Unit 1 Introduction to Hydraulics and pneumatics

Marks Distribution for this Unit

Unit No	Unit Title	Teaching Hours	R Level	U Level	A Level	Total Marks
I	Introduction to hydraulics and pneumatic system	04	02	02	02	**06**

R-Remember, U-Understand,A-Apply
* Refer syllabus for details about Bloom's taxonomy

Syllabus content

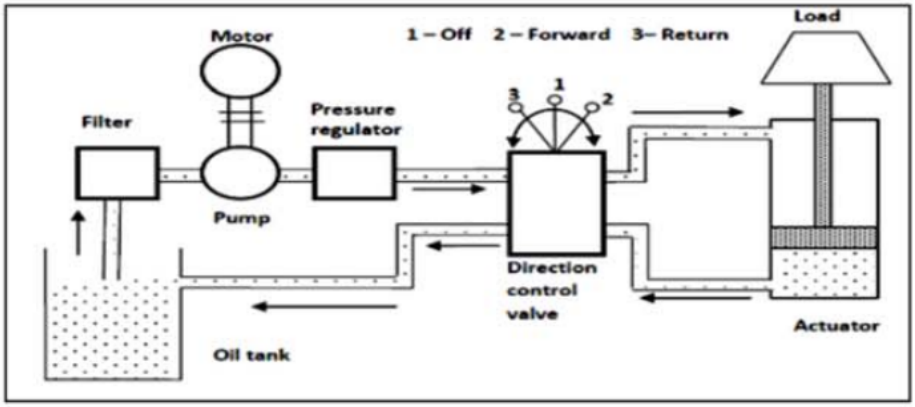
1.1 General Layout -
General layout of oil hydraulic and pneumatic system.
1.2 Applications
Applications, Merits, limitations of oil hydraulic system and pneumatic system
1.3 Properties of Fluids
Properties of fluid,ISO and SAE grades of oil.
1.4 Symbols
ISO symbols used in hydraulic and pneumatic system
1.5 Hazard and safety
Hazard and safety in industrial hydraulics and pneumatics

1.1 GENERAL LAYOUT

Q.1. Draw the general layout of hydraulic system? State the function of each component in it.?

Ans : Hydraulic systems are the power transmitting assemblies employing pressurized oil to transmit energy from an energy generating source to the application area.

The general structure of a hydraulic system is depicted in figure below. General layout Schematic diagram



The main components and their functions are

1.Oil tank : To act as reservoir for the working medium oil.The oil passes through various pipelines and after doing useful work in actuator; the oil returns back to oil tank. In the regions of low temperature, oil heaters are attached to air tanks.

2. Filter : To prevent the foreign particles from entering into circuit.

3. Motor: To provide mechanical power to pump.

4.Pump : Hydraulic pump is heart of any hydraulic system. Its main function is to create the flow of oil under pressure through entire hydraulic system and hence to assist transfer of power and motion

5. Pressure regulator : To limit the pressure developed in the circuits to a limiting value. To drain oil to tank when pressure exceeds this limit.

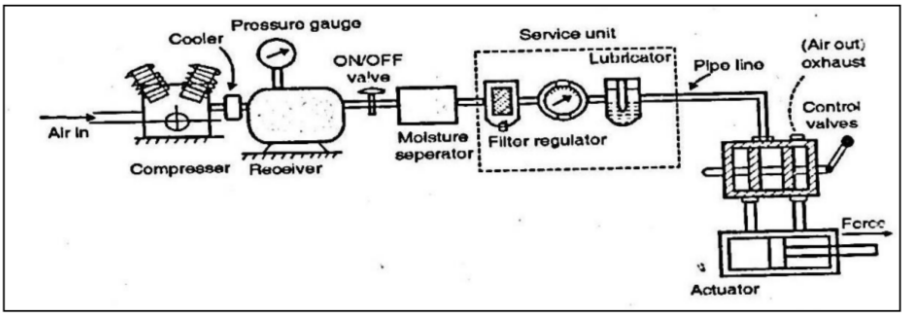
6.Direction control valve; To change the direction of oil going to actuator.

