Safety With Hydraulic Systems

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How We Go About

- Understanding Hydraulic Systems to understand Hazards / Risks only- Not Discussing Hydraulic System Technology
- Basics of System- Application- Components
- Components / Operations / Maintenance Related Hazards-
- Personal Safety- Equipment Safety- Fire Safety
- How Safety Professionals Can Look at Above Issues

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Invention

- 1646 Blaise Pascal, Scientist First to discover
- A pressure applied to any part of a confined fluid (Incompressible) transmits to every other part with no loss.
- The pressure acts with equal force on all equal areas of the confining walls and perpendicular to the walls.
- Principles of hydraulic fluids led to invention of Hydraulic Press and Syringe
- 1795 Joseph Bramha Hydraulic Press

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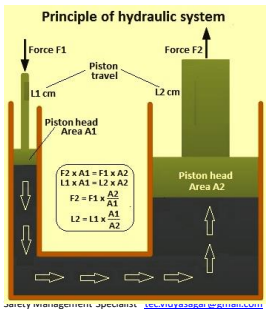

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Hydraulic Systems

- A hydraulic system is one of the drive systems which are being used for the control of machinery and equipment.
- Incompressible Liquid is main medium for transfer of Pressure

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- Pressure
- Force
- Energy

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Why Chosen

- Capable of moving heavier loads
- Constant force and torque, regardless of other parameters
- Better Durability than their electrical and mechanical counterparts.
- Longer periods with less break down
- More robust design.

- Fewer moving parts
- Comparatively Withstand hot environments
- Less maintenance
- Economical
- Comparatively Safer
- Comparatively less noise- better env.friendly

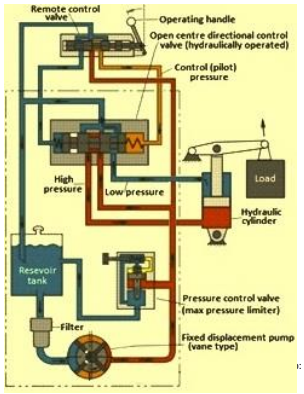
Two Systems

- In Open centre system is one which has fluid flow, but no pressure in the system when the actuating mechanisms are idle.
- Pump circulates the fluid from the reservoir, through the selector valves, and back to the reservoir.
- In closed centre system, the fluid is under pressure whenever the power pump is operating.
- Actuators arranged in parallel out of which some of the actuating units are operating at the same time, while some other actuating units are not operating.

Components of Hydraulic System

- Reservoir for hydraulic fluid- sump
- Hydraulic pump
- Filters and Breathers
- Hoses, pipes and fittings
- Accumulator
- Hydraulic Motor
- Actuator

- Directional control valve
- Flow control valve
- Pressure relief valve



Applications

Actually Can Be Different and
Number of Actuators in Applications

Examples of Application of Hydraulics

- Mining and Mineral Processes
- Manufacturing including Metal Working- Metallurgical- Furnace Operations / Robotics- Injection Moulding- Die casting etc
- Automotives
- Construction/ Agriculture/ Forestry
- Marine/ Aviation
- Exploration of Petroleum

Stationary Applications of Hydraulic Systems

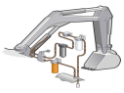
- Machine tools and transfer lines.
- Metal-forming presses- Rolling machines
- Lifts- Lifting and conveying devices.
- Plastic machinery such as injection-moulding machines.
- Food processing machinery.
- Automatic handling equipment and robots.

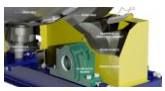
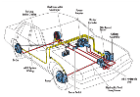
Mobile hydraulic systems

- Automobiles, tractors, aeroplanes, missile, boats, etc.
- Construction machinery.
- Tippers, excavators and elevating platforms.
- Lifting and conveying devices.
- Agricultural machinery
- Etc

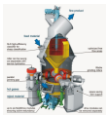
Detailed Example:
Cement Industry Applications

- Basic industrial hydraulic systems
- Stacker-reclaimer hydraulics
- Vertical mill hydraulics
- Kiln hydraulics
- Clinker cooler hydraulics
- HRP & ball mill hydraulics

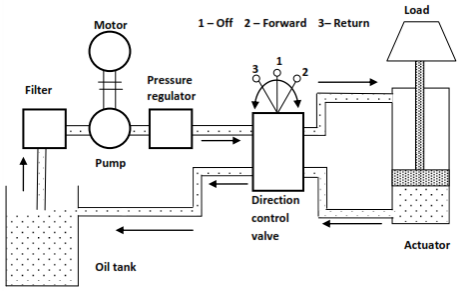




Line Diagram and Components of A Hydraulic System



Fluid Control Systems Evolution

Modern Systems

- Robust suitable for High Pressure
- High Energy
- Efficient
- Combination of
- Hydraulic / Pneumatic Instrument Control / Mechanical Equipment

Hydraulic System Hazards

Hydraulic System Hazards

- Component Hazards- Related Accidents
- Total System Related Hazards- Accidents
- Installation Hazards
- Operational Hazards
- Maintenance Hazards
- Inspection Hazards
- Testing Hazards

Hydraulic Systems Hazards

- Burns from hot fluid
- High-pressure fluid injection into skin
- Fire hazards
- Bruises, cuts or abrasions
- Unexpected movement of equipment
- Injury due to sudden release of residual pressurized oil
- Slippage due to oily floor area
- Electric shock from electrical motors/ AC solenoids etc.

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- Pressure- Pin Hole- Bursting of Hose- Coupling Blown Off – whipping hose- stored energy
- Vibration Hazards
- Temperature
- Flammability Hazards
- Mechanical Hazard
- Electrical Hazards

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Why Hydraulic System Accidents?

- Not Having Knowledge of System and Hazards
- In correct Hydraulic Fluid
- Failure to Maintain Hydraulic Fluid
- Allowing system to run at high temperature – Overheating of Hydraulic Fluid
- Hydraulic Fluid Heat Exchanger Failure

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- Instruments / Controls Malfunctioning
- Filter Choking- Filter Maintenance
- Filters at Wrong Location
- Failure of Priming and Lubrication
- Bleed System Failure Resulting in Pressure Retention during maintenance

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Short List

- Sub-standard engineering practices, Failure to Isolate – Locking out energy system
- Sub-standard material specifications,
- Sub-standard building practices,
- Code- Standard- Safe Practice violations
- Poorly trained / un qualified / in experienced workforce.

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Common Troubles

- 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 cut off
- Clogging of filters
- Motor overload

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Typical Supports

Sustaining Safety-Method of Work

- Never exceed the rated working pressure of a hose.
- Never run over a hose with equipment or vehicles.
- Never pull a hose by its coupling.
- Never lift a heavy, large-diameter hose from the middle with the ends hanging down.

- Never over bend a hose to the point of kinking.
- Remove kinked or crushed hose from service immediately for inspection.
- Remove and test any hose assembly that has been subjected to abuse.
- Visually inspect and pressure test hose at regular intervals.

- With assembly disconnected or under no pressure, check for fluid seepage by pushing at the base of the coupling with thumbs; a hose softened by fluid seepage must be replaced.

Safety Issues with Hydraulic Systems

Safety Issues With Hydraulic Systems

- The energy stored in hydraulic equipment can send failed components flying through the air with a similar impact to bullets.
- Hydraulic Energy makes equipment move faster, with more power and more articulation than any other technology, and for that reason, it can be extremely dangerous

- Fluid temperatures are often well above scolding temperatures and if leaks get near a heat source they can cause dangerous fires
- Hydraulic systems that retain stored energy while the power supply is turned off, brings an increased risk.

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- Starting up, or when shut down can be some of the most dangerous times for working near hydraulic equipment.
- Vital to read and understand the equipment's safe start up and shut down isolation procedures before work

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- Operation of Hydraulic Systems
- 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

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- Work Area
- 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.
- All oil leakage and rise in temperature must be attended immediately.

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Ventilation-Noise-Vibration

- Allow proper ventilation all-around in the cellar.
- Proper natural/ mechanical ventilation to be provided in the hydraulic room for extraction of hydraulic fumes
- Noise level in the cellars must not exceed 85 dba.
- Anti vibration pads to be periodically & replaced , if required.

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Effects of Corrosion on Hydraulic System

- Types of Corrosion
- General corrosion
- Localized corrosion
- Pitting corrosion
- Crevice corrosion.
- Uniform corrosion

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- Causes
- Sealing Failures
- Inappropriate Fluid and Material Selection
- Heavy Load or Long-time operation
- Prevention
- Design / Manufacture
- Operation / Maintenance

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Common System Problems

- Insufficient/No oil in the system
- Dirty or clogged filter
- Excess load
- Aeration/Cavitation
- Engine Speed
- Overheating of oil

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- Internal leakage of system Components
- Incorrect/Insufficient oil
- Improper selection/performance of oil cooler
- Low fluid Viscosity
- Hydraulic cylinder problems
  - Knocking
  - Thrust Reduction

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Hydraulic System Inspection- Used By One Large Organisation

- Housekeeping- cleanliness of Hydraulic Power Pack-Piping- Flooring
- Reservoir- Level- Condition of Level Indicator
- Fluid Temperature
- Visual Appearance of Hydraulic Fluid
- Condition of Filter-Breather-Suction Strainer-Return Line Filter

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- Pumps- in use- in standby- condition of pump
- Noise- heat of pump surface
- Line Pressure Indication – Filter
- Valve Stands-Mountings-condition of valve stands-leakage-valve functioning
- Accumulator Stand- Precharge Pressure-Operation
- Instruments- Pressure Gauge- Temperature Indicator
- Any other significant Observation

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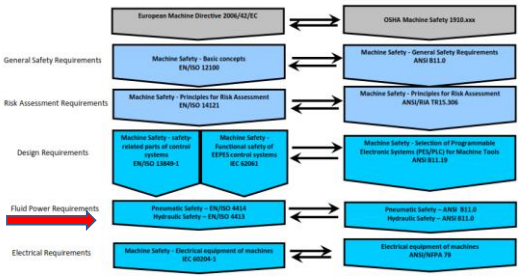
Hydraulic Equipment Safety Standards



O&M Competency

- Knowledge
- Experience
- Skill
- Qualification and Certification
- Skill Development Modules for Operators / Maintenance Persons

Emergency Stops

- Hydraulic systems shall be designed so that operation of an emergency stop or emergency return control does not result in a hazard.
- When a hazard (for example a fire hazard) exists, a hydraulic system emergency stop shall be provided.
- At least one emergency stop button shall be remotely located.

- Emergency stop and emergency return controls are applied with hydraulic systems, they shall
- be readily identifiable;
- be provided at each operator's worldng position and be readily accessible under all conditions of working.
- Additional controls maybe necessary to fulfill this requirement
- operate immediately

- be independent of, and unaffected by, the adjustments of other controls or flow restrictions
- not require operation of more than one manual control for all emergency functions.
- Whenever systems must be dismantled for transportation, the piping and connections shall be clearly identified.
- Identification shall correspond to the data on any appropriate drawings.

Start Up

Typical Start Up

- Proper PPE use
- Full isolation and tagging, or locking of the main power supply
- No one else can turn them back on without supervision.
- Check that all isolators, particularly tank return and drain lines isolators are open to tank before you turn the system on.
- Unload the system, potentially with the system relief valve, before start the pump

- Always check that electric motors have been wired correctly by first powering them for only a second, to ensure they send flow in the correct direction.
- Discharge all accumulators before you start to work on any equipment.
- Power up electrical controls to check them first, before you apply hydraulic power to the actuators.

- Make sure elevated loads are physically supported before release the pressure.
- Never work near a load supported by hydraulic pressure alone.
- Whenever possible, stand behind a physical shield, away from working hydraulic equipment, particularly during start-up.

- Always turn off the hydraulic power before adjusting the valve settings.

Torque During Installation-Maintenance

- Proper torquing of fittings is also important:
- When connecting threaded or flanged ends, follow proper torque recommendations.
- Improperly torqued (both under torqued or over torqued) fittings may not only leak, but they may not withstand system pressure or vibration.

During Operation and Maintenance

O&M Practices

- Recommended maintenance requirements to maintain the fluid system in a safe operating condition.
- Recommended inspection and tests, to check if the equipment is safe to operate.
- Identification of any hazards involved in maintaining and operating the equipment.

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- Identification of all high-risk areas.
- Energy isolation, dissipation and control procedures.
- Safe work procedures to carry out maintenance on the system, including setting of controls.
- Protective equipment requirements.

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- Trouble shooting guide.
- Safe handling and disposal of fluids.
- Recommended spares.

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Design Safety

- To avoid pressurised fluids escaping into the environment, fluid power system components should have appropriate factors of safety on the rated working pressure to bursting pressure.
- Hose assemblies should have a factor of safety of at least 4:1. (Always look for OEM support)

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- Adaptor fittings should have a factor of safety of at least 4:1 on rated working pressure to catastrophic failure of the adaptor or fitting
- Other fluid power components, such as cylinders, valves, actuators or similar should have a factor of safety of at least 2.5:1.

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- Where the above safety factors are reduced, appropriate engineering analysis and/or cycle and endurance testing should be carried out
- When considering a factor of safety for components for fluid power system due consideration should be given to fatigue life of the component.

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Before Inspection / Maintenance

- Prior to conducting any inspection of hydraulic system, it's important to understand the precautions as well as specific precautions outlined by equipment's manufacturer.
- Follow OEM Guidelines for frequency for inspection / maintenance / change of components

Maintenance- Follow Checklist

- Turnoff Equipment Power – Apply LOTO
- Release Pressure
- Remove access panels and inspect hose and fittings for damage / leak signs / corrosion
- Repair / Replace as needed
- Reinstall access panels
- After verification – remove LOTO- turn on power supply
- Loos and listen any un usuals before operation

- Never begin work on a hydraulic system until fully trained.
- Never try to repair a part without having full knowledge about it.
- Never begin work on a hydraulic system without using a risk assessment.
- Carefully review the manuals on equipments before beginning work.
- Ask questions about anything do not fully understand

- Use all required safety Equipment.
- Read the Material Safety Data Sheet (MSDS) for chemicals used.
- Each hydraulic system must have a documented procedure of de-energizing and load locking.
- This should be known to all maintenance personnel.
- Document and practice de-pressurizing procedure in each of the circuit.

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

- Positive isolation procedure to be followed before start of any hydraulic maint work as per Procedure
- Depressurize the system before start of work. Shut down/ Local Isolation may be taken, if required.
- While testing the system after repair never stand close to the unit as any component, pipe, hose, fitting may fail.

- Drain the accumulator, if any, from drain valve and check oil pressure from minimesh coupling provided in safety block or main pressure line after accumulator.
- If pressure gauge is showing zero, then also bleed the accumulator with minimesh hose for confirmation.
- During the tightening of pressurized lines hammering should not be done.

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- Tightening of Joints should be done in depressurized condition.
- 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.
- Take care in handling or working near hydraulic actuators

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

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- System of periodical cleaning of drip tray for preventing spillage to be put in place and the drip tray to be periodically cleaned.
- Hot work like gas cutting, welding should be avoided near hydraulic pipeline or near tank.

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Ensure Zero Energy Before Meddling- Deceptive Indication- Reading

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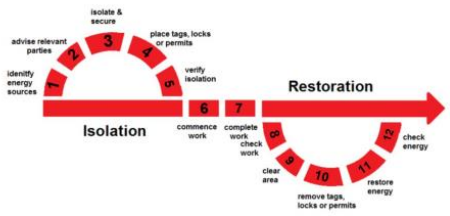
Stages-Isolation-Restoration



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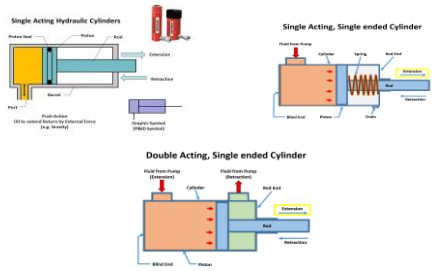
Hydraulic Cylinders



Cylinder Hazards

- There is a possibility of dangerous sudden action by cylinders if sliding parts of machinery are twisted due to external forces
- A protective cover is recommended to minimize the risk of personal injury.
- Securely tighten all stationary parts and connected parts so that they will not become loose.

- There are cases in which a deceleration circuit or shock absorber may be required.
- A possible drop in operating pressure due to a power outage or seal failure
- Consider emergency stops
- Action when operation is restarted after an emergency or abnormal stop.

- Flow control valve to adjust the hydraulic cylinder drive speed, gradually increasing from a low speed to the desired speed setting.
- Aligning the axis centre of the piston with the load and direction of movement when connecting
- Periodic maintenance on filters installed in a hydraulic system in order to keep the oil clean.

Hydraulic Valves

Hydraulic Valve

- Valves have multiple functions.
- Direct the flow of fluid through the system
- Control flow of fluid
- Regulation of pressure of fluids
  - Mechanically operated
  - Electric-solenoid operated
  - Pilot operated valves (Most Applications)

Valves- Safety Arrangements

- Shut off Valve
- Non Return Valve
- Pressure Relief Valve
- Down Direction Valve
- Rupture Valve
- Elec.Anti-creep Valve
- Speed Control- Empty and Loaded

IS 14671

- Motor Run Time Limiter
- Fluid Temperature Limiting – Prevention of overheating
- Hose Testing Pressure and Record
- Guide Rails, Guide Shoes and Buffers- clearance stopper

IS 14671

Hydraulic Fluids

Hydraulic Fluids

- Refined Mineral Oils-Petroleum-based oils.
- Fire Resistant Fluids
- Water Oil Emulsions
- Phosphate Esters
- Water Glycol (Limited Applications)

ISO3448 and BS4231

Hydraulic Fluids

- Except for its fire hazard,
- Oil is an ideal hydraulic fluid.
- It is not corrosive
- Does not affect seal much,
- Has good lubricating properties,

- Can be obtained in various viscosity ranges, and is readily available.
- Flash points range from 300° to 600°F (150° to 315°C).
- Autoignition temperatures range from 500° to 750°F (260° to 400°C).

- Synthetic hydraulic fluids (HF-D) are one of four types
- Phosphate esters
- Chlorinated hydrocarbons
- Blends of phosphate esters, and chlorinated hydrocarbons and fluids containing other compositions.

- Most of these fluids have relatively high specific gravities.
- Larger diameter or shorter pump suction lines may be needed to prevent cavitation.
- Because of the high density, particles do not settle out as easily, making good filtration necessary

- Synthetic fluids are not compatible with natural rubber or neoprene seals or hoses.
- These should be replaced with fluorocarbon, silicone, butyl rubber, Teflon, or nylon materials.
- Synthetic fluids also may attack metal protective paints, lacquers and electrical wiring insulation.

Causes of Hydraulic Injection Injury

- Damaged hydraulic seals
- Maintenance on pressurized hydraulic systems
- External leakages
- Overheated hydraulic system
- Mistakes while assembling the hydraulic system
- Lack of system maintenance, and more

Hydraulic Fluid / Oil Hazards

- Fluid Spray and Injections
- Fluid Leaks Spills
- Fluid Hose Whipping
- Burns from Conveyed Fluids
- Fire and Explosion from Conveyed Fluids
- Fire and Explosion from Static Charge
- Electric Shock

IFPS NJ

- Material Failures
- Fatigue cracking in high pressure fuel lines, pin holing in hydraulic hoses, seal failure and bulk material cracking.

IHPFII

- Industrial high-pressure fluid injection injuries (IHPFII) are largely occupational in nature, where these injuries are most often sustained by male manual workers.
- Such traumatic injuries are largely sustained with water, grease, paint, gasoline or paint thinner.

- IHPFII are extremely serious injuries with life and limb-threatening potential carrying the risk of life-long disability.

Difficult To See Pictures !?

Scalds / Burns- about 70 deg.C

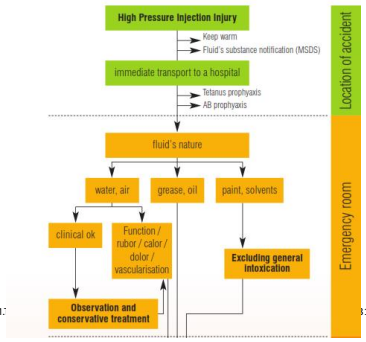
Hydraulic LOTO Best Practices

- Valve should be well marked
- Distinct from other manual valves
- Valve should be differentiated by its appearance

- Should only be able to be locked only in off position
- "Positive action" which would indicate only two positions (ON and OFF)

- A method for the employee to verify that the energy has dissipated after initiating lock out process.

Onsite / Emergency Medicare



Loss Prevention

- Avoiding Fire Sources in near by including electrical ones
- Use of Fire Resistant and Less Hazardous Hydraulic Fluids
- Rigidly supported piping- free from corrosion- erosion- vibrations
- Arrangement to remote cutting of pumps to minimize damage

- Piping material non combustible
- Checking hydraulic fluids for possible thermal break-down
- Keeping equipment free from dirt / residue/ lube residues
- Early Detection and Fire protection arrangements
- Emergency Exits

Protection

- Training/ PPE
- Do not inspect hydraulic system leakages with your hands
- Do not perform the maintenance work under pressurized condition.
- Do not work with hydraulic systems without taking safety measures
- Examine the system during regular intervals.

Mandatory Warning

- "Warning – discharging high-pressure oil to atmosphere can cause severe injury, death, or substantial property damage.
- Completely remove stored energy before loosening fittings or disconnecting transmission lines."

Other Problems Related to Hydraulic Fluid

Hydraulic Fluid

- Proper volume of hydraulic fluid.
- Variation in fluid level
- Variation in fluid properties,
- Can damage the entire hydraulic system and its application

Fluid Contamination

- Leakages, rust, aeration, cavitation, damaged seals increase Contamination
- Risk fluid contamination increases based on the increased usage of the hydraulic system.
- Contamination causes
- Degradation
- Transient
- Catastrophic failures.

- Degradation is a failure classification that affects the normal working of the hydraulic system by slowing down the operations.
- Transient is an intermittent failure that occurs at irregular intervals
- Catastrophic failure is the complete end of hydraulic system

Hoses

Hydraulic Hoses

- The flexible hydraulic hoses connect separate components like pumps, motors, cylinders, etc. and transfer fluid between them.
- The flexible nature of hoses makes it suitable for applications requiring less space.
- Ease of maintenance and installation are other benefits of hydraulic hoses.

- As Hydraulic system operates under high temperature and pressure, the hoses are constructed with several layers of reinforcement.
- Types
- Reinforced
- Coiled
- Corrugated
- Articulated Multi-element

Known Hazards

- Fluid Injections
- Whipping Hose
- Burns from Conveyed Fluids
- Fire and Explosions from Conveyed Fluids
- Fire and Explosions from Static-Electric Discharge
- Pressure Bursting

Can Lead To

- Uncontrolled movements or
- Dangerous load conditions, others
- Turning the power back on before work is finished,
- Trapped in pressure,
- Damaging negative pressures,
- Loss of fluid or
- Contamination entering the system

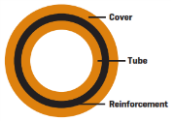
Hoses

- It is important to pay particular attention to hose routing
- Hose must be properly installed to prevent hazards and ensure long life.
- Avoid twisting.
- Avoid positioning hose next to heat sources.
- Avoid positioning hose next to metal edges or too close to other hose.

- The hose cover and reinforcement may be damaged by abrasion, creating a safety problem.
- Sleeving, clamping and abrasion resistant products may be problem solvers.

Hose Selection

- Less susceptible to vibration and movement.
- Requires no brazing or specialized bending.
- Easier to obtain in the aftermarket.
- Faster to route around obstacles.
- Absorbs sound and impulses.
- Dampens pressure surges.
- Standard (no matching of one company with other company preferred)

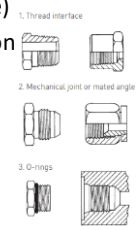


Hose Reinforcements

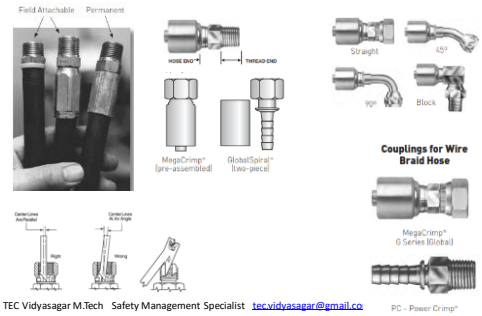
Braided
Spiraled
Helical

Avoidance of Problems

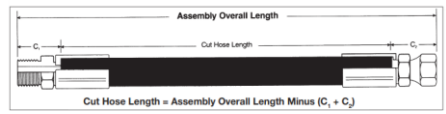
- Hose- Size-Temperature- Application-Material – Pressure- Ends- Delivery (Volume)
- Coupling- Selection – good condition
- Assembly (no mis-match)
- Integrity of system



Couplings

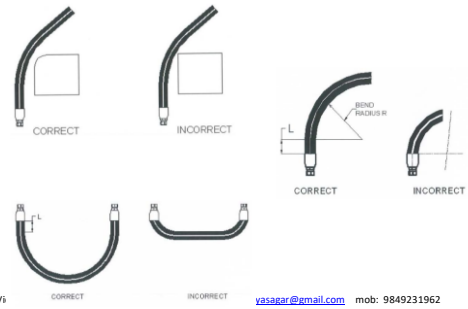


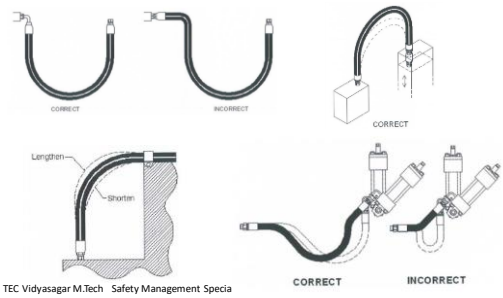
Hose Assembly

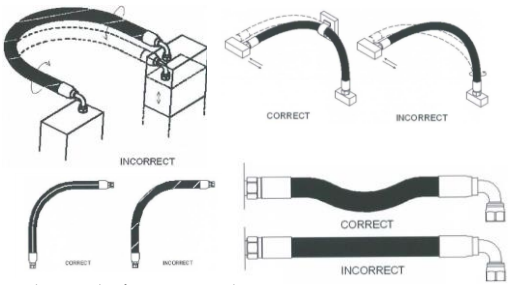


SAE Length Tolerances for Hydraulic Hose Assemblies and Specified Hose Lengths.

Length	Tolerance
For lengths from 0" up to and including 12"	±1/8"
For lengths from 12" up to and including 18"	±3/16"
For lengths from 18" up to and including 36"	±1/4"
For lengths above 36"	±1% of length measured to the nearest 1/8"

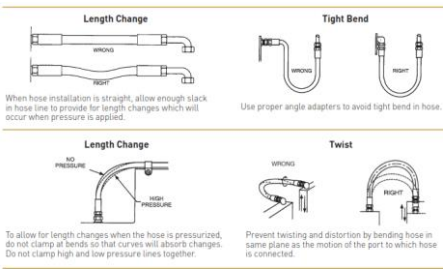


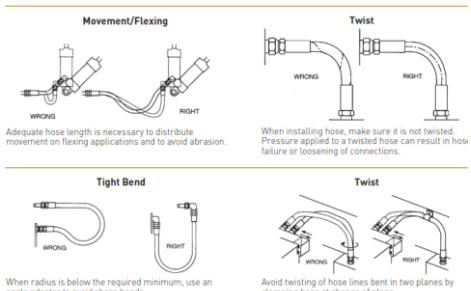


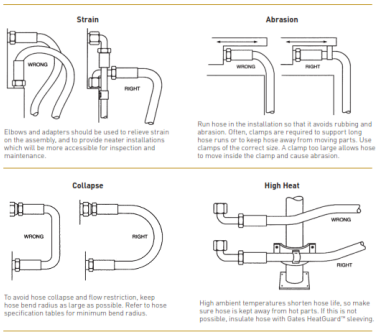


Radius

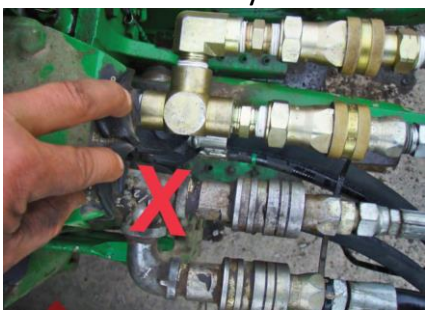
Hose Routing







Hose Assembly Defects



Hose Shell Damage

Hose Attached to Hand Rail

Incorrect Procedure

Damaged Hose

Hose Whipping

- Accidents may also occur because of hoses whipping, fittings thrown at high speeds, or electric shock.
- When working with hydraulic oil there is always a threat of fire and the risk of explosion.

Whipping

Safety – Functional Criteria-Hoses

- Selection
- Routing
- Fabrication
- Installation
- Replacement
- Maintenance
- Storage of hose and hose assemblies

Hose Deterioration

- Most personnel are Not aware of the Hydraulics System Associated Hazards
- Common Defects In Hoses
  - Abraded
  - Cracked
  - Crushed hose
  - Punctured

  - Twisted or Distorted Hoses
  - Improper Fittings
- Cracking of the cover
- Mis-matched Equipment
- Couplers- Missing or Damaged O Ring
- Fittings Damaged – Leaking
- Over-torquing

Hose Failures

- Hose rupture overload – pressure
- Overload – mechanical
- Deterioration of hose material
- Twisting damage
- Too sharp bends

- Outer sheath wear too sharp bends
- Inadequate abrasion protection
- Incorrect material selection
- Reinforcement wire corrosion
- Inadequate abrasion protection
- Incorrect material selection

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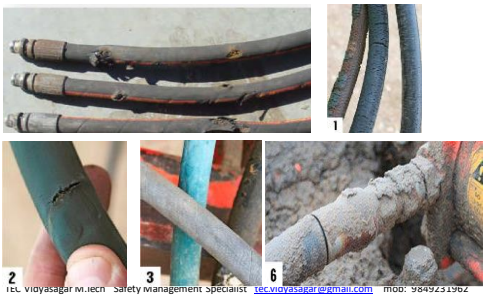

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Fitting failure

- Overload – pressure
- Overload – mechanical
- Incorrect material selection
- General wear and age maturity
- Fatigue and cyclic loading
- