

Lecture 36

CONDITIONING AND DISTRIBUTION OF COMPRESSED AIR.

Learning Objectives

Upon completion of this chapter, Student should be able to

- ✚ Explain the importance of fluid conditioners
- ✚ List the major functions of filter and selection criteria
- ✚ List application of the seven qualities of air as per ISO
- ✚ Describe the function of various types of air regulators
- ✚ List the function of FRL unit
- ✚ Explain the various compressed air net work system
- ✚ List the factors to be considered in selection of components for pneumatic network
- ✚ Size the pipe diameter, pressure drop for a given pneumatic network

1.1 FLUID CONDITIONERS

Operating instructions issued for pneumatic components almost always contain a note recommending the installation of an air filter, pressure regulator and lubricator upstream of the component. This is to ensure that only air which has been suitably conditioned will reach the consumer.

Air filter, pressure regulator and lubricator are now built as packaged combination known as service units. Other than the impurities that might be entrained with the intake air and delivered by the compressor air might pick up contaminants such as dust, scale or rust particles in the distribution main leading to the take-off point. Provided that air main has been properly installed, the major part of these impurities will collect in the condensate drain tanks. Minute particles remain suspended in the air stream however and would damage the working parts of pneumatic components by their abrasive action were they are removed beforehand. Furthermore the air flow in the main pulsated, due, for one thing, to the compressor running intermittently as controlled by

pressure in air receiver. The consumer, on the other hand, need to work with a uniform air pressure. Finally, lubrication is required for the moving parts of the pneumatic equipment.

The atmospheric air that is compressed in the compressor is obviously not clean because the atmospheric air contains many contaminants like dirt , smoke water vapour etc. this contaminated air lead to excessive wear and failure of pneumatic components. Therefore fluid conditioners are used to supply clean dry and contamination free compressed air.

The purpose of the fluid conditioners is to make the compressed air more acceptable and suitable fluid medium for the pneumatic system as well as the operating personal. The following five fluid conditioners are used in pneumatic systems

1. Air Filters
2. Air Regulators
3. Air Lubricator

4.1.1 AIR FILTERS

The purpose of the air filter is to clean the compressed air of all impurities and any condensate it contains.

a) Function of air filters

- To remove all foreign matter and allow dry and clean air flow without restriction to regulator and then to the lubricator
- To condensate and remove water from the air
- To arrest fine particles and all solid contaminants from air

Filters are available in wide range starting from a fine mesh wire cloth (which strains heavy foreign particles) to elements made of synthetic material (which removes very small particles)

Usually in line filter elements can remove contaminants in the 5-50 micron range.

b) Source of contamination.

Contaminants in a compressed air system can generally be attributed to the following:

- ***The quality of air being drawn into the compressor:*** Air compressors draw in a large volume of air from the surrounding atmosphere containing large numbers of airborne contaminants.
- ***The type and operation of the air compressor:*** The air compressor itself can also add contamination, from wear particles to coolants and lubricants.
- ***Compressed air storage devices and distribution systems:*** The air receiver and system piping are designed to store and distribute the compressed air. As a consequence, they will also store the large amounts of contaminants drawn into the system.

Additionally, piping and air receivers will also cool the moist compressed air forming condensate which causes damage and corrosion.

c) Types of contamination in a compressed air system

- ***Atmospheric dirt:*** Atmospheric air in an industrial environment typically contains 140 million per m³ of dirt particles. 80% of these particles are less than 2 microns in size and are too small to be captured by the compressor intake filter, therefore passing directly into the compressed air system
- ***Water vapour, condensed water and water aerosols:*** Atmospheric air contains water vapour (water in a gaseous form). The ability of compressed air to hold water vapour is dependent upon its temperature. The higher the temperature, the more water vapour that can be held by the air. During compression, the air temperature is increased significantly, which allows it to easily retain the incoming moisture. After the compression stage, air is normally cooled to a usable temperature. This reduces the air's ability to retain water vapour, resulting in a proportion of the water vapour being condensed into liquid water which is removed by a condensate drain fitted to the compressor after-cooler. The air leaving the after-cooler is now 100% saturated with water vapour and any further cooling of the air will result in more water vapour condensing into liquid water. Condensation occurs at various stages throughout the

system as the air is cooled further by the air receiver, piping and the expansion of valves, cylinders, tools and machinery. The condensed water and water aerosols cause corrosion to the storage and distribution system, damage production equipment and the end product. It also reduces production efficiency and increases maintenance costs. Water in any form must be removed to enable the system to run correctly and efficiently.

