INTER PLANT STANDARD – STEEL INDUSTRY		
IPSS	**SAFETY FOR HYDRAULIC SYSTEM**	**IPSS: 1-11-032-17**

0. FOREWORD

0.1 This Inter Plant Standard prepared by Standards Committee on Safety Appliances and Procedures, IPSS 1:11, with the active participation of the representatives of all the steel plants and manufacturers of safety items was adopted in April, 2017.

0.2 Objective of this Standard is to provide guidelines for operation & maintenance of Hydraulic systems

1 SCOPE

1.1 This Inter Plant Standard is applicable for all location of Steel Industry in India. This standard establishes the requirement and guidelines for operation and maintenance of hydraulic systems related to safety.

1.2 A Typical hydraulic circuit diagram and block diagram are shown in Fig.- 1 and Fig.-2 respectively.

1.3 Fire resistant hydraulic fluid to be considered in hydraulic system to be installed in fire prone area

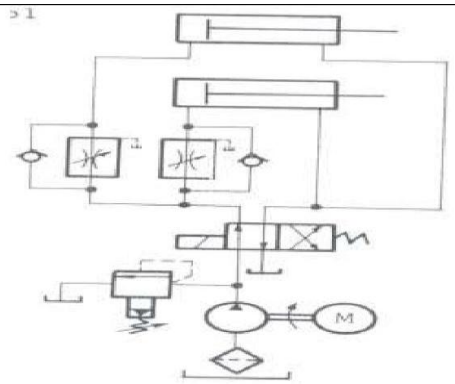
1.4 Incase the hydraulic system can not be located away from fire prone area flame proof system is to be considered.

2 HAZARDS

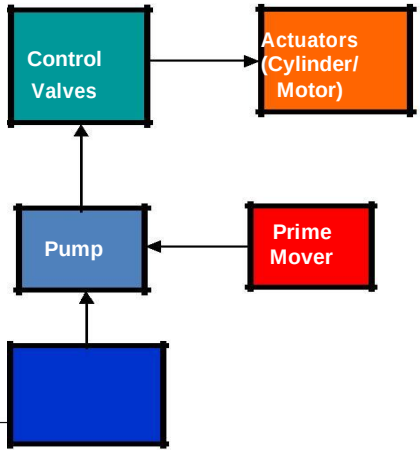
Hydraulic equipments and systems are designed to accomplish work using confined liquid pressure to produce a greater mechanical force. The operators/ maintenance crews are subjected to hazards from high pressure liquids and large mechanical forces. Hydraulic systems store fluid under high pressure. The 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.
- Electric shock from electrical motors/ A.C. Solenoids



Hydraulic circuit diagram (FIGURE- 1)



Block Diagram of a Typical Hydraulic System (FIGURE – 2)

3 General safety precautions during maintenance of Hydraulic System:

3.1.1 Positive isolation procedure to be followed before start of any hydraulic work as per Positive Isolation Procedure enclosed in Annexure-2.

3.1.2 Depressurize the system before start of work. Shut down/ Local Isolation may be taken, if required.

3.1.3 Never begin work on a hydraulic system until fully trained.

3.1.4 Never begin work on a hydraulic system without using a risk assessment.

3.1.5 Carefully review the manuals on equipments before beginning work. Ask questions about anything you do not fully understand.

3.1.6 Read the Material Safety Data Sheet (MSDS) for chemicals used.

3.1.7 Use all required safety Equipments.

3.1.8 Never try to repair a part without having full knowledge about it.

3.1.9 Each hydraulic system must have a documented procedure of de-energizing and load locking. This should be known to all maintenance personnel.

3.1.10 Document and practice de-pressurizing procedure in each of the circuit.

3.1.11 While testing the system after repair never stand close to the unit. Any component, pipe, hose, fitting may fail.

3.1.12 Before start of work, drain the pressure line through minimesh point upto the actuator.

3.1.13 Drain the accumulator, if any, from drain valve and check oil pressure from minimess coupling provided in safety block or main pressure line after accumulator. (Refer Fig.- 3 and Fig.– 4). If pressure gauge is showing zero, then also bleed the accumulator with minimess hose for confirmation.

3.1.14 During the tightening of pressurized lines hammering should not be done.

3.1.15 Tightening of Joints should be done in depressurized condition.

3.1.16 In any of the hydraulic maintenance jobs, all other agencies working in that area should be well communicated about the hydraulic work and its effects.

