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PNEUMATIC

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PNEUMATIC



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PREFACE

This book is designed mainly for mechanical engineering students and those who need a clear understanding of fundamental of automation. It is also suitable for those who are studying independently or through open-learning system. This book is explaining the fundamental of automation related to pneumatics.

The entire book is written in a simple way to enable the students understand the concepts quickly and the subject is an easy way. This book shall provide knowledge on the theory, concept and application of pneumatic and to acquire the problem solving skills related to the respective processes.

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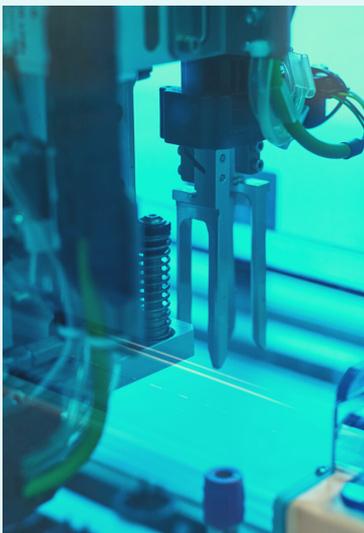


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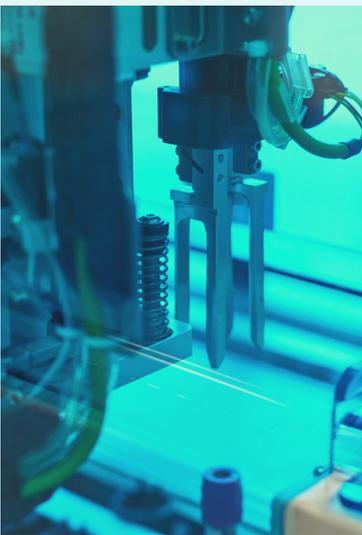


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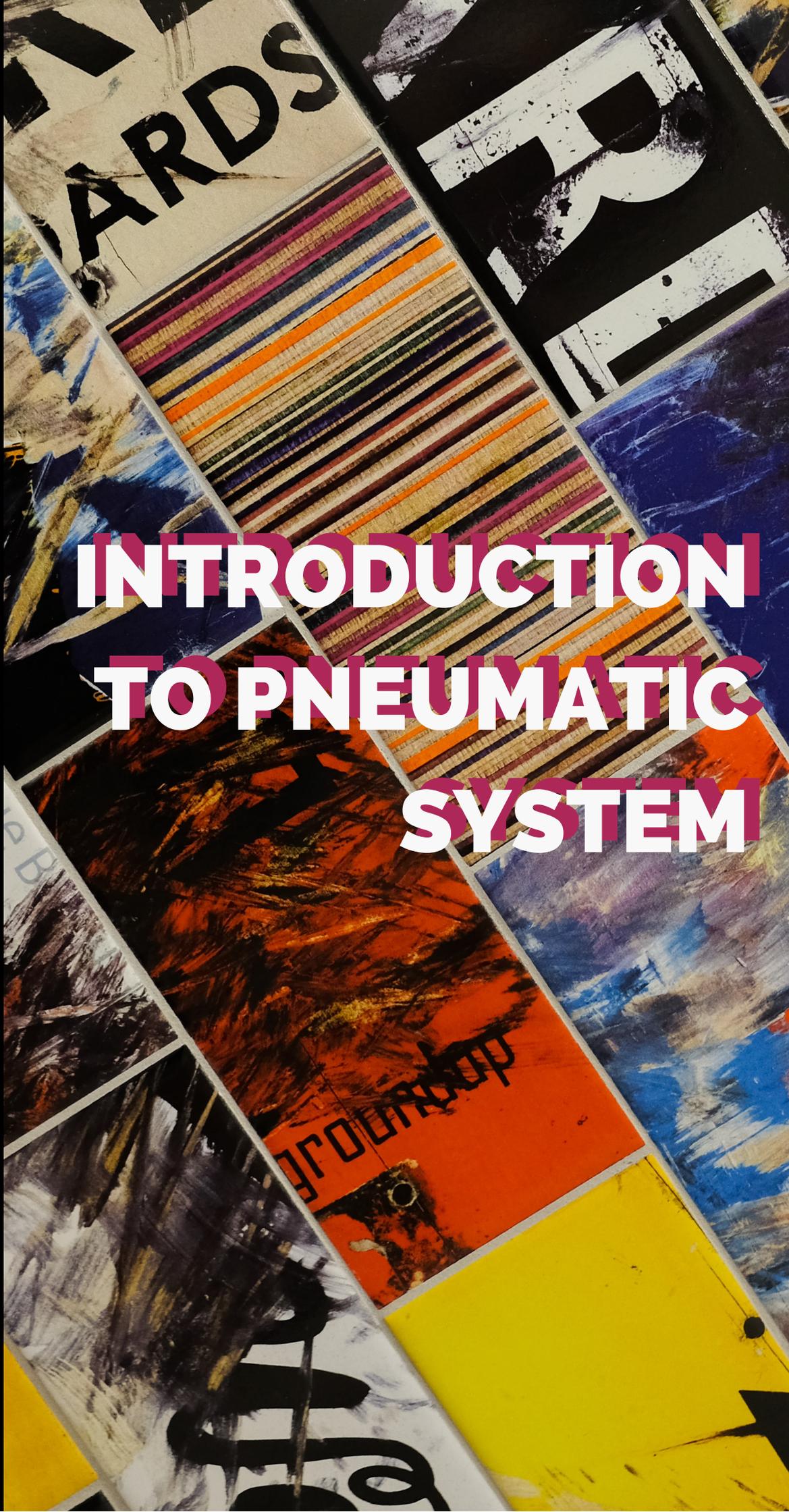
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**INTRODUCTION
TO PNEUMATIC
SYSTEM**



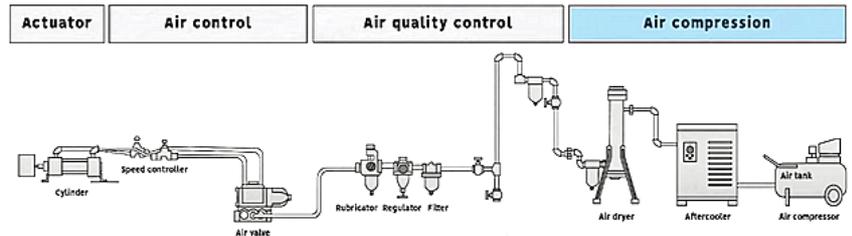
PNEUMATIC SYSTEM

DEFINITION

Pneuma = breath (Greek)
The use of compressed air in drive and control engineering

- The basic components of a pneumatic circuit or system are the following:
- The compressor is in charge of compressing the air to the required working pressure.
- Compressed air tank. Where pressurized air is stored at a certain temperature.
- The pressurized air circulation circuit and the control and distribution valves for the compressed air.

Pneumatic System



- Working mechanism, cylinders, rod, bearings, etc. to do the concrete job.
- Pneumatic tool or specific system to which it is applied (pneumatic gun, drills, hammers, elevators, etc.)

THE USAGE OF PNEUMATIC CONTROL IN THE INDUSTRY

- Pneumatic technology, one of the most effective means, with high efficiency, safety and longevity, low cost, easy maintenance, anti- overload, etc.,
- Get more and more widely used in many areas of the industrial sector.
- Machine tool industry to the machinery industry to provide 'working machine', is the basis of the machinery industry.



- The main application of pneumatic products:
- Printing machinery
- Food machinery
- Packaging machinery
- Semiconductor welding machine, chip grinding
- Mechanical arm
- CNC machine tools
- Auto industry
- Water treatment industry

INDUSTRIES THAT USE PNEUMATICS SYSTEMS

- Aerospace
- Automotive
- Chemical Manufacturing
- Electronics
- Food and Beverage
- General Manufacturing
- Glass Manufacturing
- Hospitals/Medical
- Mining
- Pharmaceuticals
- Plastics
- Power Generation
- Wood Products and many more



THE ADVANTAGES AND DISADVANTAGES OF PNEUMATIC SYSTEM

Advantages

- Infinite availability of the source Air is the most important thing in the pneumatic system, and as we all know, air is available in the world around us in unlimited quantities at all times and places.

- Easy channeled

Air is a substance that is easily passed or moved from one place to another through a small, long and winding pipe.

- Temperature is flexible

Air can be used flexibly at various temperatures required, through equipment designed for specific circumstances, even in quite extreme conditions, the air was still able to work.

- Safe

The air can be loaded more safely because it is not flammable and does not cause circuit or explode, so protection against both of these are not required, unlike the electrical system that could lead to fires.

- Clean

The air around us are to clean without chemicals that are harmful, and also, it can be minimized or cleaned with some processes, so it is safe to use pneumatic systems to the pharmaceutical industry, food and beverages and textiles.

- The transfer of power and the speed is very easy to set up

Air could move at speeds that can be adjusted from low to high or vice versa. When using a pneumatic cylinder actuator, the piston speed can reach 3 m / s. For pneumatic motors it can spins at 30,000 rpm, while the turbine engine systems can reach 450,000 rpm.

- Can be stored

The air can be stored through the seat tube fed excess air pressure. Moreover, it can be installed so that the pressure boundary or the safety of the system to be safe.

- Easy utilisation

Air can be used either directly utilized to clean surfaces such as metal and machinery, or indirectly, ie through pneumatic equipment to produce certain movements.

Disadvantages:

- Requires installation of air-producing equipment.

Compressed air should be well prepared to meet the requirements. It should meet certain criteria, such as dry, clean, and contain the necessary lubricant for pneumatic equipment. Therefore, the installation requirement for pneumatic systems are for relatively expensive equipment, such as compressors, air filter, lube tube, dryer, regulators, etc.

- Easy to leak

One of the properties of pressurized air is like to always occupy the empty space and the air pressure is maintained in hard work. Therefore, we need a seal so that air does not leak. Seal leakage can cause energy loss. Pneumatic equipment should be equipped with airtight equipment so that compressed air leaks in the system can be minimised.

- Potential noise

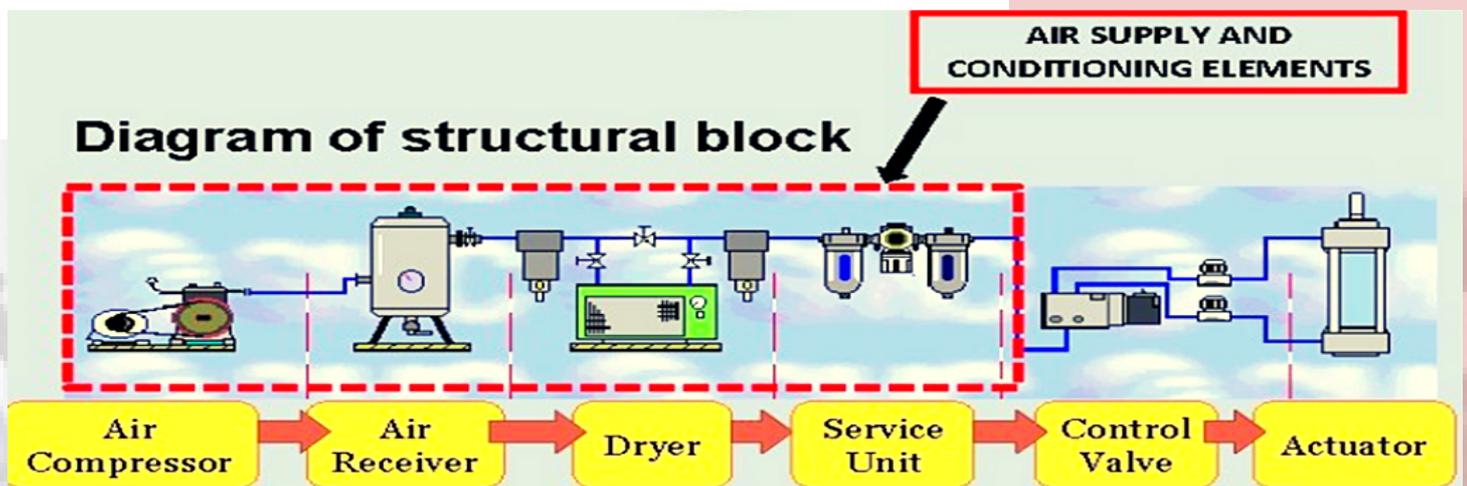
For open system utilizing pneumatic, once the purpose had been met, the compressed air need to be expelled when this occurs, the expelled air will be loud and noisy, especially on the exhaust tract. The fix is to put a silencer on each dump line.

- Condenses easily

Pressurized air is easily condensed, so before entering the system, it need to must be processed first in order to meet certain requirement, such as being dry, have enough pressure, and contains a small amount of lubricant to reduce friction in the valves and actuators.

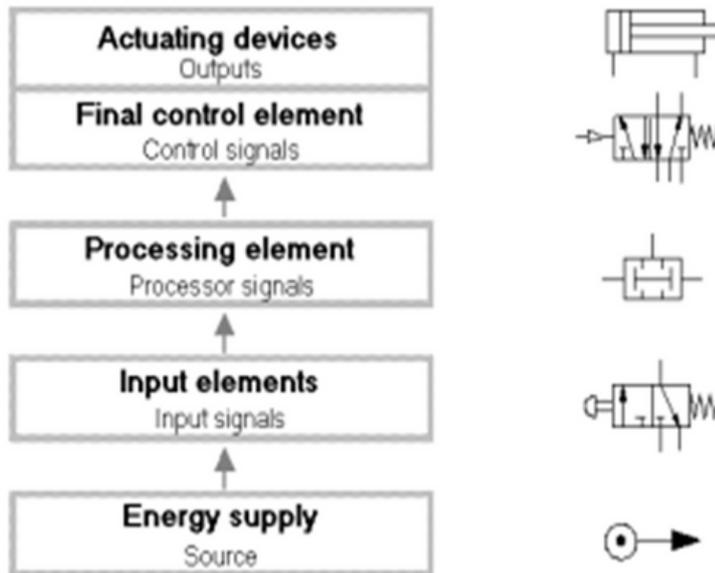
THE DIAGRAM OF STRUCTURAL BLOCK AND PNEUMATIC SYSTEM SIGNAL FLOW

- The compressor compresses the air coming from the surroundings and pressurises it for its use.
- The reservoir tank is used to store and stabilised the air pressure that is compressed.
- The Dryer removed water vapor from the compressed air.
- Air service unit is to deliver clean air, at a fixed pressure, and with lubrication to ensure proper pneumatic component operation.
- The valves have to control the flow, pressure and direction of compressed air.
- Actuators are devices that convert the energy of compressed air or gas into a mechanical motion

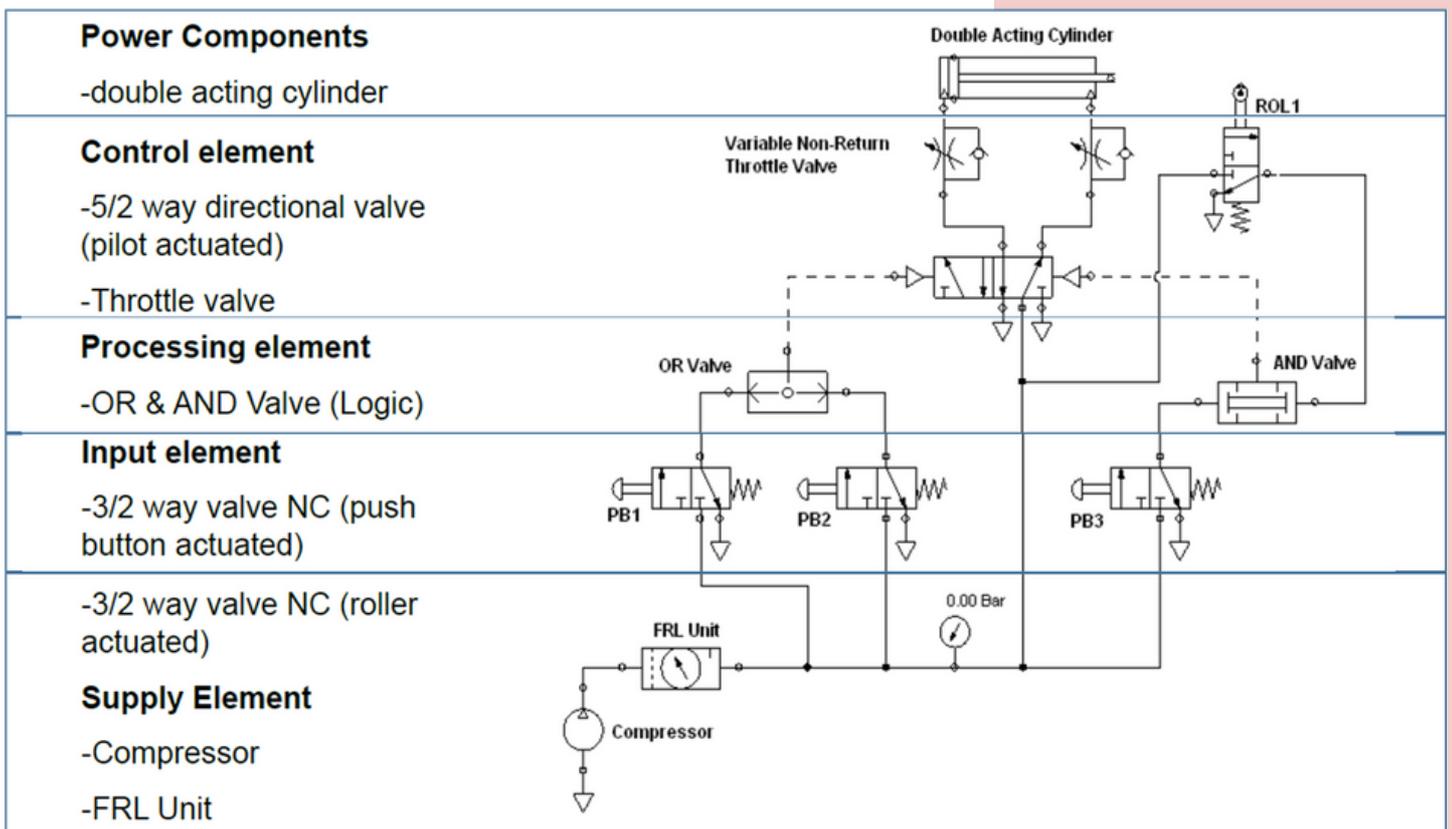


PNEUMATIC SYSTEM STRUCTURE

A pneumatic system can be broken down into a number of levels representing hardware and signal flow.

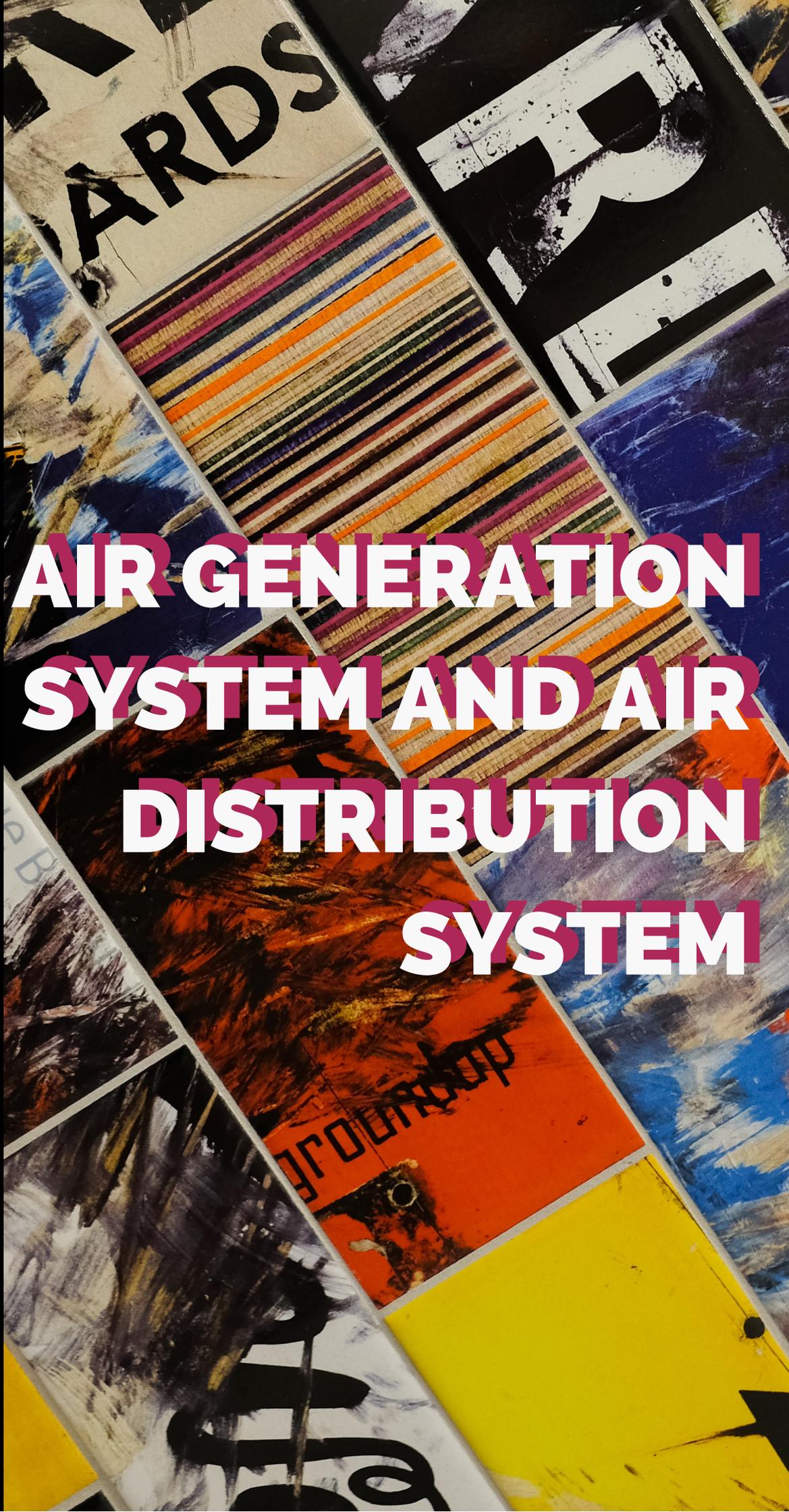


PNEUMATIC SYSTEM SIGNAL FLOW



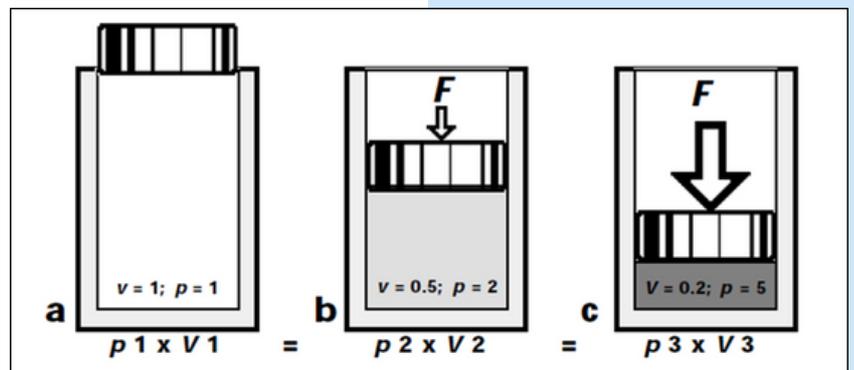
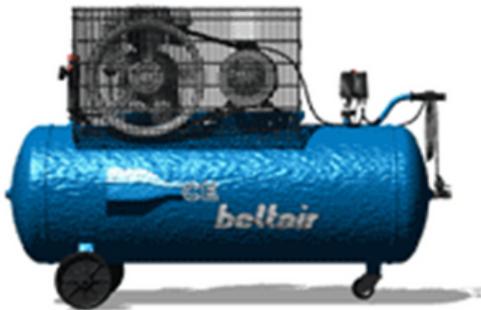
02

**AIR GENERATION
SYSTEM AND AIR
DISTRIBUTION
SYSTEM**



AIR COMPRESSOR

- A compressor is a mechanical device that increases the pressure of a gas by reducing its volume.
- Compressors are similar to pumps: both increase the pressure on a fluid and both can transport the fluid through a pipe.
- As gases are compressible, the compressor also reduces the volume of a gas.
- Liquids are relatively incompressible, so the main action of a pump is to pressurize and transport liquids.