7. Actuator ; To convert pressure energy of oil into mechanical work.

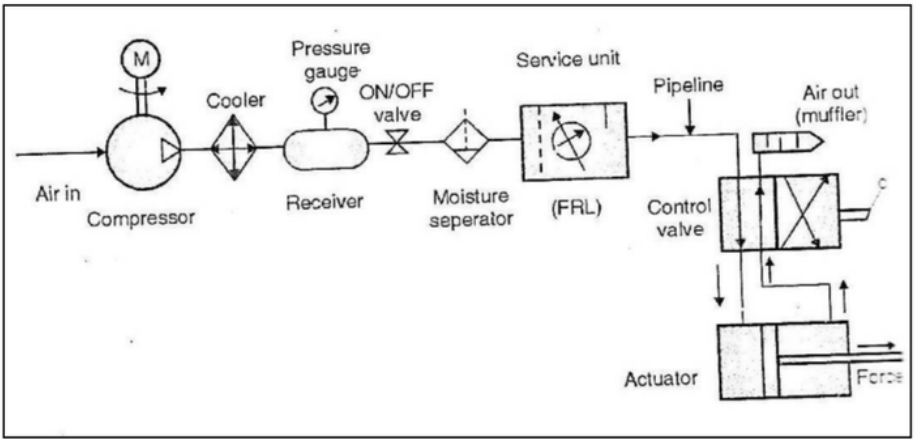
Q.2. Draw the general layout of Pneumatic system and its symbolic representation?

Ans : Pneumatic systems are the power transmitting assemblies employing pressurized air to transmit energy from an energy generating source to the application area. Pneumatic system has air as the working medium (similar to electric current in electrical system, shafts gears and belts in mechanical system and air in a pneumatic system).

The general structure of a pneumatic system is depicted in figure below.



Symbolic representation of general layout of pneumatic system



Q.3. What is function of Oil reservoir,Pressure relief valve, Direction control valve and filters in Hydraulic system.

Ans :
(i) Oil Reservoir – To store the Hydraulic oil for the circuit
(ii) Pressure Relief Valve- To release the extra pressure whenever not required by system
(iii) Direction Control Valve- To give the direction to the actuator
(iv) Filters- To filter the foreign particle from the oil and to separates sub-micron level contamination

1.2 Application of Hydraulics & Pneumatics

Q.4. State the applications of Hydraulic system. (4m)

Ans :
1)Industrial: Plastic processing machineries, steel making and primary metal extraction applications, automated production lines, machine tool industries, paper industries, loaders, crushes, textile machineries, R & D equipment and robotic systems etc.
2)Mobile hydraulics: Tractors, irrigation system, earthmoving equipment, material handling equipment, commercial vehicles, tunnel boring equipment, rail equipment,building and construction machineries and drilling rigs etc.
3)Automobiles: It is used in the systems like breaks, shock absorbers, steering system, wind shield, lift and cleaning etc.
4) Marine applications: It mostly covers ocean going vessels, fishing boats and navel equipment.
5)Aerospace equipment : used in airplanes, rockets and spaceships

Q.5.Write any four applications of hydraulic systems (2m)

Ans : 1. Earth Moving equipments 2. Broaching machine
3. CNC/VMC/HMC Machines. 4. Hydraulic thread rolling machine
5. Hydraulic press brake. 6. Material handling equipments
7. Hydraulic thread rolling machine 8. Hydraulic cranes

Q.6.Enlist Merits and demerits of Hydraulic system

Merits of Hydraulic system

1) We can generate very high pressures in hydraulic system. Due to this nature of hydraulic system we can use this power to lift, hold, press very heavy loads.

2) Weight to power ratio of a hydraulic system is comparatively less than that of an Electro-Mechanical System. Electric motor weigh appropriately 8.5 Kg/kW whereas, same power hydraulic motor weighs 0.85 kg/kW only.

3) The speed control of linear as well as rotary actuators can be achieved with ease. By merely adjusting small flow control valve, wide range of speed and feed can be obtained.

4) Limiting and balancing of hydraulic forces can be easily performed.

Demerits of hydraulic system

1) Elements of hydraulic system have to be machined to high degree of precision which increases manufacturing cost of system.

2) The hydraulic system, due to oil leakages is 'dirty' and we cannot use this system in food and pharmaceutical industry.

3) Petroleum based hydraulic oils can create fire hazards if the temperature of the system goes beyond its 'flash point'

4) Leakage of hydraulic oil during its flow in system causes heavy pressure drops

Q.7. State the applications of Pneumatic system.

