

# 7

# OIL POWER HYDRAULIC AND PNEUMATIC SYSTEMS

## 7.1 INTRODUCTION

*Oil power hydraulics is that branch of fluid mechanics which uses hydraulic oil as the working medium. Hydraulic oils are superior to water and are widely used to drive various machines and equipments.*

*Pneumatics is that branch of engineering which deals with the action of compressed air or any other gas in operating various machines and equipments.*

## 7.2 MERITS AND DEMERITS OF USING OIL AS THE MEDIUM OF POWER TRANSMISSION

### Merits:

1. More shearing force can be transmitted through the oil because oil has more resistance to shear than water.
2. Oil absorbs vibrations and shock load, if any, in a machine.
3. Oil controls the speed of moving parts of a machine easily.
4. Oil powered machines need less maintenance.
5. Oil powered machines are self lubricating. Hence, use of other lubricant is not required.
6. There is no complicated mechanism in a machine run by oil pressure.
7. Transmission of motion by oil is not noisy.

### Demerits:

1. Leakage of oil causes problems in maintenance work and makes the working area dirty.
2. There are chances of fire hazards due to rise in temperature of oil. So these equipments cannot be used in coal mines.
3. Oil loses its viscosity at high temperature. Under such conditions, oil cannot resist shear force and hence replacement of oil is required.
4. Oil powered equipments are costlier than water powered equipments.

## 7.3 APPLICATIONS OF OIL POWER HYDRAULICS

The followings are the applications of oil power hydraulics:

1. Operation of shaping machine.
2. Operation of press hammering.

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3. Hydraulic vice.
  4. Earth moving machine.
  5. In drilling operation during oil exploration.

#### 7.4 MERITS AND DEMERITS OF PNEUMATIC SYSTEM

##### Merits:

1. Air is freely available in nature without any cost.
2. Wear and tear of the parts using air as the working medium is less. This lowers the maintenance.
3. Gripping of pneumatic system is more effective as compared to mechanical system.
4. There is no chance of fire hazards. So these equipments can be used in coal mines and explosive manufacturing industries.

##### Demerits:

1. Storage vessel is required to store the compressed air. Hence, additional equipment is required in pneumatic system.
2. There are chances of leakage of air from high pressure side to low pressure side.
3. It is uneconomical to use pneumatic system for small scale production unit.

#### 7.5 APPLICATIONS OF PNEUMATIC SYSTEM

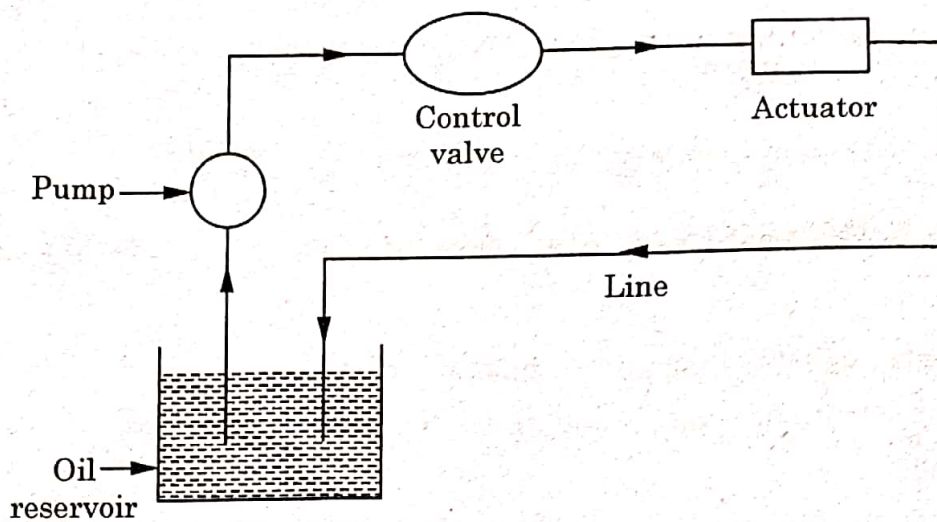
The followings are the applications of pneumatic system:

1. Pneumatic brakes in locomotives.
2. Pneumatic drills and pneumatic chucks used in a workshop.
3. Operating the blower.
4. Operating the air motor.
5. Operating the spray point gun.