ARROW IN THE PICTURE IS SHOWING DRAIN VALVE
FIGURE- 3

ARROW IN THE PICTURE IS SHOWING MINIMESH POINT
FIGURE- 4

3.1.17 If working in the valve stand, then drain the valve stand from pressure line and service line A & B (before draining, must ensure load in the lowermost position or give packing/provide mechanical lock, so that actuator should not move in any condition). Take care in handling or working near hydraulic actuators

3.1.18 Starting the system after maintenance: Before starting the system, must ensure removal of all test hoses and proper tightening of all hydraulic pipes, hoses, SAE flanges & fasteners with proper seals/"O"rings. Follow the procedure of removal of positive isolation (given in Annexure-2).

3.1.19 N_2 Charging: Cross check the condition of the bladder. If oil is coming out from bladder charging point, it means the bladder is damaged and needs to be changed. Accumulator should be in zero oil pressure condition. Pressure should read zero at minimess point of accumulator safety block. Pump should be off and positive isolated. In let valve should be closed and locked. Drain valve of accumulator should be open during charging.

3.1.20 Gas pressure must be discharged while attempting to dismantle an accumulator.

3.1.21 Replacement of components to be done after checking their rating and capability.

3.1.22 Minmess coupling to be checked for proper functioning before starting maintenance job. If pressure from minimess coupling is showing zero then oil has to be bleeded to cross check the functioning of the minimess coupling.

3.1.23 All hydraulic pipes and hydraulic cylinders should be tested at 1.5 times working pressure. All accumulators should be tested for its wall thickness and pressures as per Factories Act.

3.1.24 Do not use bare hand to check the hydraulic leakage; any fluid leakage through pinhole leakage can be injected into your skin. Use a card board or wooden piece to check leakages.

3.1.25 Hot work like gas cutting, welding should be avoided near hydraulic pipeline or near tank.

3.1.26 Any modification being carried out in Hydraulic System Circuit, should be approved by competent authority.

3.2 **Reservoir/Sump:**

3.2.1 Do not weld on a hydraulic reservoir/sump without emptying the oil.

3.2.2 Ensure all vents (air breather & hatch plate) should be opened. For any maintenance/ cleaning job to release entrapped gases.

3.2.3 Ensure no chocking of the air breather. Inspect and replace faulty breathers.

3.3 **Pump:**

3.3.1 Put off the motor power from MCC and lock out & Tag out. Obtain permit to work as per plant procedures.

3.3.2 Close the suction & delivery valve and lock out & Tag out.

3.3.3 Drain the pump casing and depressurize (ensure zero pressure).

3.3.4 Incase pump flange is opened, do not open all the bolts of flange at a time, loosen the flange joint first and ensure there is no entrapped oil.

3.3.5 In case of pump change, handling of pump should be done with a proper lifting/placement tools.

3.3.6 Before start of motor, ensure correct direction of motor rotation.

3.3.7 Before installing a new pump, check pressure rating of pump. Its pressure rating should be higher than the required system pressure.

3.3.8 While changing of pumps, please ensure all fasteners & hoses have been properly tightened. Before start of pump , the pump casing must be filled with hydraulic oil. Ensure that the pressure compensator must be fully in open condition to start with (pressure should be zero), and then pressure should be set. Entrapped air to be released from delivery line. Flushing circuit for the pump, if available, should be kept on prior to switching on the pump.

3.3.9 Relief Valve Pressure should always be set 20-30 bar more than the Pump compensator setting.

Actuator (hydraulic cylinder/motor):

3.3.10 Removal of Old actuator. Ensure that the load attached to the actuator is mechanically secured.

3.3.10.1 De-pressurize the actuator, and then start loosening the hose pipe. After opening of 3-4 threads, shake the hose pipe for removing any residual pressure.

3.3.10.2 Start loosening of actuator mounting bolt. If actuator is heavy then hold with Crane or chain block. (**If actuator is a cylinder, then do not hold the cylinder from piston rod side because there is chance of rod coming out from cylinder barrel**.) Before lifting of actuator plug the port of actuator, because piston rod can come out because of self-weight.

3.3.11 Fixing of New actuator:

3.3.11.1 After removal of old actuator, place new actuator (If actuator is a cylinder, then do not hold the cylinder from piston rod side because there is chance of rod coming out from cylinder barrel.)

3.3.11.2 Secure the position rod to prevent extension of the rod while removal or fixing (by plugging the cylinder ports/ restraining by tying with ropes).

3.3.11.3 Fix the hose connection and after proper tightening and bleeding of entrapped air during cylinder trial only, leave the work place.

3.3.11.4 Hydraulic Motor should always be started with casing filled with fluid.

3.3.11.5 Ensure there is no pressure inside actuator, especially if there is pilot operated check valve or counter balance valve in the lines.

3.3.11.6 Never pressurize the bore end of double acting cylinder with rod end port plugged.

3.3.11.7 While closing the lines to differential double acting cylinders, close the bore end valves first and then the rod end valves. For opening the valves reverse sequence is to be followed.