Ans :

1.Manufacturing industries, Automotive industry, machine tool manufacturers and domestic and commercial appliance manufacturers.

2.Processing industries, such as chemical, petrochemical, food processing, textiles, paper, etc.

3.Used in the brake system of automobiles, railway coaches, wagons and printing presses.

4.Application of Pneumatics systems is widely in industrial robots

Q.8.Enlist Merits(Advantages) and demerits(Disadvantages) of Pneumatic system

Advantages of pneumatic system :

1.Easily available air - The working medium used by pneumatic system is easily and freely available everywhere.

2.Neat and clean system **-** Due to air being working medium the system is very neat and clean (as compared to oil in hydraulics) this advantage makes it highly applicable in food processing industries. Where neatness and cleanliness is of prime importance.
3.Explosion proof characteristic of air – This characteristic of air makes the pneumatic system more applicable in hazardous area.
4.Air is easily transportable under pressure through common pipings.
5.Pneumatic elements are simpler and easier to operate. The pneumatic valves can be easily operated without applying much force.
6.Pneumatic system requires no reservoir, return line, complex filtering etc. hence, system is simple and light in weight.
7.Pneumatic systems are easier and quicker to maintain.
8.Pneumatic system has lower initial and operating costs.

Limitation of pneumatic system :

On the limitation side the major limitations are operating pressure and accuracy in motion of the pneumatic system.

1) Pressure is limited:
The pneumatic system can be used up-to maximum pressure of 8 to 10 bar, is very less as compared to 400 to 500 bar of hydraulic system
2) Accuracy of positioning:
Due to the compressible nature of air, highly reliable and accurate motions can not be obtained, as that obtained by the hydraulic system.
3) Pressurized air storage

In pneumatics air should be compressed and kept under pressure at all times even there is no load on the system where as in hydraulics pressure is developed due to external load.

Q.9.Compare hydraulic and pneumatic system.

Criteria	Hydraulics	Pneumatics
Energy Carrier	Oil	Air
Energy conversion From mech.	Hydraulic pumps	Air Compressors
Energy transmission	Pipes, hoses, tubes etc.	Pipes hoses tubes, etc.
Energy control	Very good with various valves	Very good with various valves
Re- conversion of	Hydraulic cylinder	Air Cylinders and Air

energy	and motors	motors
Energy storage	Limited with Accumulator	High with air reservoir.
Efficiency	Low Due to losses in primary conversion, in valves and secondary conversions.	Fair to good.

Q.10. Compare oil and air as a medium in fluid system

Ans :

1. When the system requirement is high speed, medium pressure (usually 6 to 8 bar) and less accuracy of position, then pneumatic system is preferred.
2. If the system requirement is high pressure and high precision, a fluid system with oil is good.
3. When the power requirement is high like in forging presses, sheet metal press, it is impossible to use air system. Oil hydraulics is the only choice .
4.Air is used where quick response of actuator is required.
5. If temperate variation range in the system is large, then use of air system may run into condensation problems and oil is preferred.
6. Air is non-explosive, it is preferred where fire/electric hazard are expected. Oil systems are more prone to fire and electrical hazards and are not recommended in such applications. Because air contains oxygen (about 20%) and is not sufficient alone to provide
7. Adequate lubrication of moving parts and seals, oil is usually introduced into the air stream near the actuator to provide this lubrication preventing excessive wear and oxidation. If the application requires only a medium pressure.

1.3 Properties of Fluid

Q.11.Enlist and explain in brief the functions of Hydraulic oil in a hydraulic system

Following are the main functions of hydraulic fluid:

1. To transmit power(basic purpose).
2. To lubricate the moving parts.
3. To seal gaps and clearances between mating components.
4. To dissipate heat generated by internal friction.
5. To prevent rust and corrosion of internal parts.

Q.12 .List desirable properties of hydraulic oil.

Following are the main Properties of hydraulic oil required to fulfill its functions:

1) Stable viscosity characteristics
2) Good incompressibility (High bulk modulus)
3) Good lubricity
4) Compatibility with system material
5) Good Demulsibility
6) better fire resistance
7) Good heat dissipation capability
8) Better rust and corrosion preventive qualities
9) Minimum toxicity
10) Ready availability and inexpensive

Q.13.Describe essential properties of oils used in oil hydraulic circuits

1. Demulsibility: The ability of a fluid that is insoluble in water to separate from water with which it may be mixed in the form of emulsion. Or it is the oil's ability to release water.