#### 7.6 BASIC COMPONENTS OF HYDRAULIC SYSTEM

The followings are the basic components of hydraulic system:

1. Oil reservoir,
2. Pump,
3. Valves,
4. Filters,
5. Seals,
6. Pipe,
7. Actuator.



**Fig. 7.1 : Basic Components of Hydraulic System**

1. **Oil Reservoir:** *Oil reservoir stores the oil which acts a working medium for the oil power hydraulic system. Oil is taken from the reservoir to different parts of the machine and it returns back to the reservoir after completing its function. The oil reservoir is usually kept at the bottom of the hydraulic system so that oil may flow back to the reservoir under the force of gravity.*
2. **Pump:** *Pump sucks the oil from the oil reservoir and delivers it to the hydraulic system under pressure. Pump is driven with the help of prime mover.*
3. **Valves:** *Valves control the discharge, pressure and direction of oil to be pumped into the system. There are many types of valves which are used is oil power hydraulic system.*
4. **Filters:** *Filters separate the insoluble particles present in the oil. A coarse filter is called strainer.*
5. **Seals:** *Seals are used to prevent the leakage of oil in the hydraulic system.*
6. **Pipe:** *Pipe is used to carry the oil power from one stage to another.*
7. **Actuator:** *Actuator receives the oil from the pump and converts the hydraulic energy into mechanical work.*

## 7.7 HYDRAULIC OIL

*Hydraulic oil transmits hydraulic energy in the hydraulic system. Therefore, it is an essential part of the hydraulic system. The most common oil used is petroleum based mineral oil. Besides transmitting energy, it performs various functions which are as follow:*

1. **Lubrication:** *It lubricates various parts of the hydraulic system and reduces friction, wear and tear.*
2. **Cooling:** *It carries away the heat generated in the system and dissipates the heat through a reservoir or a heat exchanger.*
3. **Sealing:** *It seals the moving parts to avoid leakage.*

- Oil -
4. **Removal of Contaminants:** It carries the contaminants to the tank, where these can be removed through filters.

## 7.8 TYPES OF HYDRAULIC OILS

The various types of hydraulic oils are as follow:

1. **Mineral Oils:** Mineral oils are the petroleum based oils which are most commonly used hydraulic oils. These are easily available and economical. In addition, these offer best lubrication properties, least corrosion problems and are compatible with most sealing materials. The only disadvantage of these oils is their flammability. These cause fire hazards mainly from the leakages in high temperature environments such as steel industries etc. Mineral oils are good for operating temperatures below 50°C. At higher temperatures, these oils lose their chemical stability and form acids, varnishes etc. All these lead to the loss of lubrication properties, increased wear and tear, corrosion and related problems. However, additives are available which can improve chemical stability, reduce oxidation and other problems.

2. **Emulsions:** *Emulsion is a mixture of two liquids which do not chemically react with each other.* Emulsions of petroleum based oil and water are commonly used. There are two types of emulsions:

- (i) **Oil-in-Water Emulsions:** Oil-in-water emulsions are basically water based in which small droplets of oil are dispersed throughout the water phase. Generally, the oil dilution is limited *i.e.* about 5%. Hence, these emulsions possess the characteristics of water. The limitations of these emulsions are poor viscosity leading to leakage and poor lubrication properties. However, these problems can be overcome to a greater extent by using certain additives. Such emulsions are used in high displacement, low speed pumps such as in mining applications.

- (ii) **Water-in-Oil Emulsions:** Water-in-oil emulsions are basically oil based in which small droplets of water are dispersed throughout the oil phase. These possess oil like characteristics. Hence, these have good viscosity and lubrication properties. The commonly used emulsion has a dilution of 60% oil and 40% water. These emulsions are good for operations at 25°C because at a higher temperature, water evaporates and leads to the loss of fire resistant properties.

