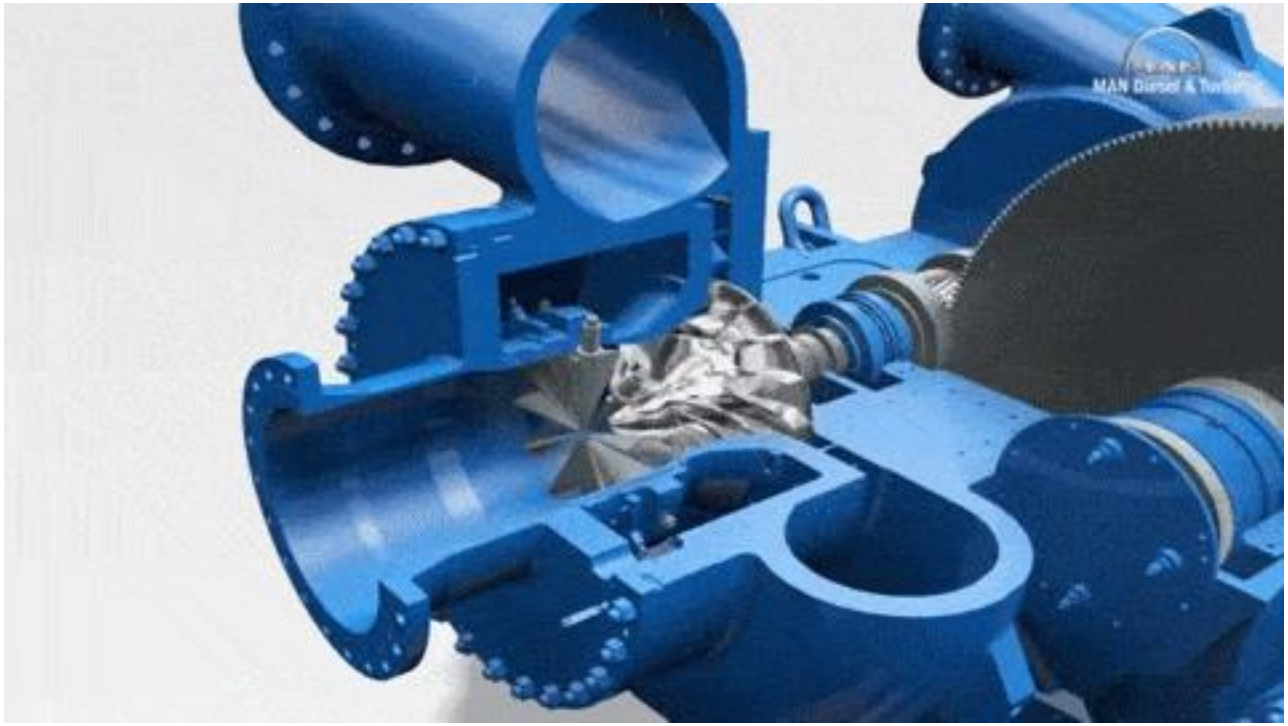


➢ Centrifugal Compressor-



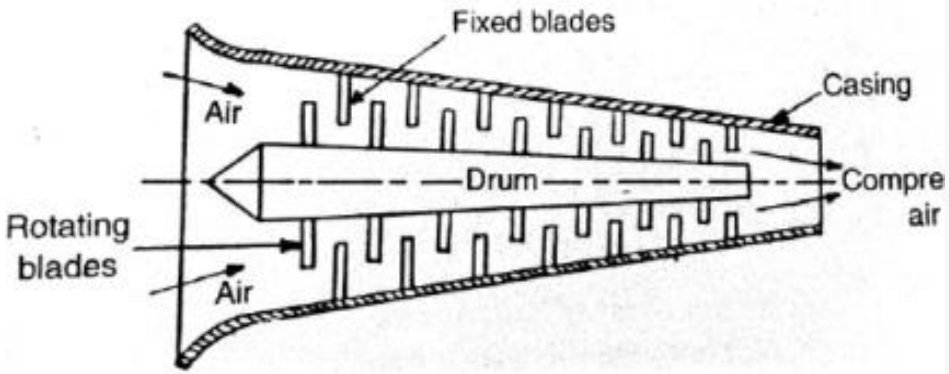
- A centrifugal blower compressor, in its simplest form, consists of a rotor (or impeller) to which numbers of curved vanes are fitted symmetrically.
- The rotor rotates in an air tight volute casing with inlet and outlet ports.
- The casing for the compressor is so designed that the kinetic energy of the air is converted into pressure energy before it leaves the casing as shown in Fig.
- The mechanical energy is provided to the rotor from some external source.