COMPRESSED AIR PLANT

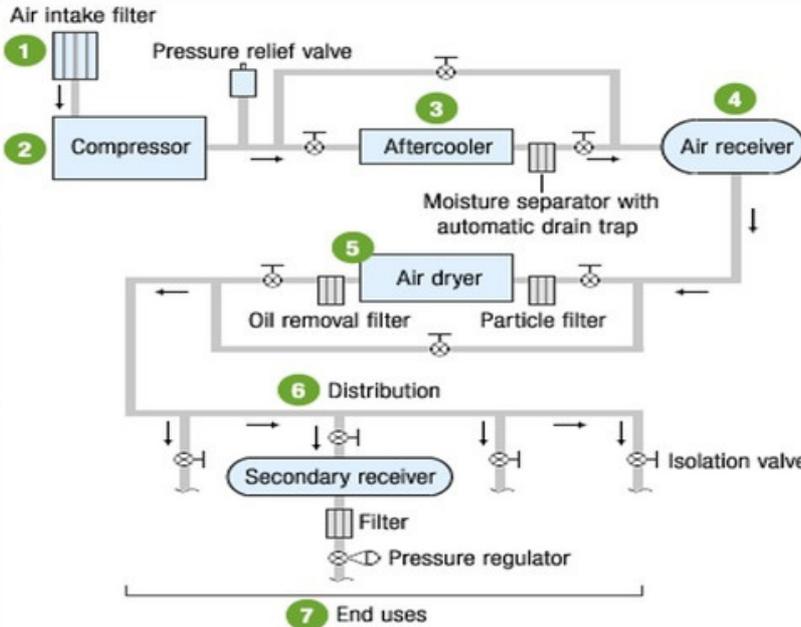
- A typical instrument air skid package contains multiple compressors with dryers and filtration systems that provide high-quality, dry air for a range of applications from pneumatic controls and actuation of critical valves, to buffer sealing gas. Compressed air is one of the Key utilities across various industrial sectors.
- Compressed air is used in thousands of applications, like manufacturing/ assembly, pharmaceuticals, Power Generation units, Processing units, to perform painting activities, pneumatic pressure testing, Oil and Gas ,etc.
- It can power rotary equipment.
- It drives reciprocating equipment.
- It can impact, and convey.
- It can atomize, spray, sand blast, agitate, and cool.
- It can operate controls. The applications are endless

EQUIPMENT OF COMPRESSED AIR PLANT

1. Intake Air Filters:
Prevent dust from entering compressor; Dust causes sticking valves, scoured cylinders, excessive wear etc.

2. Compressor:
The compressor produces compressed air at the required pressure.

6. Moisture Drain Traps:
Moisture drain traps are used for removal of moisture in the compressed air. These traps resemble steam traps. Various types of traps used are manual drain cocks, timer based / automatic drain valves etc.



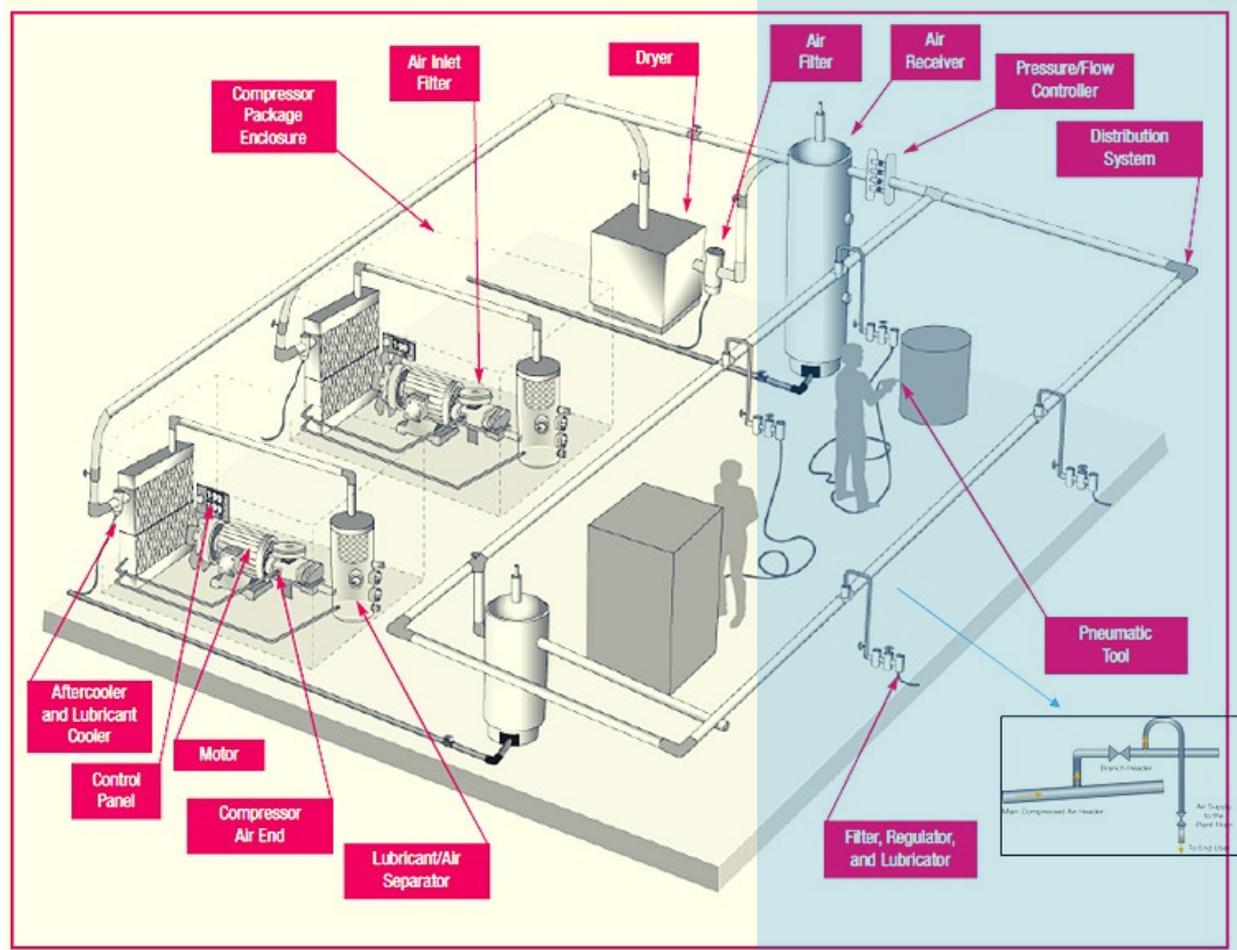
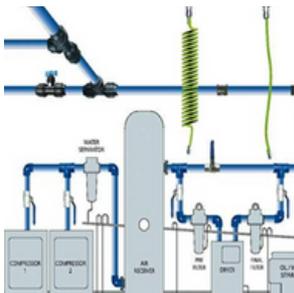
3. After Coolers:
The objective is to remove the moisture in the air by reducing the temperature in a water-cooled heat exchanger

4. Air Receiver/Tank:
Air receivers are provided as storage and smoothening pulsating air output - reducing pressure variations from the compressor

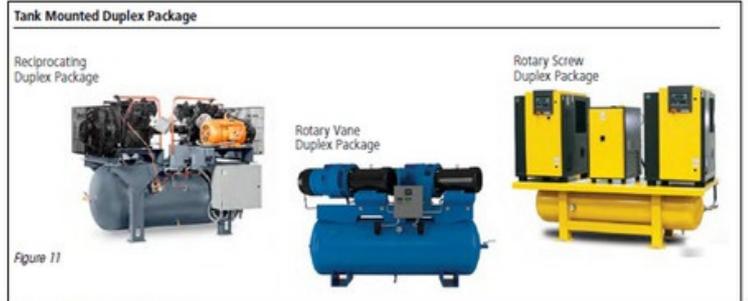
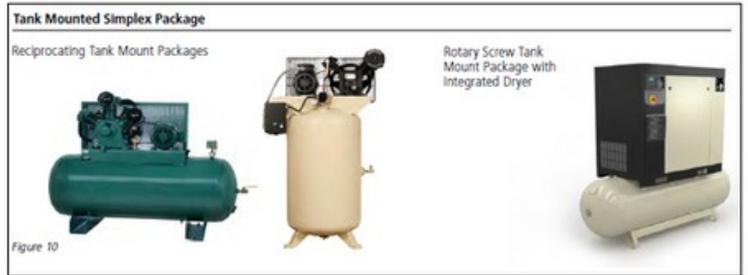
5. Air-Dryers:
The remaining traces of moisture after after-cooler are removed using air dryers, as air for instrument and pneumatic equipment has to be relatively free of any moisture. The moisture is removed by using adsorbents like silica gel /activated carbon, or refrigerant dryers, or heat of compression dryers.

7. Piping System:
The piping system will be designed for a maximum allowable pressure drop of 5% from the compressor to the most distinct point of use. The piping system should be arranged in a closed loop to allow more uniform pressure distribution.

AIR DISTRIBUTION SYSTEM



STATE AND COMPARE THE TYPES OF AIR COMPRESSOR



TYPES OF COMPRESSORS

Compressors are broadly classified as: Positive displacement compressor and Dynamic compressor.

- Positive displacement compressors increase the pressure of the gas by reducing the volume. Positive displacement compressors are further classified as reciprocating and rotary compressors.
- Dynamic compressors increase the air velocity, which is then converted to increased pressure at the outlet. Dynamic compressors are basically centrifugal compressors and are further classified as radial and axial flow types. The flow and pressure requirements of a given application determine the suitability of a particular type of compressor.

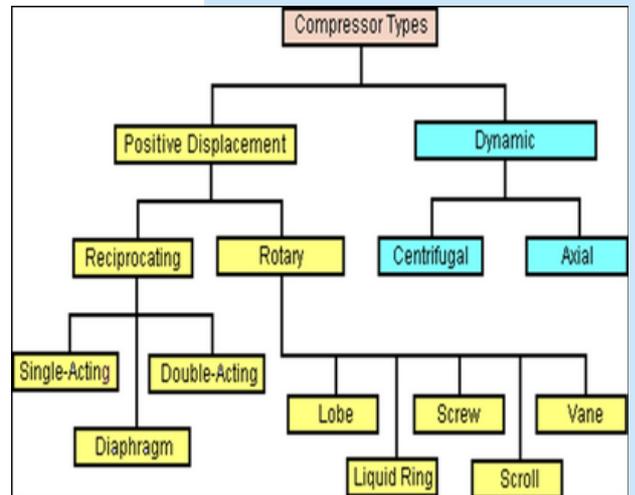
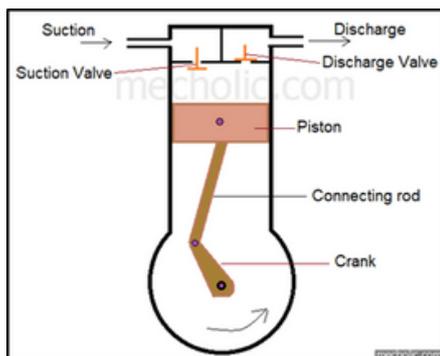
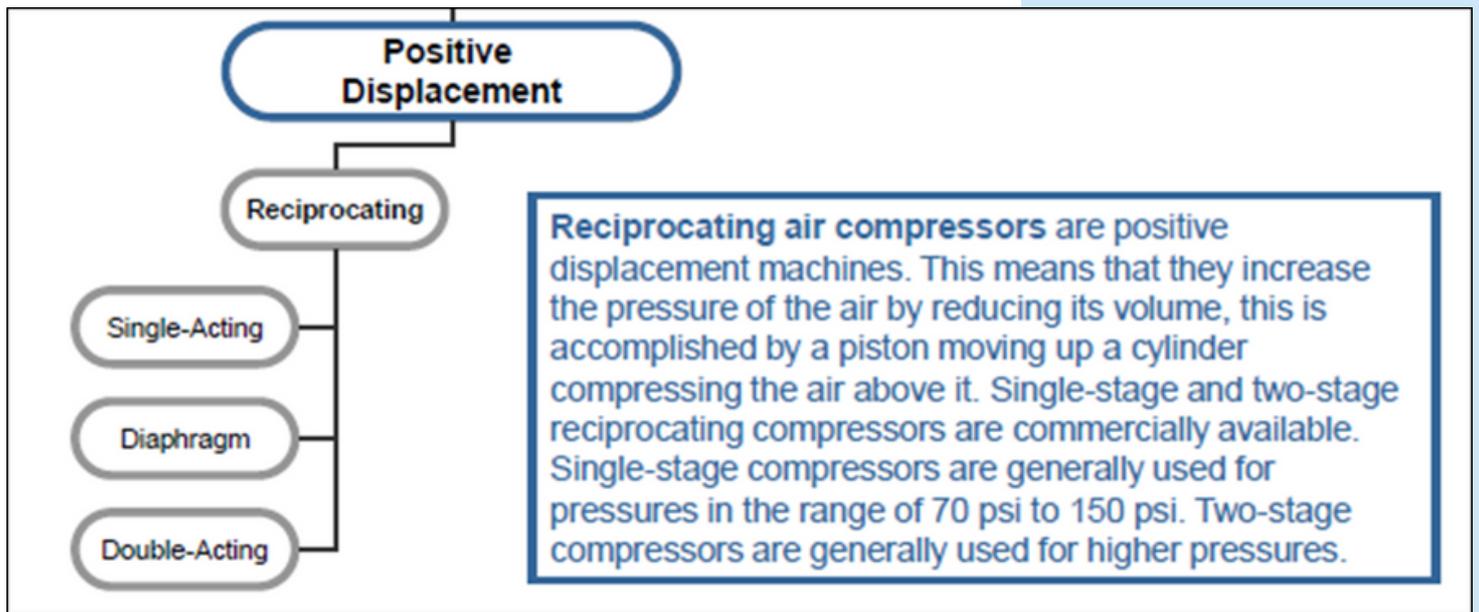


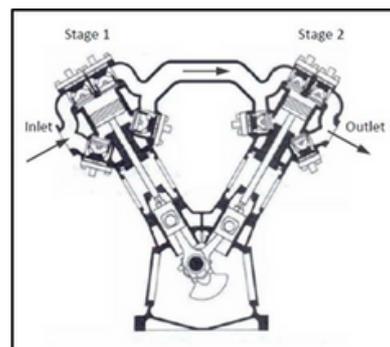
Table 3.1 General Selection Criteria for Compressors

Type of Compressor	Capacity (m ³ /h)		Pressure (bar)	
	From	To	From	To
Roots blower compressor single stage	100	30000	0.1	1
Reciprocating - Single / Two stage	100	12000	0.8	12
- Multi stage	100	12000	12.0	700
Screw - Single stage	100	2400	0.8	13
- Two stage	100	2200	0.8	24
Centrifugal	600	300000	0.1	450

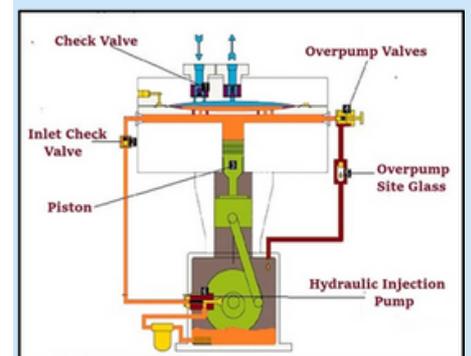
RECIPROCATING COMPRESSORS



Single-Acting

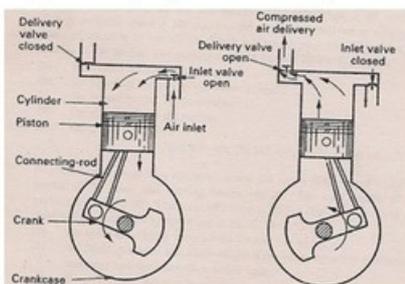


Double-Acting



Diaphragm

Single stage piston compressor

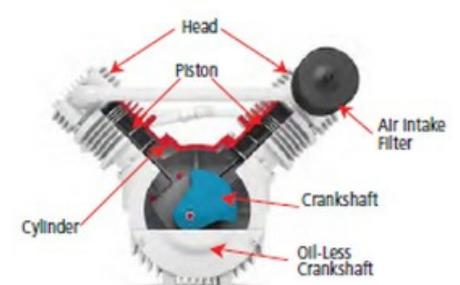
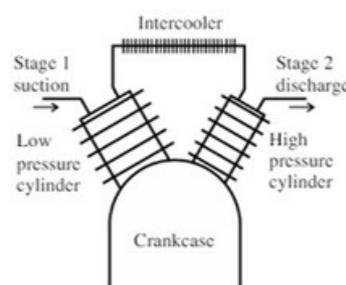


- Consists of cylinder in which a piston reciprocates.
- Piston driven by crank through connecting rod.
- Valve are pressure differential type.
- Valve operate automatically by the difference of pressure across the valve.



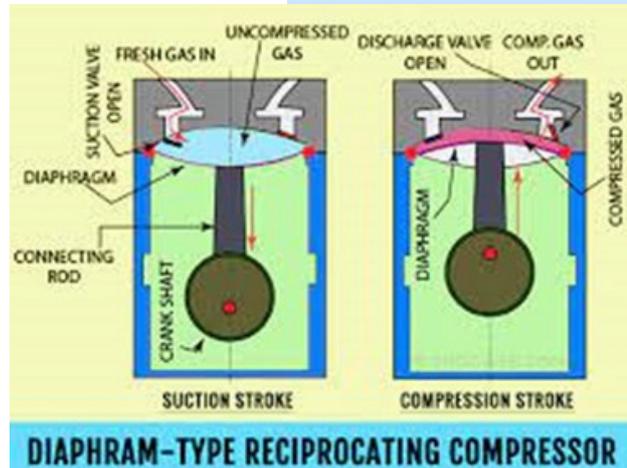
Double stage piston compressor

Two stage machines are used for high pressures and are characterized by lower discharge temperature (140 to 1600C) compared to single-stage machines (205 to 2400C). In some cases, multi-stage machines may have a **lower specific power consumption** compared to single stage machines operating over the same total pressure differential.

