KEMENTERIAN PENDIDIKAN TINGGI

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DJJ5123 PNEUMATIC & HYDRAULICS

1.0 INTRODUCTION TO PNEUMATIC SYSTEM

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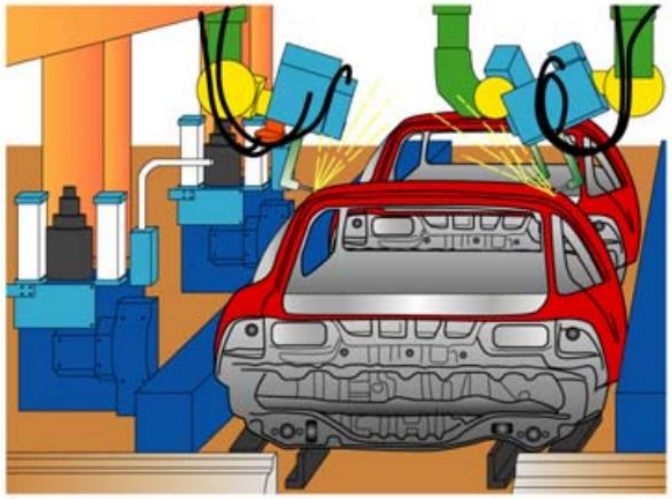
PNEUMATIC SYSTEM

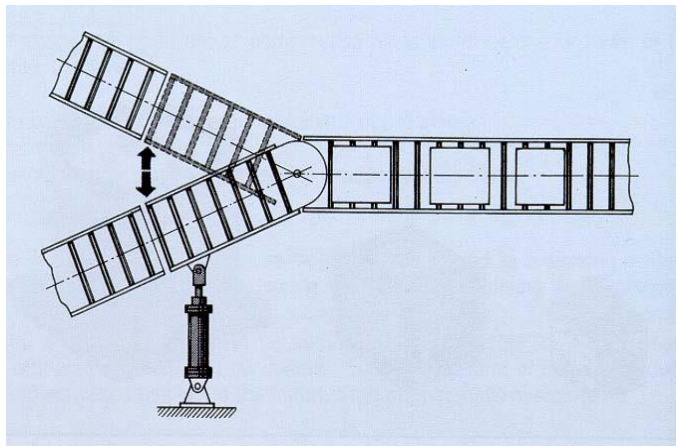
- The term “pneumatics” was derived from the word “pneuma” which is derived from the ancient Greek, and meant breath or wind, and also the soul in philosophy.
- Pneumatics is a section of technology that deals with the study and application of pressurized gas to produce mechanical motion.
- A pneumatic system is a system that uses compressed air to transmit and control energy.
- Systems based on pneumatics are found in factories that deal with compressed air and inert gases. Energy produced by pneumatic systems can be more flexible, less costly, more reliable and less dangerous than some actuators and electric motors.

APPLICATIONS OF PNEUMATIC SYSTEM

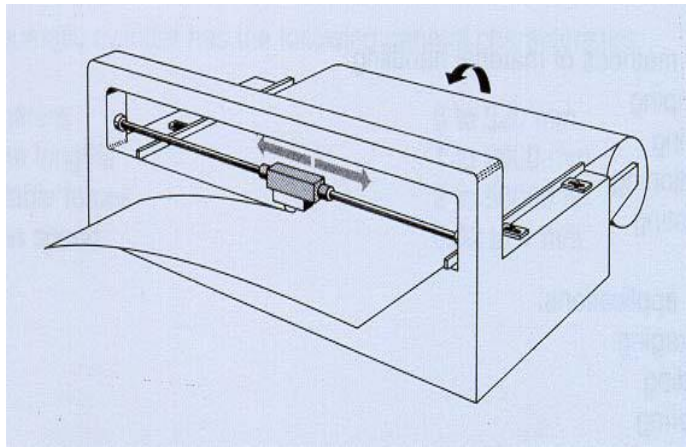


Automobile production lines

Pneumatic system of an automatic machine

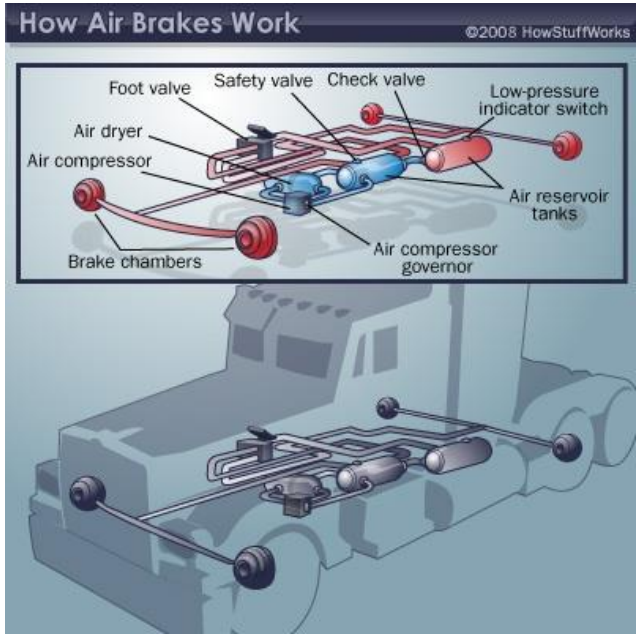


Line Divider for Two Tracks



Pneumatic Cutter

APPLICATIONS OF PNEUMATIC SYSTEM



Air brakes on buses and trucks

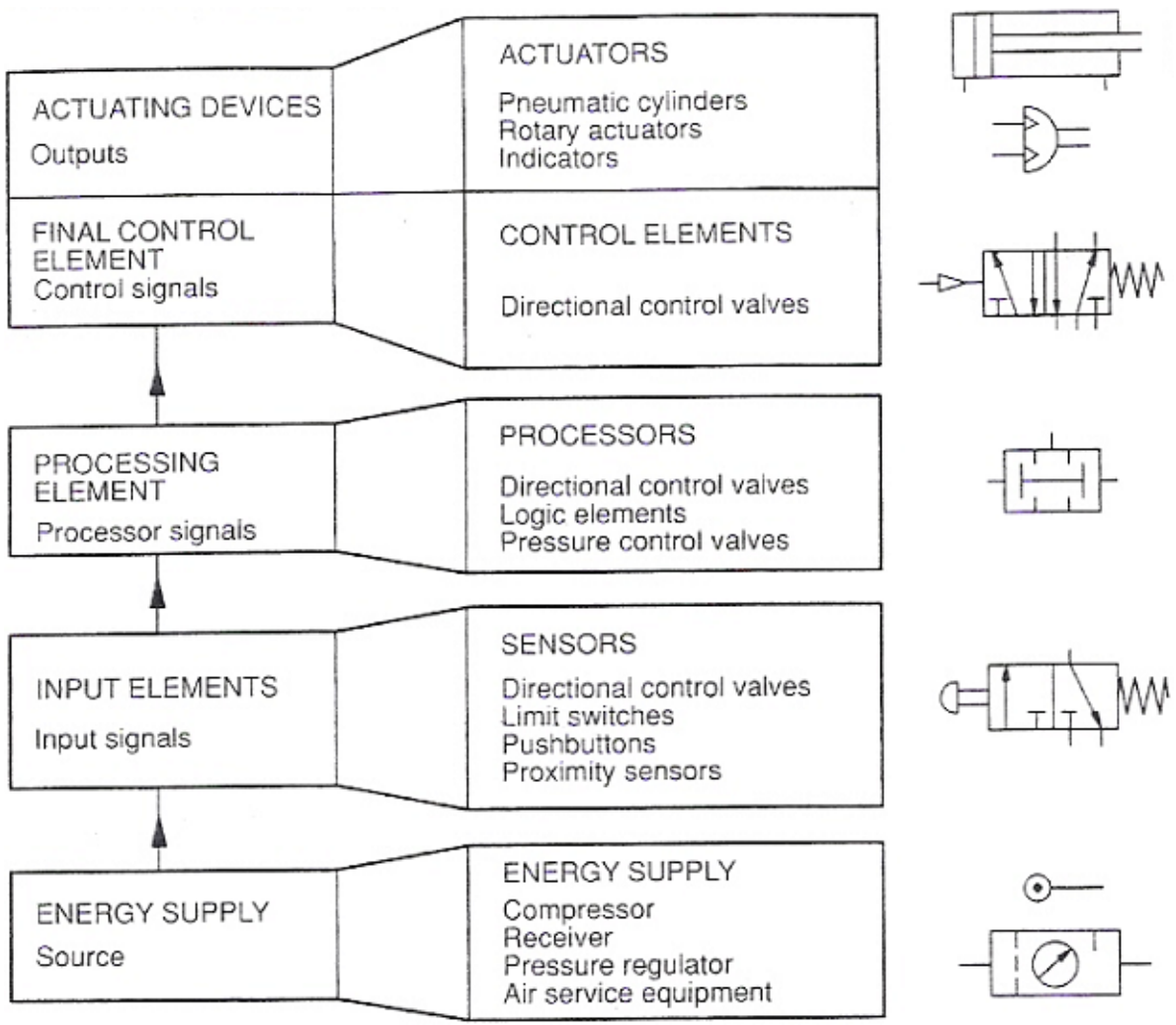
ADVANTAGES & DISADVANTAGES

ADVANTAGES	DISADVANTAGES
High effectiveness - Many factories have equipped their production lines with compressed air supplies and movable compressors. There is an unlimited supply of air in our atmosphere to produce compressed air. Moreover, the use of compressed air is not restricted by distance, as it can easily be transported through pipes. After use, compressed air can be released directly into the atmosphere without the need of processing.	**Relatively low accuracy -** As pneumatic systems are powered by the force provided by compressed air, their operation is subject to the volume of the compressed air. As the volume of air may change when compressed or heated, the supply of air to the system may not be accurate, causing a decrease in the overall accuracy of the system.
High durability and reliability - Pneumatic components are extremely durable and can not be damaged easily. Compared to electromotive components, pneumatic components are more durable and reliable.	**Low loading -** As the cylinders of pneumatic components are not very large, a pneumatic system cannot drive loads that are too heavy.
Simple design - The designs of pneumatic components are relatively simple. They are thus more suitable for use in simple automatic control systems.	**Processing required before use -** Compressed air must be processed before use to ensure the absence of water vapour or dust. Otherwise, the moving parts of the pneumatic components may wear out quickly due to friction.
High adaptability to harsh environment - Compared to the elements of other systems, compressed air is less affected by high temperature, dust, corrosion, etc.	**Uneven moving speed -** As air can easily be compressed, the moving speeds of the pistons are relatively uneven.