- ***Rust and pipe scale:*** Rust and pipe scale can be found in air receivers and the piping of “wet systems” (systems without adequate purification equipment) or systems which were operated “wet” prior to purification being installed. Over time, this contamination breaks away to cause damage or blockage in production which can also contaminate final product and processes.
- ***Micro-organisms:*** Bacteria and viruses will also be drawn into the compressed air system through the compressor intake and warm, moist air provides an ideal environment for the growth of micro-organisms. If only a few micro-organisms were to enter a clean environment, a sterile process or production system, enormous damage could be caused that not only diminishes product quality, but may even render a product entirely unfit for use and subject to recall.
- ***Liquid oil and oil aerosols:*** Most air compressors use oil in the compression stage for sealing, lubrication and cooling. During operation, lubricating oil is carried over into the compressed air system as liquid oil and aerosols. This oil mixes with water vapour in the air and is often very acidic, causing damage to the compressed air storage and distribution system, production equipment and final product.
- ***Oil vapour:*** In addition to dirt and water vapour, atmospheric air also contains oil in the form of unburned hydrocarbons. The unburned hydrocarbons drawn into the compressor intake as well as vaporized oil from the compression stage of a lubricated compressor will carry over into a compressed air system where it can cool and condense, causing the same contamination issues as liquid oil.

d) Factor affecting selection of filters

While selecting the filters, the following factors should be taken into account.

- Size of particles to be filtered from the system
- Capacity of the filter
- Accessibility and maintainability
- Life of the filter
- Ability to drain the condensate

e) Construction

The construction of typical cartridge type filter along with graphical symbols is shown in Figure 1.1. It consists of filter cartridge, Deflector, bowl, water drain valve. Filter bowl is usually made of plastic and transparent. For pressure more than 10 bar, bowl may be made of brass.

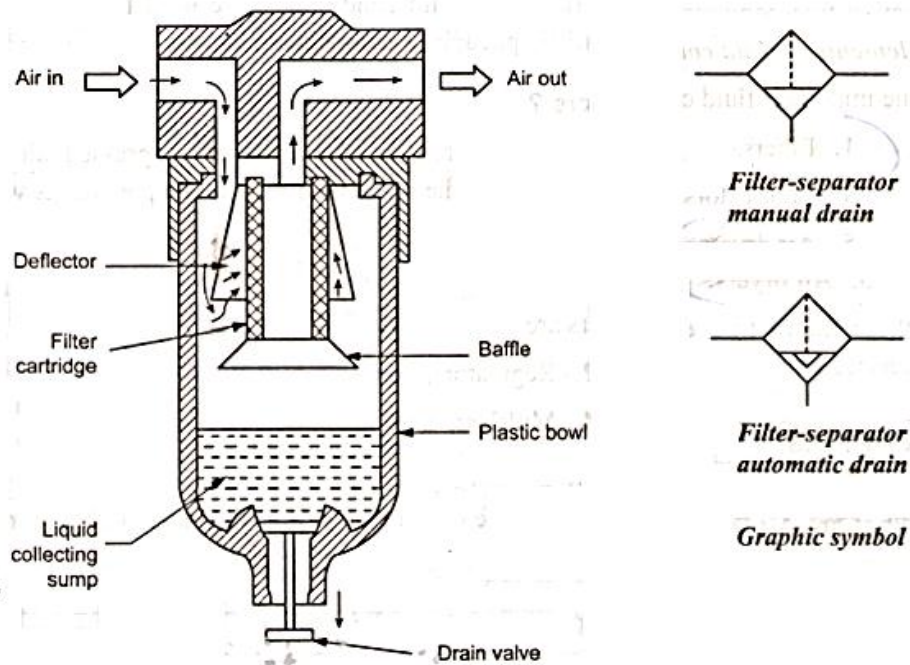


Figure 1.1 Construction of a Air filter.

f) Operation

Air enters the inlet port of the air filter through angled louvers. This causes the air to spin as it enters the bowl. The centrifugal action of the rotating air causes the larger pieces of dirt and water particles to be thrown against the inner wall of the filter bowl. These contaminants then flow down into the bottom of the filter bowl.

A baffle prevents turbulent air from splashing water on to the filter element. The air, which has been pre-cleaned in this way, then passes through the filter element, where the fine dirt particles are filtered out. The size of the dirt particles which can be filtered out depends on mesh size of filter element (usually 5-50 microns). The compressed air then exits through the outer port.

The pressure difference between inlet and outlet will indicate the degree to which the filter element is clogged. Commercially available filters have many additional features like automatic drain facility, coalescing type filter element, service life indicator etc.

g) Seven Quality levels of air required in production systems.