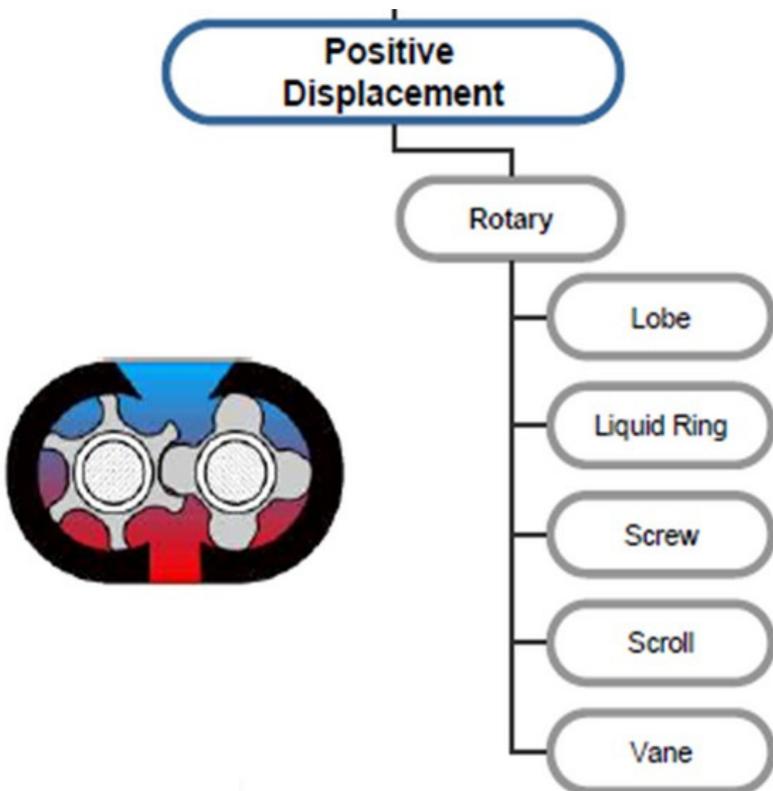


RECIPROCATING DIAPHRAGM COMPRESSOR

- A Diaphragm compressor uses a flexible membrane, usually made of rubber or silicone, instead of a metal piston, to compress the air.
- Due to limited stiffness of these materials, these are used in low pressure applications, like compression of hydrogen or CNG.
- No lubrication is needed - clean



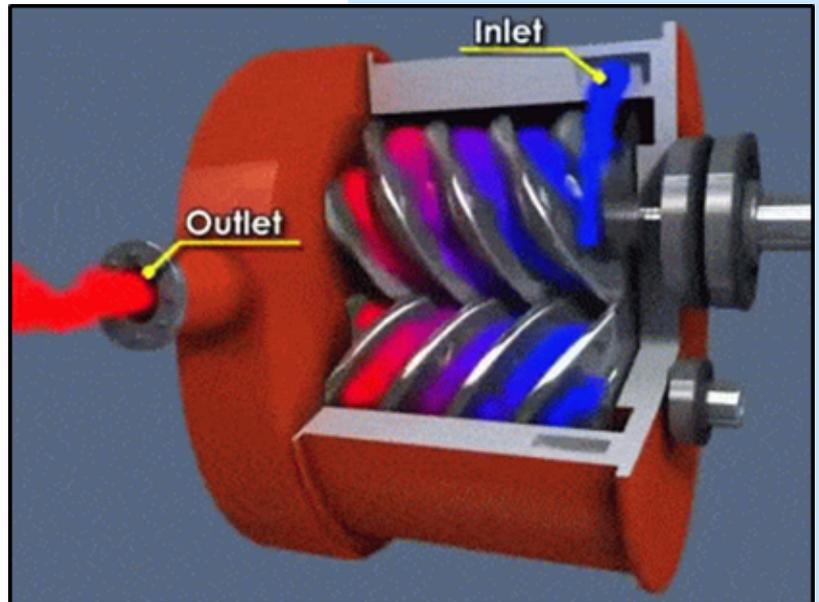
ROTARY COMPRESSORS



Rotary air compressors are positive displacement compressors. The most common rotary air compressor is the single stage helical or spiral lobe oil flooded screw air compressor, consisting of two rotors within a casing where the rotors compress the air internally. There are no valves. These units are basically oil cooled with the oil sealing the internal clearances. Since the cooling takes place right inside the compressor, the working parts never experience extreme operating temperatures making them continuous duty compressors.

SCREW COMPRESSOR

- Rotary screw compressors use two meshed rotating positive-displacement
- helical screws to force the air into a smaller space
- These are usually used for continuous operation in commercial and industrial applications and may be either stationary or portable. Because of simple design and few wearing parts, rotary screw air compressors are easy to install, operate, and maintain.



ROTARY SCREW AIR COMPRESSOR

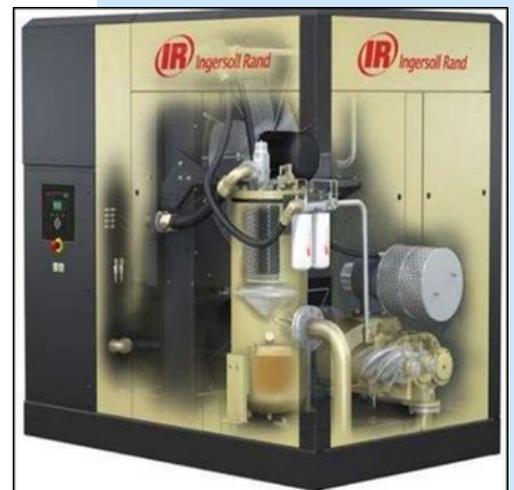
This is the most widely used compressor type in the industry for Instrument where large volumes of high-pressure air are needed, unlike reciprocating type. Rotary screw compressors are available in oil-free (Dry) and oil-flooded (oil injected) construction.

Oil Flooded or Oil Injected Screw Compressors

- In an oil-injected rotary-screw compressor, oil is injected into the compression cavities to aid sealing and provide cooling sink for the gas charge. The oil is separated from the discharge stream, then cooled, filtered and recycled.

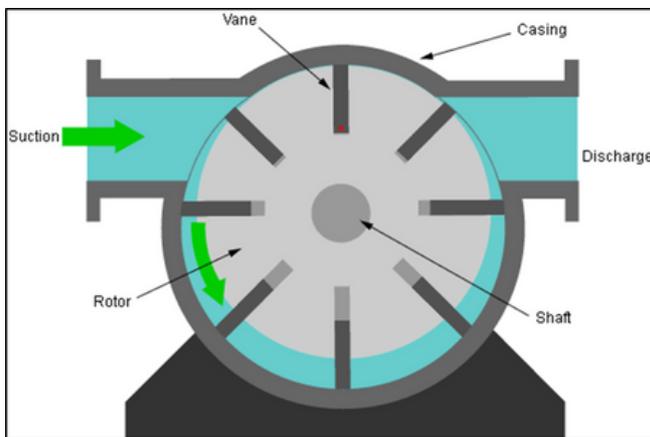
Oil Free or DryScrew Compressors

- Oil-free compressors are used in applications where carry over entrained oil is not acceptable, such as medical research and semiconductor manufacturing.



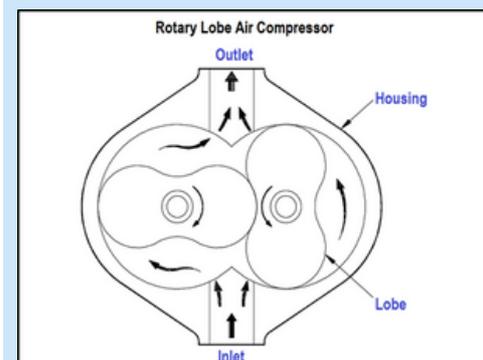
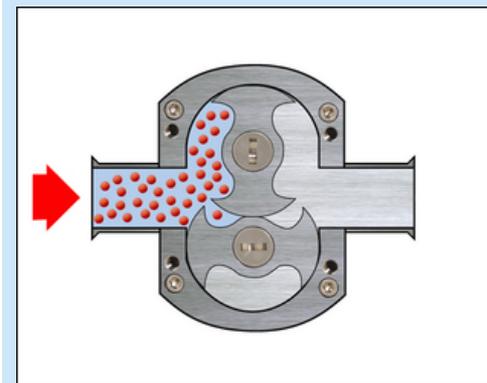
SLIDE RAM(VANE) COMPRESSOR

- One of the oldest compressor technologies, rotary vane compressors consist of a rotor with a number of blades inserted in radial slots in the rotor.
- The rotor is mounted offset in a larger housing that is either circular or a more complex shape. As the rotor turns, blades slide in and out of the slots keeping contact with the outer wall of the housing. Thus, a series of decreasing volumes is created by the rotating blades
- They can be either stationary or portable, can be single or multistage, and can be driven by electric motors or internal combustion engines. They are well suited for electric motor drive and is significantly quieter in operation than the equivalent piston compressor. They can have mechanical efficiencies of about 90%



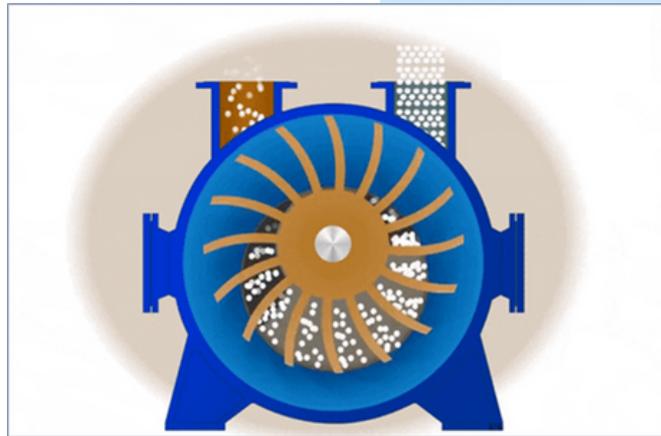
ROTARY LOBE AIR COMPRESSOR

- Rotary Lobe type Air Compressor has two mating lobe-type rotors mounted in a case.
- The lobes are gear driven at close clearance, but without metal-to-metal contact.
- The suction for the unit is located where the cavity made by the lobes is largest.
- As the lobes rotate, the cavity size is reduced, causing compression of the vapor within.
- The compression continues until the discharge port is reached, at which point the vapor exits the compressor at a higher pressure.

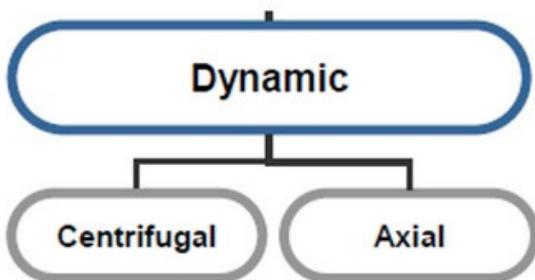


LIQUID RING AIR COMPRESSOR

- An offset rotor is placed in a cylindrical housing, and air is fed into this housing. As the rotor spins, the air is thrown by centrifugal force outside
- The void created in the center holds air drawn in through the inlet port of the compressor. As the air travels around the pocket of air in the centre, it is compressed. This compressed air is then fed back out through the discharge port.



DYNAMIC COMPRESSOR

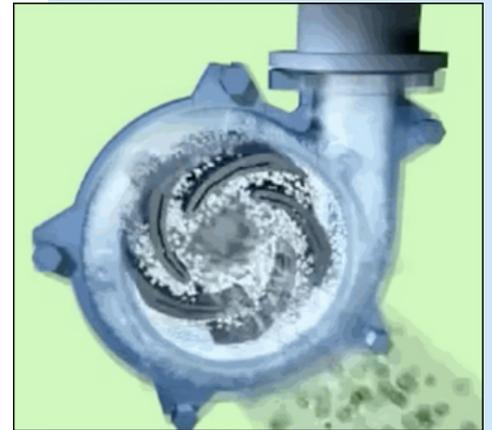
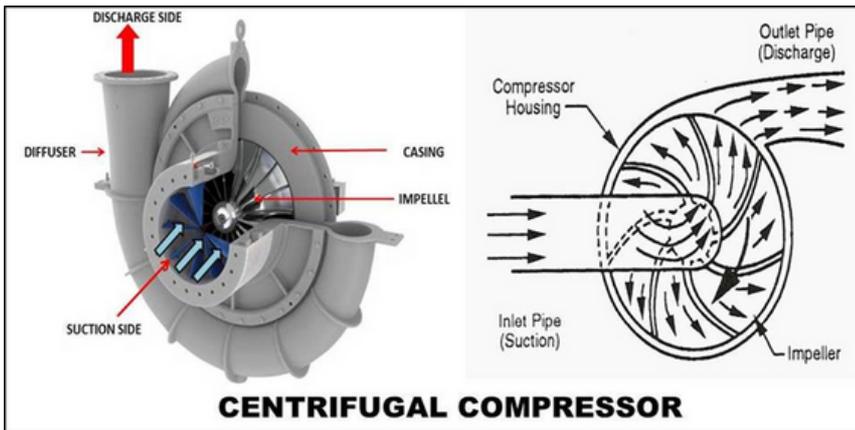


Dynamic compressor depends on a rotating impeller to compress the air. In order to do this efficiently, centrifugal compressors must rotate at higher speeds than the other types of compressors. These types of compressors are designed for higher capacity because flow through the compressor is continuous and oil free by design.

- Dynamic compressors are mainly centrifugal compressors and operate on similar principles to centrifugal pump.
- These compressors have appreciably different characteristics as compared to reciprocating machines.
- A small change in compression ratio produces a marked change in compressor output and efficiency.
- Centrifugal machines are better suited for applications requiring very high capacities, typically above 12,000 cfm.

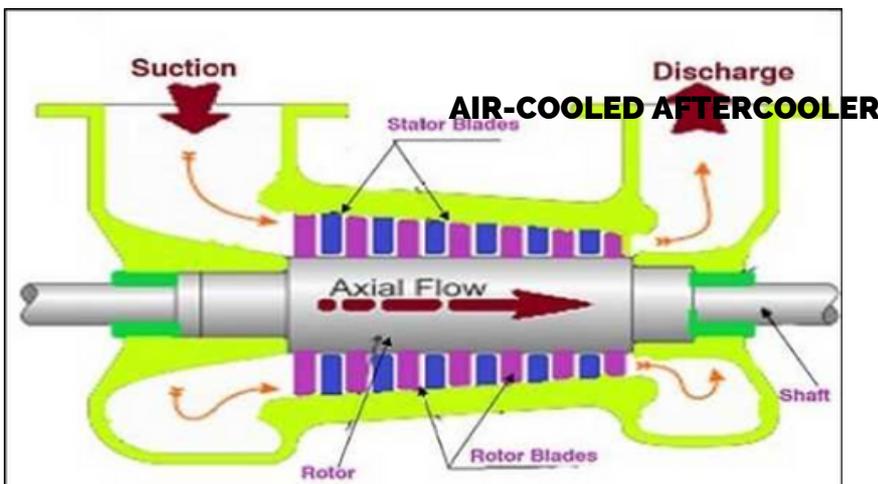
DYNAMIC CENTRIFUGAL AIR COMPRESSOR

- A single-stage centrifugal machine can provide the same capacity as a multi-stage reciprocating compressor.
- Machines with either axial or radial flow impellers are available.



DYNAMIC AXIAL FLOW AIR COMPRESSOR

- Axial flow compressors are suitable for higher compression ratios and are generally more efficient than radial compressors.
- Axial compressors typically are multi-stage machines, while radial machines are usually single-stage designs.



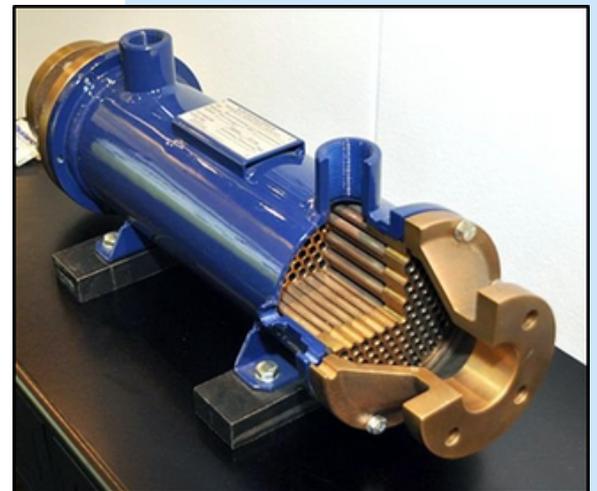
AIR-COOLED AFTERCOOLER

- An air to air aftercooler uses environmental air to achieve its compressed air cooling effect.
- The typical setup is a series of coiled tubes through which the heated compressed air is channeled.
- Ambient air is pulled from the external environment by motor-driven fans and forced over the coils to cool the air within the aftercooler's tubing.
- Once the compressed air has cooled sufficiently the suspended moisture condenses and can be collected by a dedicated basin while dry compressed air is channeled to a separate outlet.



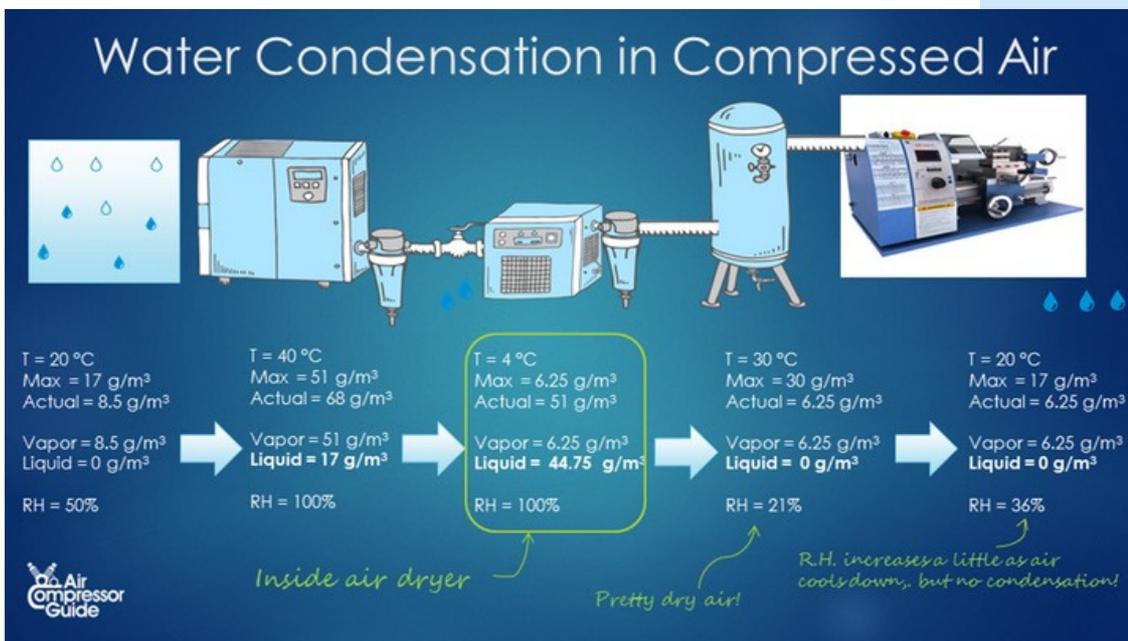
WATER-COOLED AFTERCOOLER

- Different variants of water-cooled aftercoolers are available for compressed air drying processes.
- A common water-cooled aftercooler is the shell and tube version.
- This heat exchanger type is composed of a network of coiled tubes within a shell casing.
- While heated compressed air is passed through the tubes in one direction, cool water is channeled through the surrounding shell eliminating the heat from the process. As cooling is achieved, suspended water is precipitated into the aftercooler coils and is removed by an attached moisture separation unit.



AIR DRYER

- All compressed air treatment components should be installed to dry and clean the air.
- Dryers typically grouped into two major categories:
 - a. Desiccant
 - b. Refrigerant

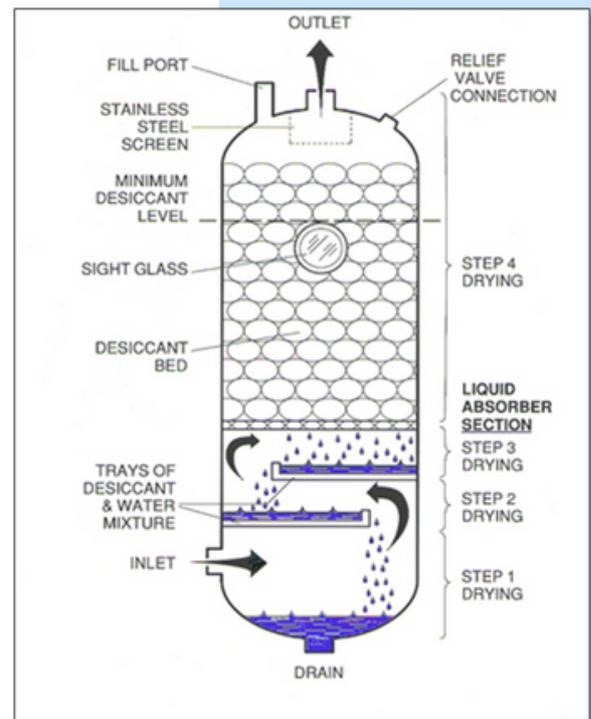


DESICCANT DRYER

For Desiccant dryer, water vapor is removed through absorption and adsorption processes. In the event compressed air lines are exposed to temperatures below 32°F (or 0°C), the use of a desiccant dryer is required to eliminate the hazard of a compressed air line freezing.

ABSORPTION PROCESSES

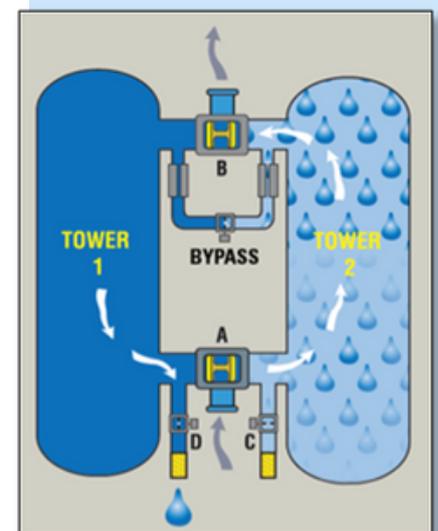
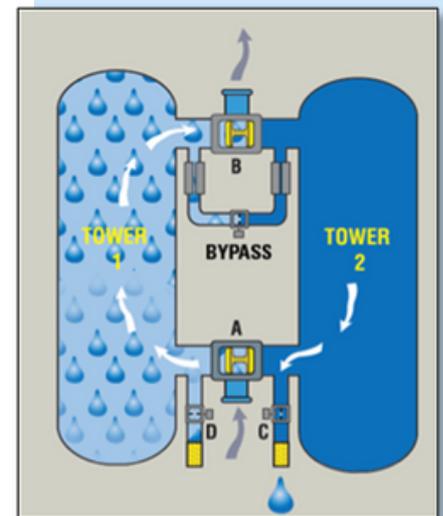
- Absorption drying is a chemical process in which water vapor is bound to absorption material.
- The absorption material can either be a solid or liquid.