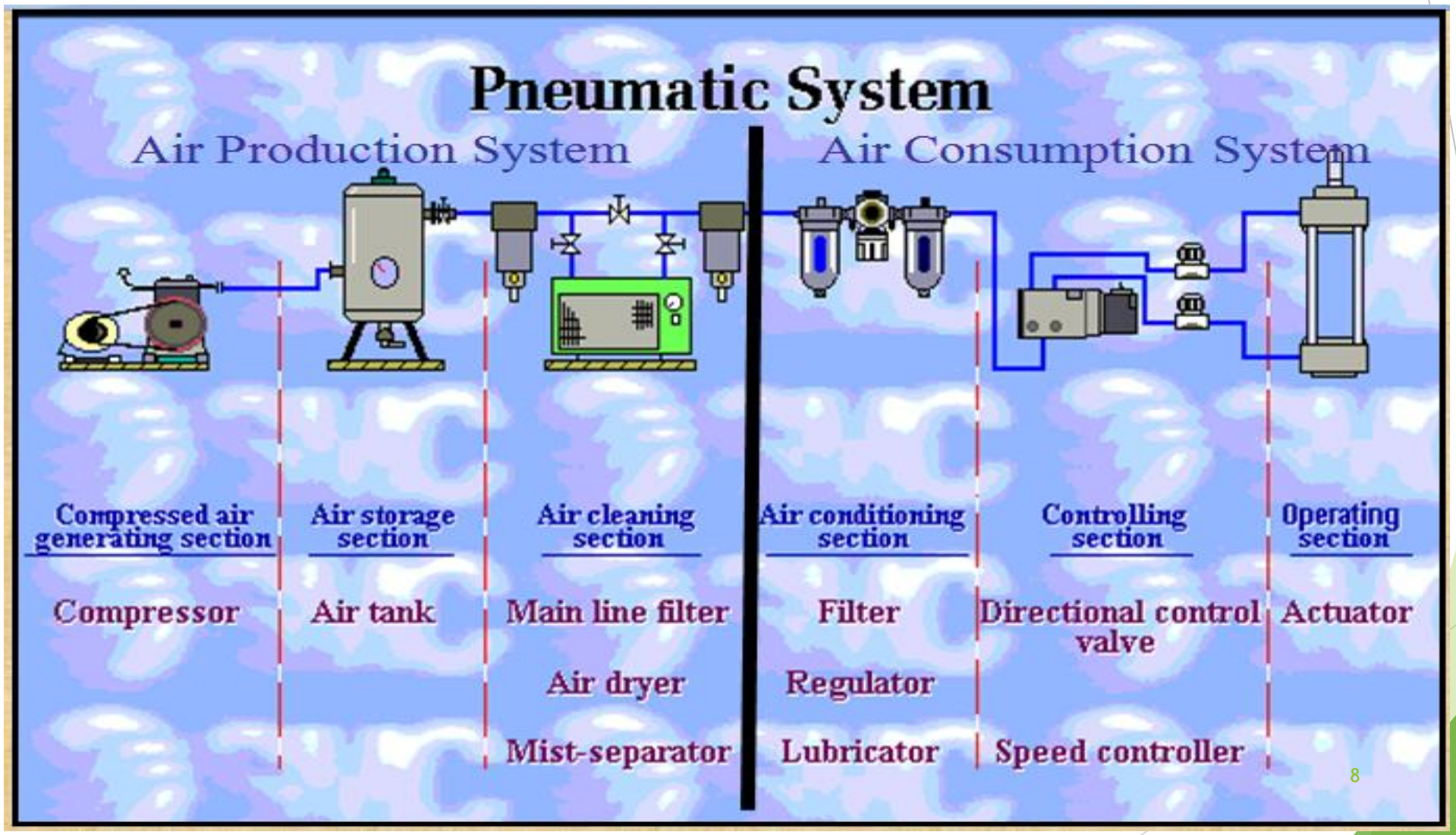
ADVANTAGES & DISADVANTAGES…cont

ADVANTAGES	DISADVANTAGES
Safety - Pneumatic systems are safer than electromotive systems because they can work in inflammable environment without causing fire or explosion. Apart from that, overloading in pneumatic system will only lead to sliding or cessation of operation. Unlike electromotive components, pneumatic components do not burn or get overheated when overloaded.	**Noise -** Noise will be produced when compressed air is released from the pneumatic components.
Easy selection of speed and pressure - The speeds of rectilinear and oscillating movement of pneumatic systems are easy to adjust and subject to few limitations. The pressure and the volume of air can easily be adjusted by a pressure regulator.	
Environmental friendly - The operation of pneumatic systems do not produce pollutants. The air released is also processed in special ways. Therefore, pneumatic systems can work in environments that demand high level of cleanliness. One example is the production lines of integrated circuits.	
Economical - As pneumatic components are not expensive, the costs of pneumatic systems are quite low. Moreover, as pneumatic systems are very durable, the cost of repair is significantly lower than that of other systems.	

STRUCTURAL BLOCK DIAGRAM



PNEUMATIC SYSTEM SIGNAL FLOW



PNEUMATIC SYSTEM SIGNAL FLOW…cont

The Air Production and Distribution System

1) Compressor : Air taken in at atmospheric pressure is compressed and delivered at higher pressure to the pneumatic system. It thus transforms mechanical energy into pneumatic energy.
2) Air Tank : Stores the compressed air.
3) Refrigerated Air Dryer : Cools the compressed air to a few degrees above freezing point and condenses most of the air humidity.
4) Line Filter : It helps to keep the line free from dust, water and oil.

The Air Consuming System

1) Air Service Unit.
2) Directional Valve : Alternatively pressurizes and exhaust the cylinder connections to control the direction of movement.
3) Speed Controllers : Allows easy speed adjustment of the actuator movement.
4) Actuator.

ISO STANDARD SYMBOL OF COMPONENTS IN PNEUMATIC SYSTEM

The development of pneumatic systems is assisted by a uniform approach to the representation of the elements and the circuits. The symbols used for the individual elements must display the following characteristics:

- Actuation and return actuation methods
- Number of connections (all labelled for identification)
- Number of switching positions
- General operating principle
- Simplified representation of the flow path

- Earlier the ports were designated with letter system. Now as per ISO5599 the ports are designated based on number system. The port designations are shown in table;

Port	Letter system	Number system
Pressure port	P	1
Working port	A	4
Working port	B	2
Exhaust port	R	5
Exhaust port	S	3
Pilot port	Z	14
Pilot port	Y	12

ISO Designation	Symbol	Picture Representation
Basic Information		
Lines		
Continuous		Represents a working fluid line. This fluid comes from a prime mover and goes to the actuator to perform work. May be a 1/8" plastic air line or any size pipe or tube in a hydraulic system.
Non-Flowing	Black	
Pump Flow	Red	
Tank Flow	Blue	
Suction Flow	Green	
Metered Flow	Yellow	
Reduced Pressure	Orange	COLOR CODING FOR OVERHEADS
Intensified Fluid	Purple	
Long Dashes	Orange	Represents pilot lines that supply a small amount fluid to another valve or device making it operate. The length of these dashes should be at least ten times their thickness .
Short Dashes	Green	Represents drain lines for hydraulic circuits. Many hydraulic valves have internal leakage that can get trapped and cause a malfunction .A drain line is a small line giving trapped fluid a free flow path to tank. The length of these dashes is five times their thickness.
Double Lines		Represents a mechanical connection Between components, A pump motor shaft, feedback connections between valves and actuators, etc. The outside dimension of these lines should be at least five times the line thickness.
Center Line		Represents an enclosure outline that indicates the parts inside it are a unit. This unit may be a casting with the parts machined in it or it might be a several components assembly.
Electric Line		Denotes a line carrying electrical power or signal.

Source: http://hydraulicspneumatics.com/other-technologies/chapter-4-iso-symbols

ISO Designation	Symbol	Picture Representation
Flexible Line		Shows hose or other flexible line. Could be whole length or only a portion of the conduit.
Pipe Junction		Denotes a tee or cross where lines connect to one another. The connecting Dot is always used with the Jumper below. Preferred way.
Pipe Junction		Denotes pipes connecting at a tee or cross Optional way.
		Denotes pipes crossing. Preferred way
Pipes Crossing		Denotes pipes crossing. Optional way
Plug		
Air Bleed		Shows a connection for bleeding trapped air
Pressure Takeoff		A connection for taking power from a line or for pressure testing. Shown plugged.
		With takeoff line connected .
Energy Triangle	 Pneumatic Hydraulic	Shows direction of flow and type of fluid.
Power Source	 General Pneumatic Hydraulic	Denotes a power source from another part of the schematic or a another source
Arrows		Indicates direction of rotation of a pump or motor shaft, valve actuator or other actuator.
		Indicates direction of movement of a component.
		Arrows used for flow direction in valves. Arrows with a perpendicular line opposite the arrow head Arrows with a perpendicular line at the head end indicates the path stays connected to its outlet when it moves
Sloping Arrow		A sloping arrow through a pump, valve, spring, cushion plunger, solenoid or other device indicates it is adjustable or variable.