3. **Vegetable Oils:** The increase in the global pollution has led to the use of more environmental friendly oils. Vegetable oils are biodegradable oils and are environmental friendly. These possess good lubrication properties, moderate viscosity and are less expensive. These can be formulated to have good fire resistant properties with certain additives. Vegetable oils have a tendency to easily oxidise and absorb moisture. The acidity, sludge formation and corrosion problems are more severe in vegetable oils than in mineral oils. Hence, vegetable oils need good inhibitors to minimize oxidation problems.

## 7.9 PROPERTIES OF AN IDEAL HYDRAULIC OIL

The various properties required for an ideal hydraulic oil are as follow:

1. Ideal viscosity.
2. Good lubrication properties.
3. Good chemical and environmental stability.
4. Incompressibility.
5. Fire resistance.
6. Low flammability.
7. Foam resistance.
8. Low volatility.
9. Good heat dissipation ability.
10. Low density.

## 7.10 SEALS

*Seal is a material which is used in the hydraulic system to prevent leakage of oil. Leakage of oil to the atmosphere or any other area is due to the fact that the pressure in the hydraulic system is higher than the outside atmosphere/area. Seal maintains the working pressure inside the hydraulic system.*

## 7.11 ADVANTAGES OF SEALS IN HYDRAULIC SYSTEM

1. Increase in efficiency.
2. Prevention of loss of power.
3. Prevention of failure of components such as valves etc.

## 7.12 CLASSIFICATION OF SEALS

1. Positive and non-positive seals.

2. Static and dynamic seals.

**1. Positive and Non-positive Seals:** *Positive seals are those which do not permit any leakage of oil. Non-positive seals are those which permit a small amount of leakage of oil to the extent of providing lubricating film on the rotating parts.*

**2. Static and Dynamic Seals:** *Static seals are those which are used to prevent leakage of oil through stationary surfaces. These are used where no relative movement occurs between the mating parts.*

*Dynamic seals are those which are used to prevent leakage of oil around the rotating or moving parts. These seals are subject to wear because one of the mating parts rubs against the seal.*

## 7.13 TYPES OF OIL SEALS

Oil seals are of following types:

1. Gaskets,
2. O-ring,
3. Packing,
4. Wiper rings,
5. Piston rings.

1. **Gaskets:** This seal is made of soft material. It is used for static joints. It is used between two flat mating surfaces of hydraulic fittings. Commonly used gasket materials are oil heated paper, cork, lead foil, synthetic rubber etc.
2. **O-Ring:** This seal is widely used in hydraulic system. The shape of this seal is of the English alphabet 'O'. It is made of synthetic rubber. It is used both as static seal and dynamic seal. It is used against high pressure. However, it is not used for sealing rotating shaft.
3. **Packing:** This seal is used to prevent leakage of oil through the moving parts. It is in the form of a clip which is forced by the system pressure to form a sealing against the surface of the adjacent members.
4. **Wiper Rings:** This seal is designed to stop the abrasive or corrosive material from entering a cylinder. It is made of synthetic rubber. It is stiff enough to sweep or wipe all the dust and dirt particles from the rod.
5. **Piston Rings:** This seal is used on pistons. It is made of cast iron or steel. It is coated with zinc phosphate or manganese phosphate to prevent corrosion and rusting.

## 7.14 COMMONLY USED SEAL MATERIALS

The commonly used seal materials are as follow:

1. Leather,
2. Metal,
3. Asbestos,
4. Rubber, elastomers and plastics.

1. **Leather:** It is commonly used seal material in hydraulic system both for static and dynamic seals. It is inexpensive. The seals made from leather are preferred due to the following properties:

- (i) Low coefficient of friction.
- (ii) High resistance to wear and abrasion.
- (iii) Good lubricating property.

The temperature range of leather seals is  $-50^{\circ}\text{C}$  to  $100^{\circ}\text{C}$ , but these are used upto  $80^{\circ}\text{C}$ . Leather seals are acidic in nature and operate in a medium where pH is 3 to 7. These seals cannot withstand alkaline conditions.