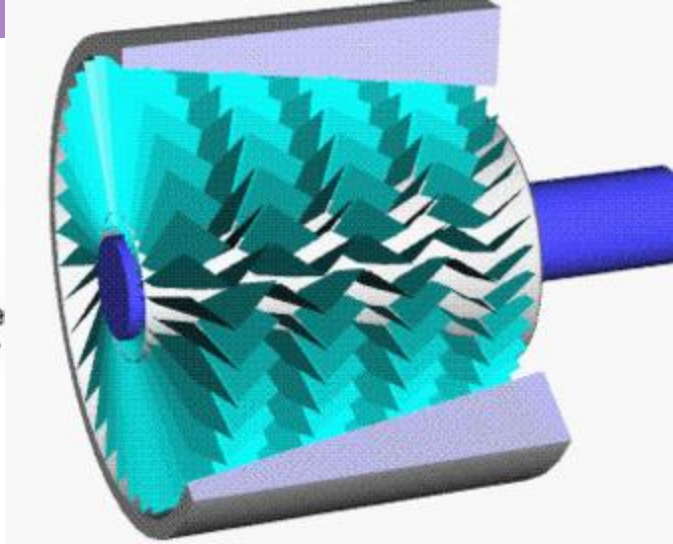
- As the rotor rotates, it sucks air through its eye, increases its pressure due to centrifugal force and forces the air to flow over the diffuser.
- The pressure of air is further increased during its flow over the diffuser.
- Finally, the air at a high pressure is delivered to the receiver.
- It will be interesting to know that the air enters the impeller radially and leaves the vanes axially.



What is centrifugal compressor?
Centrifugal compressors, also known as dynamic compressors, **efficiently converts the energy utilizing a series of stages to compress and cool the air as it continuously flows through the unit**.