Source: http://hydraulicspneumatics.com/other-technologies/chapter-4-iso-symbols

ISO STANDARD SYMBOL OF COMPONENTS IN PNEUMATIC SYSTEM…cont

Symbol for Supply & Service Equipment

Supply

- Compressor with fixed capacity
- Air reservoir with T junction
- Pressure source

Service equipment

- Filter — Separation and filtration of particles
- Water separator, — Manually operated
- Water separator, automatic
- Lubricator — Metered quantities of oil passed to the air stream
- Pressure regulator — Relieving type - vent hole for excess upstream pressure - adjustable

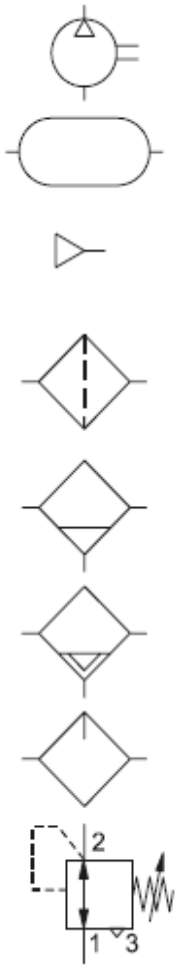
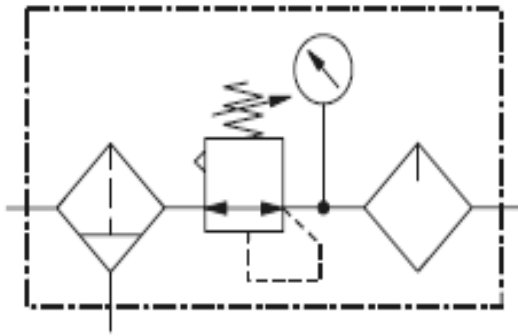


Fig. 3.1
Symbols used in energy conversion and preparation

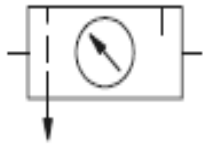
an example of two-piece service unit: filter-regulator and lubricator, three-piece service unit: filter, pressure reducing valve and lubricator.

Combined symbols

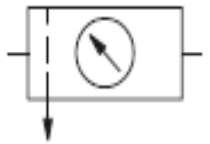
- Air service unit — Filter, Regulator, Gauge, Lubricator



Simplified air service unit



Simplified air service unit without lubricator

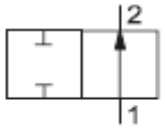


ISO STANDARD SYMBOL OF COMPONENTS IN PNEUMATIC SYSTEM…cont

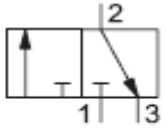
Symbol for Directional Control Valve (DCV)

Number of ports
Number of positions

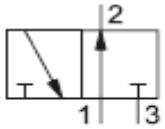
2/2 – Way directional control valve, normally open



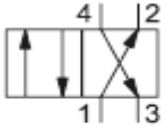
3/2 – Way directional control valve, normally closed



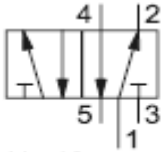
3/2 – Way directional control valve, normally open



4/2 – Way directional control valve
Flow from 1 → 2 and from 4 → 3



5/2 – Way directional control valve
Flow from 1 → 2 and von 4 → 5



5/3 – Way directional control valve
Mid position closed

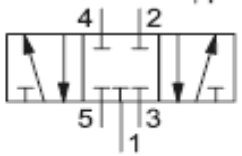


Fig. 3.3
Directional control valves: ports and positions (ways)

A numbering system is used to designate directional control valves and is in accordance with DIN ISO 5599-3. Prior to this a lettering system was utilised and both systems of designation are presented here:

Working lines

ISO 5599-3	Lettering System	Port or Connection
1	P	Pressure port
2, 4	A, B	Working lines
3, 5	R, S	Exhaust ports

Pilot lines

10	Z	Applied signal inhibits flow from port 1 to port 2
12	Y, Z	Applied signal connects port 1 to port 2
14	Z	Applied signal connects port 1 to port 4
81, 91	Pz	Auxiliary pilot air

ISO STANDARD SYMBOL OF COMPONENTS IN PNEUMATIC SYSTEM…cont

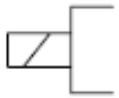
Symbol for Actuation Method

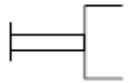
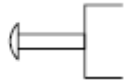
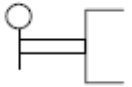
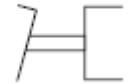
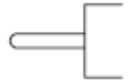
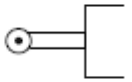
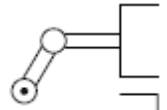
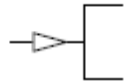
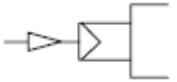
The methods of actuation of pneumatic directional control valves is dependent upon the requirements of the task. The types of actuation vary, e.g.

- manually actuated
- mechanically actuated
- pneumatically actuated
- electrical and
- combined actuation.

The symbols for the methods of actuation are detailed in DIN ISO 1219.

When applied to a directional control valve, consideration must be given to the method of initial actuation of the valve and also the method of return actuation. Normally these are two separate methods. They are both shown on the symbol either side of the position boxes. There may also be additional methods of actuation such as manual overrides, which are separately indicated.

Electrical	Single solenoid operation	
	Double solenoid operation	
Combined	Double solenoid and pilot operation with manual override	

Manual	General	
	Pushbutton	
	Lever Operated	
	Detend lever operated	
	Foot pedal	
Mechanical	Plunger	
	Roller operated	
	Idle return, roller	
	Spring return	
	Spring centred	
Pneumatic	Direct pneumatic actuation	
	Indirect pneumatic actuation (piloted)	

ISO STANDARD SYMBOL OF COMPONENTS IN PNEUMATIC SYSTEM…cont

Symbol for Non-return Valve

The non-return valve (check valve) is the basis for the development of many combined components. There are two main configurations for non-return valves, with and without the spring return. In order to release flow, the pressure force on the spring return design must be greater than the spring force.

Non-return valves and derivatives

Check valve

Spring-loaded check valve

Shuttle valve

Dual-pressure valve

Quick exhaust valve

Fig. 3.6
Non-return valves and derivatives

ISO STANDARD SYMBOL OF COMPONENTS IN PNEUMATIC SYSTEM…cont

Symbol for Flow Control Valve

Flow control valves

Most flow control valves are adjustable and permit flow control in both directions. The arrow shows that the component is adjustable but does not refer to the direction of flow; it is diagrammatic only. In the case of the one-way flow control valve, a non-return valve is switched in parallel with the flow control valve. Flow control is effected in one direction only.

Flow control valve, adjustable 

One-way flow control valve 

Fig 3.7
Flow control valves

ISO STANDARD SYMBOL OF COMPONENTS IN PNEUMATIC SYSTEM…cont

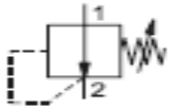
Symbol for Pressure Valve

Pressure valves The function of pressure valves, is to influence the pressure in an overall pneumatic system or in a part of the system. Pressure regulating valves are generally adjustable against spring compression. The symbols are distinguished according to the following types:

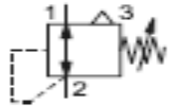
- Pressure regulating valve without relief port
- Pressure regulating valve with relief port
- Pressure sequence valves

Fig. 3.8 Pressure valves

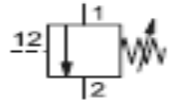
Adjustable pressure regulating valve, non – relieving type



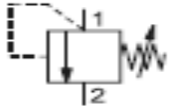
Adjustable pressure regulating valve,relieving type



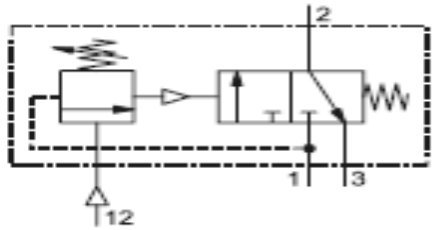
Sequence valve external source



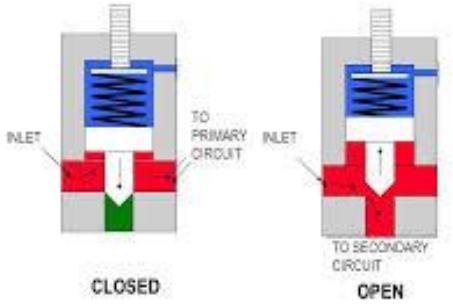
Sequence valve in – line



Sequence valve combination



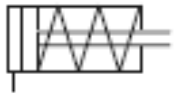
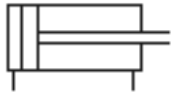
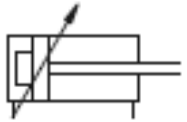
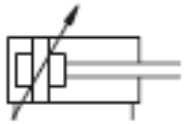
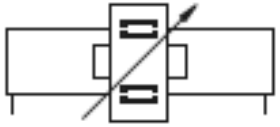
Pressure Sequence Valve



The symbols represent the pressure valve as a single position valve with a flow path that is either open or closed initially. In the case of the pressure regulator the flow is always open, whereas the pressure sequence valve is closed until the pressure reaches the limit value as set on the adjustable spring.

ISO STANDARD SYMBOL OF COMPONENTS IN PNEUMATIC SYSTEM...cont

Symbol for Linear Actuator

Single-acting cylinder	
Double-acting cylinder	
Double-acting cylinder with double ended piston rod	
Double-acting cylinder with non-adjustable cushioning in one direction	
Double-acting cylinder with single adjustable cushioning	
Double-acting cylinder with adjustable cushioning at both ends	
Linear drive with magnetic coupling	

The linear actuators or cylinders are described by their type of construction and method of operation.

The single-acting cylinder, the double-acting cylinder and the rodless cylinder form the basis for design variations. The use of cushioning to reduce loads on the end caps and mountings during deceleration of the piston is important for long-life and smooth operation. The cushioning piston is shown on the exhaust air side of the piston. The arrow indicates adjustable cushioning and not the direction of cushioned motion.

ISO STANDARD SYMBOL OF COMPONENTS IN PNEUMATIC SYSTEM…cont

Symbol for Rotary Actuator

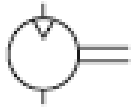
Rotary actuators

Rotary actuators are divided into continuous motion and limited angle of rotation.

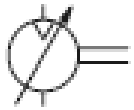
The air motor is normally a high speed device with either fixed or adjustable speed control. Units with limited angle of rotation are fixed or adjustable in angular displacement. The rotary actuator may be cushioned depending upon the load and speed of operation.

Fig. 3.10 Rotary motion

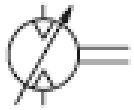
Air motor, rotation in one direction fixed capacity



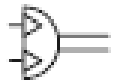
Air motor, rotation in one direction variable capacity



Air motor, rotation in both directions variable capacity



Rotary actuator



Pneumatic rotary actuators, like this rack-and-pinion model, are used in machine automation and material-handling applications, and for operating valves and brakes.

ISO STANDARD SYMBOL OF COMPONENTS IN PNEUMATIC SYSTEM…cont

Auxiliary Symbols

There are a number of important symbols for accessories which are utilised in conjunction with pneumatics.