2. **Metal:** Metals are very good sealing materials for high temperature and high pressure systems. Metal seals are not suitable where pressure is low. These seals are suitable for radioactive environments.
3. **Asbestos:** Like leather, asbestos is also used for both static and dynamic seals. These seals are used for high temperature applications. However, use of these seals is limited being unhygienic for environment.
4. **Rubber, Elastomers and Plastics:** These are very commonly used sealing materials due to the following reasons:
  - (i) Wide temperature range.
  - (ii) Excellent resilience.
  - (iii) Wide availability.
  - (iv) Easy fabrication.

Common elastomeric sealing materials are as follow:

- (i) Fluorocarbon,
- (ii) Butyl,
- (iii) Ethylene propylene,
- (iv) Neoprene,
- (v) Polyurethane,
- (vi) Silicone.

## 7.15 REQUIREMENTS OF GOOD SEALING MATERIALS

Good sealing materials must fulfill the following requirements:

1. These should resist wear and abrasion.
2. These should recover from deformation quickly.
3. These should resist harmful effects such as deterioration, excessive swelling and shrinkage caused by acids.
4. These should withstand system temperature and pressure without leakage.

## 7.16 COMMON FAULTS IN A HYDRAULIC SYSTEM

The common faults which may occur in a hydraulic system during working are as follow:

1. Sharp noise in the system.
2. Excessive leakage in the system.
3. High rate of seal failure.
4. Excessive loss of system pressure.

5. Sharp rise in oil temperature.
6. Reduced speed of machine tool elements.
7. Cavitation of pump.
8. Poor oil life.

It should be noted that the above faults occur due to various factors which are inter-related. Once the cause of fault is known, it becomes easy during breakdown maintenance or during the system reconditioning period.

## 7.17 SIMPLE VISUAL CHECKS OF OIL

The following characteristics may change during the service life of oils:

1. Visual appearance.
2. Smell.
3. Viscosity.
4. Tardiness.
5. Oxidation.
6. Acidity.
7. Foaming.
8. Water content.
9. Solid content.

It should be noted that in the modern hydraulic system, continuous monitoring of oil is must to maintain a safe hydraulic system. The following visual checks should be carried out during routine maintenance of hydraulic systems in order to determine the oil health.

1. **Appearance:** The oil should be inspected visually to see whether it is clear and bright or hazy and cloudy which may indicate water contamination, suspended material etc. A milky oil indicates that it is aerated and contains more air than the maximum of 8% by volume. In such situation, the system should be kept idle for long to allow the oil to settle inside the reservoir. If not much change is observed, there is no other alternative, but to change the entire oil.
2. **Colour:** A dark colour of oil indicates oxidation or excessive contamination. However, the appearance and colour of oil may be dependent upon the type of service to which oil is subjected.
3. **Odour:** Used oils normally have a bland or oily odour. Oxidised oils have burnt or pungent odours.

## 7.18 CAUSES OF CONTAMINATION

Contaminants are generated or may enter the hydraulic system in the following ways:

1. These are present in the new system due to insufficient cleaning of components or parts of the system.
2. These are generated during the manufacturing and/or assembly of the system.
3. Fluid used to fill a hydraulic system may have contaminants.
4. Contaminants are generated by the chemical breakdown of hydraulic fluid.
5. Contaminants are generated whenever cavitation occurs in a hydraulic system.
6. The system may ingest air borne contaminants particularly through air breathers and cylinder rod seals.
7. Contaminants are introduced when a system is opened or closed during servicing and/or maintenance.

## **7.19 PROBLEMS CAUSED BY CONTAMINATION**

Contamination causes following problems in the hydraulic system:

1. Rapid wear of components/parts resulting in decrease in system performance.
2. Sluggish operation and seizure of moving parts.
3. Leakage due to damage of seals.
4. Rapid oxidation of hydraulic fluid resulting in low fluid life.