2. Lubricity: it is the measure of the reduction in friction due to use of oil between two surfaces.

3. High flash point: Flash point is a temperature at which liquid catches fire automatically. The flash point of good hydraulic oil must be as high as possible so that fire possibility nullified.

4. Minimum Toxicity: Good hydraulic oil must be minimum toxic to human being working with them. Some fire resistance hydraulic oils are highly toxic which can cause occupational diseases.
5. Low Foaming Tendency: When oil returns to receiver, it comes in contact with air above the liquid surface. The oil has tendency to absorb air or gas which results in foam formation. Good hydraulic oil must release the air/gas very quickly so that it does not form foam.
6. Fire resistance: Good hydraulic oil must be fire resistant to avoid accidents.
7. Viscosity: It is the resistance offered by the liquid to flow. It is inherent property of the liquid and this resistance to flow depends on some other physical properties such as temperature, pressure, etc.
8. Compressibility: It is the ability of a fluid to get compressed and liquids are less compressible. Compressibility is the reciprocal of bulk modulus.

Q.14.Enlist various ISO and SAE grades of hydraulic oils

The ISO and SAE grades are based on the main property of kinematic viscosity, it ranges from 32 centistrokes to 220 centistrokes.
Higher the number of the grade more the kinematic viscosity of the oil.

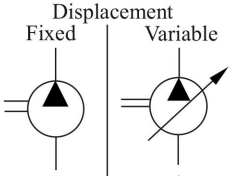
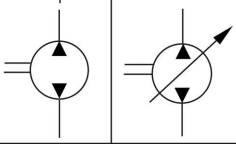
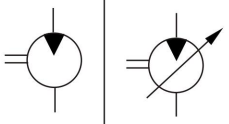
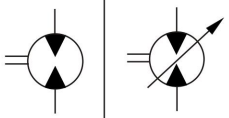
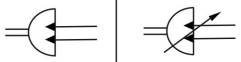
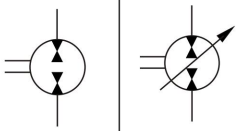
ISO Grade	Equivalent SAE Grade	Kinematic Viscosity		Density
		centiStokes		*kg/m^3*
		40 ^oC	*100 ^oC*	
32	10W	32	5.4	857
46	20	46	6.8	861
68	20W	68	8.7	865
100	30	100	11.4	869
150	40	150	15	872
220	50	220	19.4	875

The letter W indicates that the oil is suitable in cold conditions also.

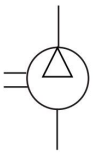
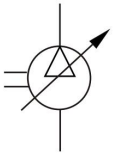
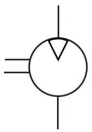
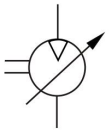
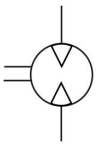
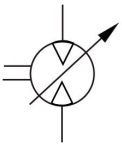
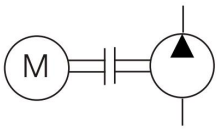
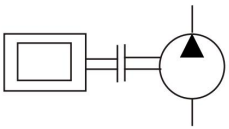
1.4 ISO symbols

FLUID POWER SYMBOLS

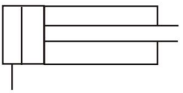
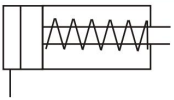
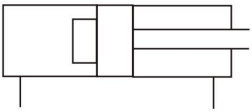
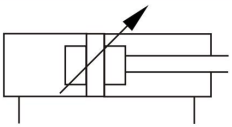
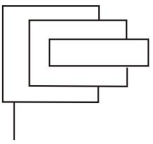
a) Energy Conversion Elements

Elements	Description	Symbol
Hydraulic Pumps Conversion of Mech.energy to hyd. energy.	a) With one directional flow	
	b) With two directional flow	
Hydraulic Motor Conversion of hyd. energy to Mech. energy.	a) With one directional flow	
	b) With two directional flow	
	c) Limited rotation motor	
Pump / Motor	Components which can operate both as Pump and Motor	

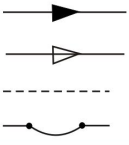
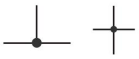
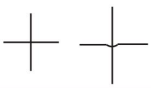
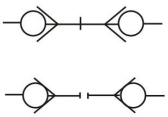
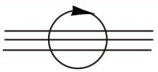
a) Energy Conversion Elements

Elements	Description	Symbol Displacement	
		Fixed	Variable
Compressors Conversion of Mech. energy to pressure energy.			
Air Motors Conversion of pressure energy into Mech. energy.	a) With one directional flow		
	b) With two directional flow		
Drives Provide mechanical energy to system	Electric Motor		
	Internal Combustion Engine		

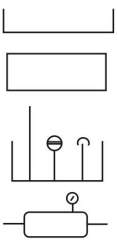
b) Hydraulic cylinders

Elements	Description	Symbol
Cylinders	Conversion of pressure energy into Mechanical energy.	
a) Single acting	Fluid exerts pressure on one side only.	
b) Single acting with Spring return	Return action caused by Spring .	
c) Double acting cylinder with single piston rod.	Two different piston areas	
d) Double acting cylinder with double piston rod.	Two identical piston areas	
e) Cylinder with end cushioning		
f) Adjustable cushion at both ends		
g) Telescopic Cylinder		

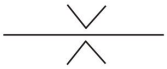
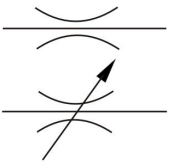
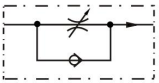
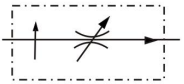
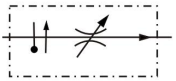
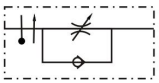
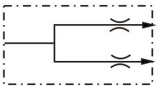
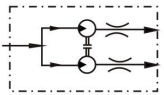
c) Energy Transmitting Elements

Elements	Description	Symbol
Conduct Lines	Main working line Pilot (control) Drain line Flexible connection lines	
Line Junction	Dot at cross point	
Crossed Line with no connection	No dot at cross point	
Pressure Line with plug		
Quick acting coupling	Note that in connected position both check valves are open & when disconnected they are closed by spring force.	
Rotating joint		

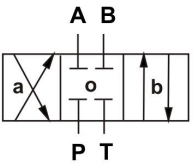
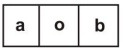
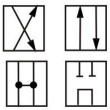
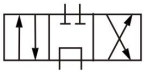
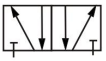
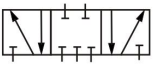
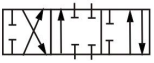
d) Fluid Storage Elements

Storage Tank	A vented reserve oil A Pressurised reseroil Tank with Piping oil level indicator and air bleeding Air Tank or reservoil	

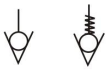
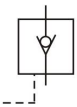
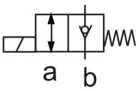
e) Flow Control Valves

Elements	Description	Symbol
a) Orifice Valve	Short throttle segment	
b) Throttle valve Flow depends on thepressure difference	Fixed Variable	
c) Throttle and check valve in one consturction		
d) Flow control Valve	Pressure Compensated Pressure & temperature Compensated Pressure & temperature flow control valve with by pass check valve.	  
e) Flow divider	Divides flow into two equal parts. Flow divider with two coupled motors.	 

f) Directional Control Valves

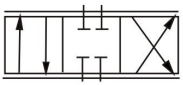
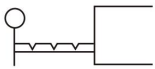
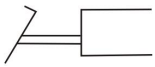
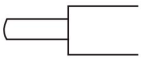
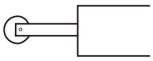
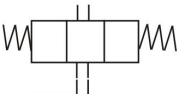
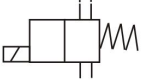
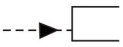
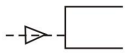
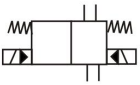
Elements Description	Symbol
Parts of Valves are named with letters P - Pump, Pressrue T - Tank, Return A,B - Load, Consumer X,Y,Z - Pilot Ports L- Leakage Oil Port R- Return line	
Designation **4/3** directional control valve └ Number of switching position └ Number of Ports	
Switching Positions shown by blocks	
Internal connections shown by arrows and lines	
2/2 directional control valve	
3/2 directional control valve	
4/2 directional control valve	
4/3directional control valve	
5/2 directional control valve	
5/3 directional control valve	
6/3 directional control valve	