Exhaust port without fixture for connection	
Exhaust port with threaded connection	
Silencer	
Line connection	
Crossing lines	
Pressure gauge	
Visual indicator	

AIR GENERATION& AIR DISTRIBUTION SYSTEM

The compressed air supply for a pneumatic system should be adequately calculated and made available in the appropriate quality.

Air is compressed by the air compressor and delivered to an air distribution system in the factory. To ensure the quality of the air is acceptable, air service equipment is utilised to prepare the air before being applied to the control system.

Malfunctions can be considerably reduced in the system if the compressed air is correctly prepared. A number of aspects must be considered in the preparation of the service air:

- Quantity of air required to meet the demands of the system
- Type of compressor to be used to produce the quantity required
- Pressure requirements
- Storage required
- Requirements for air cleanliness
- Acceptable humidity levels to reduce corrosion and sticky operation
- Lubrication requirements, if necessary
- Temperature of the air and effects on the system
- Line sizes and valve sizes to meet demand
- Material selection to meet environmental and system requirements
- Drainage points and exhaust outlets in the distribution system
- Layout of the distribution system to meet demand.

AIR GENERATION& AIR DISTRIBUTION SYSTEM…cont

As a rule pneumatic components are designed for a maximum operating pressure of 800-1000 kPa (8 - 10 bar) but in practice it is recommended to operate at between 500-600 kPa (5 and 6 bar) for economic use. Due to the pressure losses in the distribution system the compressor should deliver between 650-700 kPa (6.5 and 7) bar to attain these figures.

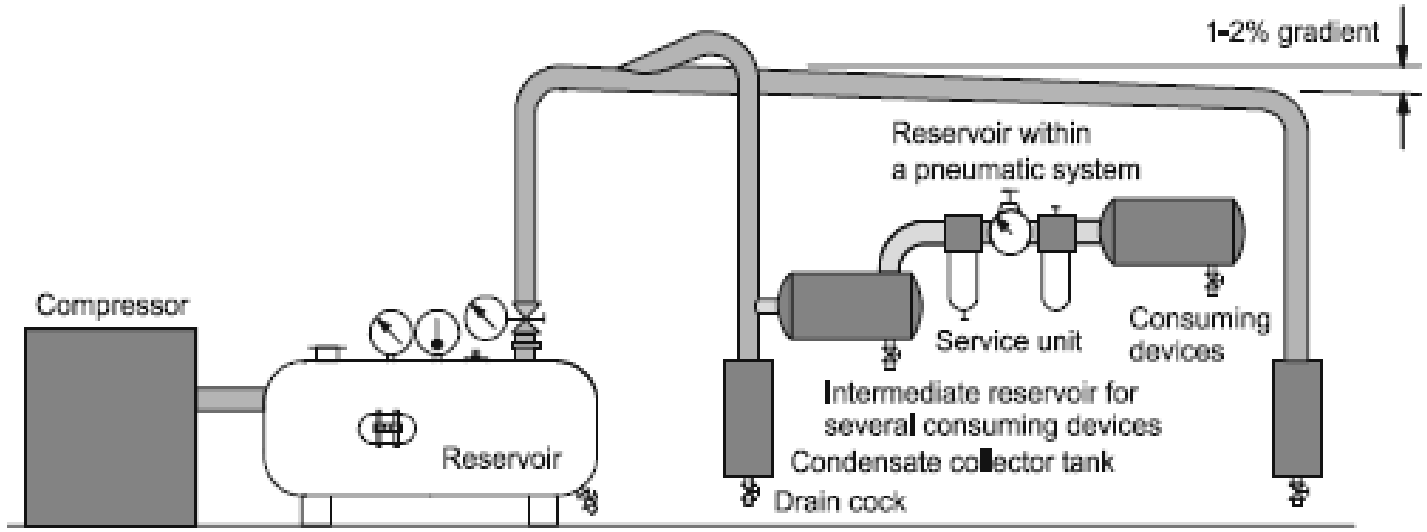
A reservoir should be fitted to reduce pressure fluctuations. In some cases, the term 'receiver' is also used to describe a reservoir.

The compressor fills the reservoir which is available as a storage tank.

The pipe diameter of the air distribution system should be selected in such a way that the pressure loss from the pressurised reservoir to the consuming device ideally does not exceed approx. 10 kPa (0.1 bar). The selection of the pipe diameter is governed by:

- Flow rate
- Line length
- Permissible pressure loss
- Operating pressure
- Number of flow control points in the line

AIR GENERATION& AIR DISTRIBUTION SYSTEM…cont



a) AIR COMPRESSOR

- collect air and compressed it to certain pressure. For example reciprocating compressor and rotary compressor.

b) AIR RECEIVER

- Collect compressed and dry air before deliver to system. Air receiver also known as air tank. It is also can control the pressure by **pressure relief valve.**

c) CONDENSSATE COLLECTOR TANK

- Dry compressed air from water vapor before the dry air are delivered to the system. It avoids the pneumatic system from rust. For example absorption dryer and adsorption dryer.

d) SERVICE UNIT

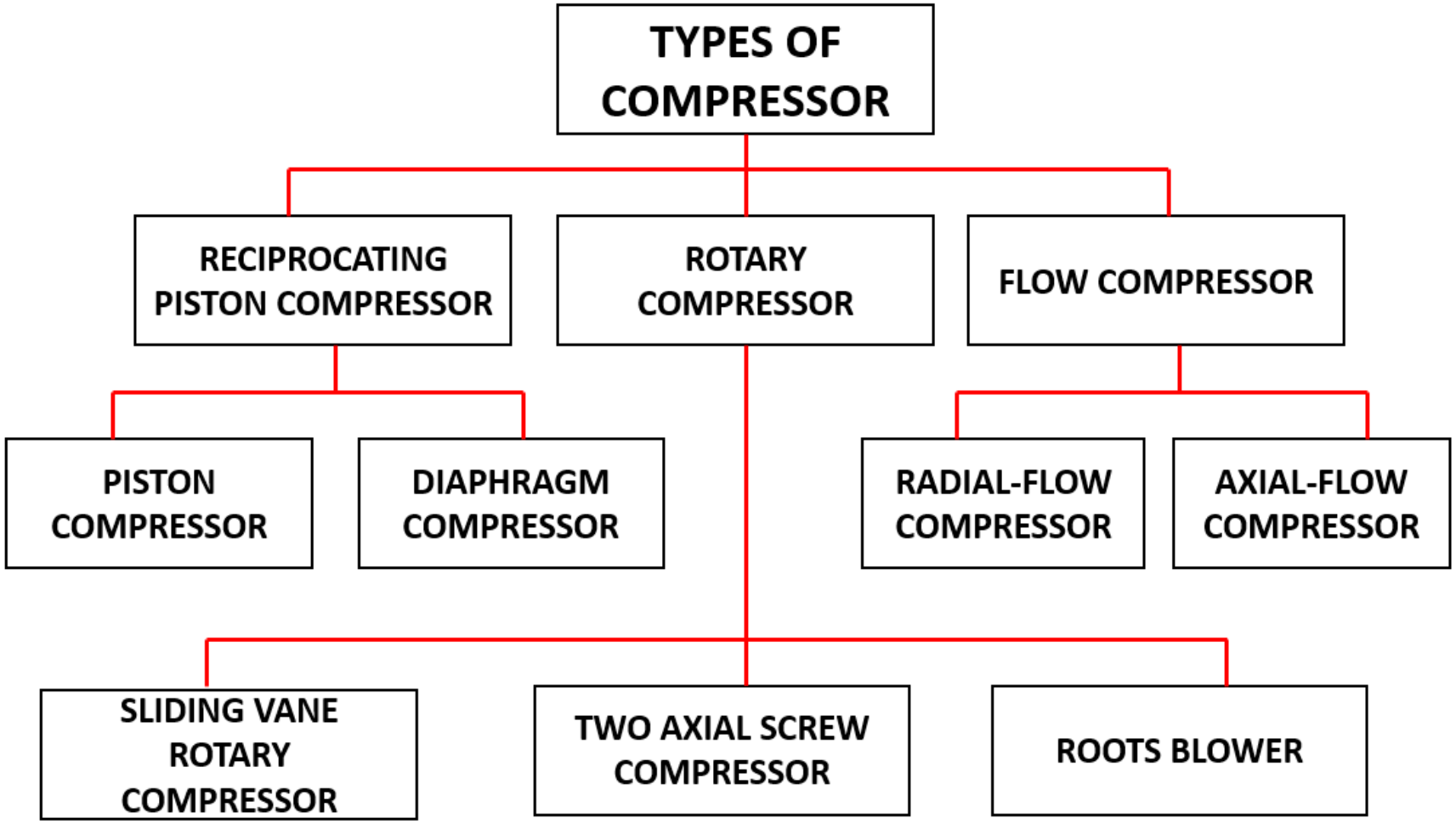
- Service unit consist of three components which are pressure regulator, pressure gauge and lubricant. It functions to control the pressure and lubricates air before work to system.

e) CONSUMING DEVICES

- It is the last component in this system. It is also known as a driver for the machine.