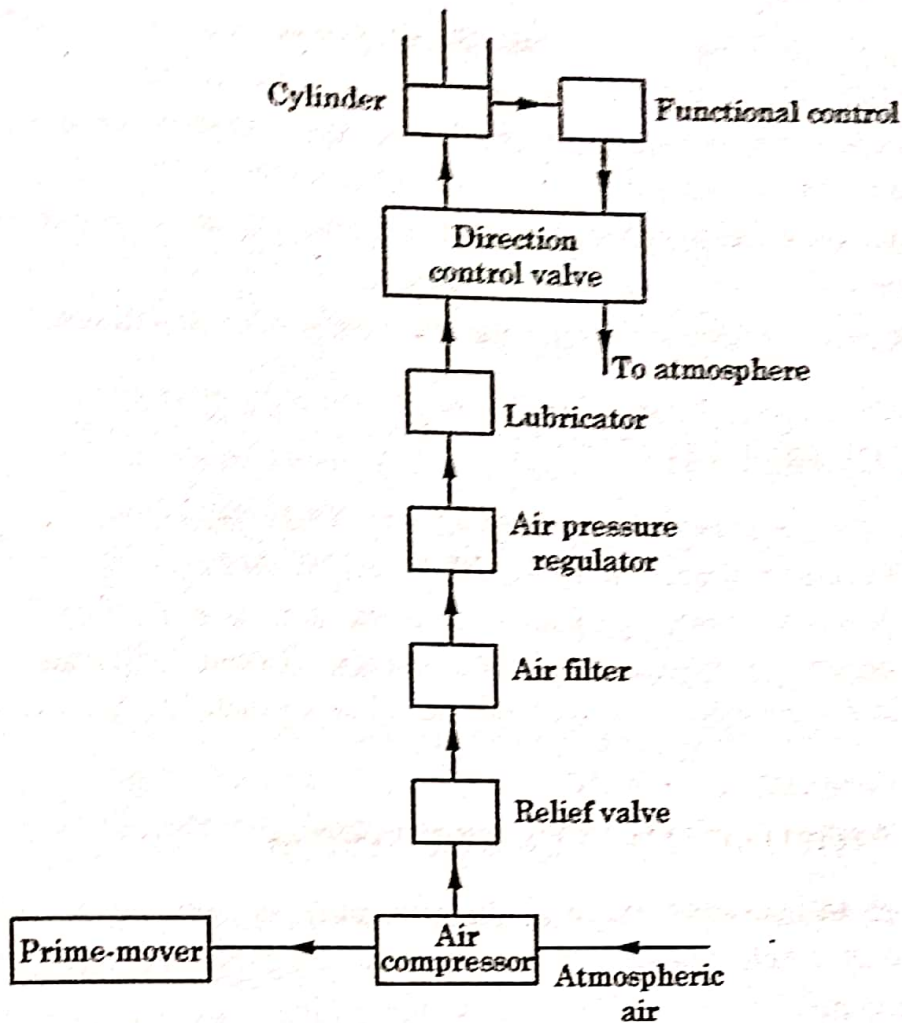
## **7.20 PREVENTIVE MEASURES OF CONTAMINATION**

There are many measures which help to reduce the entry and adverse effects of contaminants in the system:

1. Use pipes, tubings and fittings which are free from rust, dirt, scale etc. in the hydraulic system.
2. Flush the entire hydraulic system with the same type of fluid to be used before the start of normal operation.
3. Filter the hydraulic fluid before using to minimise entry of contaminants in the system.
4. Locate filters in the hydraulic system where they can provide most effective protection.
5. Provide continuous protection from the air borne contamination by sealing the hydraulic system.
6. Minimise source of water entry into the hydraulic system.
7. Maintain fluid viscosity and pH level.
8. Clean or replace filter elements on routine basis.
9. Avoid introducing thread sealants into the fluid stream.
10. Use non-corroding piping.

## **7.21 BASIC COMPONENTS OF PNEUMATIC SYSTEM**

The basic components of a pneumatic system are shown in fig. 7.2.