- Sodium chloride and sulfuric acid are frequently used, which means that the possibility of corrosion must be taken into consideration.
- This method is unusual and involves high consumption of absorbent materials. The dew point is only lowered to a limited extent.

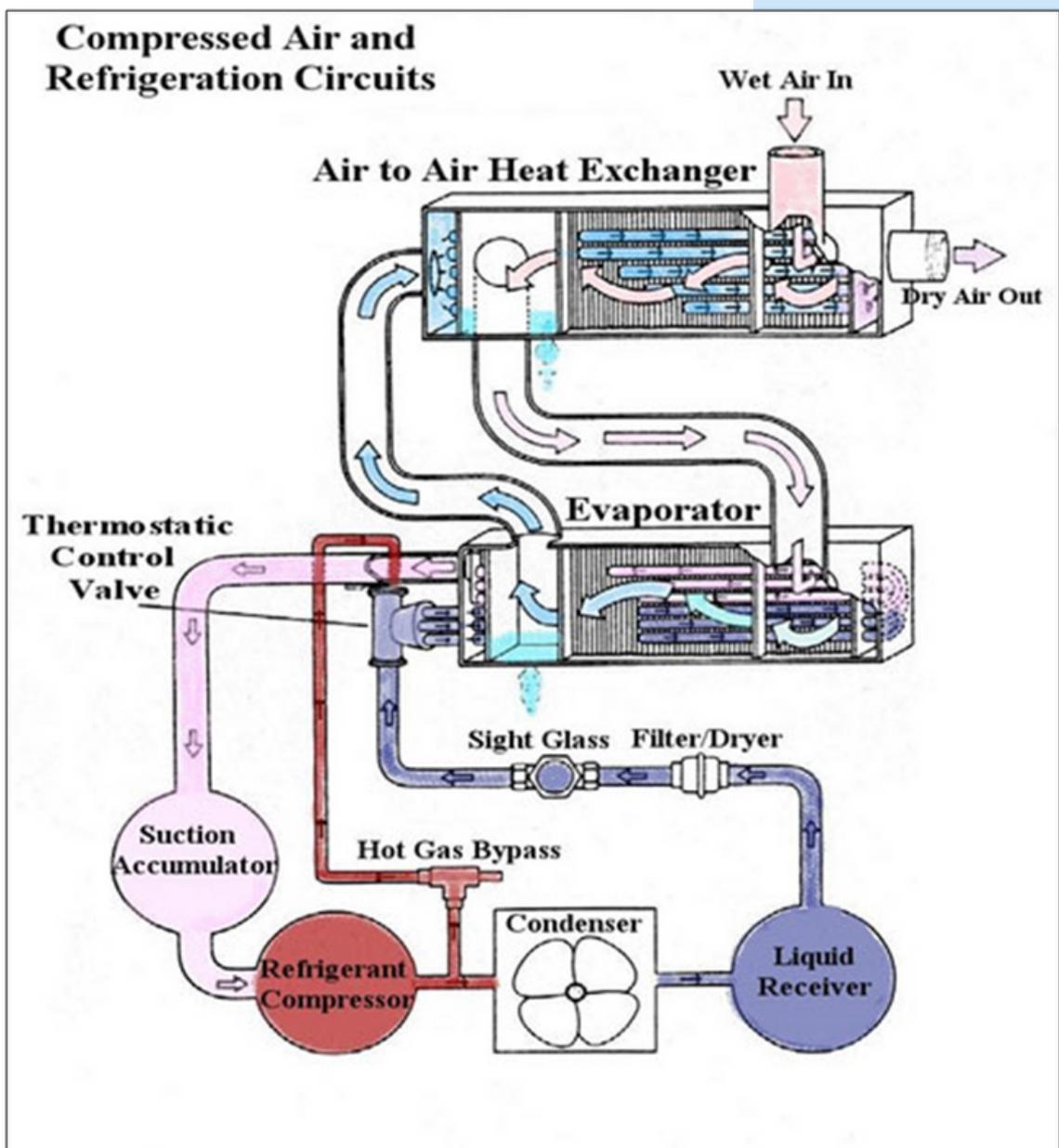
ADSORPTION PROCESSES

- Adsorption drying is a chemical process in which water vapor is bound to adsorption material that can either be a solid or liquid.
- The general working principle of adsorption dryers is simple: moist air flows over hygroscopic material – typically silica gel, molecular sieves or activated alumina – and is then dried.
- The exchange of water vapor from the moist compressed air into the hygroscopic material or desiccant causes the desiccant to gradually become saturated with adsorbed water.
- Therefore, adsorption dryers are typically built with two drying vessels to regularly regenerate the desiccant so it regains its drying capacity.
- The first tower dries the incoming compressed air while the second tower is being regenerated.
- Each tower switches tasks when the other tower is completely regenerated.
- These dryers are suitable for providing very, dry air for more critical applications since a typical pressure dew point of -40°F can be achieved.



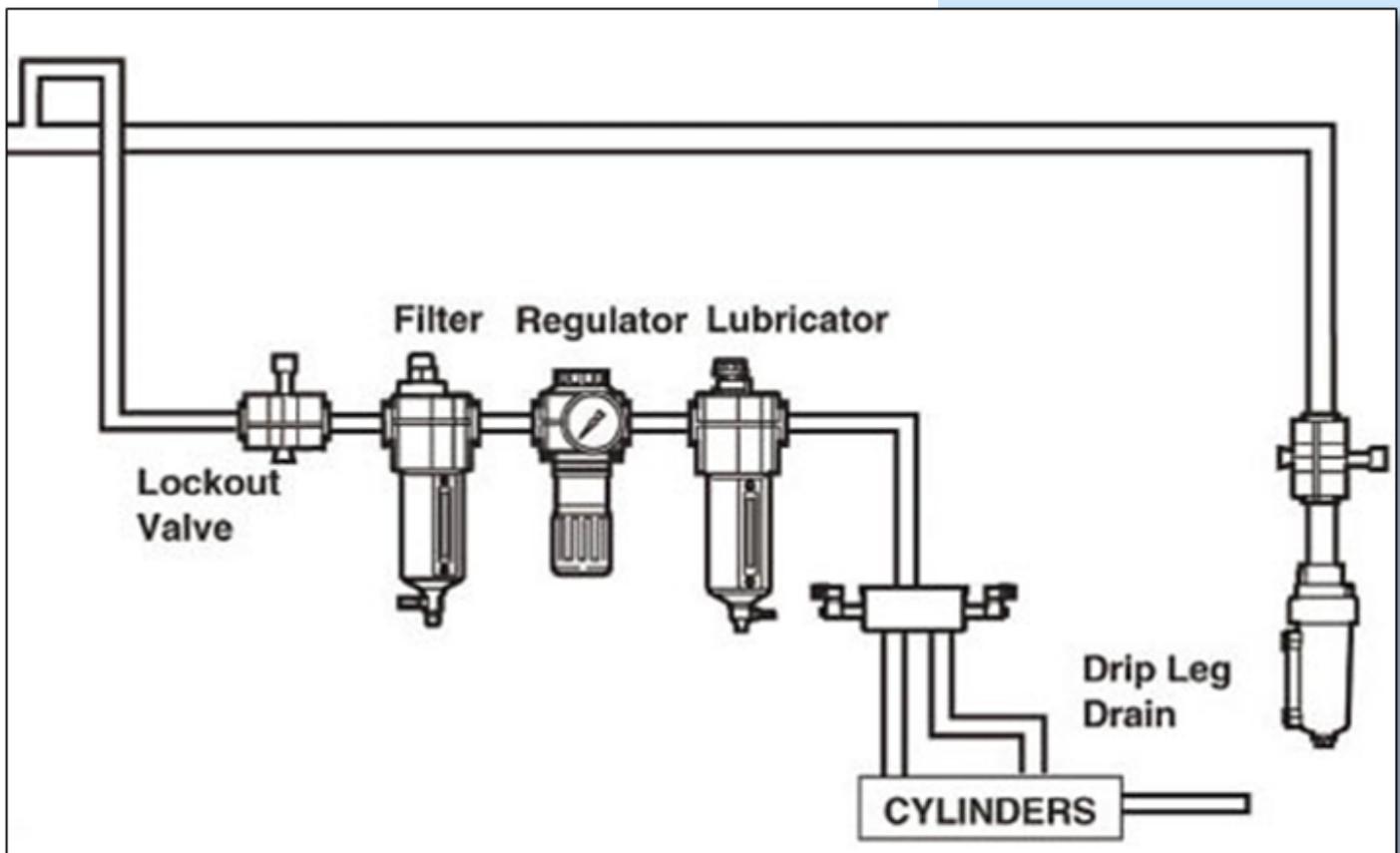
REFRIGERANT DRYER

- Refrigerant type air dryers are the most economical compressed air dryers
- Within a refrigerant air dryer, compressed air is cooled, water vapor is condensed into liquid water where it is mechanically separated and drained from the compressed air system.
- Refrigerant air dryers are supplied with automatic condensate drains.



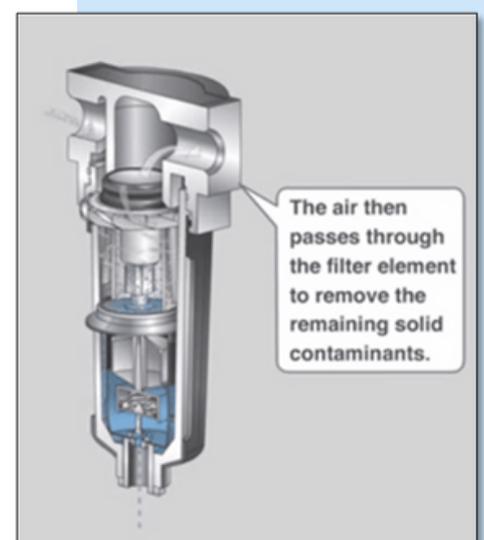
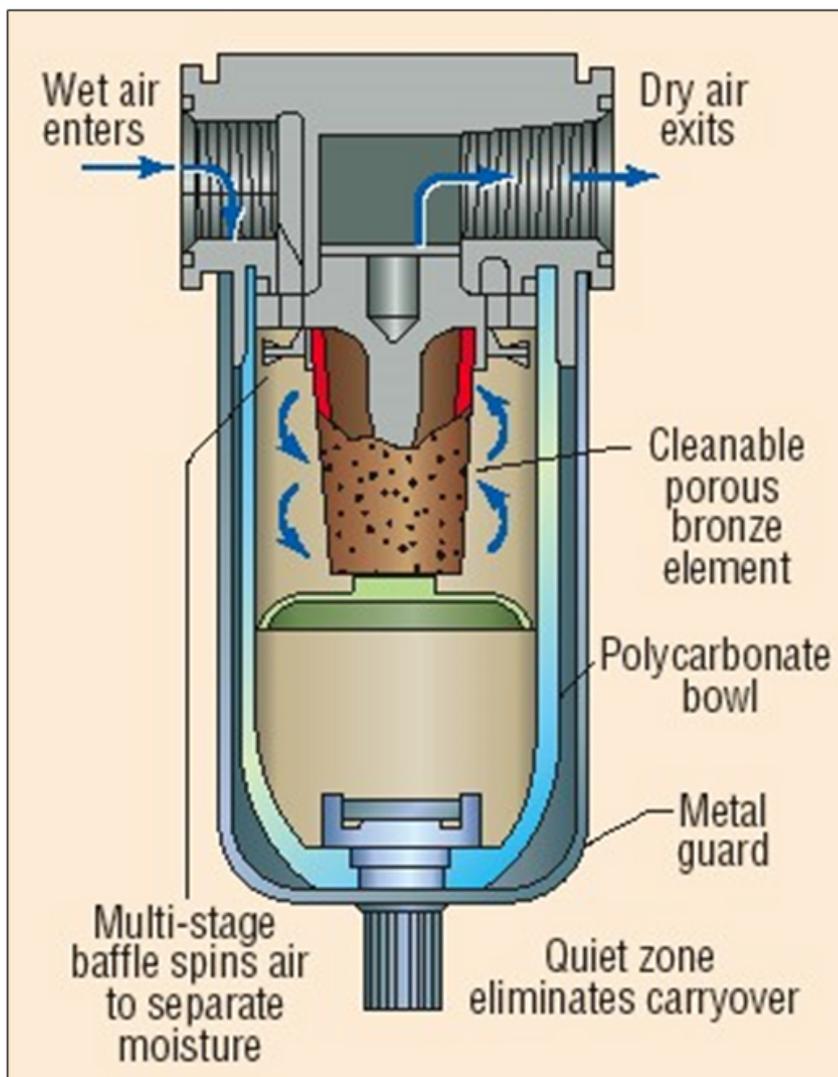
FRL UNIT : FILTER, REGULATOR, & LUBRICATOR

- Filter, regulator, and lubricator (FRL) compressed air systems are used to deliver clean air, at a fixed pressure, and lubricated (if needed) to ensure proper pneumatic component operation and increase their operation lifetime.
- The air supplied by compressors is often times contaminated, over pressurized, and non-lubricated meaning that an FRL unit is required to prevent damage to equipment.
- Filters, regulators, and lubricators can be bought individually or as a package



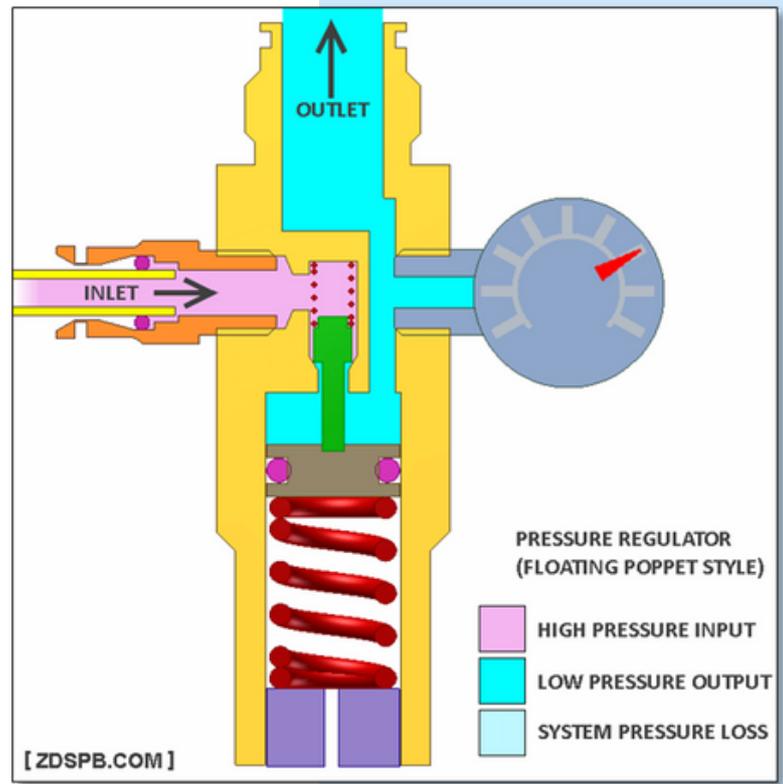
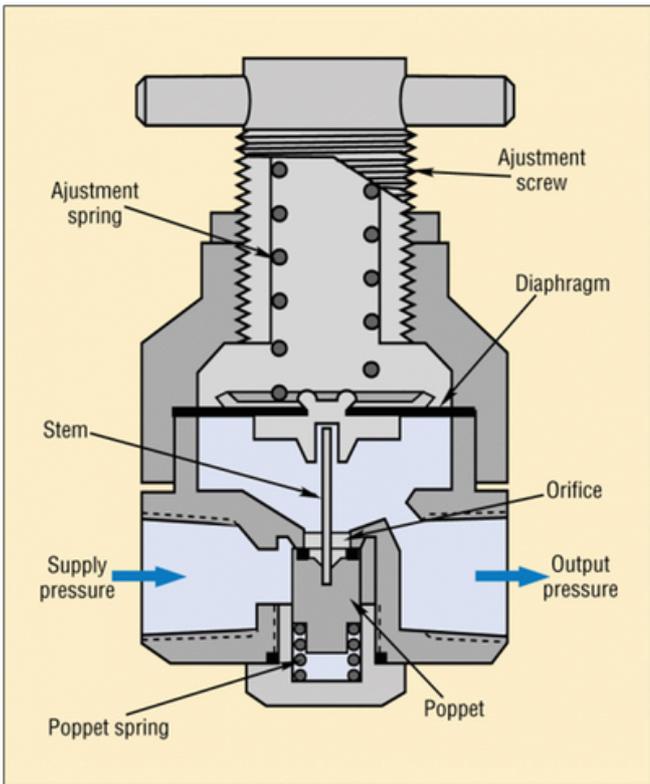
COMPRESSED AIR FILTER

- Filters remove water, dirt and other harmful debris from an air system
- The type and size of contaminants present in the system and the air requirements for components will ultimately affect what micron size and bowl material is needed for the filter. Common applications generally only require a filter rated between 5-40 microns.
- Filters will accumulate debris and must be cleaned and the media replaced on a regular basis. The service life of the media is generally based on no more than a 5 psig pressure drop across the device.



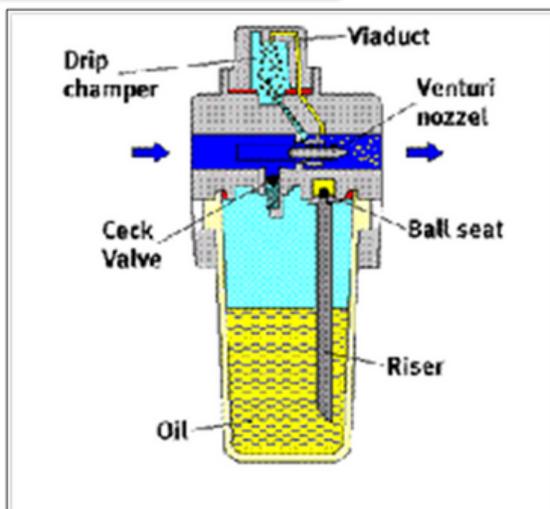
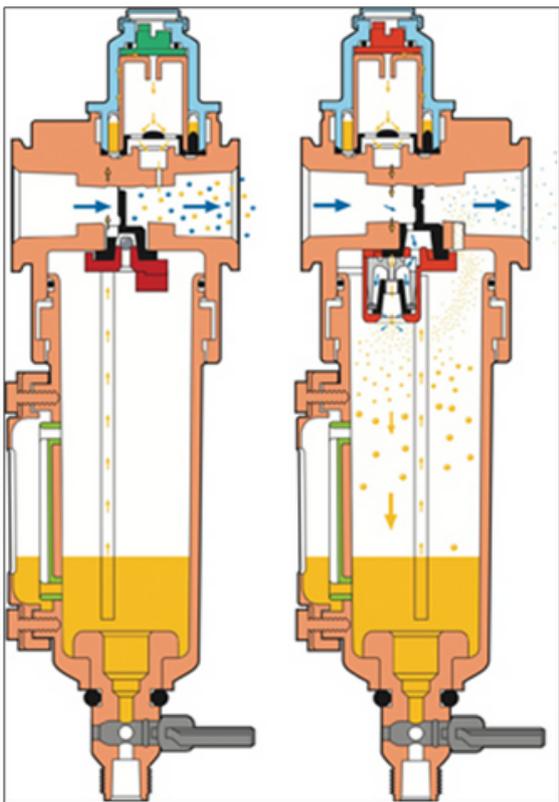
PRESSURE REGULATOR

Regulators, also called pressure reducing valves, adjust and control the air pressure of the system to ensure that down-line components do not exceed their maximum operating pressures



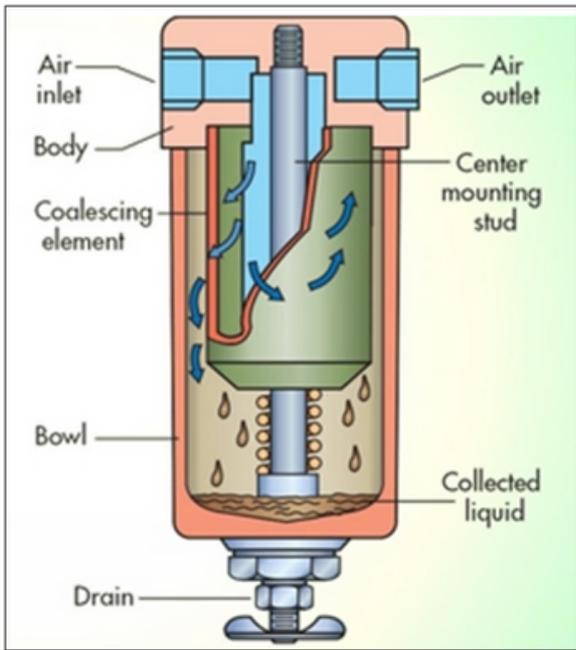
COMPRESSOR LUBRICATOR

- Pneumatic systems requiring heavy lubrication, such as a single air tool or a single cylinder, benefit from oil-fog delivery systems.
- However, in this high delivery system, the oil aerosol produced contains relatively large oil particles, which are affected by gravity, making this system unsuitable for lubricating a device at a higher level than itself or at a distance away.