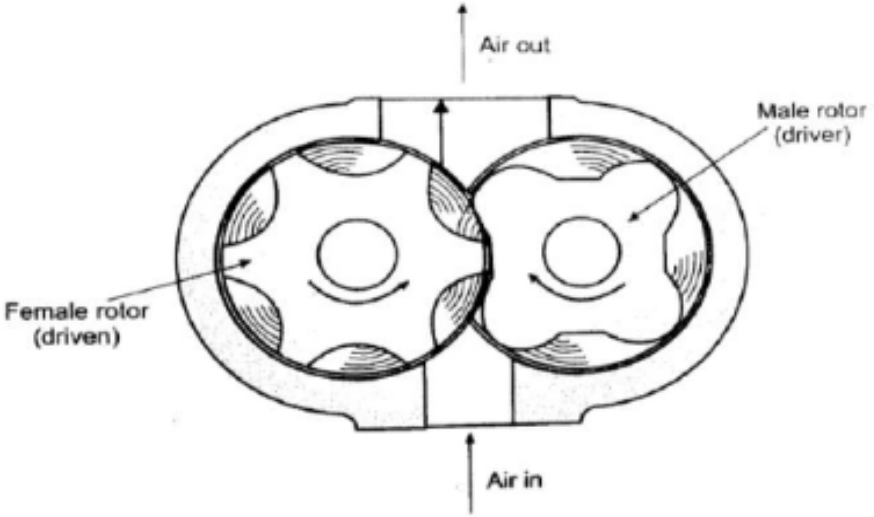
Axial Flow Compressor-

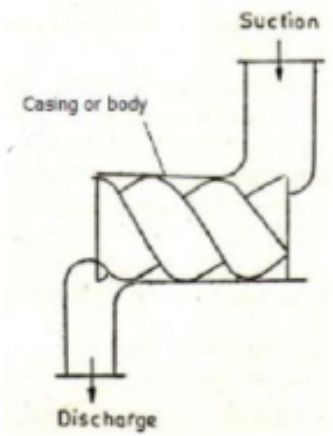




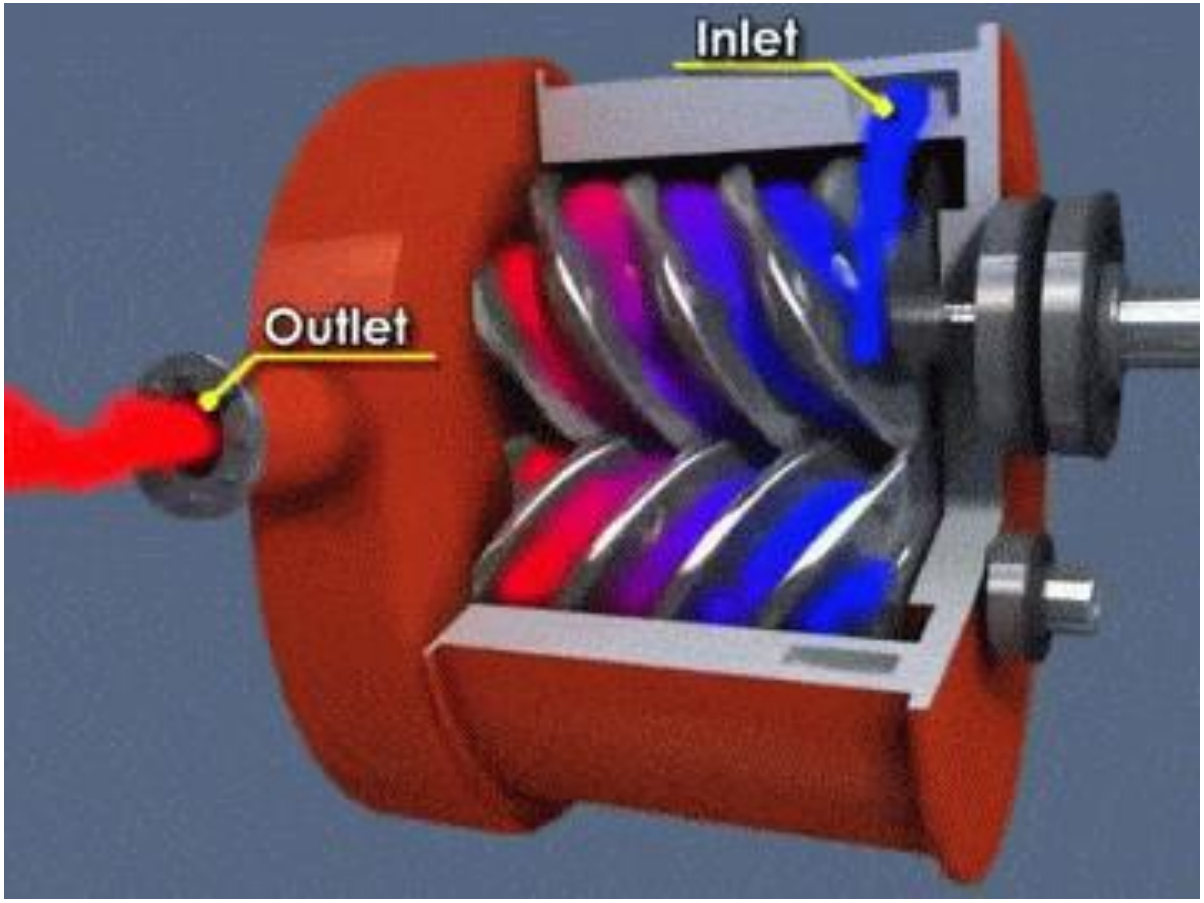
- It consists of a number of rotating blade rows fixed to rotating drum (rotor).
- The drum rotates inside an air tight casing to which are fixed stator blade row as shown in Fig. The blades are made of aerofoil section to reduce the loss caused by turbulence and boundary separation.
- The mechanical energy is provided to the rotating shaft, which rotates the drum (rotor).
    - The air enters from left side of compressor. As the rotor rotates, the air flows through the alternately arranged fixed blade and moving blade.
    - As the air flows from one set of fixed and moving blade to another it gets compressed.
    - Thus, successive compression of air in all the sets of fixed blade and moving blade, the air is delivered at high pressure at the outlet.
    - Pressure rise in each stage is 12-15%, total number of stages from 5 to 14; it handles air up to 30,000 m'/min. It is used in gas turbine power plant.

Screw Compressor-





- It consists of two mutually engaged helical grooved rotors which are suitably housed in a casing. Out of two rotors male rotor is driver and female rotor is driven.
- Male rotor has four lobes and female rotor has six flutes.
- During rotation of rotor, air enters and takes space between male and female rotor. This air traps and moves axially and radially with rotation of rotors and gets compressed due to volume reduction.
- Then this air discharges from upward direction. Speed of rotors is different due to different number of lobes and flutes.
- It handles 3.5 to 300 m/min and maximum pressure ratio of 20. This system requires lubrication. This compressor is noisy in operation. Used in refrigeration industry.



Screw Type compressor

Applications Of Air Compressors

supplying high-pressure clean air to fill gas cylinders,

supplying moderate-pressure clean air to a submerged surface supplied diver,

supplying moderate-pressure clean air for driving some office and school building pneumatic HVAC control system valves.

Supplying a large amount of moderate-pressure air to power pneumatic tools, such as jackhammers, filling high-pressure air tanks (HPA), for filling tires, and to produce large volumes of moderate-pressure air for large-scale industrial processes (such as oxidation for petroleum coking or cement plant bag house purge systems).
Air compressors are also widely used in oil and gas, mining, and drilling applications as the flushing medium, aerating muds in underbalanced drilling, and in air pigging of pipelines.

Most air compressors either are reciprocating piston type, rotary vane, or rotary screw. Centrifugal compressors are common in very large applications, while rotary screw, scroll, and reciprocating air compressors are favored for small and medium-sized applications.

Air Receiver

An air receiver is used to store high-pressure air from the compressor.