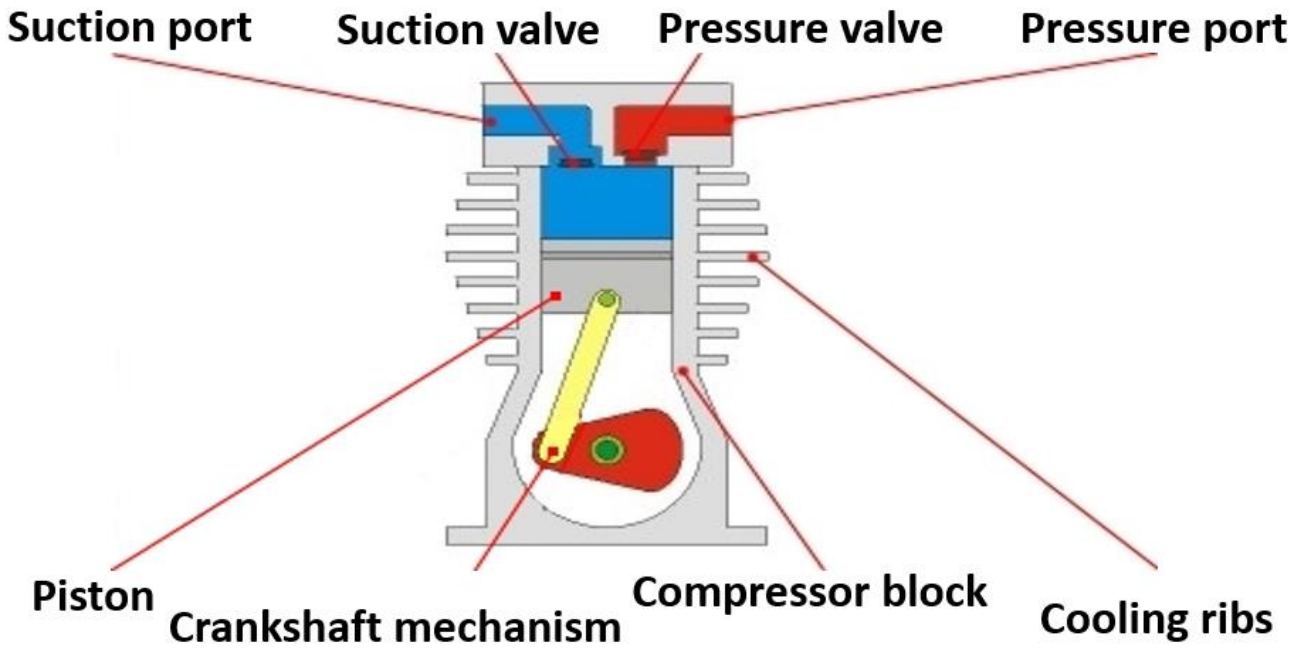
COMPRESSOR

TYPES OF AIR COMPRESSORS



a) Reciprocal Compressor

i. One level piston compressor



Continue……

- The device, that generates compressed air in a pneumatic system is the **compressor. The compressor converts mechanical energy to pneumatic energy of the compressed air.** There are various types of compressors, depending on their construction. The most frequently used compressors are **piston compressors**. They are suitable for pneumatic systems, where **low, middle or high values of air pressure** is needed.

Continue……

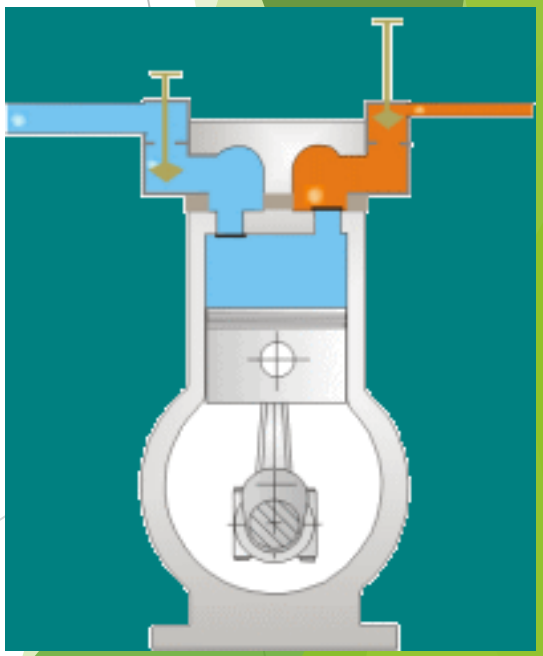
Mode of Operation

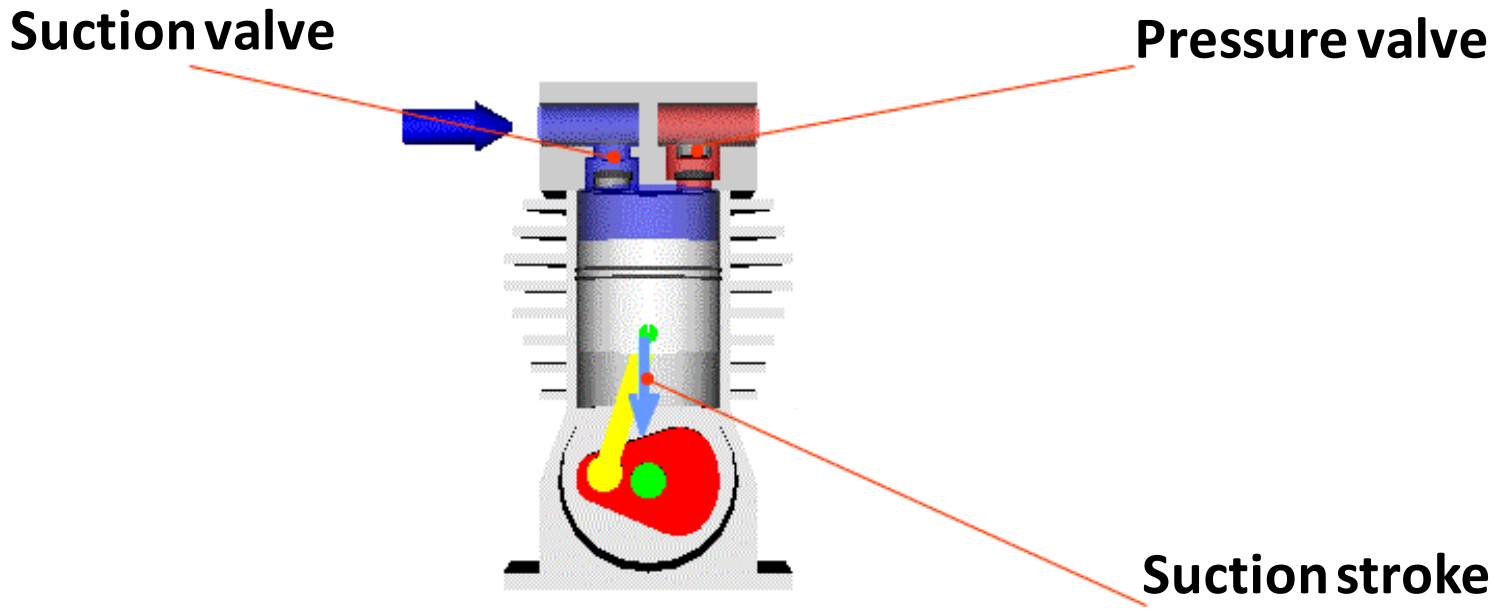
One of the main parts that convert mechanical to pneumatic energy in piston compressors is the **piston**.

The piston performs linear reversible motion in the compressor **cylinder**. This is achieved by converting the rotary motion of a **drive shaft** by a counter-balanced **crankshaft**, to which the piston is mechanically connected.

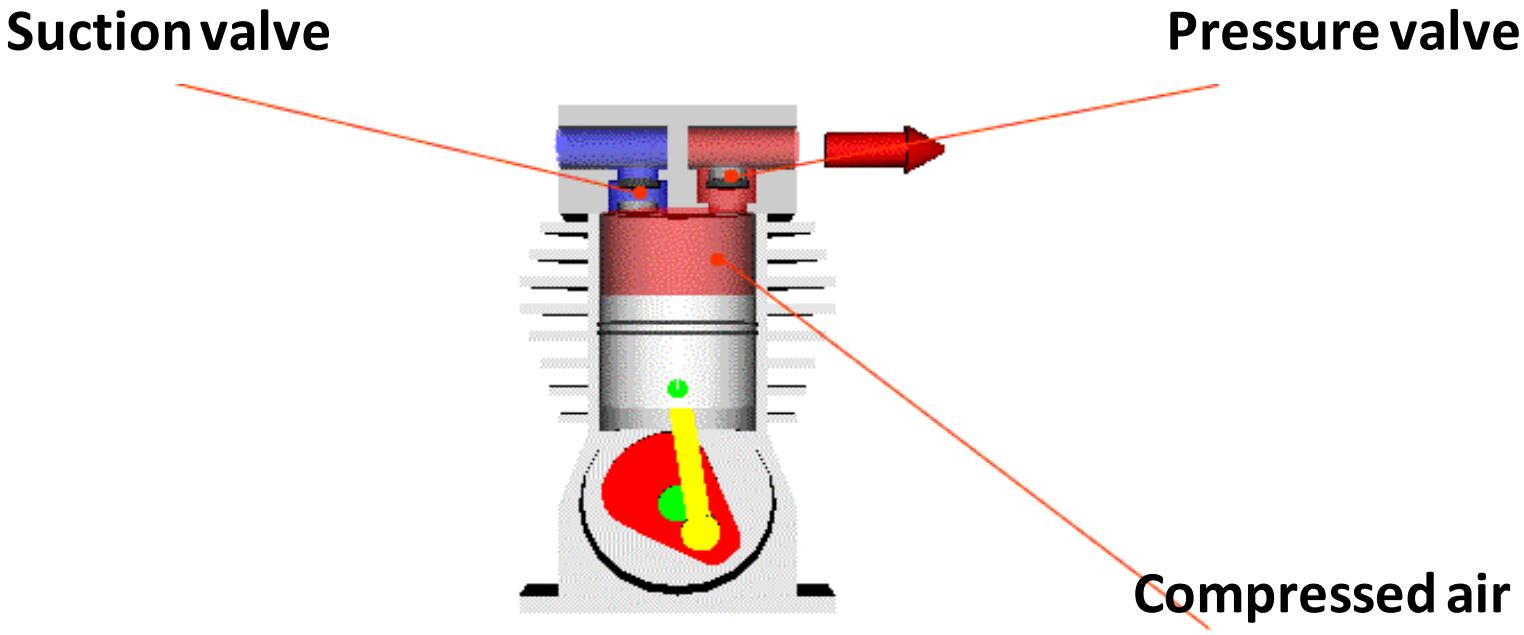
The drive shaft of the compressor is normally powered by an electrical motor, which is the source of mechanical energy.

A specific construction characteristic in piston compressors is the fact, that the **suction port** and the **pressure port** are physically disconnected by the respective suction or pressure valves.





The top-most position, which the piston may reach in the cylinder is called the top dead center **(TDC)**. Similarly, the lower-most position is called the bottom dead center **(BDC)**. When the piston moves from the top dead center **(TDC)** to the bottom dead center **(BDC)** the **pressure valve** is closed. The atmospheric air flows through the inlet **suction valve** into the piston area. This motion of the piston is called the **suction stroke**.



When the piston moves from the bottom dead center **(BDC)** to the top dead center **(TDC)**, the **suction valve** closes. The air trapped in the cylinder volume is compressed by the piston. The compressed air opens the outlet **pressure valve** and flows in the subsequent component of the pneumatic power supply. This motion of the piston is called the **compressing motion**.