g) Check Valves

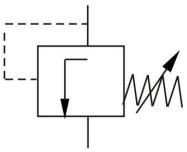
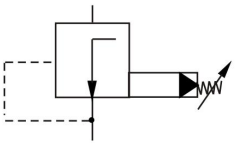
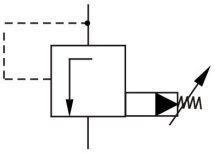
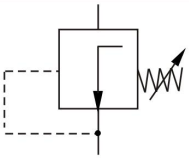
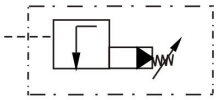
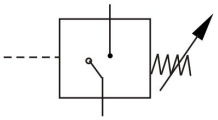
Elements	Description	Symbol
a) Non-return valves	With /without closing spring	
b) Pilot Operated check valve	Opens in One direction only when set pressure is reached at pilot line	
c) Solenoid operated check valve	Position a) allows flow in both direction b) allows flow in only one direction	

h) Fluid Conditioning elements

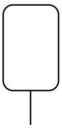
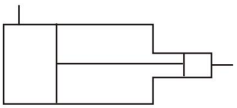
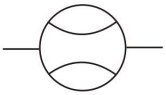
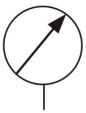
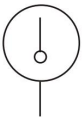
a) Filter		
b) Cooler	Outside arrows indicates heat flowing out of system	
c) Heater	Inside arrow indicates heat flowing into the system.	
	Heater with liquid heating medium	
	Heater with gaseous heating medium	
d) Separator [removing water from air]	Separator with a manual drain	
	Separator with automatic drain	

Elements	Description	Symbol
Infinite Position valves	Additional parallel lines are added on top & bottom of envelope 4/3 way valve with infinite position control	
Control Mechanism for directional control valves	Manual Control lever (each detent indicates one position)	
	Pedal	
	Plunger	
	Roller	
	Return Spring	
	Spring Centered	
	Electrical solenoid operated	
	Hydraulic Pilot actuated	
	Pneumatically actuated	
	Pilot Operated Directional control valve with spring centering	

i) Pressure Control Valve

Elements	Description	Symbol
a) Directly operated pressure relief valve.	Normally closed (Open on actuation)	
b) Pilot operated pressure relief valve.		
c) Directly operated pressure reducing valve.	Normally open (Closes on actuation) See difference in symbol.	
d) Pilot operated pressure reducing valve.		
e) Pilot operated sequence valve with external signal input	The valve switches & opens flow when set value of pressure is reached.	
f) Pressure switchs		

j) Accessories

Elements	Description	Symbol
a) Accumulators.		
	Weight loaded	
	Spring loaded	
	Gas charged	
b) Intensifier [Pressure booster]		
c) Flow meter		
d) Pressure gauge		
e) Temperature gauge.		

1.5 Hazard and safety in hyd.& Pneu.

HAZARDS:

Hydraulic equipments and systems are designed to accomplish work using confined liquid pressure to produce a greater mechanical force. The operators/ maintenance crews are subjected to hazards from high pressure liquids and large mechanical forces. Hydraulic systems store fluid under high pressure. The workmen are exposed to following hazards:

- burns from hot, high-pressure fluid
- Injection of fluid into the skin
- Fire Hazards
- bruises, cuts or abrasions from flailing hydraulic lines
- Injury of people due to unexpected movement of equipment.
- During maintenance of equipment and their parts.
- Injury due to sudden release of residual pressurized oil.
- Slippage due to oily floor area.

SAFETY

1) Positive isolation procedure to be followed before start of any hydraulic work.
2) Depressurize the system before start of work. Shut down/ Local Isolation may be taken, if required.
3) Never begin work on a hydraulic/pneumatic system until fully trained.
4) Never begin work on a hydraulic/pneumatic system without using a risk assessment.
5) Carefully review the manuals on equipments before beginning work. Ask questions about anything you do not fully understand.
6) Use all required safety Equipments like gloves,masks etc.
7) Never try to repair a part without having full knowledge about it.
8) Each hydraulic system must have a documented procedure of de-energizing and load locking. This should be known to all maintenance personnel.
9) Document and practice de-pressurizing procedure in each of the circuit.
10) While testing the system after repair never stand close to the unit. Any component, pipe, hose, fitting may fail.
11) Tightening of Joints should be done in depressurized condition.