Figure 1.2 illustrates different levels of purity for various applications. Air from a compressor passes through an after cooler with an auto drain to remove condensate. As the air cools further in the air receiver more condensate is removed by an auto drain, installed on the bottom. Additional drains may be fitted to all low points on the pipeline. The system divides into three main parts:- Branches (1 and 2) provide air direct from the air receiver. Branches (3 – 6) use air conditioned by a refrigerated type of dryer. Branch 7 incorporates an additional dryer of the adsorption type. Standard filters in sub branches 1 and 2, equipped with auto drains remove condensate; sub-branch 2 being higher purity because of the micro filter. Sub branches 3 – 5, use refrigerated dry air, thus, branch 3 requires no auto drain, branch 4 needs no pre filtering and branch 5 gives an improved level of air purity using a micro filter and sub micro filter, the moisture having been removed by a refrigerated type of air dryer. Sub branch 6 incorporates an odour removal filter. An adsorption type dryer eliminates all risk of condensation at low temperatures in sub branch 7. Typical applications are listed in **Table 1.1**

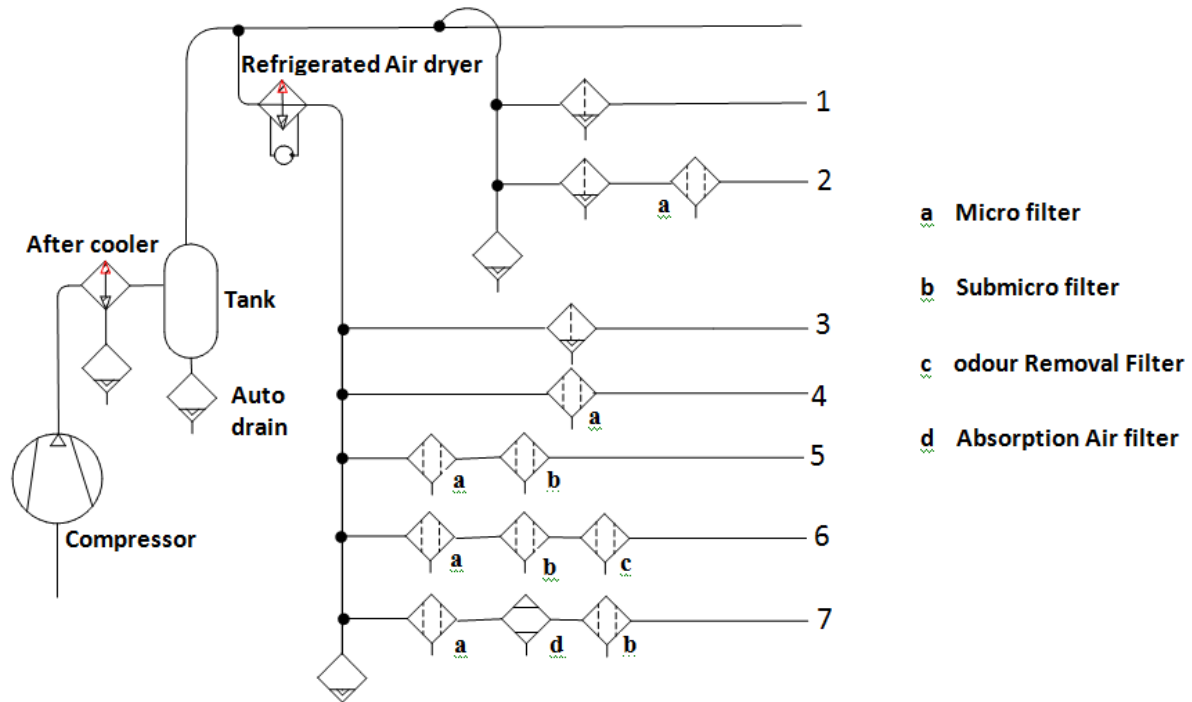


Figure 1.2 Schematic Definition of 7 Degrees of Filtration

Table 1.1 Definition and typical applications of the seven qualities of air.

No.	Removal of	Application	Typical examples
1	Dust particles > 5 micron Liquid oil to 99% Saturated humidity to 96%	Where some solid impurities humidify and oil can be accepted	Workshop air for clamping blowing and simple pneumatic drives
2	Dust particles > 0.3 micron Oil mist to 99.9% Saturated humidity to 99%	Where removal of dust and oil dominates, but a certain amount of condensation can be risked	General industrial equipment, pneumatic controls and drives, seamless metallic joints, air tools and air motors
3	Humidity to atmosphere dew point of -17°C	Where removal of humidity is imperative	Similar to (1) as the air is dry additional spray painting