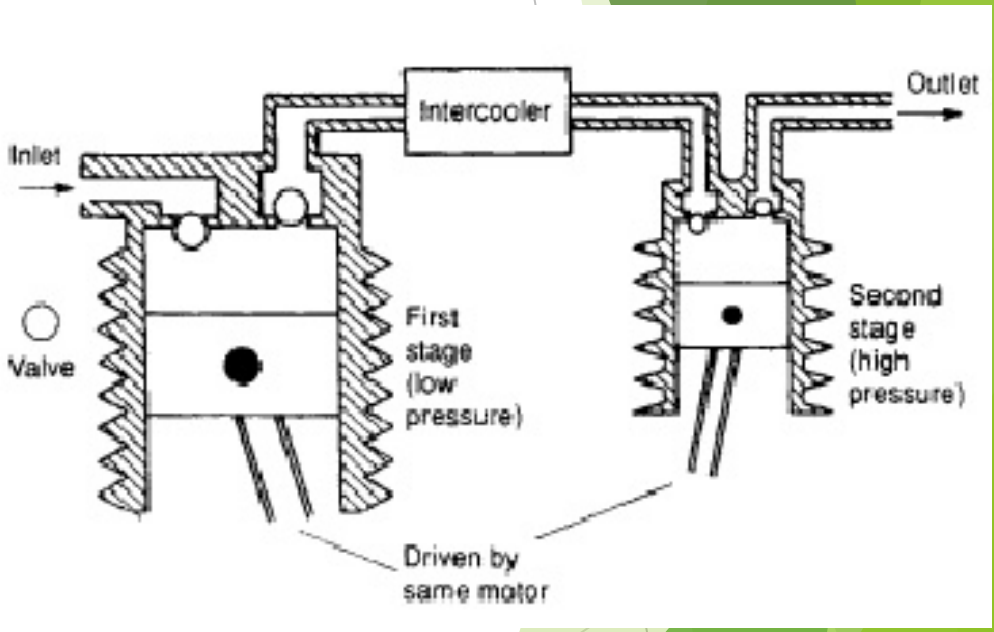
a) Reciprocal Compressor

ii. Two level piston compressor

Normally two stages are used for pneumatic pressures of 10 to 15bar, but multistage compressors are available for pressures up to around 50bar.

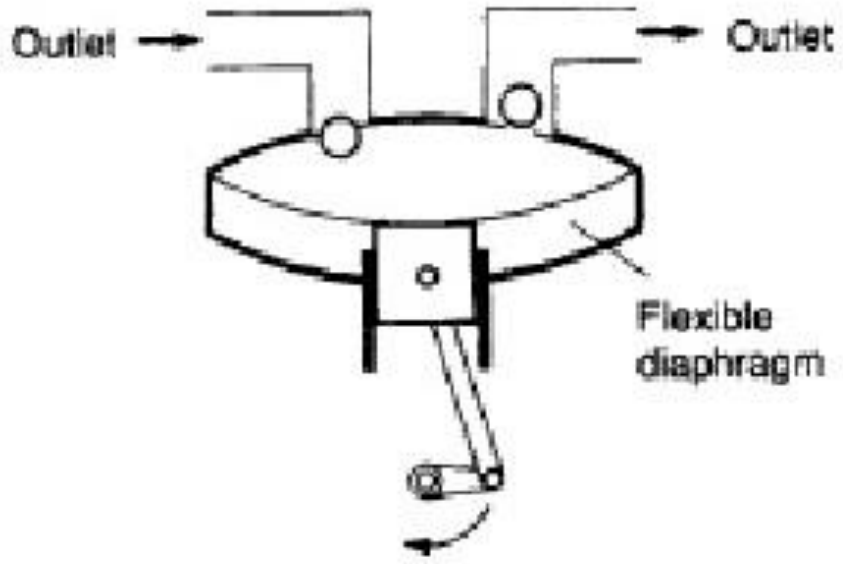
Multistage compressors can be manufactured with multi cylinders as shown in Fig or, more compactly, with a single cylinder and a double diameter piston as shown in Fig There is contact between pistons and air, in standard piston compressors, which may introduce small amounts of lubrication oil from the piston walls into the air.

This very small contamination may be undesirable in food and chemical industries.



a) Reciprocal Compressor

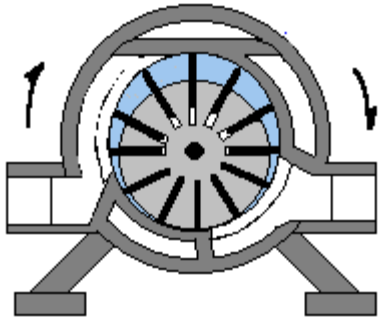
iii. Diaphragm compressor

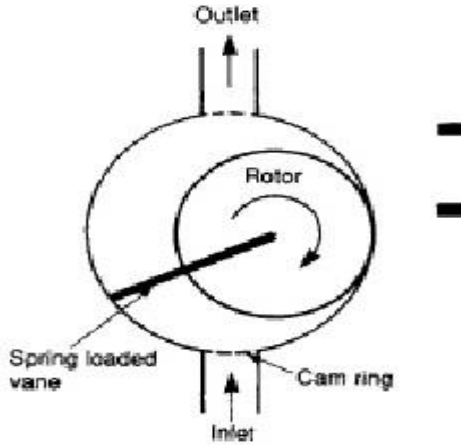


- the compressor chamber is separated from the piston by a diaphragm.
- the advantage of this is that no oil can enter into the air flow from the compressor.

b) Rotation Compressors

i. Sliding vane compressor



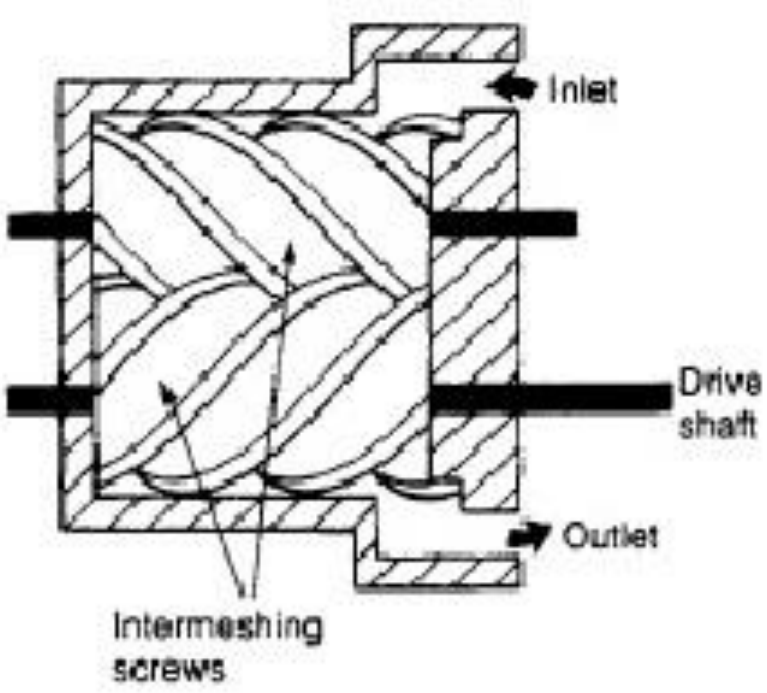


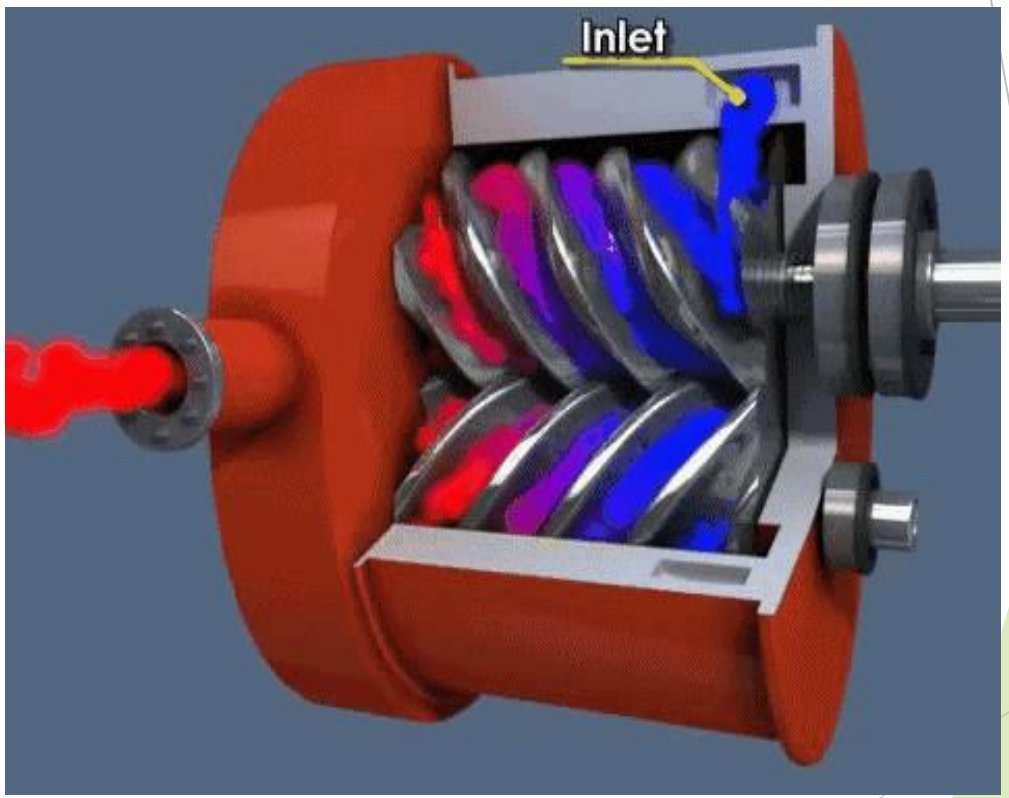
Continue……

- The vane compressor operates on similar principles to the hydraulic vane pump described, although air compressors tend to be physically larger than hydraulic pumps.
- Vanes can be forced out by springs or, more commonly, by centrifugal force.
- A single stage vane compressor can deliver air at up to 3 bar, a much lower pressure than that available with a screw or piston compressor.
- A two-stage vane compressor with large low pressure and smaller high pressure sections linked by an intercooler allows pressures up to 10 bar to be obtained

b) Rotation Compressors

ii. Screw compressor





Continue……

- For these applications, rotary compressors have the advantage of simplicity, with fewer moving parts rotating at a constant speed, and a steady delivery of air without pressure pulses.