**Fig. 7.2 : Basic Components of Pneumatic System**

1. **Air Compressor:** An air compressor is a machine which is used to compress air at a desired pressure. Air from atmosphere is sucked by the air compressor. It is then compressed to the desired pressure. This high pressure air is delivered to the storage tank from where it is further delivered to the place of requirement with the help of pipeline. Air compressor is driven by an electric motor or diesel engine.
2. **Relief Valve:** The function of the relief valve is to release the pressure when the pressure of compressed air becomes greater than the allowable limit. In this way, relief valve keeps the system safe.
3. **Air Filter:** Air filter is used to separate dirt and dust from the air. It prevents the entry of solid particles into the pneumatic system. Also it condenses and removes water vapours present in the air passing through it.
4. **Air Pressure Regulator:** An air pressure regulator is used to keep the air pressure constant to the pneumatic system.
5. **Lubricator:** Lubricator is used to produce the mist of oil and air. The mist so formed provides lubrication to the mating components of valves, cylinders etc.

6. **Direction Control Valve:** *The function of direction control valve is to regulate the direction of motion of compressed air.*
7. **Cylinder:** *Pressure energy of compressed air is converted into mechanical energy in the cylinder fitted with a piston.*
8. **Functional Control:** *Functional control regulates the speed of movement of piston in the cylinder.*

*The three units i.e. air filter, pressure regulator and lubricator together are called service unit or FRL unit.*

## 7.22 NECESSITY OF FRL UNIT

*The three units i.e. air filter, pressure regulator and lubricator together are called service unit or FRL unit. FRL unit is needed to protect the system from undesirable foreign particles, to maintain a steady pressure of air supply and to ensure a mist of lubricating oil film to the compressed air to protect the system from failure due to friction. FRL unit should be given adequate attention in the preventive maintenance schedule to maintain the overall health of the system.*

## 7.23 COMMON PROBLEMS IN PNEUMATIC SYSTEM

The common problems which occur in the pneumatic system are due to leakage of air because of loose glands or failure of seals. A few problems are explained as follow:

1. **Line Problems:** The major problems in the piping system are related to leakage of compressed air. Leakage through pipeline fittings and glands is a routine problem. Leakage is caused due to loose joints or glands which require to be tightened at regular intervals to stop leakage. The following problems may occur due to leakage of compressed air:

- (i) Increased load on the air compressor.
- (ii) Wastage of costly compressed air without serving any useful purpose.
- (iii) Higher operating and maintenance cost of air installation plant.
- (iv) Risk of product rejection, etc.

Leakage can be prevented by adopting the following steps:

- (i) Tighten loose joints, fittings and glands.
- (ii) Replace faulty and damaged fittings, ruptured pipes and hoses.
- (iii) Use commercial bonding compounds available in the market.

2. **FRL Unit:** To maintain the overall health of the pneumatic system, the FRL unit should be given adequate attention. The following steps should be carried out to give adequate attention:-

- (i) Clean the filter cartridge at regular interval of time with kerosene or tri-chloro-ethylene.
- (ii) Drain off the accumulated water and other foreign particles from the filter bowl.

- (iii) Look for any external damage to the regulator.
- (iv) Check if the supply of pressure air is steady or not. Pressure limits should be tested.
- (v) Count the number of oil drops per minute to ensure proper lubrication and compare the same with the service recommendation.
- (vi) Maintain the oil level if it goes below the permissible level.
- (vii) Use only specified oil as recommended.
- (viii) Inspect the colour of oil in the bowl and if the colour turns greyish, replace the oil.

If the FRL unit is not of the proper type, the following problems may occur:

- (i) Blockage of valve points and other passages.
- (ii) Undesirable wear of elements due to abrasive particles.
- (iii) Corrosion of pipes and other valves due to water.
- (iv) Formation of gum like substances due to break down of oil.
- (v) Formation of weak acids or electrolytes causing galvanic corrosion.

**3. Pneumatic Components:** Major reasons of failure of pneumatic components are dirt, lack of lubrication, damaged seals etc. Hence if the FRL unit is maintained in a good condition, then this type of failure does not occur. For a normal system, the following points should be checked regularly:

- (i) Check cylinders and valves.
- (ii) Check for general cleanliness.
- (iii) Check for wear and tear of mechanical parts.
- (iv) Check whether the pipeline is in good condition or not.
- (v) Check whether return spring is safe.

**4. Other Problems:** Sometimes, a pneumatic system fails due to mechanical troubles from other associated mechanical components or electrical systems. Now-a-days, more and more solenoid operated valves are in use. Hence, electrical failure may stop the operation of the system.

## 7.24 MAINTENANCE SCHEDULE OF PNEUMATIC SYSTEM

For periodic check up and inspection of pneumatic system, the following parts of the pneumatic system must be given more importance:

1. Air mains, lines and fittings.
2. FRL unit.
3. On and off valve in line.
4. Pneumatic cylinders and air motors.
5. Pneumatic control valves.
6. Mechanical drive elements.
7. Pneumatic accessories and other associated elements.

## 1. Air Mains, Lines and Fittings:

### Name of the Work

### Periodicity

- |  |                       |
|--|-----------------------|
| (i) Condensate traps   | Daily                 |
| (ii) Airlines, cuts in lines and holes                         | Weekly                |
| (iii) Detection and arrest of air leakage                      | Monthly               |
| (iv) Inspection of unions, bends, tees, elbows, couplings etc. | Once in three months. |
| (v) Pressure rating in strategic points                        | Once in three months. |
| (vi) Automatic draining of condensate                          | Once in three months. |
| (vii) Thorough inspection of complete line system              | Once in a year.       |

## 2. FRL Unit:

- |  |                                   |
|--|-----------------------------------|
| (i) Detection and arrest of air leakage            | Daily                             |
| (ii) Drain condensate from filter                  | Daily                             |
| (iii) Top up oil level                             | Weekly                            |
| (iv) Pressure rating of pressure regulators        | Monthly                           |
| (v) Arrest leakage of oil                          | Once in three months              |
| (vi) Cleaning of filter cartridge                  | Half yearly                       |
| (vii) Calibrate pressure gauge                     | Half yearly                       |
| (viii) Clean up oil jet passage                    | Half yearly                       |
| (ix) Change of oil after thorough cleaning of bowl | Half yearly or yearly as per need |
| (x) Cleaning filter bowl                           | Yearly                            |
| (xi) Adjust oil jet                                | As per need                       |

## 3. On and off Valve:

- |   |         |
|---|---------|
| (i) Actuating handle of valve                       | Weekly  |
| (ii) Leakage of air through valve and hose fittings | Monthly |
| (iii) Overhauling if possible                       | Yearly  |

## 4. Pneumatic Cylinders and Air Motors:

- |   |             |
|---|-------------|
| (i) Inspect the cylinder for force and speed accuracy | Weekly      |
| (ii) Mechanical damage to piston rod                  | Weekly      |
| (iii) Check r.p.m. of motor                           | Weekly      |
| (iv) Check torque of motor                            | Weekly      |
| (v) Check vibrations produced by the motor            | Weekly      |
| (vi) Check for leakage and its arrest                 | Monthly     |
| (vii) Check the tie rod tensions                      | Half yearly |

- (viii) Inspect the mechanical support and mountings of cylinders Half yearly
- (ix) Replace cup seal Half yearly or as per need
- (x) Check alignment of piston and piston rod Yearly or as per need

**5. Pneumatic Control Valves:**

- (i) Possible air leakage and its arrest Monthly
- (ii) Check solenoid and its electrical parameters Monthly
- (iii) Check possible seal failure Half yearly
- (iv) Inspect actuating elements Half yearly
- (v) Check valve adjustment Half yearly
- (vi) Check spring and valve actuators Yearly or earlier if dismantled due to contingency
- (vii) Mechanical damage to valves and their parts Yearly or earlier if dismantled due to contingency

**6. Mechanical Drive System and Other Pneumatic Accessories:**

- (i) Mechanical links to power source for looseness etc. Monthly
- (ii) Mechanical alignment Half yearly
- (iii) Inspect silencers Half yearly
- (iv) Check guides for mechanical motion Half yearly