Its volume reduces pressure fluctuations arising from changes in load and from compressor switching.

Air coming from the compressor will be warm (if not actually hot!) and the large surface area of the receiver dissipates this heat to the surrounding atmosphere.

Any moisture left in the air from the compressor will condense out in the receiver, so outgoing air should be taken from the receiver top.

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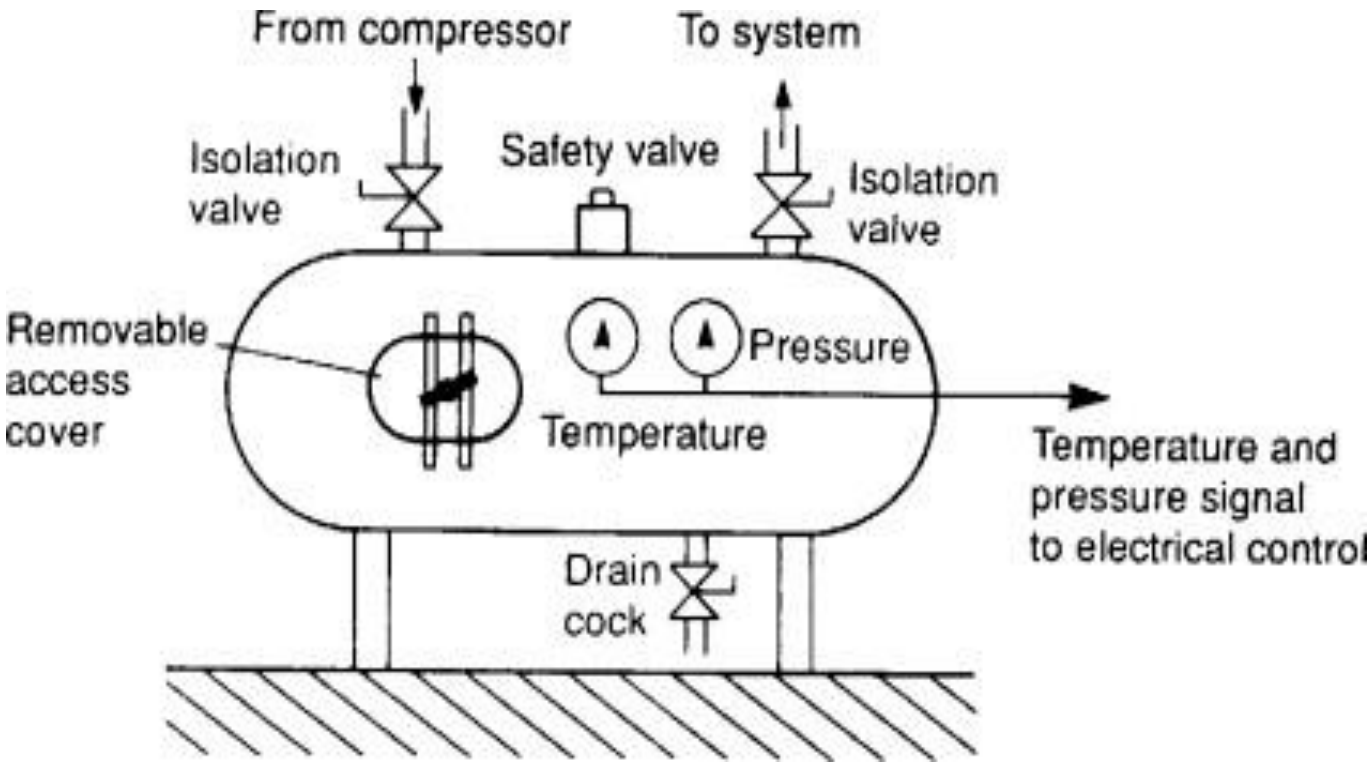

They are usually of cylindrical construction for strength, and have a safety relief valve to guard against high pressures arising from failure of the pressure control scheme.

Pressure indication and, usually, temperature indication are provided, with pressure switches for control of pressure and high-temperature switches for remote alarms.

https://www.youtube.com/watch?v=Kop_K-94MdA

Air Dryer Air Service Treatment:
Air Filter, air regulator and Gauge

- **1. dryers are essential for air compressors**.

- They keep **compressors free of moisture**, and **prevent condensate and rust problems** from occurring.

- Air compressors produce a lot of water. While this water can be drained, the moisture isn't removed entirely from the system.
- https://www.youtube.com/watch?v=Kop_K-94MdA

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2. **An air filter system** can be crucial to keeping your air compressor from clogging from foreign items and a dryer system will **keep air lines from collecting moisture or freezing.**

Case study of Robotic Pick and Place robot

Example

https://www.youtube.com/watch?v=IfojHo9cVOk

https://golangbot.com/diy-pick-and-place-robot/