- One rotary compressor, known as the dry rotary screw compressor, is shown in Fig and consists of two intermeshing rotating screws with minimal (around 0.05 mm) clearance.

- As the screws rotate, air is drawn into the housing, trapped between the screws and carried along to the discharge port, where it is delivered in a constant pulse-free stream.

Continue……

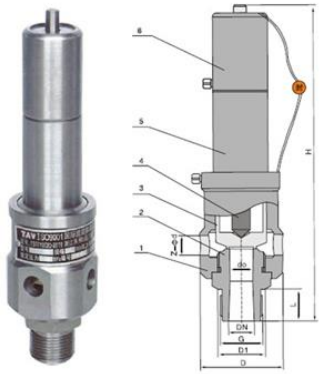
- Screws in this compressor can be synchronized by external timing gears. Alternatively one screw can be driven, the second screw rotated by contact with the drive screw.
- This approach requires oil lubrication to be sprayed into the inlet air to reduce friction between screws, and is consequently known as a wet rotary screw compressor.
- Wet screw construction though, obviously introduces oil contamination into the air which has to be removed by later oil separation units

COMPRESSOR'S ACCESSORIES

a . Air tube - The right compressed air tubing for your specific system is integral to the optimal efficiency of your air compressor. Depend on size, wall thickness, working pressure, temperature range, length and price.

b . Input strainer - the strainer prevents dirt from passing into the compressor

c . Pressure-relief valve - The relief valve is designed or set to open at a predetermined set pressure to protect pressure vessels and other equipment from being subjected to pressures that exceed their design limits



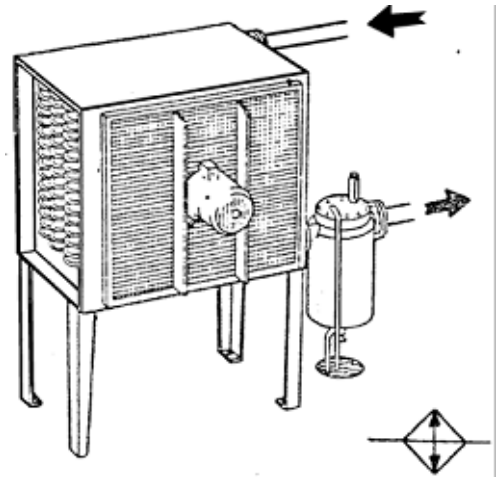
AIR DEHYDRATION

Air Dehydration process is to decrease the temperature and dry the air after compression process. Air dehydration process has 2 types which are continuous cooler and air dryer.

a. Continuous cooler

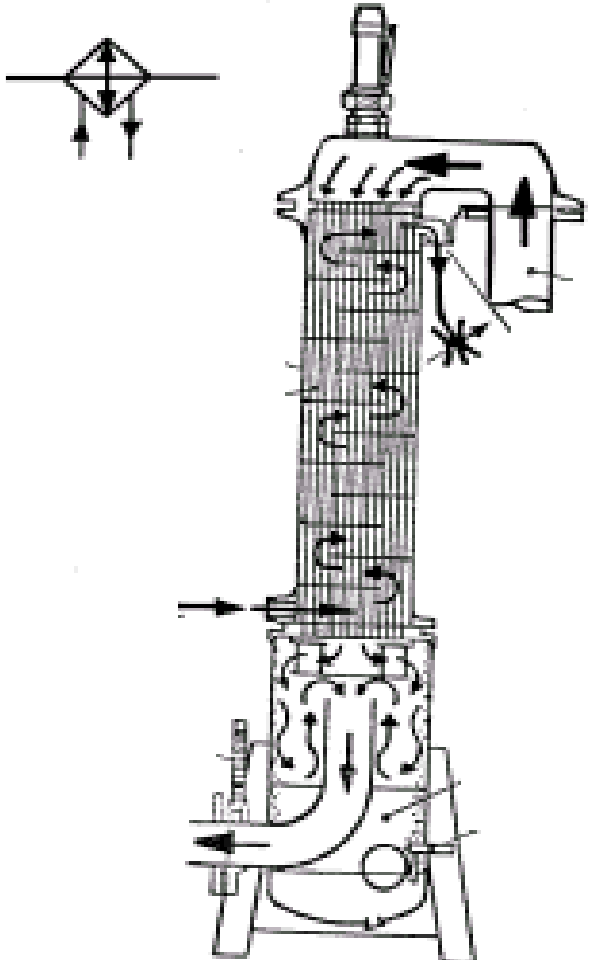
Cooler is a device which brings down the temperature of the compressed air in pneumatic systems. This is needed for the normal operation of pneumatic systems

i . Air cool



AIR DEHYDRATION…cont

ii . Water cool



AIR DEHYDRATION…cont

b. Air dryer

i. Absorbance drying

Absorption: A solid or liquid substance bonds a gaseous substance.

Absorption drying is a purely chemical process. Absorption drying is not of major significance in present-day practice, since the operating costs are too high and the efficiency too low for most applications.

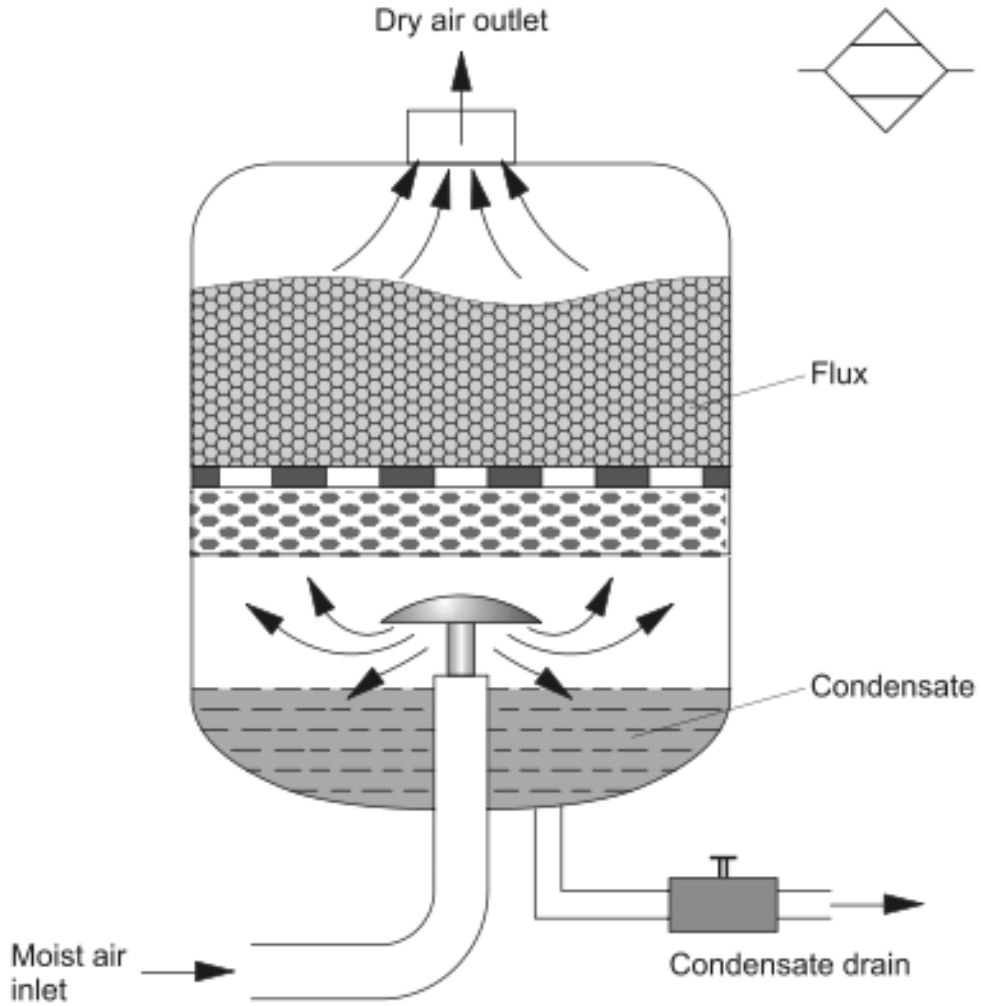
Oil vapour and oil particles are also separated in the absorption dryer. The moisture in the compressed air forms a compound with the drying agent in the tank. This causes the drying agent to break down; it is then discharged in the form of a fluid at the base of the tank.

The mixture must be regularly drained and the fluxing agent must be regularly replaced.

The features of the absorption process are :

- Simple installation of the equipment
- Low mechanical wear because there are no moving parts in the dryer
- No external energy requirements.

The chemical are commonly use in absorption drying is urea, lithium and calcium chloride.