	Dew point Saturated humidity to 99%	but traces of fine dust and oil are acceptable	
4	Dust particles > 0.3 micron Oil mist to 99.9% Humidity up to an atmospheric dew point of -17°C	Where no humidity, fine dust and oil vapour are acceptable	Process control, measuring equipment , high quality spray painting, cooling of foundry and injection moulding dies
5	Dust particles > 0.3 micron Oil mist to 99.9999% Humidity up to an atmospheric dew point of -17°C	Where pure air , practically free from any impurity is required	Pneumatic precision measuring devices, electrostatic spray painting, cleaning and drying of electronic assemblies
6	As in (5) with odour removal	Where absolutely pure air, as under (5) but odour free	Pharmacy , food industry for packaging , air transport, brewing and breathing air
7	All impurities as in (6) but with atmospheric dew point of greater than -30°C	Where risk of condensation during expansion and low temperature must be avoided,	Drying electronic components, storage of pharmaceuticals, marine measuring equipment, air transport of powder.

h) Main Line Filter

A large capacity filter should be installed after the air receiver to remove contamination, oil vapours from the compressor and water from the air. This filter must have a minimum pressure drop and the capability to remove oil vapour from the compressor in order to avoid emulsification with condensation in the line. It has no deflector, which requires a certain minimum pressure drop to function properly A built-in or an attached auto drain will ensure a regular discharge of accumulated water.

The filter is generally a quick change cartridge type. **Figure 1.3** shows schematic diagram of Main line filter.

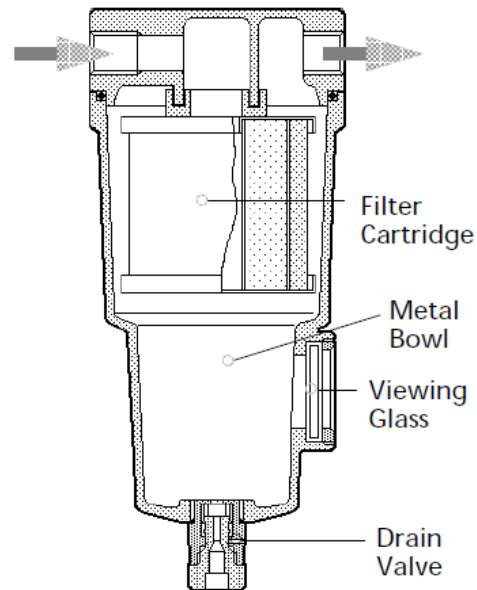


Figure 1.3 Typical main line filter

1.1.2 AIR REGULATOR

a) Function: The function of the air pressure regulator is to maintain working pressure virtually constant regardless of fluctuations of the line pressure and air consumption. When the pressure is too low, it results in poor efficiencies and when the pressure is too high, energy is wasted and equipment's performance decay faster.

In pneumatic system, pressure fluctuations occur due to variation in supply pressure or load pressure. It is therefore essential to regulate the pressure to match the requirement of load regardless of variation in supply pressure or load pressure.

b) Where to regulate

Generally pressure is regulated in pneumatic system at two places.

- At the receiver tank
- In the load circuits

Pressure regulation at the receiver tank is required as a safety measure for the system. In the load circuits, pressure regulator is used to regulate the pressure for downstream components such as valves and actuators.

c) Types of Pressure regulator

There are two types of Pressure regulators

- i) Diaphragm type regulator
- ii) Piston type regulator

Diaphragm type regulator is commonly used in Industrial pneumatic system. There are two types of diaphragm type regulator

- i) Non-relieving or non-venting type.
- ii) Relieving or venting type

Relieving or venting type is commonly used and is explained below.

1.1.2.1 Relieving or Venting Type Pressure regulator

A Relieving type pressure regulator is shown in **Figure 1.4**, Outlet pressure is sensed by a diaphragm preloaded with an adjustable pressure setting spring. The compressed air, which flows through a controlled cross section at the valve seat, acts on the other side of the diaphragm. The diaphragm has a large surface area exposed to secondary (outlet) pressure and is quite sensitive to its fluctuations. The movement of the diaphragm regulates the pressure.