3.4 **Valves:**

3.4.1 Removal of old valve

3.4.1.1 Ensure 100 % positive isolation & depressurization of P,T,A,B line before opening of any hydraulic valve.

3.4.1.2 Start cross loosening of valve bolts. After loosening of 3-4 threads; shake the valve for removal of locked pressure. If oil is not coming, then start loosening of valve.

3.4.2 Fixing of new valve

3.4.2.1 Before changing the valves, match the valve specification & port matching in case of stack mounted valves. If there is some mismatch, get comment from expert. (Because low pressure valve are also available in same mounting.)

3.4.2.2 After replacement of O-ring / valve, start tightening of valve mounting bolt (cross wise). Do not uses too much long pipe for Allen key. In case bolts are required to be changed, bolts of same property class to be used.

3.4.2.3 Pressure setting of pressure relief / reducing valve: First check pressure rating of pressure relief / reducing valve. Identify right measuring point in system by hydraulic circuit diagram. If valve is external drain type, drain must be connected to tank without any restriction. Slowly adjust the pressure.

3.4.2.4 Pressure relief valves incorporated into the hydraulic system will avoid pressure buildups during use. Keep these valves clean and test them periodically to ensure correct operation.

3.4.2.5 While working on spring loaded valves take precaution to ensure that no spring back action takes place.

3.4.2.6 All direction control valves should be marked to identify the solenoid responsible for forward or backward motion of actuator.

3.5 **Hoses & fittings**

3.5.1 Before replacing hoses, depressurize the system as per positive isolation procedure (Annexure-2). Check the hose or hoses to be replaced by twisting or squeezing them to see if the pressure has been relieved, or by another method suitable to the hose being used. If pressure is still in the hose or hoses, take appropriate measures to relieve the pressure before loosening the fittings. Care to be taken that replacement of hose should be with hoses with same size and specifications.

3.5.2 All the hoses in hot area shall be with stainless steel braided cover and silica cloth cover.

3.5.3 Each and every hose in a hydraulic system must be able to handle the highest pressure produced by the system. Pressure surges or peaks exceeding the hose rated working pressure are destructive and must be considered when selecting a hose. Please ensure compatibility of hose with design pressure of system.

3.5.4 Improper Length/Routing - Forcing a hose into an improper geometry causes high stresses in the hose components that may also reduce pressure capacity (avoid multi-plane bending, small bend radii, tension in hose, etc.). Hose life can be reduced by 90% when subject to these type of stresses (Refer Figure 6).

3.5.5 Locking arrangement may be provided to avoid swinging of hoses in case of failure from crimping portion (Refer Figure 5).

FIGURE - 5

3.5.6 Abrasion and Cuts - Wear against other hoses or objects will wear off the outer cover and lead to corrosion of the reinforcing mesh.

3.5.7 Extreme Pressure Fluctuations - Pressure surges above the hose working pressure will damage hose components.

3.5.8 Vibration - Cyclic loading of hoses can damage hose components even when motion seems relatively small.

3.5.9 Hoses having bulges or getting wet surface to be immediately replaced.

3.5.10 Hose rupture valve may be provided near the actuator for enhanced safety in case of hose failure.

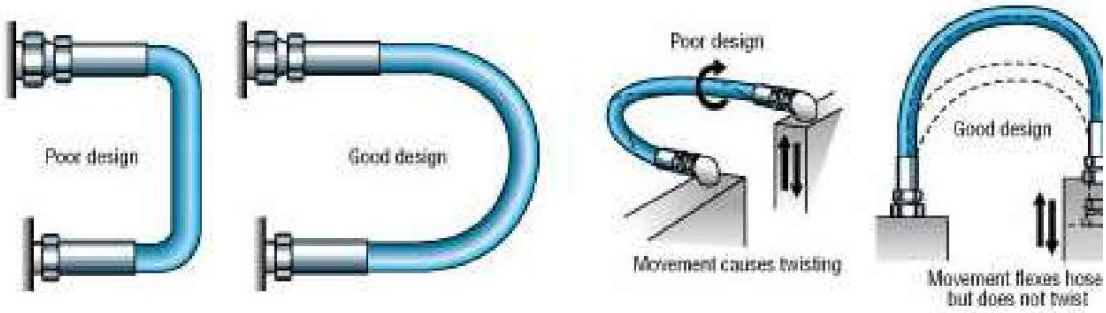

Poor design
Good design
Poor design
Movement causes twisting
Good design
Movement flexes hose
but does not twist

FIGURE - 6

3.6 **Pipes & fittings**

3.6.1 Seamless and pre-treated (pickled, washed and oiled) precision steel tubes are to be used for all piping. All pipes & fittings should be rated for at least 1.5 times working pressure.