AIR DEHYDRATION…cont

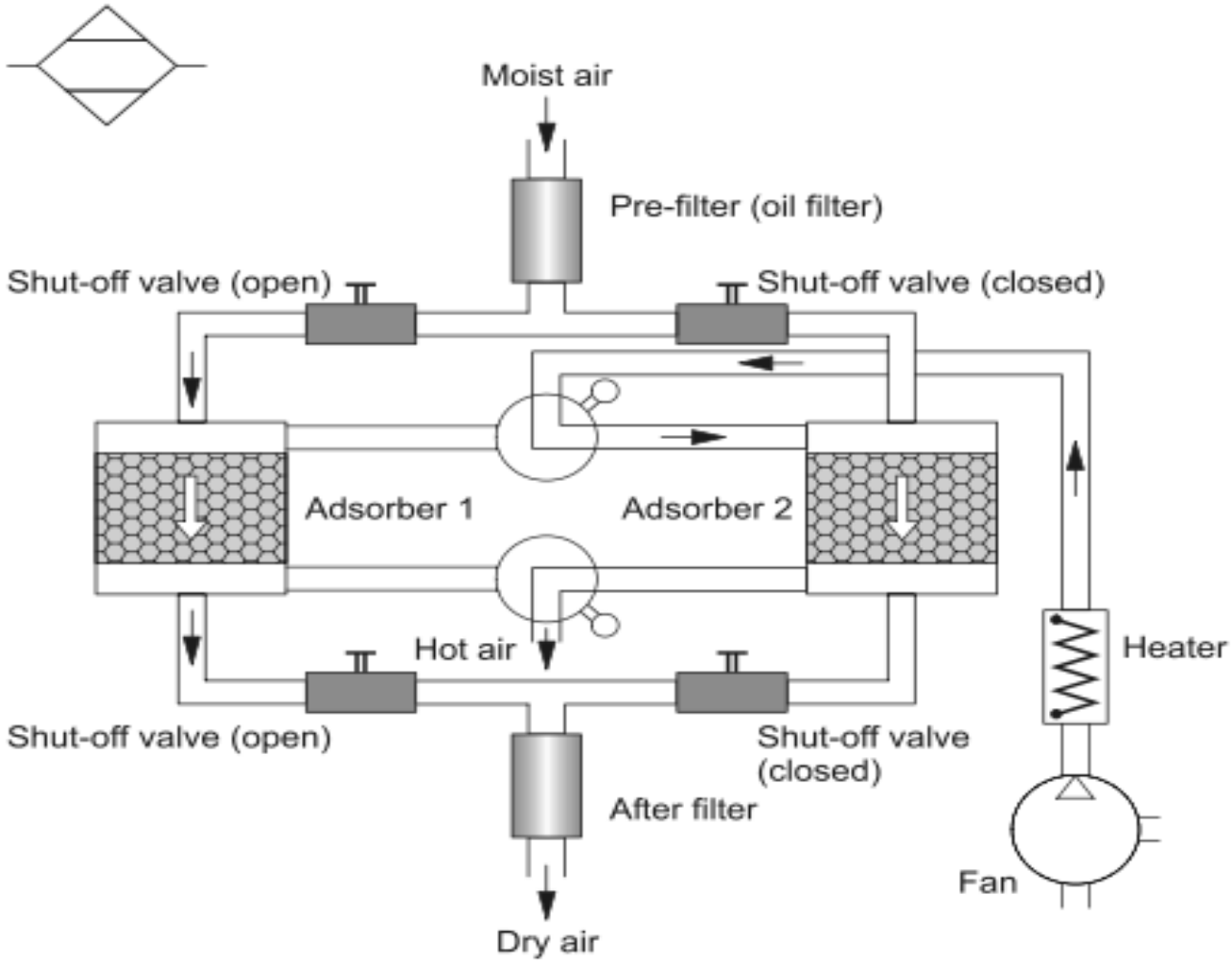
ii. Adsorption drying

Adsorption: water is deposited on the surface of solids.

The drying agent is a granular material (gel) consisting almost entirely of silicon dioxide.

Usually two tanks are used. When the gel in one tank is saturated, the air flow is switched to the dry, second tank and the first tank is regenerated by hot-air drying.

The lowest equivalent dew points (down to – 90 °C) can be achieved by means of adsorption drying.



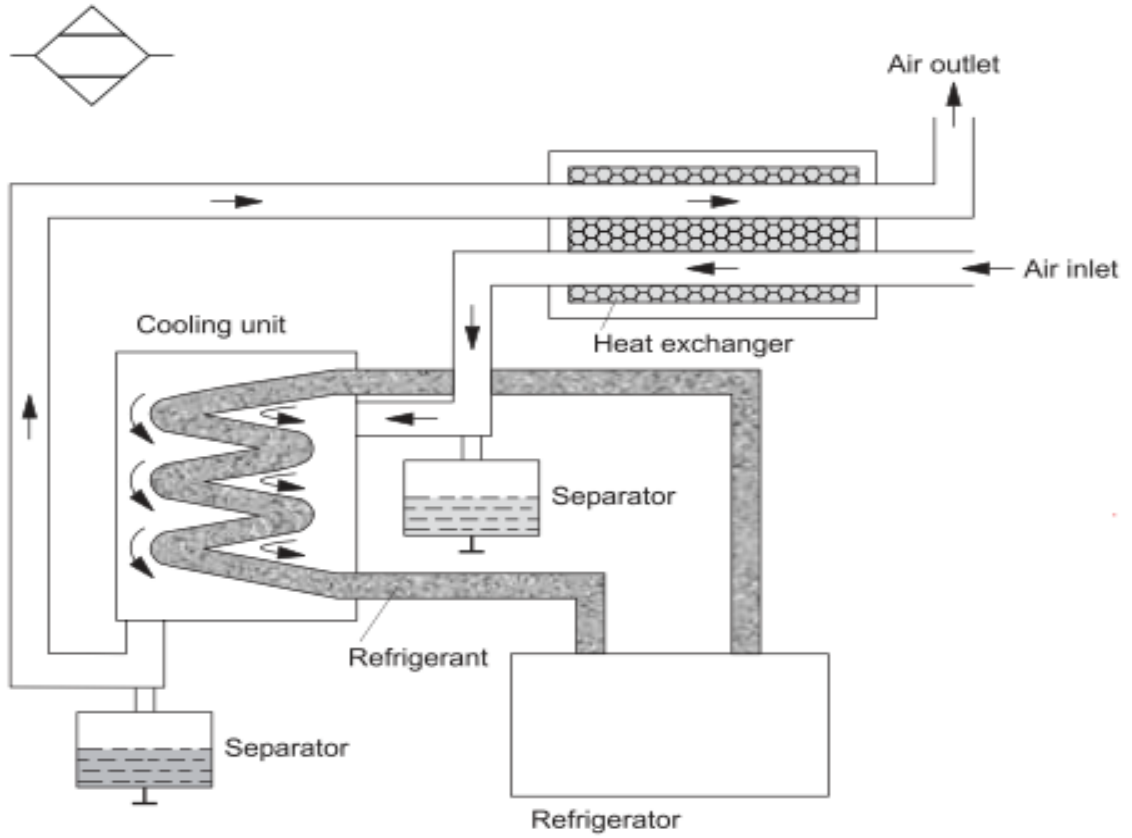
AIR DEHYDRATION…cont

iii. Coolant drying

The most common type of dryer today is the refrigeration dryer. With refrigerated drying, the compressed air is passed through a heat-exchanger system through which a refrigerant flows. The aim is to reduce the temperature of the air to a dew point which ensures that the water in the air condenses and drops out in the quantity required.

The air entering into the refrigeration dryer is pre-cooled in a heat exchanger by the escaping cold air. It is then cooled in the cooling unit to temperatures between + 2 and + 5 °C. The dried compressed air is filtered. Before the compressed air is output into the network, the air is heated to bring the air back to ambient conditions.

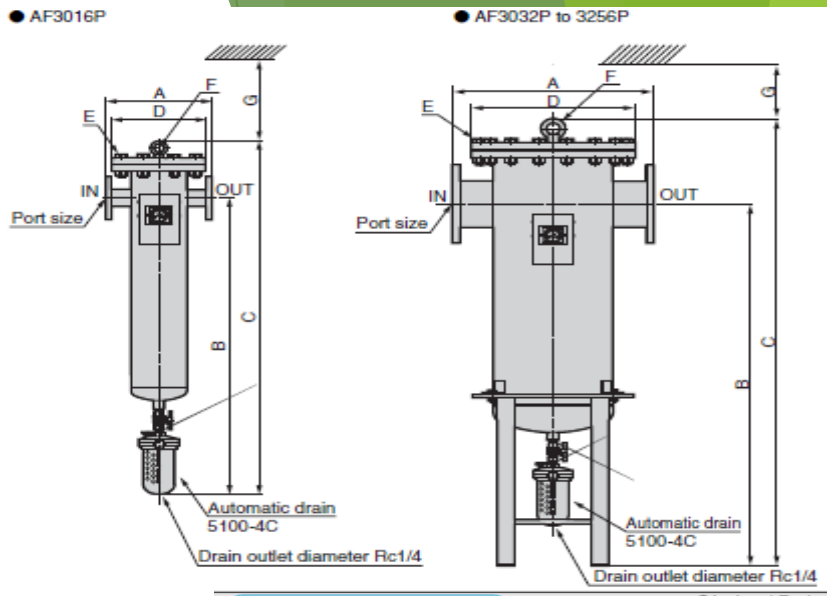
Using refrigeration methods, it is possible to achieve dew points of between + 2 and + 5 °C.



AIR DEHYDRATION…cont

iv. Mail line filter

Main-line compressed air filters are large, high-flow air filters used on the main lines of compressed air systems. Main-line air filters are often placed inside the compressor room and are used to protect the compressor room components as well as the components downstream in the compressed air system. Particulate pre-filters and coalescing filters are used to remove contaminants and hydrocarbons from the compressed air before it enters the dryer. After-filters are used at the exit of the dryer.



STAGE 1 1/2" Main Line 80 CFM
5 Micron

Asturo
SA5 80 CFM Main Line Filter Multiple Outlet
part #: DEV-HAR602

- One regulator with 160 lb inverted gauge and air cock.
- Two regulated outlet with 200 lb gauge.
- Air inlet 1/2" N.P.T
- .Shipping weight: 9 lbs.
- Filter capacity: 80 cfm

Main line unit

●Index / P. 1
●Series variation / P. 6

Main line unit

Air filter

Page P.153 -

■ Medium main line filter NEW

Series	Treating air flow rate	Features	Page
Popular type			
AF2000P	3.7 to 25.8m³/min. (ANR)	Oil removing filter	168
AF2000M		High performance oil removing filter	
AF2000X		Deodorization (activated charcoal) filter	
Oil free			
AF4000P	3.7 to 18.8m³/min. (ANR)	Pre-filter stainless steel vessel provided	178
AF4000S		Solid removing filter stainless steel vessel provided	
AF4000M		High performance oil removing filter, stainless steel vessel provided	
AF4000X		Deodorization (activated charcoal) filter, stainless steel vessel provided	

Assignment:

1. Explain on air treatment caused by:
    a. Allergen
    b. Oil
    c. Moisture

2. Explain on the function principals:
    a. Standard filter
    b. Micro filter
    c. Sub-micro filter

3. Explain on the function principals:
    a. Pressure regulator
    b. Filter-regulator (FR) unit
    c. Air lubricator
    d. Filter-regulator-lubricant unit (FRL)

*Please include pictures/sketching
*Hand writing