WATER SEPARATORS

- Compressors turn water vapor in the intake air into free water inside the compressor.
- Compressors also increase the amount of water vapor in the compressed air in the tank. Both free water and water vapor laden air.
- Water Is Generated Right Away enter your air line and through it to your air tools.
- Water separator is installed on the air pressure line to remove water drops from compressed air.



03

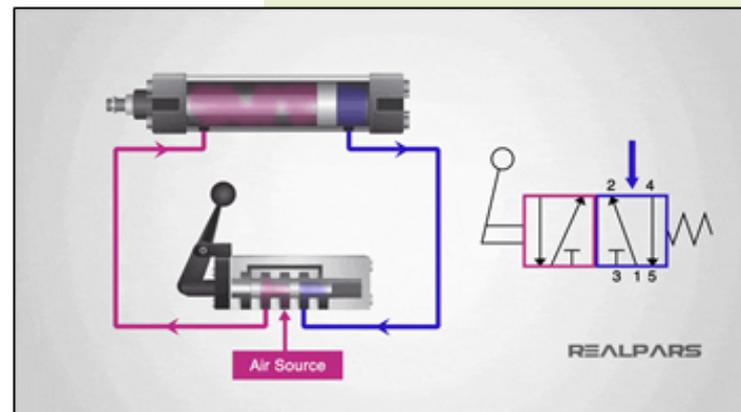
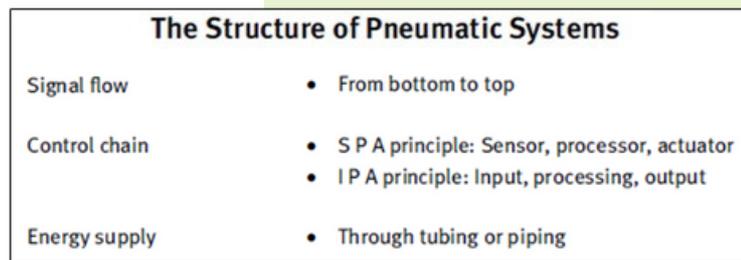
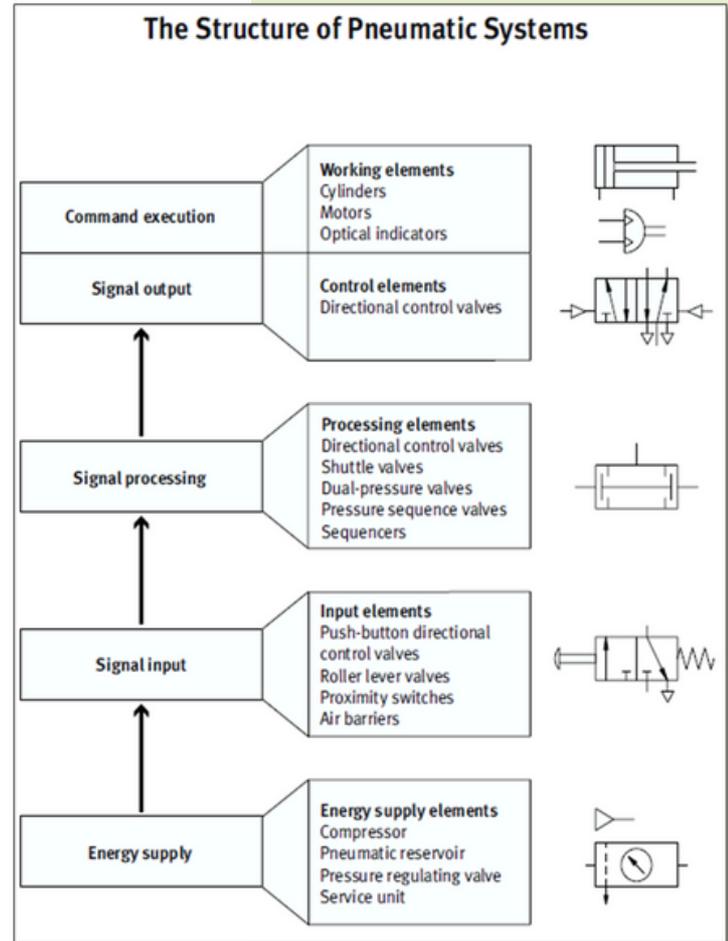
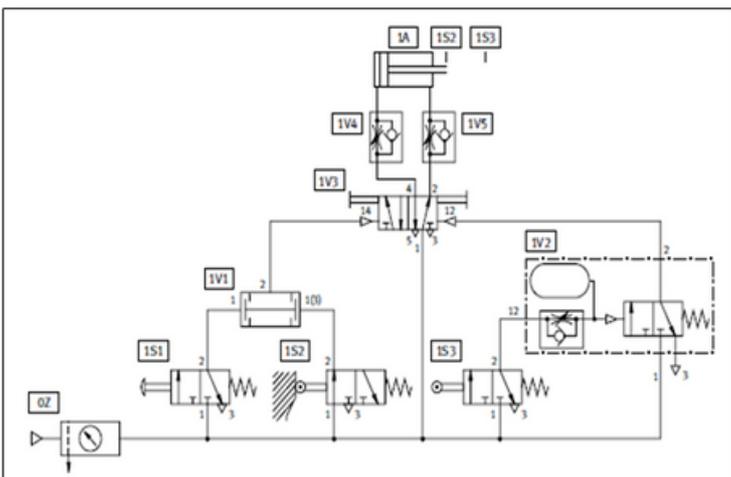
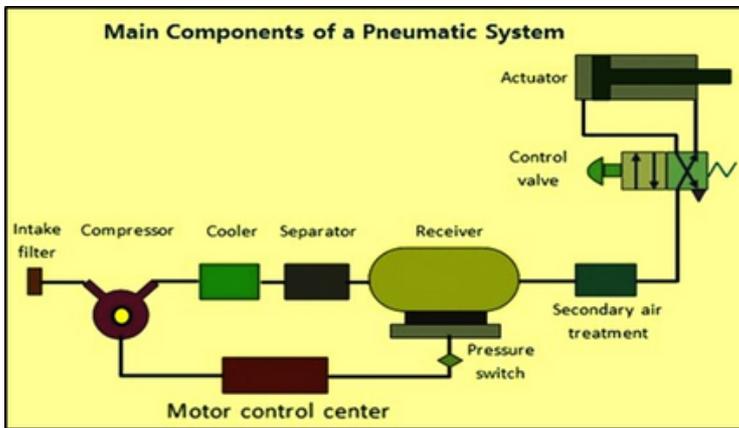
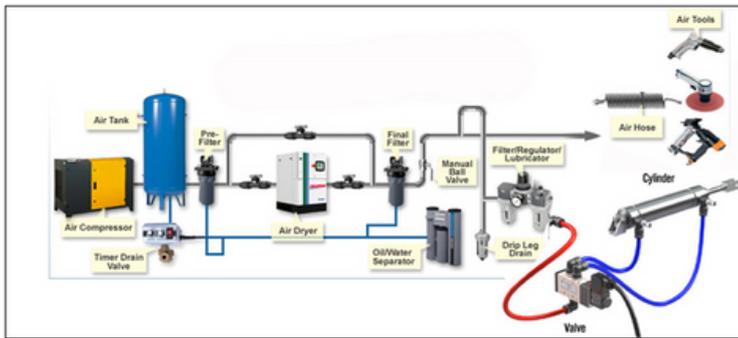


**SYMBOLS AND
STANDARDS IN
PNEUMATICS**

THE SYMBOLS AND STANDARDS IN PNEUMATICS

Graphic Symbols Standards

- Pneumatic symbols conform to and are devised from the International Standard ISO 1219-1 1991
- This covers graphical symbols for Fluid Power Systems and Components



DIRECT ACTUATION OF CYLINDERS

Single-acting cylinders

- Perform work in only one direction
- Return position via spring
- Air supply port, vent hole

3/2-Way valve

- 3 Working ports, 2 switching positions
- Manually actuated, spring return

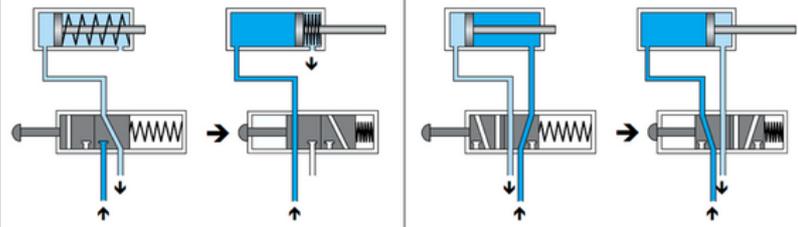
Double-acting cylinder

- Performs work in both directions
- 2 air supply ports

5/2-Way valve

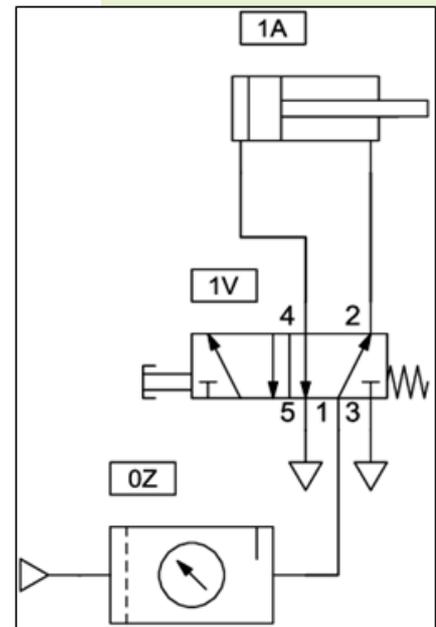
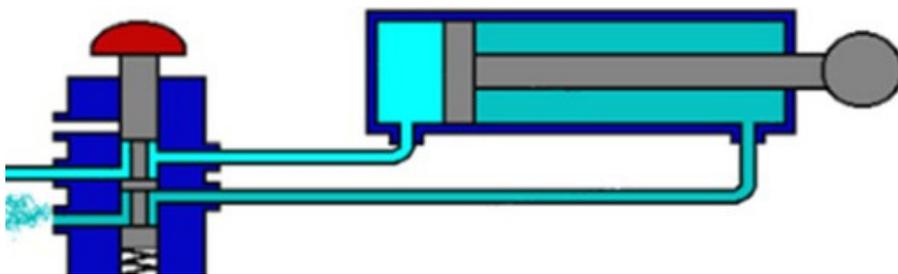
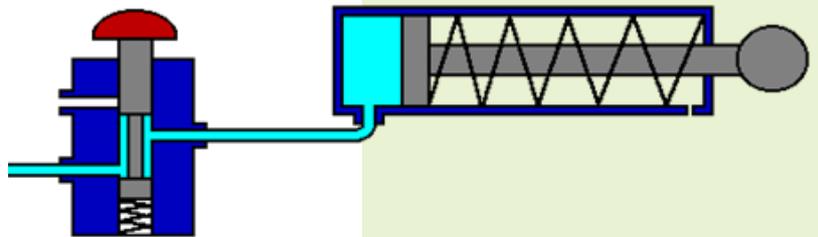
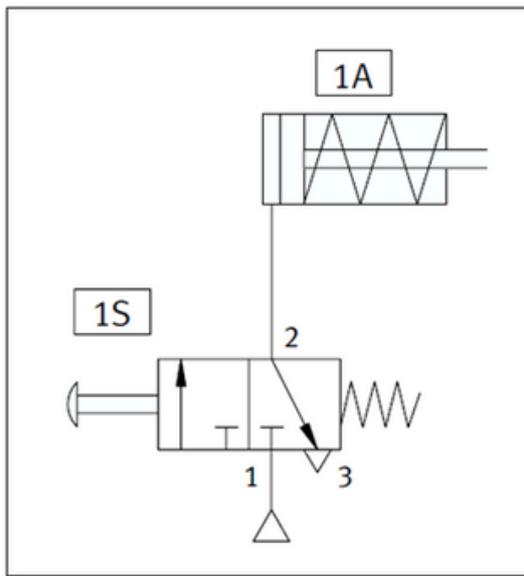
- 5 Working ports, 2 switching positions
- Manually actuated, spring return

Direct Actuation of Cylinders



Single-acting cylinder

Double-acting cylinder



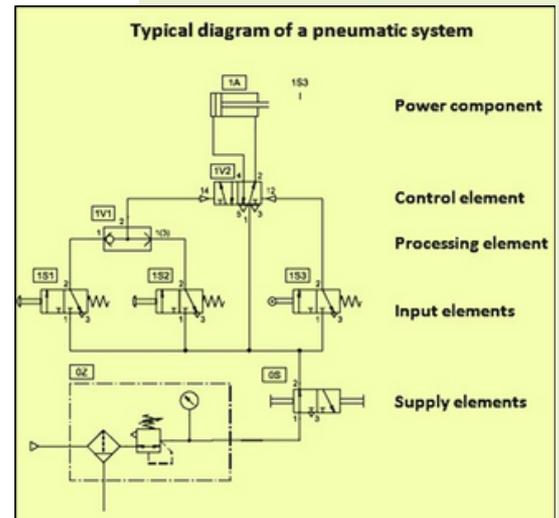
THE SYMBOLS AND DESCRIPTIONS OF COMPONENTS

Identification code for components

- System number
beginning with 1; used only when the entire circuit consists of more than one system
- Circuit number
beginning with 1; all accessories with 0
- Component identification
by letter
- Component number
beginning with 1

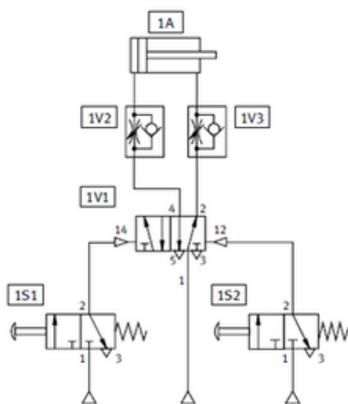
Circuit Diagram

- From top to bottom
- Working element
1A
marking line of input element 1S3
- Control element
1V2
- Processing element
1V1
- Input elements
1S1, 1S2, 1S3
- Energy supply elements
0Z, 0S

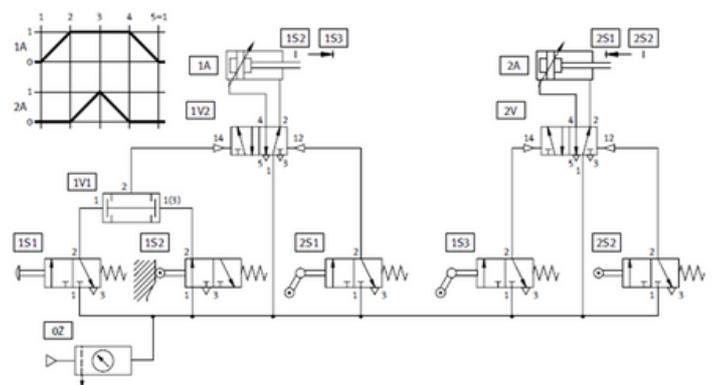


EXAMPLE OF THE SYMBOLS USED IN PNEUMATIC CIRCUIT

Circuit Diagram: 5/2-Way Double Pilot Valve (Speed Control)



Circuit Diagram: Overlapping Signals



SYMBOLS FOR THE POWER SUPPLY SECTION

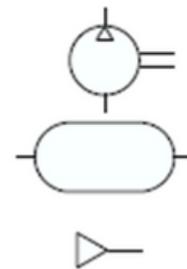
Symbols in accordance with DIN ISO 1219 "Fluid Technique – Graphical Symbols and Circuit Diagrams"

The triangle indicates the flow direction.

In general, the symbols for pneumatics and hydraulics are the same.

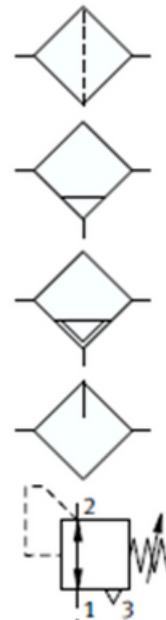
Energy Supply

- Compressor with constant displacement volume
- Pneumatic reservoir
- Pressure source



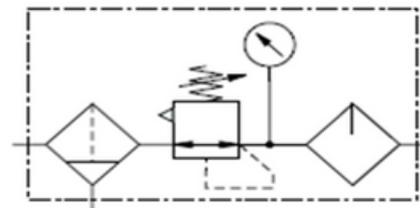
Maintenance

- Filter
- Water separator with manual actuation
- Water separator with automatic condensate drain
- Lubricator
- Pressure regulating valve with relief port, adjustable

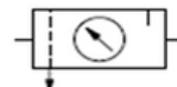


Combined Symbols

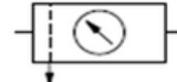
- Air service unit
Consisting of Compressed air filter, Pressure regulating valve, Pressure gauge and compressed air lubricator

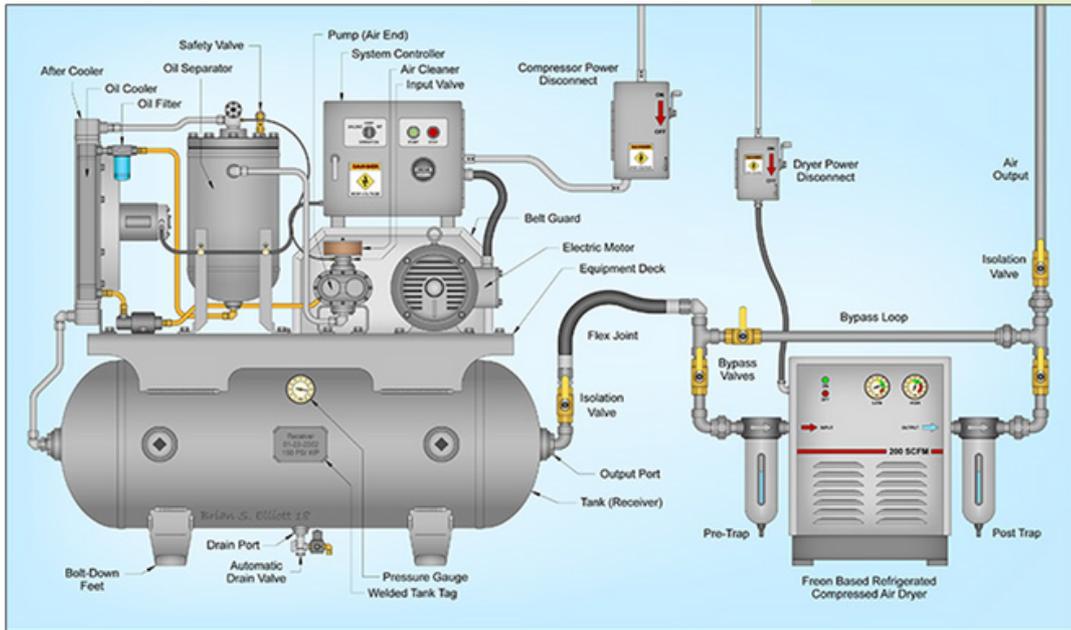


Simplified representation of a service unit



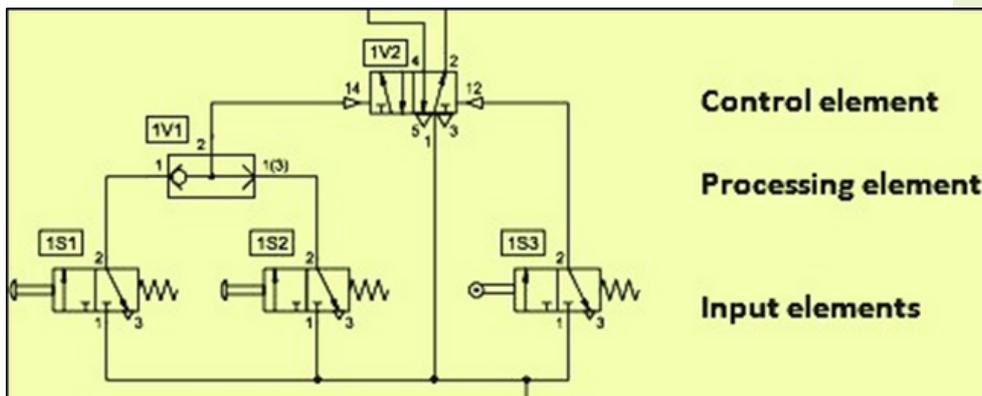
Simplified representation of a service unit without compressed air lubricator





SYMBOL FOR DIRECTIONAL CONTROL VALVES

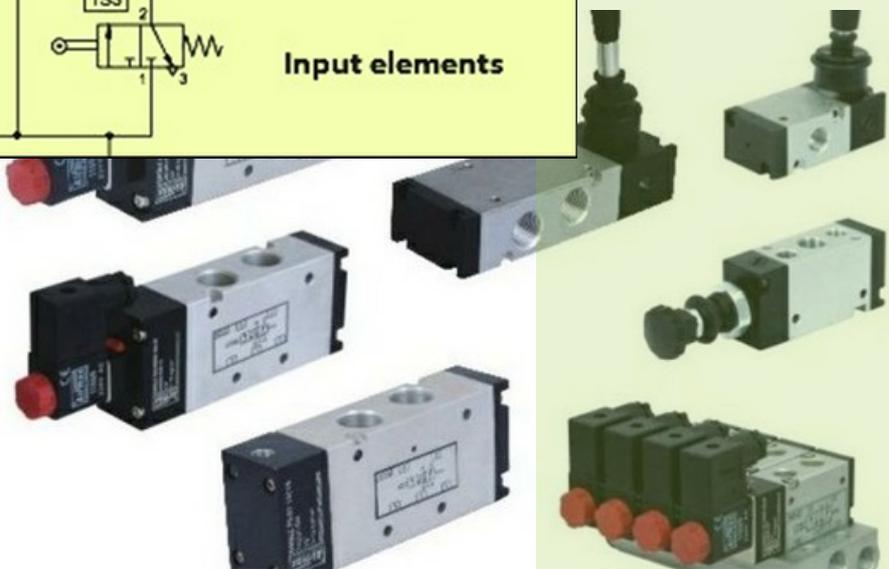
Directional control valves are used in pneumatic systems to direct or stop the flow of compressed air or oil to their appliances. They are probably the most used elements in pneumatic systems and can be used for example to actuate a cylinder, a larger industrial valve, or air tools.