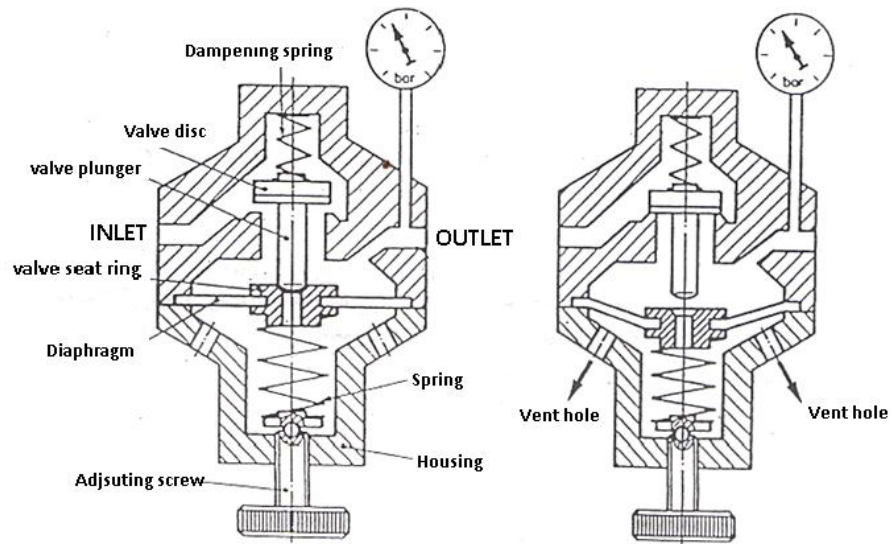


Figure 1.4 venting type pressure regulator

If the outlet pressure is low: whenever the more compressed air is consumed on secondary side or load side, then load pressure reduces. Therefore less force acts on diaphragm. The opposing higher spring force pushes the diaphragm in such a way as to move the valve disc more and permitting more air to flow to secondary side and thus increasing the pressure again.

If the outlet pressure is high: whenever the less compressed air is consumed on secondary side or load side, then load pressure increases. Therefore more force acts on diaphragm. The opposing higher spring force pulls down the diaphragm in such a way as to move the valve disc less and permitting air to flow to vent hole and thus decreasing the pressure again

1.1.2.2 Non-Relieving or Non-Venting Type Pressure regulator

In this case compressed air cannot escape to the atmosphere in the event of high backpressure acting on the diaphragm, as there is no exit path provided in the diaphragm for the trapped air.

Figure 1.5 shows the non-relieving venting type pressure regulator.

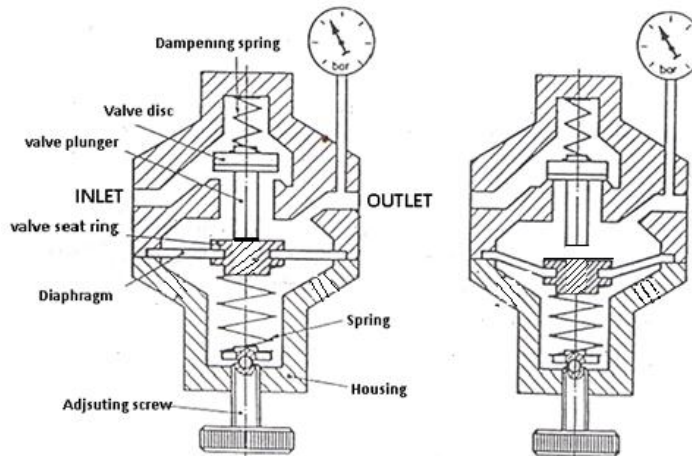


Figure 1.5 Non-venting type pressure regulators

1.1.3 AIR LUBRICATOR

Function: The function of air lubricator is to add a controlled amount of oil with air to ensure proper lubrication of internal moving parts of pneumatic components. Lubricants are used to

- To reduce the wear of the moving parts
- Reduce the frictional losses
- Protect the equipment form corrosion

The lubricator adds the lubricating oil in the form of fine mist to reduce the friction and wear of moving parts of pneumatic components such as valves, packing used in air actuators

Excessive lubrication is undesirable. Excessive lubrication may results in

- malfunctioning of components,
- seizing and sticking of components after prolonged downtime
- environmental pollution

Operation: The operation is similar to the principle of the carburettor. Schematic diagram is shown in **Figure 1.6**. As air enters the lubricator its velocity is increased by a venture ring. The pressure at the venture ring will be lower than the atmospheric pressure and the pressure on the

oil is atmospheric. Due to this pressure difference between the upper chamber and lower chamber, oil will be drawn up in a riser tube. Oil droplets mix with the incoming air and form a fine mist. The needle valve is used adjust the pressure differential between across the oil jet and hence the oil flow rate. The air – oil mixture is forced to swirl as it leaves the central cylinder so that large particles of oil is goes back to bowl and only the mist goes to outlet.

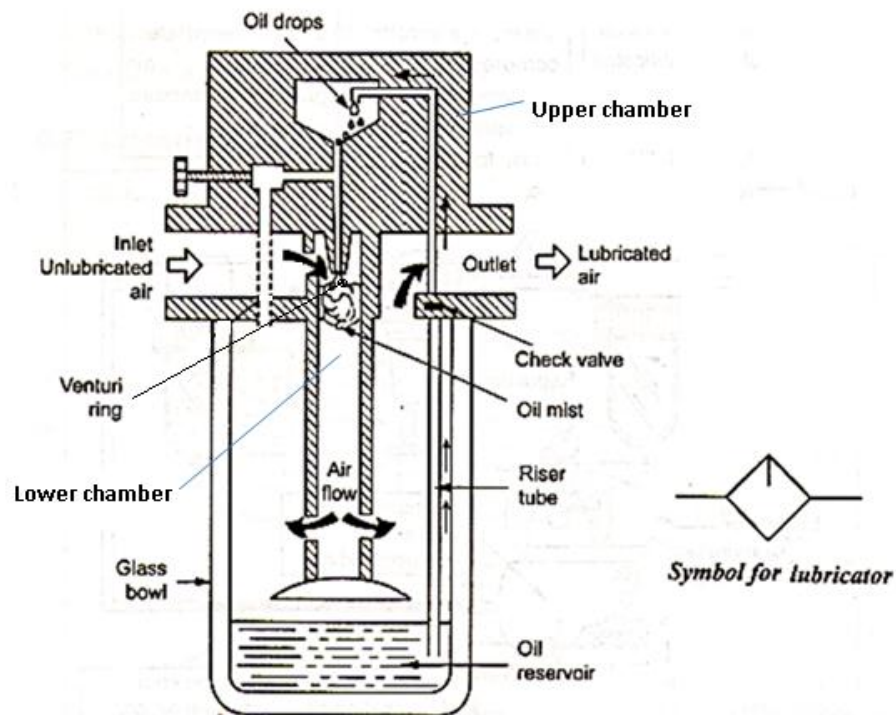


Figure 1.6 Air lubricator

The lubricator starts to operate only when there is sufficient flow of air. If too little air is drawn off, the flow velocity at the nozzle is not sufficient to produce an adequate vacuum and hence to draw oil out of the vessel. Only thin mineral oil may be used in pneumatic system lubricator. Viscosity ratings are normally 10-50 Centistokes or SAE 10 . **Table 1.2** give the normally used oil. The list is purely alphabetic and not in order of preference.

Table 1.2 Typical oils used in air lubricator

Suitable oil grades/Trade name	Viscosity at 20 °C
ARAL OEL TU 500	23.6 cSt
Avia Avilub RSL 3	34 cSt
BP Energol HL 40	27 cSt
ESSO SPINNESSO 34, Nutto H5, H10	23 cSt
Mobil Vac HLP 9, Velocite oil no 6	25.3 cSt
Shell TELLUS OEL 15, OL 10	22 cSt
TEXACO Rando oil AAA	25 cSt
VALVOLINE RITZOL R-60	26 cSt
Vedol Andarin 38	20.5 cSt
Aral , Vitamol, GF10, DE10, CM5, CM10	21 cSt

1.1.4 Filter Regulator Lubricator Unit (FRL Unit) /Service Unit

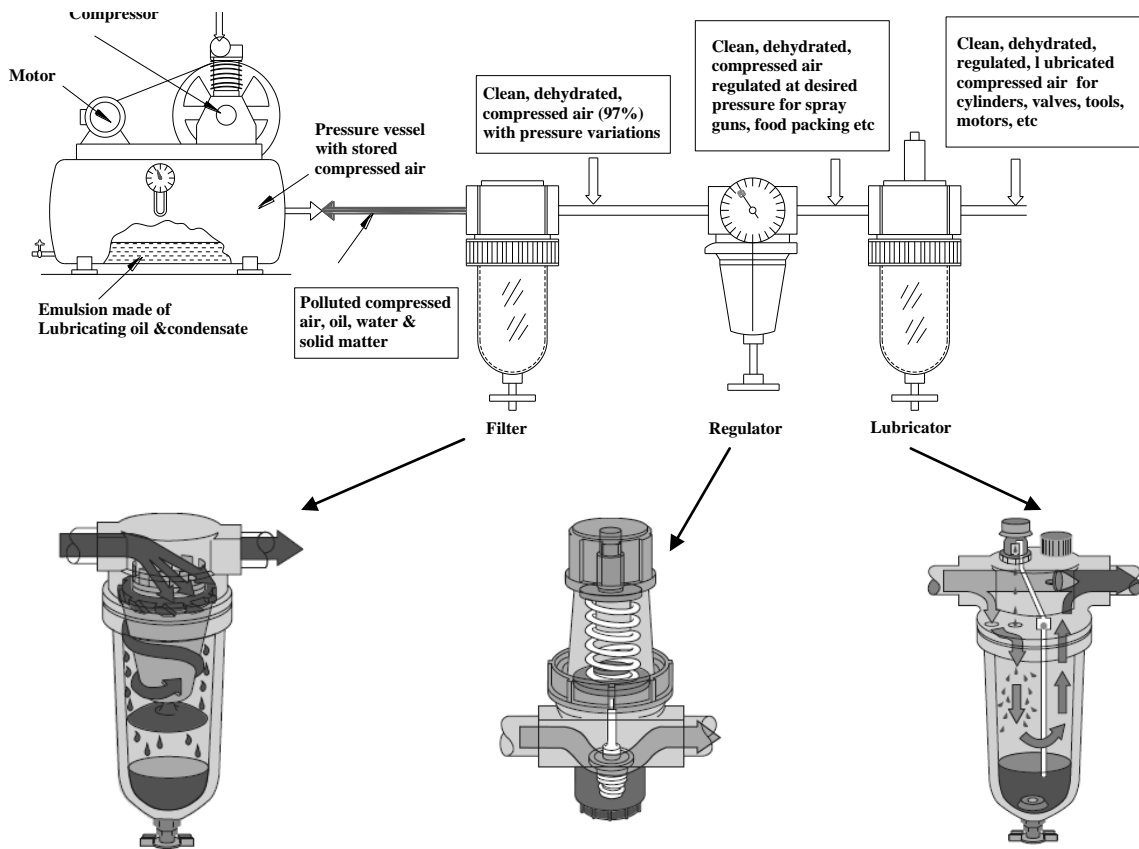


Figure 1.7 Installation of FRL unit

In most pneumatic systems, the compressed air is first filtered and then regulated to the specific pressure and made to pass through a lubricator for lubricating the oil. Thus usually a filter, regulator and lubricator are placed in the inlet line to each air circuit. They may be installed as separate units, but more often they are used in the form of a combined unit. Figure 1.6 shows the schematic arrangement of installation of Filter, Regulator and Lubricator unit .

The combination of filter, regulator and lubricator is called FRL unit or service unit. Figure 1.7 (a) gives the three dimensional view of FRL unit. Figure 1.7(b) gives detailed symbol of FRL unit. Figure 1.7(c) gives simplified symbol of FRL unit.

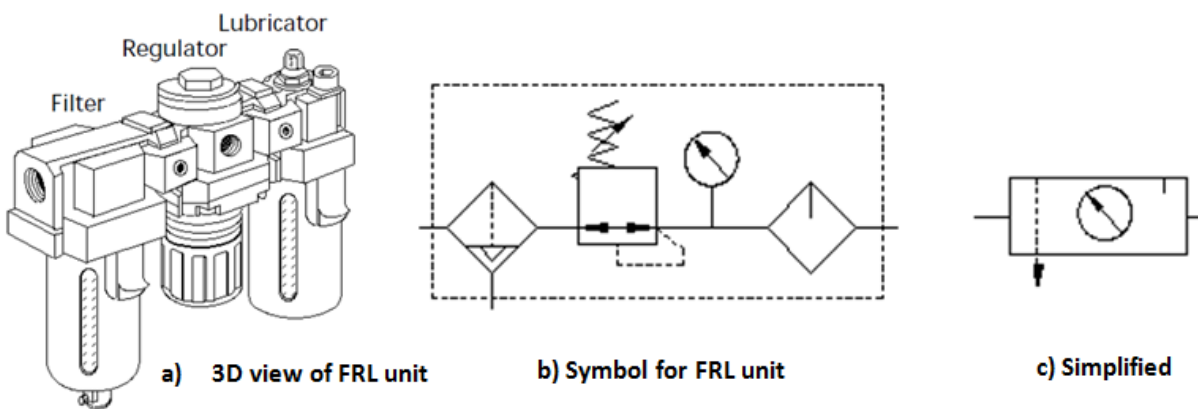


Figure 1.7 a) Three dimensional view of FRL unit b) detained symbol c) simplified symbol of FRL

1.2 AIR DISTRIBUTION SYSTEM

The main objective of air distribution system is to provide a distribution channel for compressed air without any leak and keep the pressure drop within permissible limits. The air distribution system consists of conductors and fittings which interconnect various components of a pneumatic system. Figure 1.8 shows a typical air distribution system. It consists of compressor, water cooled after cooler, Air receiver, dryer and ring main system. The air main takes the shape of a ring. Air from main header is drawn by sub headers. Sub headers may have its own accumulators.

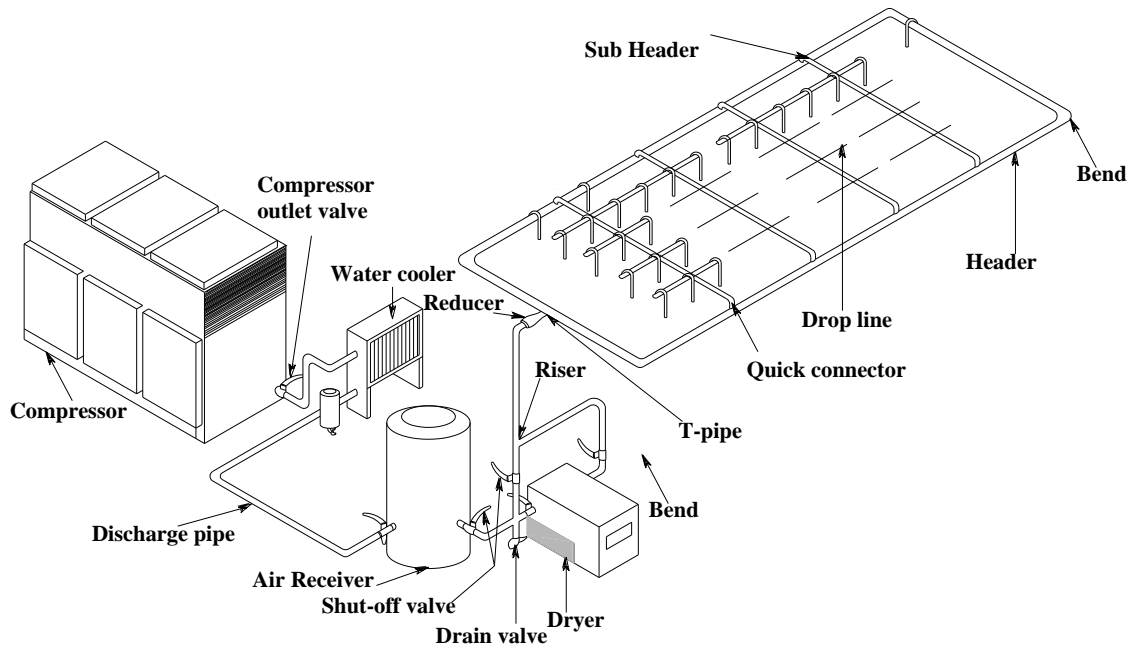


Figure 1.8 : Typical Air distribution system (Ring type)

The air distribution should take into account the following parameters

1. Choice of fluid conductor
2. Flow resistance
3. Correct sizing of pipes
4. Correct sizing of fittings.
5. Pipe layout

Objective Type Questions

1. Air filter, pressure regulator and lubricator are now built as packaged combination known as FRL unit or ----- units.
2. The pressure difference between inlet and outlet will indicate the degree to which the air filter element is -----
3. In pneumatic system, pressure fluctuations occur due to variation in ----- pressure or load pressure.
4. The main objective of air distribution system is to provide a distribution channel for compressed air without any leak and keep the ----- within permissible limits.
5. Equivalent pipe length is length of straight pipe of the same ----- size giving the same pressure drop

State True or False

1. Usually in line filter elements can remove contaminants in the 0.005-0.0005 micron range
2. A manifold type pneumatic network has the advantages that, being in the form of closed circuit, the velocity of the air the main will be reduced and the pressure drop will be less.
3. Two Quality levels of air required in pneumatic production and distribution systems.
4. In Non-Venting Type Pressure regulator case compressed air cannot escape to the atmosphere in the event of high backpressure acting on the diaphragm, as there is no exit path provided in the diaphragm for the trapped air.
5. A single, large air compressor is more efficient and less costly than the several smaller units if the demand is fairly constant

Review Questions

1. State the importance of fluid conditioning
2. Describe the function of air filter.
3. With help of neat sketch explain the working of air filter.
4. State clearly nine qualities of filtered air requirement and its application
5. Describe the function of an air pressure regulator
6. With the help of neat sketch explain the working of air regulator
7. Difference between venting and non-venting type of pressure regulator.
8. Describe the function of an air lubricator
9. With the help of neat sketch explain the working of air filter.
10. List commonly used oil in an air lubricator
11. State the advantage of main ring pneumatic net work
12. List five important considerations in pipe layout in pneumatic network
13. With the help of neat sketch, explain ring and manifold type of pneumatic network
14. List the guidelines for selection of pneumatic components and compressor
15. Discuss the three ways to remove the water from the air in the air distribution system

Answers

Fill in the Blanks

1. service
2. clogged
3. supply
4. pressure drop
5. diameter

State True or False

1. False
2. False
3. False
4. True
5. True