3.6.2 Pipe bends should be supported by clamps as near to the bends as possible. Pipe bend radius should be minimum 5 times of pipe diameter. Clamping of the pipelines should be proper. The distance between two clamps should not be greater than 1.5 m.

3.6.3 For pipe joints up to 38 mm OD pipe, weld-nipple type fittings(24 deg)/ walform fittings with 'O'-ring shall be used and above 38 mm OD pipe, SAE flanges of suitable pressure class with 'O'-ring shall be used for each hydraulic system. Ferrule Fittings should not be used in hydraulic systems. “O” rings should be of reputed make and of 90 shore hardness.

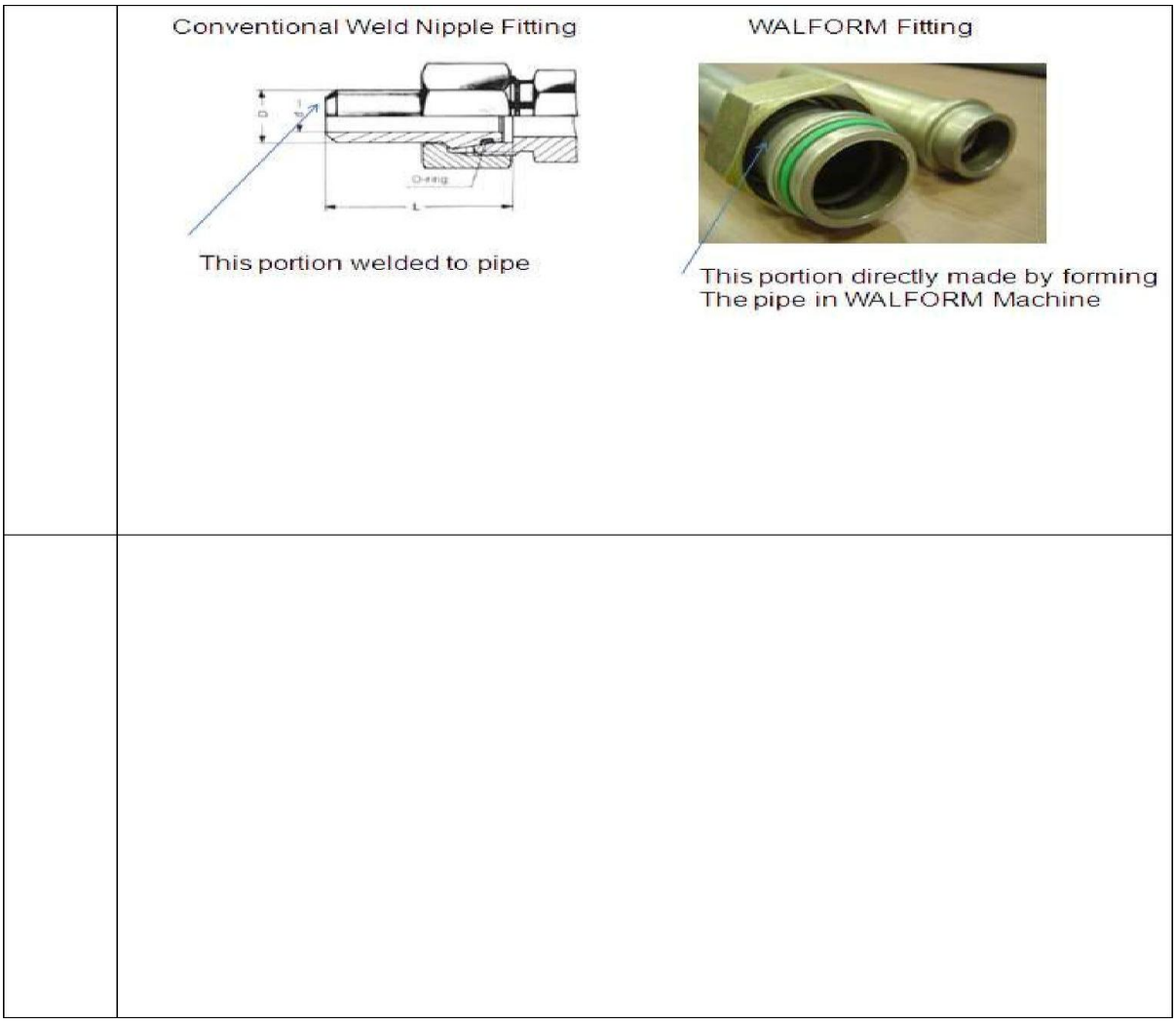


FIGURE-7

3.6.4 Up to 38 mm OD pipe, welding of pipes and pipe joints shall be carried out by TIG welding only. For pipe sizes above 38 mm OD, the root shall be TIG welded and the balance portion shall be electric ARC welded.

3.7 In addition to the above general guidelines, every hydraulic machine will have specific hydraulic safety procedure, which is must adhered to.

4 Operation of Hydraulic Systems:

4.1 Audio and visual alarms should be provided for following faults in the hydraulic system.

- Low pressure in the system
- Excessive temperature of oil in reservoir
- High level of oil in reservoir
- Low level of oil on the reservoir
- Low-low level of oil in the reservoir and pump cutoff
- Clogging of filters
- Motor overload

4.2 Maintain cleanliness around work surroundings. Good house keeping standard to be maintained in the hydraulic room, machine parts/ hoses and floor made to be free from Oil smears.

4.3 All oil leakage and rise in temperature must be attended immediately.

4.4 Allow proper ventilation all-around in the cellar. Proper natural/ mechanical ventilation to be provided in the hydraulic room for extraction of hydraulic fumes

4.5 Noise level in the cellars must not exceed 85 dba. Anti vibration pads to be periodically & replaced , if required.

4.6 Install a Fire Extinguisher (Dry Chemical or CO2) near the hydraulic system.

4.7 Oil Cellar must have fire hydrant lines as per standard (IS 3844:1989) .

4.8 Suitable automatic Fire Detectors and suppression system to be provided in hydraulic room for early detection and suppression of fire.

4.9 Suitable personnel protective equipment (PPEs) like Spectacles, Gloves (preferable Nitrile), Oil resistant aprons etc to be used by the person working on hydraulic systems.

4.10 Probably the most common injury associated with hydraulic systems is the result of pinhole leaks in hoses. These leaks are difficult to locate. A person may notice a damp, oily, dirty place near a hydraulic line. Not seeing the leak, the person runs a hand or finger along the line to find it. When the pinhole is reached, the fluid can be injected into the skin as if from a hypodermic syringe. Immediately after the injection, the person experiences

only a slight stinging sensation and may not think much about it. Several hours later, however, the wound begins to throb and severe pain begins. By the time a doctor is seen, it is often too late, and the individual loses a finger or entire arm. Unfortunately, this kind of accident is not uncommon. To prevent this type of injury, run a piece of wood or cardboard along the hose (rather than fingers) to detect the leak (refer figure 8).

4.11 Material safety data sheet (MSDS) to be displayed in the hydraulic room.

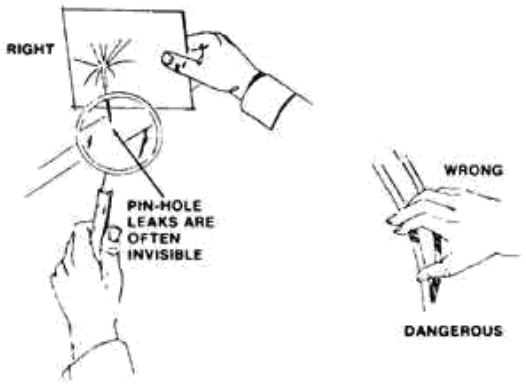


Figure 8: Detecting pinhole leaks in a hydraulic system.

4.12 System of periodical cleaning of drip tray for preventing spillage to be put in place and the drip tray to be periodically cleaned.

4.13 Full body showers/ eye wash showers to be provided in the close vicinity of hydraulic system for drenching / flushing of eyes of persons affected by hydraulic oil and location to be displayed with proper signage.

5 **Audit.**

A system of Audit is to be developed to conduct periodic audit of hydraulic systems. An indicative checklist is attached at Annexure-1

6 **Records:**

1. Records on Inspection and Maintenance of Hydraulic Systems shall be available at Department.
2. Records on Hydraulic System Audit shall be maintained by the Department and auditing agency.

ANNEXURE-1

Form No. : MED(M)/ PCL-HYD/REP/01/00

MAINTENANCE ENGINEERING DEPARTMENT (MECHANICAL)
INSPECTION REPORT OF HYDRAULIC SYSTEM

INSP.REPORT NO :
DEPARTMENT :
EQUIPMENT :

Inspected By :
Date & Time :

Temp Taken by Non Contact Gauge

SL. NO.	ITEMS TO BE CHECKED	OBSERVATION
A.	HOUSE KEEPING OF HYDRAULIC ROOM (FLOOR CLEANLINESS/ILLUMINATION ETC.)	
B.	CLEANLINESS OF HYDRAULIC POWER PACK & PIPING	
C.	**RESERVIOR :**	
	1. HYDRAULIC FLUID LEVEL IN TANK	
	2. CONDITION OF LEVEL INDICATOR	
	3. HYDRAULIC FLUID TEMPERATURE	
	4. VISUAL APPEARANCE OF HYDRAULIC FLUID	
	5. CONDITION OF FILLER/BREATHER	
	6. CONDITION OF SUCTION STRAINER	
	7. RETURN LINE FILTER	
D.	**HEAT EXCHANGER :**	
	1. INLET FLUID TEMPERATURE	
	2. OUTLET FLUID TEMPERATURE	
	3. INLET COOLANT TEMPERATURE	
	4. OUTLET COOLANT TEMPERATURE	
E.	**RECONDITIONING UNIT :**	
	1. NO. OF PUMPS INSTALLED	
	2. PUMP NO. IN SERVICE	
	3. NOISE - HEAT ETC. OF PUMPS IN SERVICE	
F.	**PILOT PRESSURE UNIT :**	
	1. PUMP NO. IN SERVICE	
	2. CONDITION OF STANDBY PUMP	
	3. LINE PRESSURE	
	4. CONDITION OF FILTER	

ANNEXURE-1

SL. NO.	ITEMS TO BE CHECKED	OBSERVATION
G.	**MAIN SYSTEM :**	
	1. NO. OF PUMP INSTALLED	
	2. PUMP NOS. IN SERVICE	
	3. PUMP MOUNTING (OK / NOT OK)	
	4. NOISE - HEAT ETC. OF PUMPS IN SERVICE	
	5. LEAKS	
	6. PUMP OPERATION (SMOOTH / NOISY)	
	7. CONDITION OF STAND BY PUMP	
	8. DELIVERY PRESSURE	
H.	**VALVE STANDS :**	
	1. MOUNTING OF VALVES	
	2. CONDITION OF VALVE STANDS	
	3. LEAKAGES	
	4. FUNCTIONING OF THE VALVES	
I.	**ACCUMULATOR STANDS :**	
	1. PRE-CHARGE PRESSURE	
	2. ACCUMULATOR WORKING / NOT WORKING	
J.	**ACTUATORS :**	
	1. CLEANLINESS	
	2. OPERATION (SMOOTH / JERKY)	
	3. MOUNTING (TIGHT / LOOSE)	
	4. CONDITION OF HOSES	
K.	**INSTRUMENTS AND PROTECTIVE DEVICES :**	
	1. PRESSURE GAUGES	
	2. TEMPERATURE GAUGES	
L.	**ANY OTHER OBSERVATION & REMARKS**	

Signature of Inspector :
Date :

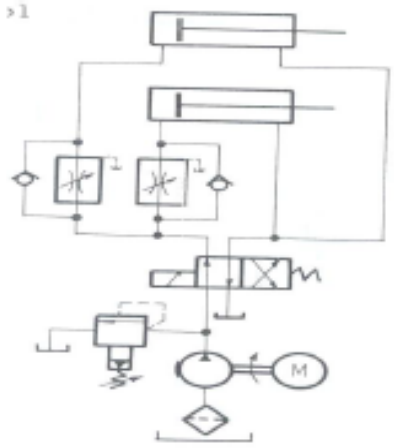
Signature of Dept. Rep. :
Name :
Date :

ANNEXURE -2

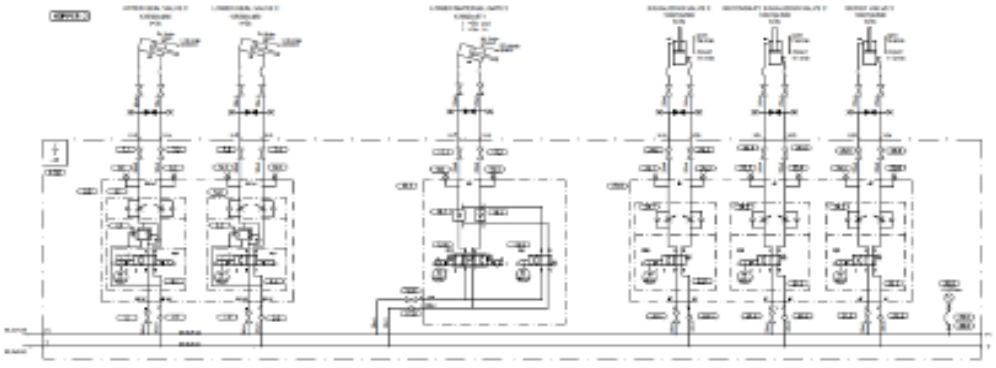
Annexure2: Positive Isolation of Hydraulic Systems:

A typical hydraulic system may have single or multiple valve stands. One Valve Stand may supply to one or multiple actuators.

Following is the example of a simple Hydraulic System with Single Vave Stand.



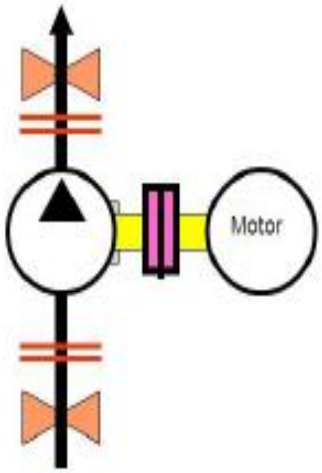
A typical hydraulic circuit with multiple valve stands is shown below. Each valve stand is used to actuate a particular actuator or set of actuators.



ANNEXURE - 2

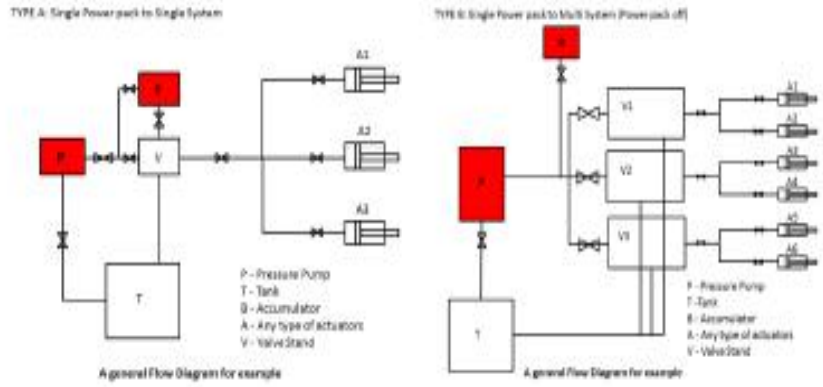
Following procedure is followed for positive isolation of hydraulic systems.

a) Cut off power of pump and lock the respective electric panels by pad lock as per positive isolation procedure SS/ENG/26 revision4.
b) Close the isolation valve at suction and delivery side of each pump.
c) Lock the handle of isolation valve at pump delivery by a pad lock.
d) Drain the accumulator (if provided in the system) to ensure zero pressure (read zero pressure in the gauge).



e) Bleed off the actuators to release entrapped hydraulic pressure as per safe work procedure.
f) Close and lock isolation ball valves as per requirement.
g) Always ensure zero pressure (read zero in the pressure gauge) in the line where work is being performed.
f) Lower the hanging load if any.
g) Mechanical Locking of equipment is done to prevent hydraulic cylinder movement because of load.
g) All trials should be taken in the end once positive isolation is deactivated.

ANNEXURE -2



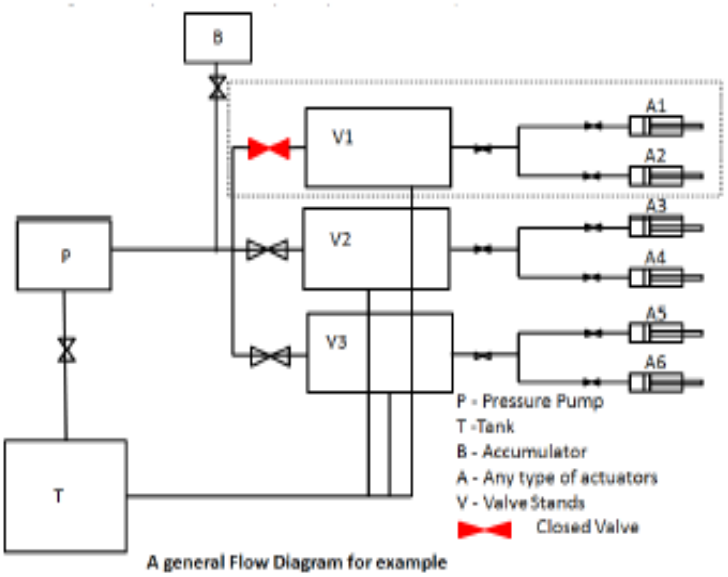
Block Diagram showing Power Pack (P) put-off and Accumulator Block (B) drained

Note: In few exceptional cases, process constraints do not allow power pack to be put-off. In such cases, isolation is done by closing and locking the ball valve and depressurizing the hydraulic line after the ball valve (there is full system pressure before the ball valve). Few such examples are Slide Gate Hydraulic System at LD1 and Mudgun Hydraulics at Blast Furnaces.

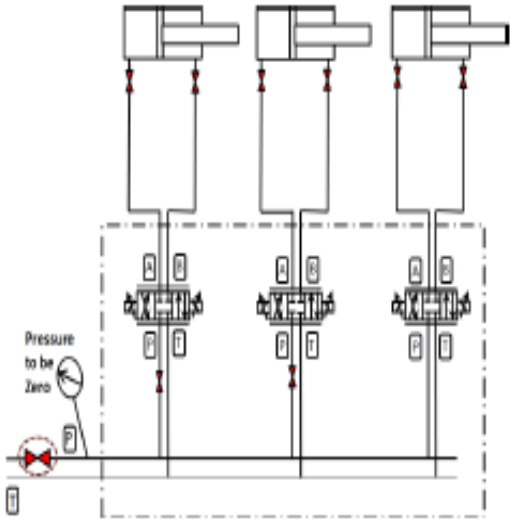
In all such cases, there must be a pressure measuring minimess point after the ball valve being isolated. Pressure must be read zero after connecting the Pressure Gauge to the minimess point. After that, minimess hose should be kept open (remove the pressure gauge) and work should only be done if no oil is dripping from the minimess (which means that there is no leak from the ball valve). During the entire work, this should be kept under observation. Connected hose with minimesh should be rigidly fixed and open point of minimesh should be diverted to drain.

Photograph of minimess point and minimesh hose

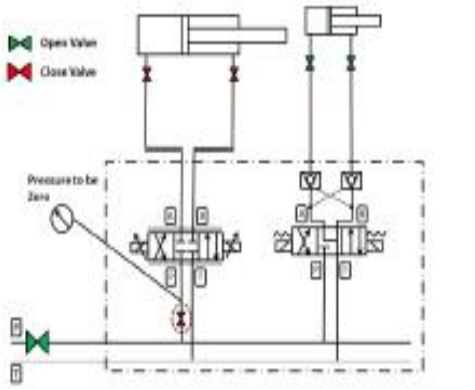
ANNEXURE -2

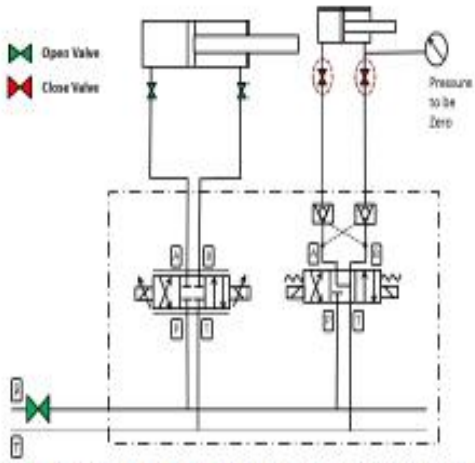


A general Flow Diagram for example



ANNEXURE -2





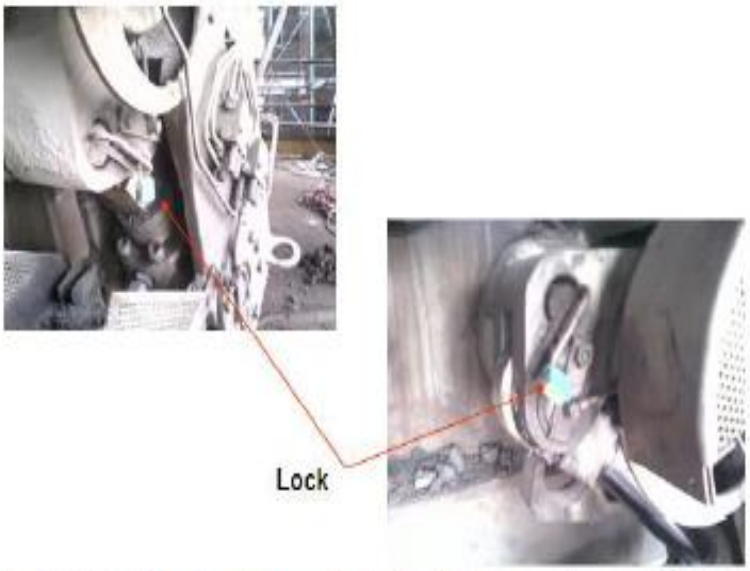
Isolation could be done by either closing the ball valve before manifold or in P line going to individual cylinder or by closing the ball valve just before the actuator.

Some of the photographs of ball valve locking and mechanical locking of equipment are shown below.

ANNEXURE -2

Locking of Ball Valves

Mechanical locking arrangement



Mechanical locking of equipment to prevent hydraulic cylinder movement because of Load

Mechanical Jamming of wheel in NBM Fce. Walking Beam to prevent Hydraulic Cylinder Movement

ANNEXURE -2

Arrangement made to lock hydraulic line ball valve at HSM

Ball valves with provision made for locking

DEISOLATION OF HYDRAULIC SYSTEM-:

1. Deairation of hydraulic system by connecting the pressure line with return line/ looping of P&T line.
2. Set the system at low pressure and start.
3. Removal/ disconnection of P&T line.
4. Slowly increase pressure to the rated pressure.
5. If the system is having the provision of loading / unloading valves, then above procedure can be done through these valves following the procedure given by OEM.