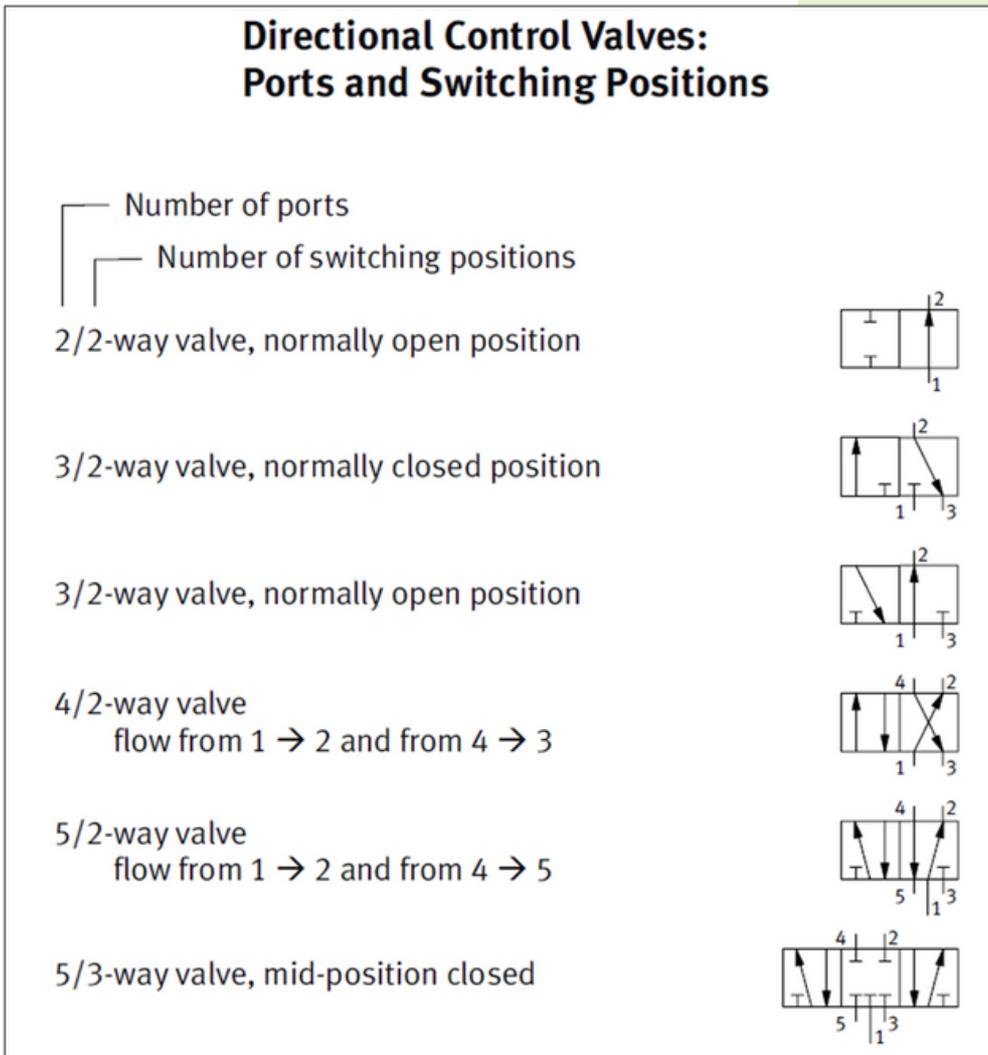
Control element

Processing element

Input elements



SYMBOLS FOR DIRECTIONAL CONTROL VALVES : PORTS AND SWITCHING POSITIONS

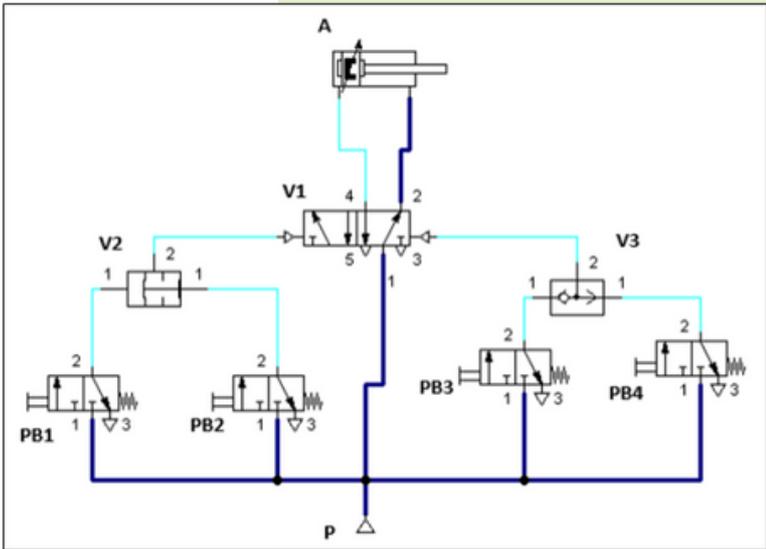


Directional control valves are used as

- Control elements
- Processing elements or
- Input elements

Written title: 2/2-Way valve
Spoken title: Two-slash-two way valve
Port identification: By numbers

Open position/Normally open position
Closed position/Normally closed position



SYMBOLS FOR DIRECTIONAL CONTROL VALVES : PORTS DESIGNATIONS

Port designations

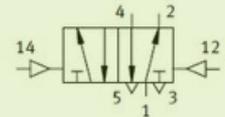
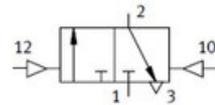
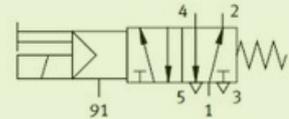
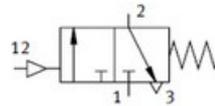
Port designation in accordance with DIN ISO 5599-3 "Fluid Technology – Pneumatics, 5-Way Valves"

Working ports

- 1 Supply port
- 2, 4 Working ports
- 3, 5 Exhaust ports

Pilot ports

- 10 Signal applied blocks flow from 1 to 2
- 12 Signal applied opens flow from 1 to 2
- 14 Signal applied opens flow from 1 to 4
- 81, 91 Auxiliary pilot air



SYMBOLS FOR DIRECTIONAL CONTROL VALVES : TYPE OF ACTUATION

Types of Actuation

Symbols in accordance with DIN ISO 1219 "Fluid Technology – Graphical Symbols and Circuit Diagrams"

The symbols for the types of actuation are drawn directly on the valve symbols.

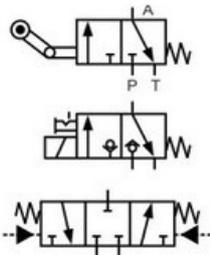
Selection

Depending upon system requirements

- Manually actuated
- Mechanically actuated
- Pneumatically actuated
- Electrically actuated
- Combined types of actuation

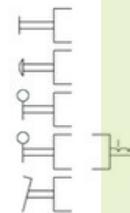
Purpose

- Actuate
- Reset
- Center



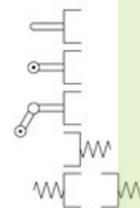
Manual actuation

- General
- Pushbutton operated
- Lever operated
- Via lever with detent
- Foot pedal operated



Mechanical actuation

- Stem actuated
- Roller actuated
- Roller actuated only in one direction
- Spring actuated
- Spring centered



Pneumatic actuation

- Direct pneumatic actuation
- Indirect pneumatic actuation, piloted



Solenoid actuation

- Single-solenoid operation
- Double-solenoid operation



Combined actuation

- Double solenoid valve, piloted, with manual override



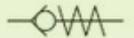
SYMBOLS FOR NON-RETURN

Non-return valves allow compressed air to flow in one direction and prevent it from flowing in the other. Fitted upstream of the circuit to be protected, they provide total protection.

– Non-return valve (check valve)



– Non-return valve, spring-loaded



SYMBOLS FOR FLOW CONTROL VALVE

– One-way flow control valve



– Flow control valve (throttle valve), adjustable

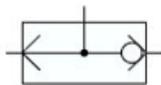


SYMBOLS FOR LOGIC VALVE

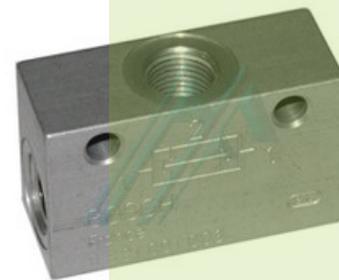
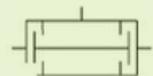
The signal processing in the pneumatics takes place within the control circuit via logic valves. In this case, any complex logic function can be installed using the three basic logic functions "- OR - AND - NOT".

Each air logic valve is built differently but is made to produce the same function, which is to provide the ability to insert logic into a control system.

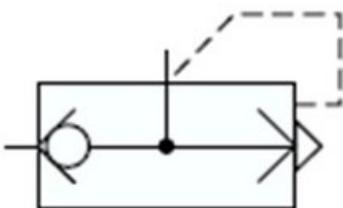
- Shuttle valve (OR function)



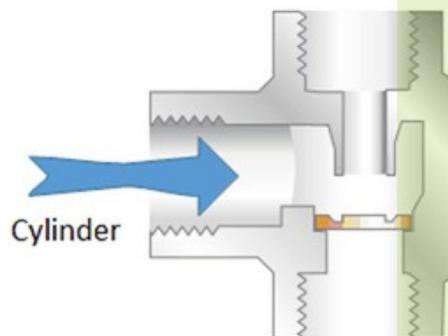
- Dual pressure valve (AND function)



SYMBOLS FOR QUICK EXHAUST VALVE



Quick exhaust into the environment



Way valve

Cylinder extends fast

SYMBOLS FOR PRESSURE VALVES

The pressure control valve (also known as relief valves) are used to restrict the pressure downstream of a unit. They are utilized mainly to prevent the pneumatic system from overpressure and to ensure safety

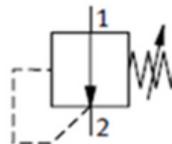
Pressure control valves

Types of pressure valves:

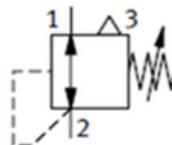
- Pressure regulating valves
- Pressure sequence valves

Sloping arrow: denotes an adjustable valve

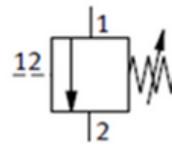
– Adjustable pressure regulating valve without relief port



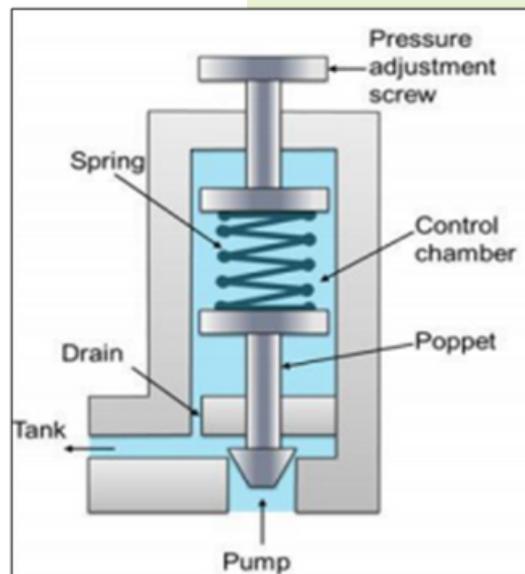
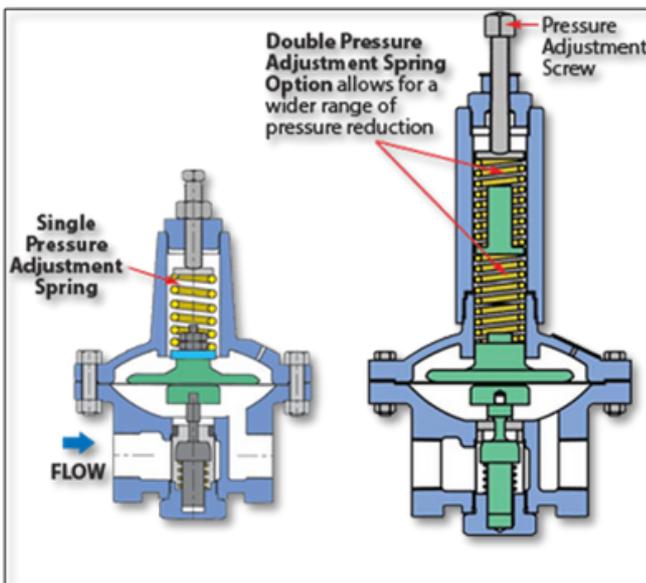
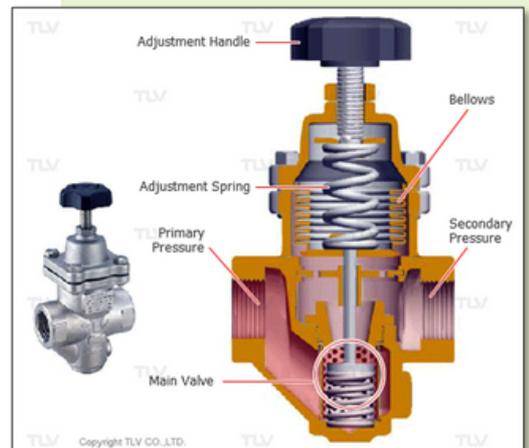
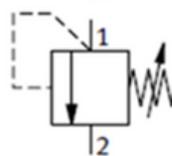
– Adjustable pressure regulating valve with relief port



– Pressure sequence valve with external supply line



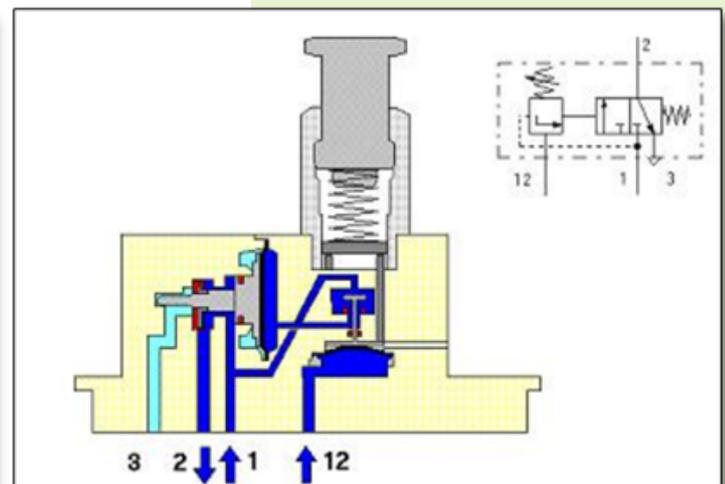
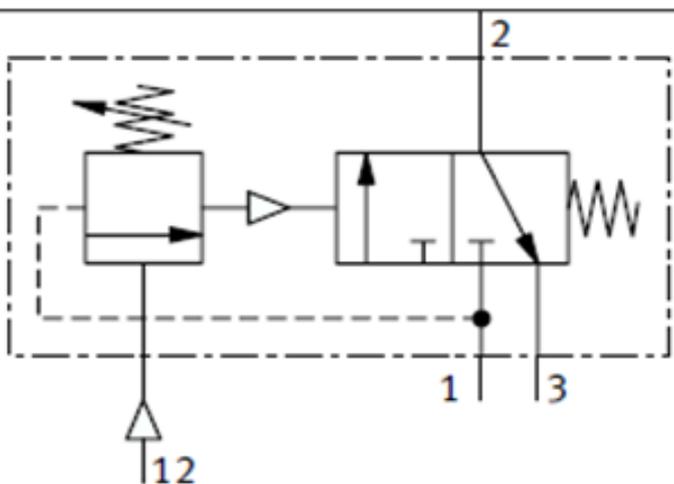
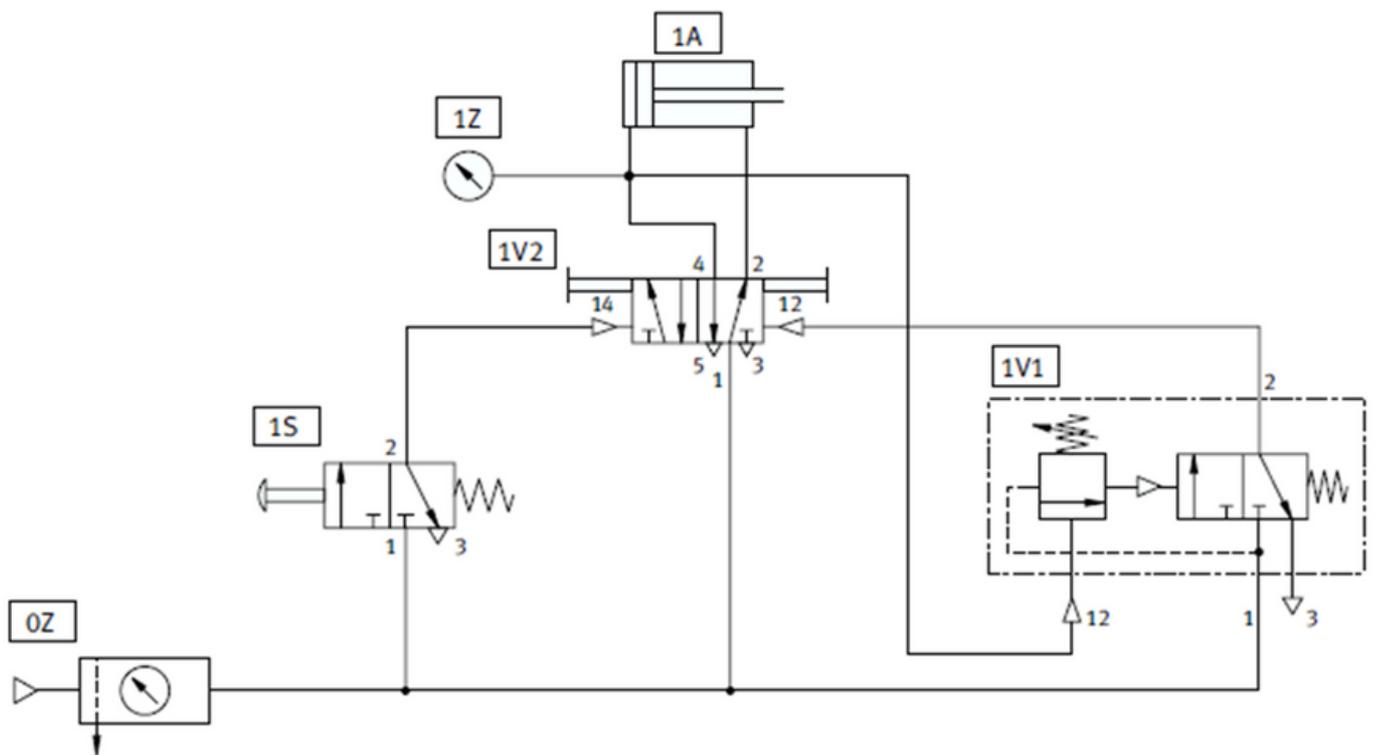
– Pressure-relief valve



SYMBOLS FOR COMBINATION VALVES

- Pressure Sequence valve is essentially a switch on or off valve
- Sequence Valve generates a pneumatic signal if the sensing pressure [signal input] is more than the desired set pressure
- This generated out put signal is used to control the movement of cylinder by using it as a set signal or reset signal to the final control valve to obtain forward or return motion respectively

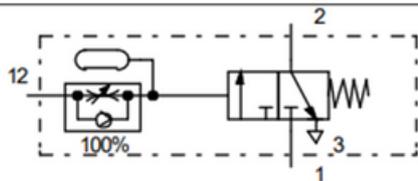
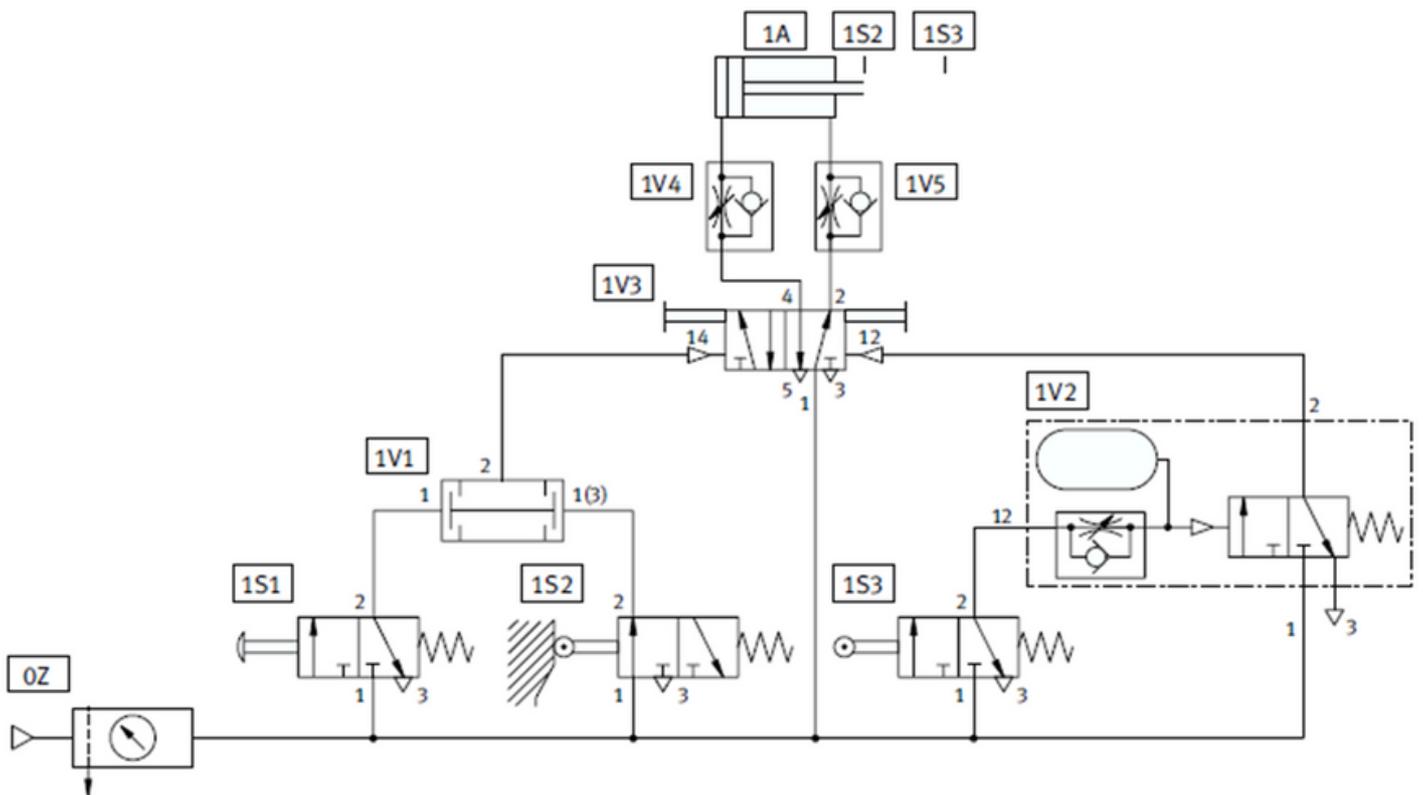
Circuit Diagram: Pressure Sequence Valve



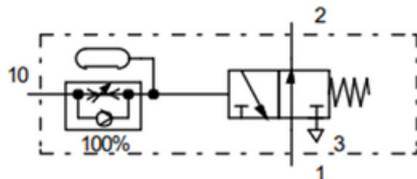
PNEUMATIC TIMERS

- Pneumatic Timers are used to create time delay of signals in pilot operated circuits.
- Available as Normally Closed Timers and Normally Open Timers.
- Usually Pneumatic timers are On Delay Timers
- Delay of signals is very commonly experienced in applications such as
- Bonding of two pieces.
- Normally Open Pneumatic Timer are also used in signal elimination
- Normally Open Pneumatic Timers are used as safety device in Two Hand Blocks

Circuit Diagram: Time Delay Valve



NORMALLY CLOSED TIMER

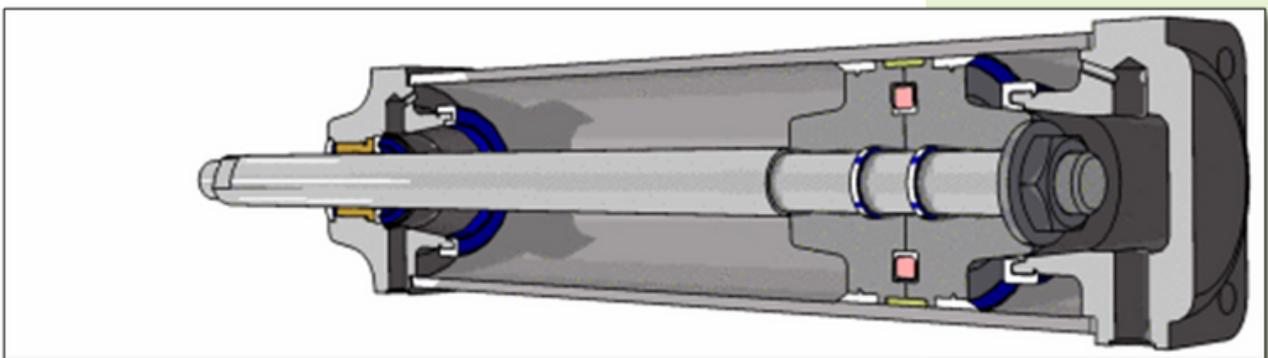
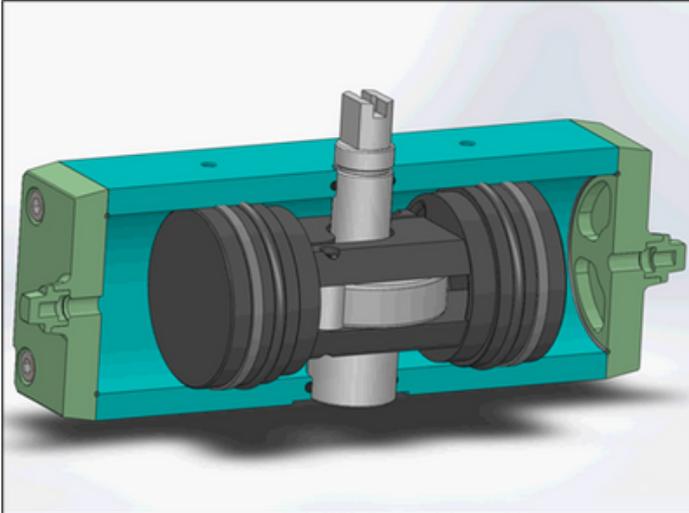


NORMALLY OPEN TIMER



SYMBOLS FOR THE PRINCIPLE WORKING ELEMENTS

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.



SYMBOLS FOR LINEAR ACTUATORS

A linear actuator creates motion in a straight line.

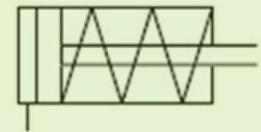
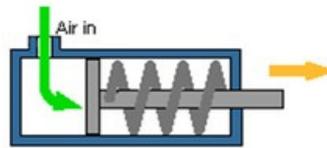
The symbol is represented with the advance motion to the right in the system circuit

Single-acting: Performs work in one direction

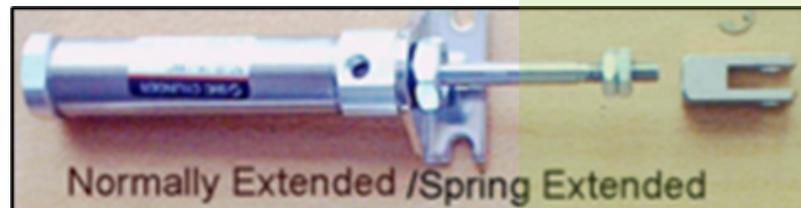
Double-acting: Performs work in both directions

Sloping arrow over piston: denotes adjustable end position cushioning

– Single-acting cylinder

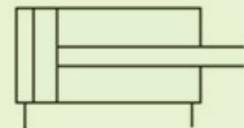
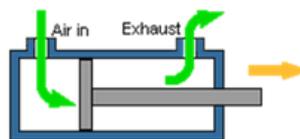


Normally Retracted /Spring Return



Normally Extended /Spring Extended

– Double-acting cylinder



SYMBOLS FOR COMPONENTS DESIGNATION

System number

- Beginning with 1
- Is used only if the entire switching circuit consists of more than one system

Circuit number

- Components of energy supply, accessories 0
- Fluid circuits; Number assignment per cylinder 1, 2, ...

Component designation

by letter

- Working elements A
- Compressors P
- Sensors S
- Valves V
- Other components Z

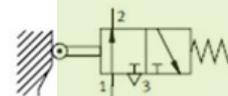
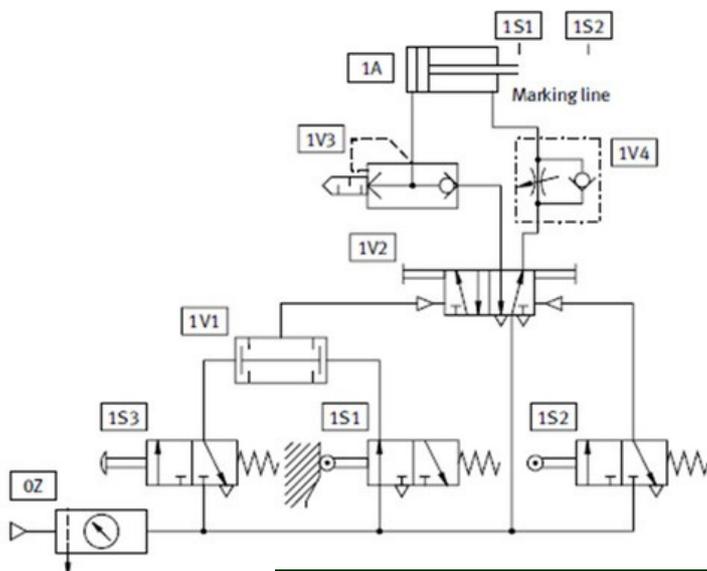
Component number

- Beginning with 1
- Continuous numbering of the same types of component

Numbers assigned from left to right and from bottom to top

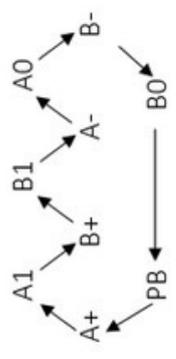
Actuated input elements:

Identified by the representation of a switching cam

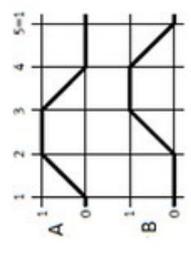


EXAMPLE OF SYMNBLS APPLICATION IN MULTI ACTUATOR PNEUMATIC CIRCUIT DESIGN

STEP 1: INPUT/OUTPUT SIGNAL FLOW



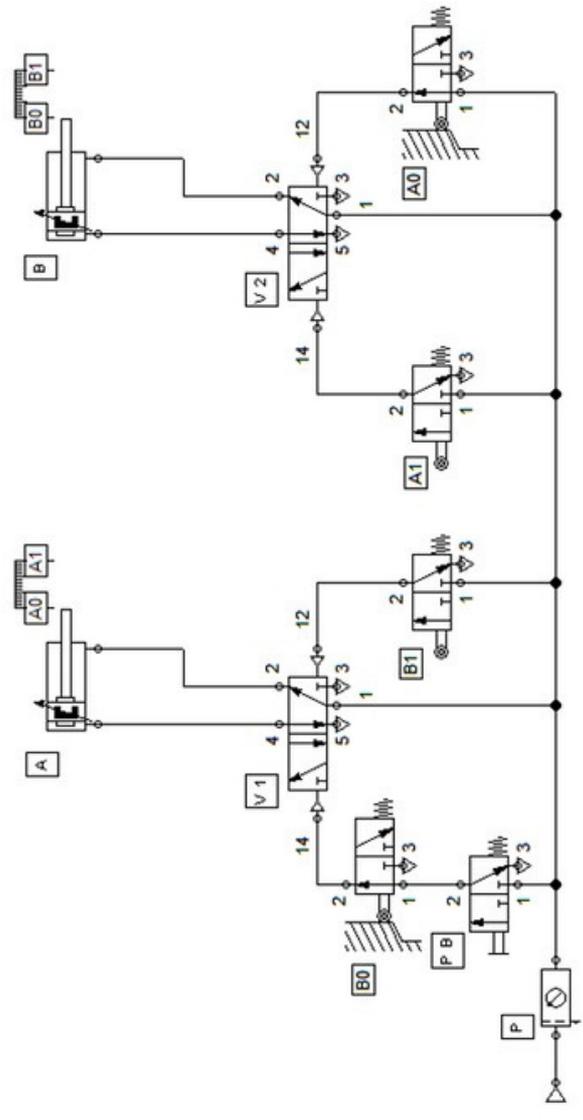
STEP 2 : TIME MOTION DIAGRAM



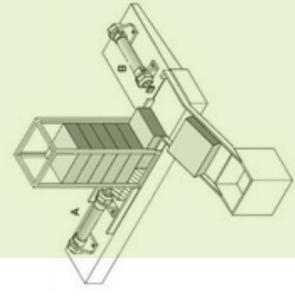
STEP 3 : LIST OF COMPONENTS

Label	Component
A	Cylinder A
B	Cylinder B
V1	5/2 Way Double Air Piloted Valve
V2	5/2 Way Double Air Piloted Valve
A0	3/2 Way Roller Limit Switch
A1	3/2 Way Roller Limit Switch
B0	3/2 Way Roller Limit Switch
B1	3/2 Way Roller Limit Switch
PB	Push Button
P	Power Supply

STEP 4 : CIRCUIT DESIGN



POSITIONAL DIAGRAM

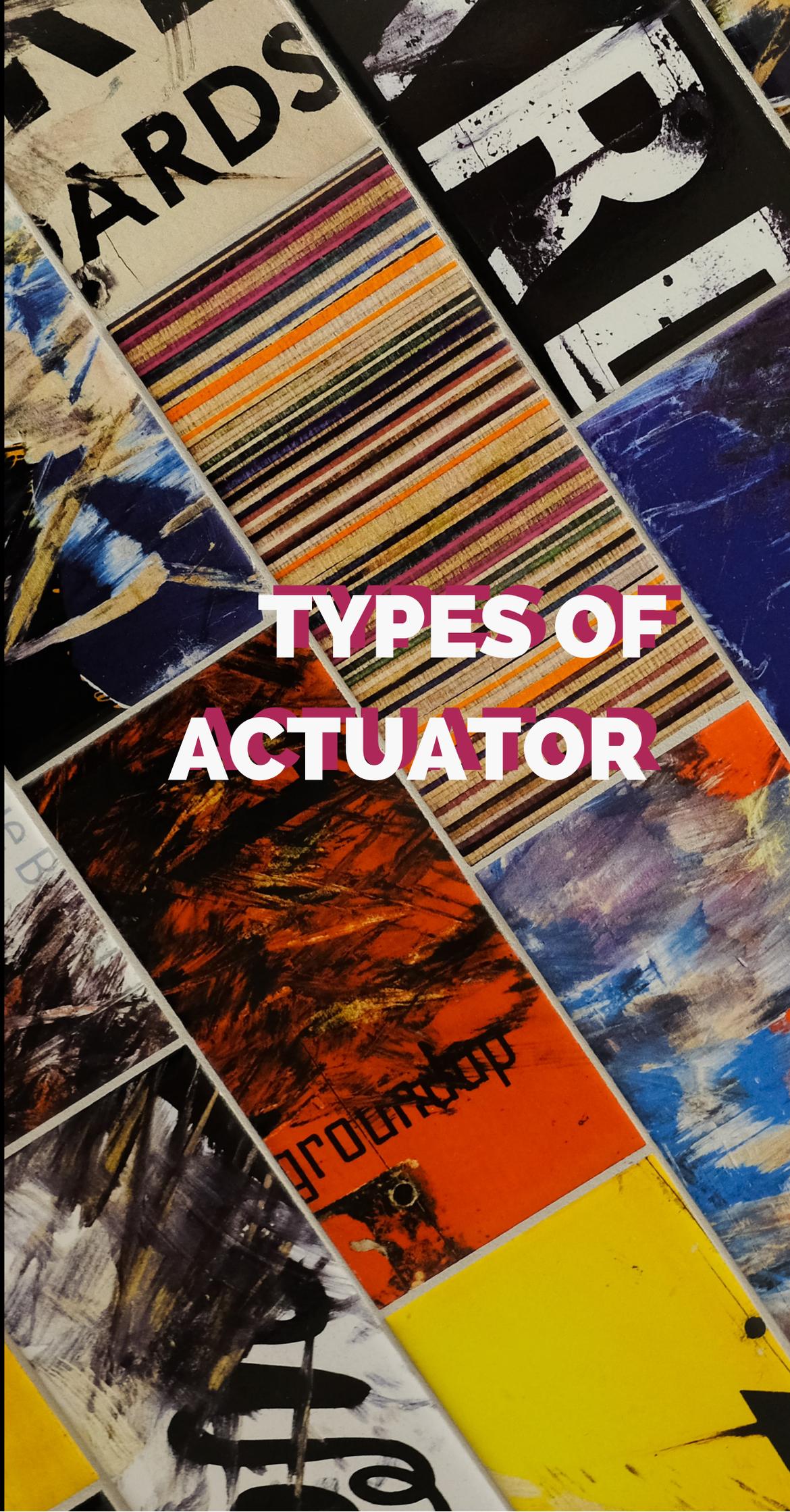


STEP 5 : CIRCUIT OPERATION

INITIAL POSITION :
 P → PB(1), → V1(1 → 2) → A- → V1(4 → 5), → B1(1), → A1(1), → V2(1 → 2) → B- → V2(4 → 5), → A0(1 → 2)
A+ : Cylinder A Extend
 P → PB(1 → 2) → B0(1 → 2) → V1,14(1 → 4) → A+ → V1(2 → 3)
B+ : Cylinder B Extend
 P → A1(1 → 2) → V2,14(1 → 4) → B+ → V2(2 → 3)
A- : Cylinder A Retard
 P → B1(1 → 2) → V1,12(1 → 2) → A- → V1(4 → 5)
B- : Cylinder B Retard
 P → A0(1 → 2) → V2,12(1 → 2) → B- → V2(4 → 5)

04

TYPES OF
ACTUATOR



WHAT IS PNEUMATIC ACTUATORS

Pneumatic actuators are the devices used for converting pressure energy of compressed air into the mechanical energy to perform useful work. In other words, actuators are used to perform the task of exerting the required force at the end of the stroke or used to create displacement by the movement of the piston. The pressurized air from the compressor is supplied to reservoir. The pressurized air from storage is supplied to pneumatic actuator to do work.

THE BENEFITS OF ACTUATORS:

Components – Another major advantage offered by pneumatic actuators is their simple design and operating components. They are not just easily available, but are also relatively inexpensive & low priced.

Heavy loads – These actuators can easily tolerate heavy loads, and are thus, quite commonly used in a number of applications.

High force & speed – When used in linear motion control applications, wherein high precision is not a much essential parameter, these actuators offer high force and speed, which is difficult to find in any other actuator, except the hydraulic ones.

Easy accessibility of the source – For any pneumatic system to work, air is a major source. Easy availability of this source makes pneumatic actuators the preferred choice of many.

Easy channeling – Apart from being easily available, air can also be channeled and routed from one place to another. Thus, using the pneumatic actuators becomes easy through easy channeling of the source.

Safe to be used – Pneumatic actuators are safe to be used. Thanks to the use of air, they are not flammable and are not susceptible to short circuit, in contrast to the electric actuators.

Storage functionality – It is great to understand the fact that as the pneumatic actuators contain just compressed gases, they can be stored even in the absence of electricity or power. Thus, the users get another benefit with their use.

Clean technology – These types of actuators offer a clean technology to the users as they are less prone to contamination. Due to the use of air, which is free from harmful chemicals the pneumatic systems are quite well known in the food and pharmaceutical industries.

No overheating issue – The pneumatic actuators do not overheat upon excessive use, and are thus favoured by many users in applications that require longer use.

Cost-effective substitute – A pneumatic actuator is said to be a cost effective tool for systems. With its easy installation and maintenance, it has become a great option to go for when you are looking for inexpensive actuators.

High durability – Another benefit of having pneumatic actuators is that they offer a long term use, thanks to their high durability. It's good to note that these actuators can easily sustain constant pressures, which is great when you compare them with the other types of actuators.

TYPES OF PNEUMATIC ACTUATORS

Linear Actuator or Pneumatic cylinders



Rotary Actuator or Air motors



Limited angle Actuators



THE DIFFERENT CLASSIFICATION SCHEME OF THE PNEUMATIC CYLINDERS

1. Based on application for which air cylinders are used

- i) Light duty air cylinders
- ii) Medium duty air cylinders
- iii) Heavy duty air cylinders

2. Based on the cylinder action

- i) Single acting cylinder
- ii) Double acting cylinder
 - Single rod type double acting cylinder
 - Double rod type double acting cylinder

3. Based on cylinder's movement

- i) Rotating type air cylinder
- ii) Non rotating type air cylinder

4. Based on the cylinder's design

- i) Telescopic cylinder
- ii) Tandem cylinder
- iii) Rod less cylinder
 - Cable cylinder,
 - Sealing band Cylinder with slotted cylinder barrel
 - Cylinder with Magnetically Coupled Slide
 - Impact cylinder
 - Duplex cylinders
 - Cylinders with sensors

5. Based on the cylinder action

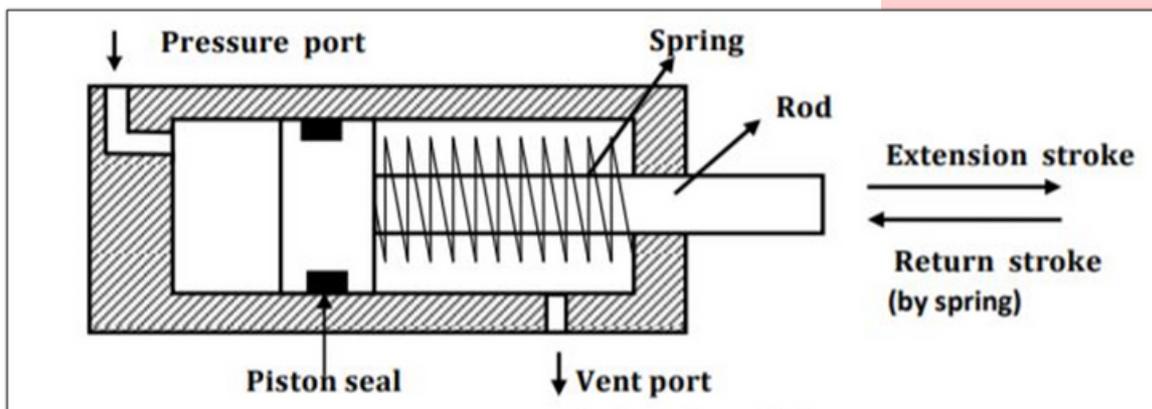
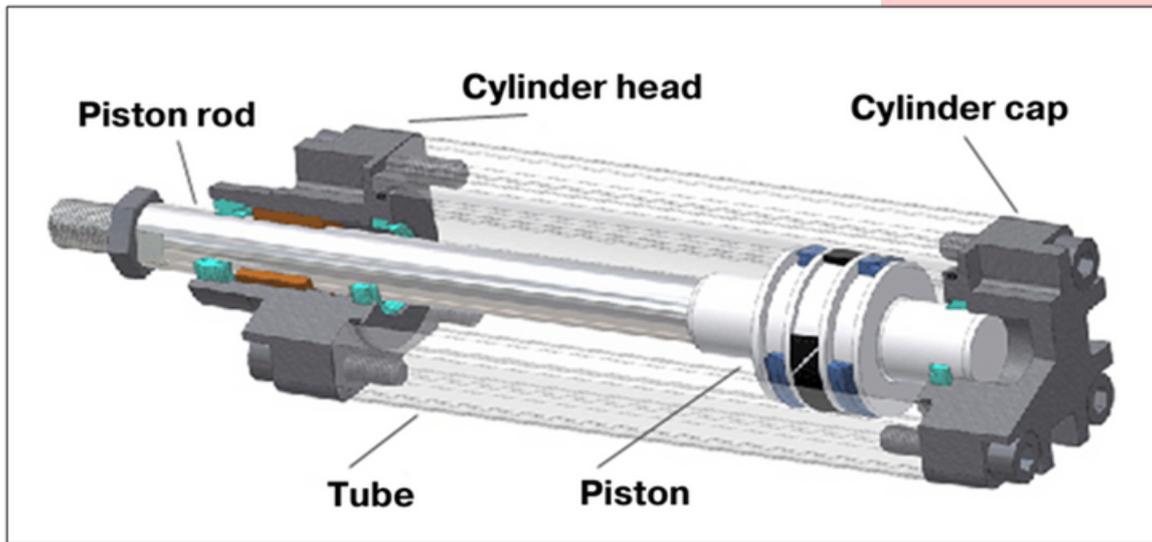
Based on cylinder action we can classify the cylinders as single acting and double acting. Single acting cylinders have single air inlet line. Double acting cylinders have two air inlet lines.

Advantages of double acting cylinders over single acting cylinders are

1. In single acting cylinder, compressed air is fed only on one side. Hence this cylinder can produce work only in one direction. But the compressed air moves the piston in two directions in double acting cylinder, so they work in both directions
2. In a single acting cylinder, the stroke length is limited by the compressed length of the spring. But in principle, the stroke length is unlimited in a double acting cylinder
3. While the piston moves forward in a single acting cylinder, air has to overcome the pressure of the spring and hence some power is lost before the actual stroke of the piston starts. But this problem is not present in a double acting cylinder.

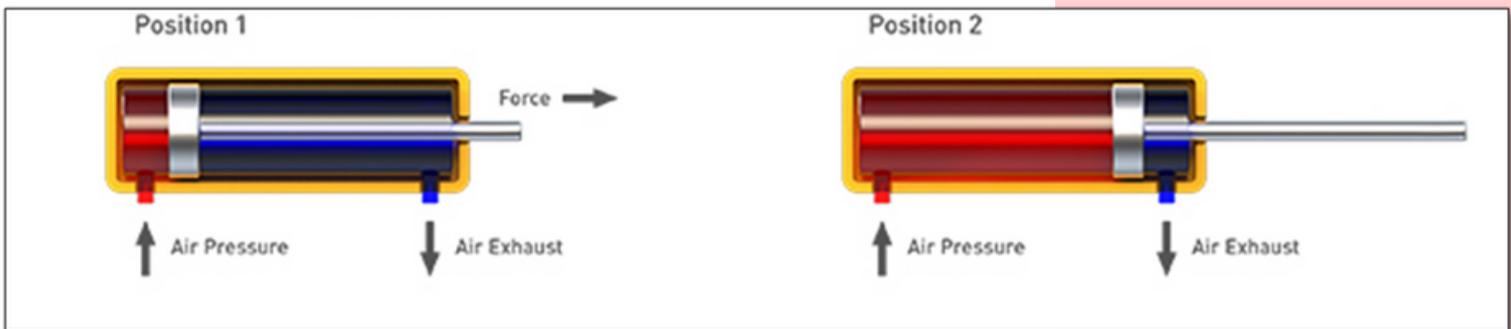
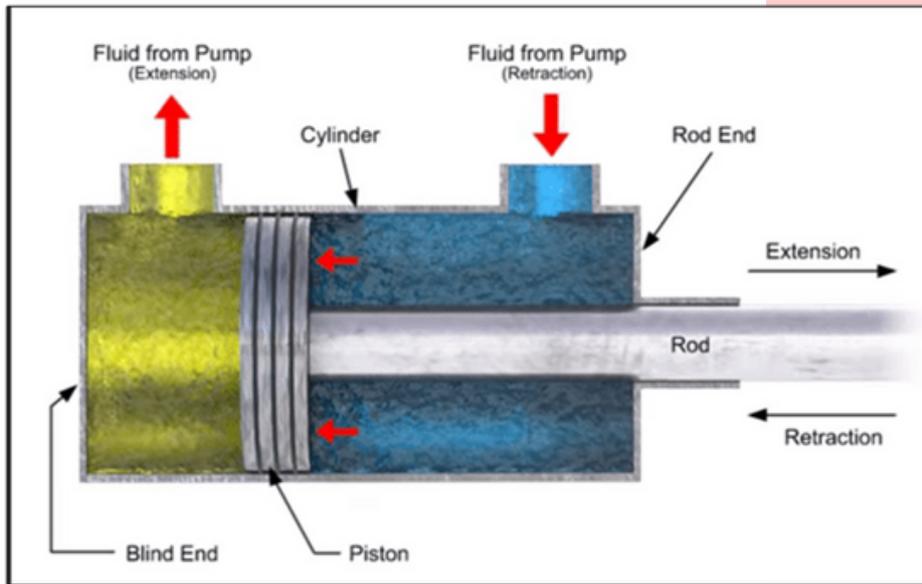
SINGLE-ACTING CYLINDERS

- It consists of a piston inside a cylindrical housing called barrel. On one end of the piston there is a rod, which can reciprocate. At the opposite end, there is a port for the entrance and exit of oil.
- Single-acting cylinders produce force in one direction by pneumatic pressure acting on the piston. (Single-acting cylinders can exert a force in the extending direction only.)
- The return of the piston is not done pneumatically.
- In single-acting cylinders, retraction is done either by gravity or by a spring.



DOUBLE-ACTING CYLINDERS

- A double-acting pneumatic cylinder is one where the thrust, or output force, is developed in both extending and retracting directions.
- Double-acting cylinders have a port at each end and move the piston forward and back by alternating the port that receives the high-pressure air, necessary when a load must be moved in both directions such as opening and closing a gate.



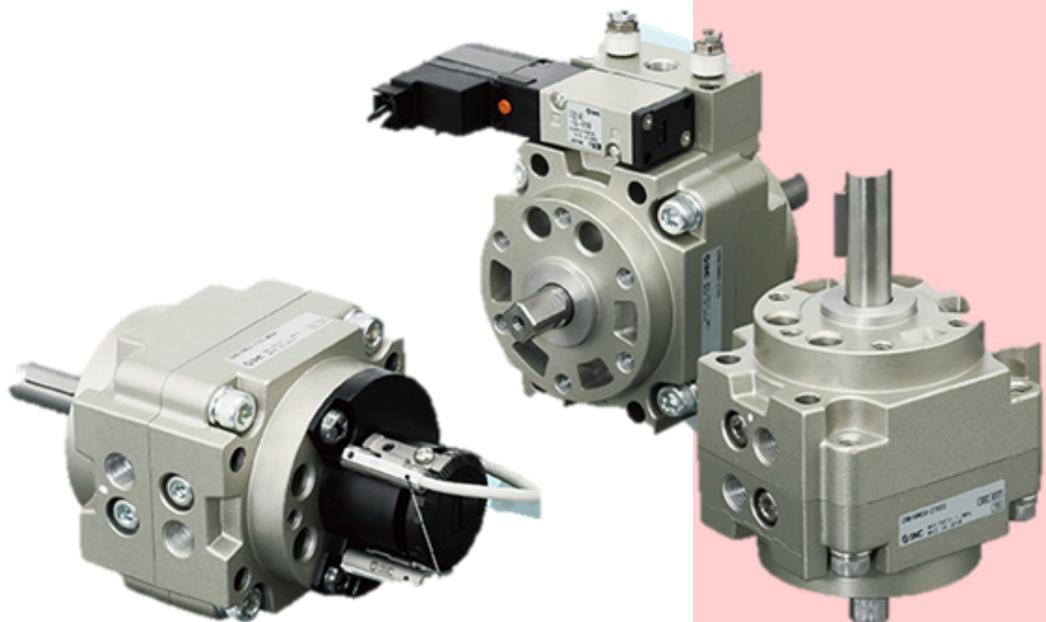
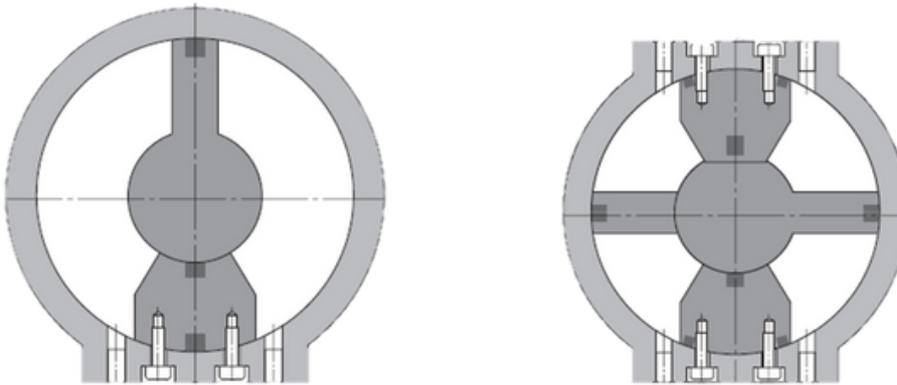
ROTARY ACTUATOR

- A pneumatic motor (air motor), or compressed air engine, is a type of motor which does mechanical work by expanding compressed air.
- Pneumatic motors generally convert the compressed air energy to mechanical work through either linear or rotary motion.
- Rotary motion is supplied by either a vane type air motor, piston air motor, air turbine or gear type motor.



AIR MOTOR (VANE AIR MOTOR)

- The vane-type rotary actuator is like the vane-type pneumatic motor, but its revolving angle is limited and its output is determined by the vane's pressure-receiving area and working air pressure.
- As shown in Figure 1, the number of vanes determines whether an actuator is a single vane or double vane type.
- Tilting the angle decreases as the number of vanes increases, but the torque increases.
- The single vane type applies about 270-300 degrees of tilting angle, while the double vane type applies about 90-120 degrees.
- Also, the vane type rotary actuator is subject to a small amount of air leakage because it cannot be completely air-tightened.



ROTARY CYLINDER (RACK-AND-PINION)

- A rack-and-pinion, as shown in Figure below, consists of a circular gear (the pinion) engaged to a linear gear (the rack).
- When actuated, the piston which is attached to the rack moves linearly.
- Due to the gear connection to the pinion, it rotates it with the attached output shaft effectively turning the linear motion into rotational.

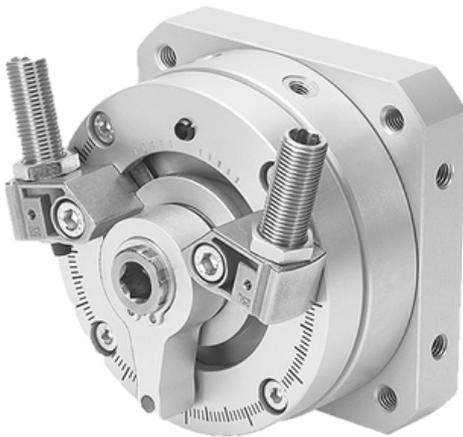


- Often two pistons and racks are installed on the opposite side of each other to double the amount of torque on the pinion as shown in Figure below.
- In this double acting actuator, the two chambers on the sides are filled with pressurized air which pushed the pistons to the centre.
- To return the pistons to the initial position, the chamber in the center is in turn pressurised.



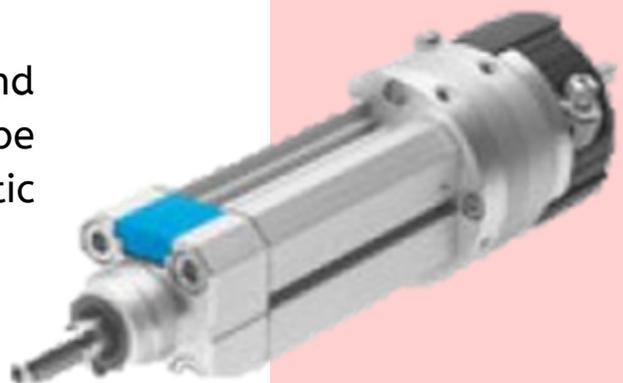
SWIVEL DRIVE

- Pneumatic swivel delivers a versatile rotating drive solution for difficult and larger loads.
- Ideal for manufacturing automation, the swivel drive eliminates the need for additional guidance or bearing system while seamlessly combining a precision heavy duty bearing with a high performance semi-rotary vane drive to conveniently rotate larger loads via adjustable angle up to 270 degrees.
- From a standard compressed air supply of 1.5 to 10 bar, pneumatic swivel module delivers significant torque output and accommodates higher moments of inertial and high radial and axial forces.
- This makes the swivel module suitable for use in demanding applications with offset or large loads as well as in semi- or fully-automatic manufacturing handling and assembly automation that may require the application of additional force to its flange during operation.



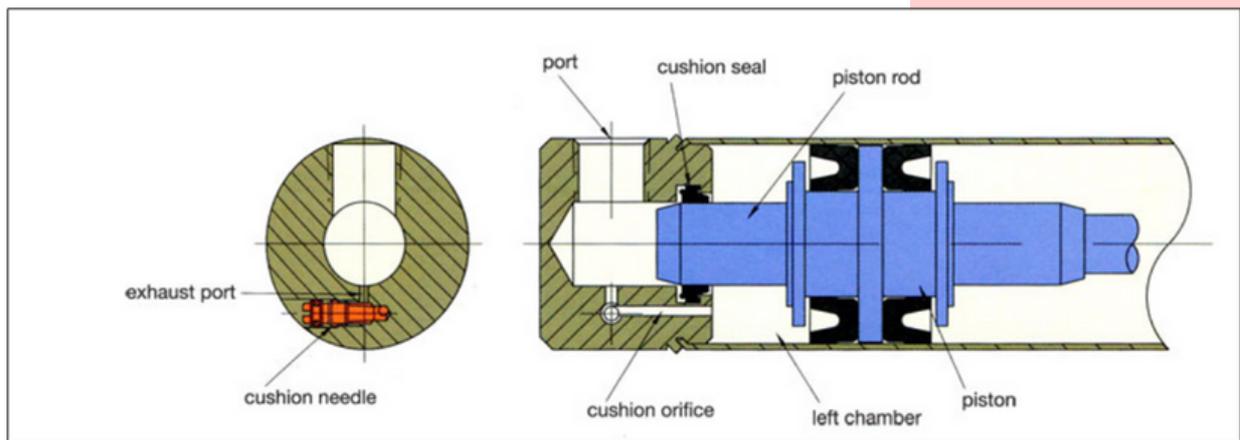
Rotate large or unwieldy products in assembly, handling, and packaging applications.

Indexing in packaging and assembly machines can be completed easily with pneumatic swivels.

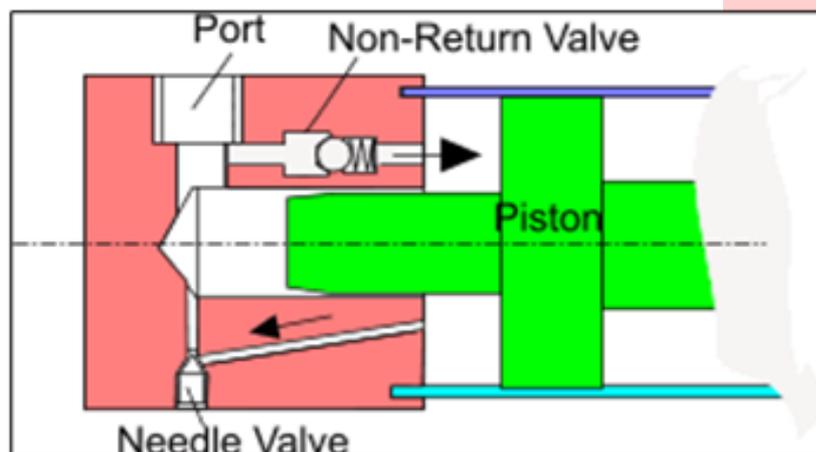


CLARIFY CUSHIONED DOUBLE ACTING CYLINDER

- A tube in which a piston operates under the action of fluid pressure is referred to as cylinder housing. Cylinder cushioning is an arrangement intended to regulate the speed of the piston as it ends the stroke.
- Cushioning is needed to lower the speed of the cylinder before it reaches the end cap. Lowering the speed of the piston helps reduce stress on the components within the cylinder. It also lessens vibration conveyed to the other parts of the machine.



- A needle valve in the head provides a parallel path for the air to exit. Clippard's needle design has a high flow gain, allowing the user to fine-tune the cushion's effectiveness anywhere from little effect to actually stopping the cylinder.
- Cushioned cylinders are not designed to decelerate machine members or to take the place of shock absorbers in applications with high kinetic energy. Cushions cannot be added to existing cylinders (requires additional components and machining).



DETERMINE THE SIZE OF CYLINDER

- Stroke length, force requirements, and operating environment are among many considerations when specifying pneumatic cylinders.
- In retract mode, air pressure can act only part of the piston, because the rod blocks the centre portion of the piston

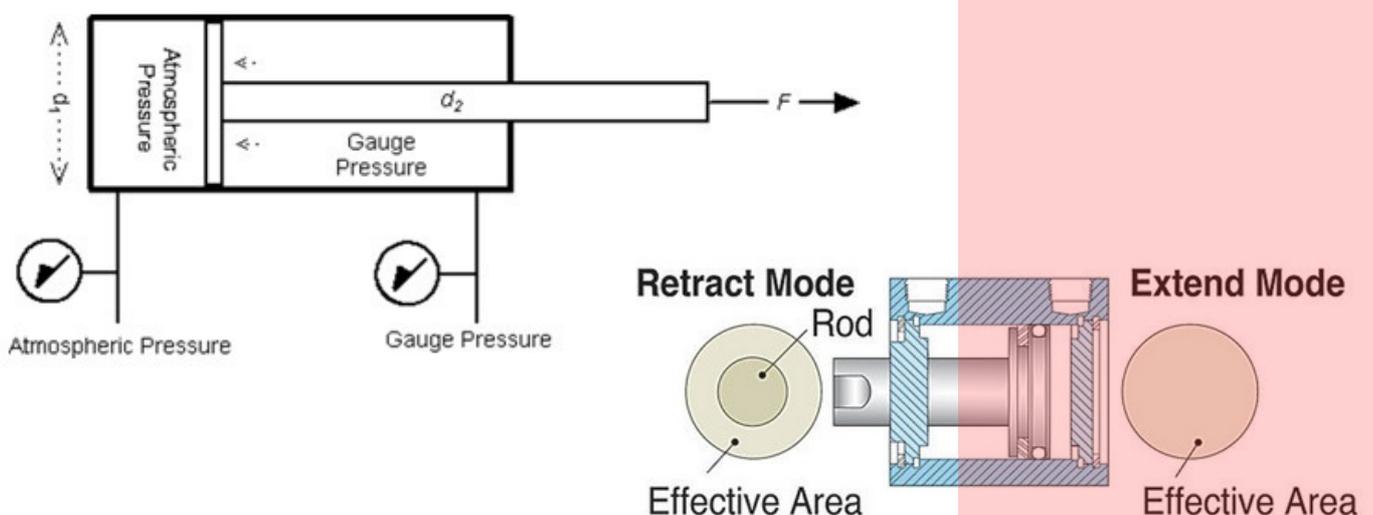
How to choose a cylinder of the correct size, based on an application

Example - Double Acting Piston

The force exerted from a single acting pneumatic cylinder with 1 bar (105 N/m²), full bore diameter of 100 mm (0.1 m) and rod diameter 10 mm (0.01 m) can be calculated as

$$\begin{aligned} F &= p \pi (d_1^2 - d_2^2) / 4 \\ &= (105 \text{ N/m}^2) \pi [(0.1 \text{ m})^2 - (0.01 \text{ m})^2] / 4 \\ &= 778 \text{ N} \\ &= 0.78 \text{ kN} \end{aligned}$$

instroke capacity is reduced compared to outstroke capacity - due to the rod and reduced active pressurised areal



05

EXERCISE



REFERENCES

Main reference supporting the course

Totten G.E & De Negri V.J (2017). Handbook of Hydraulic Fluid Technology, Second Edition. Taylor & Francis Group.

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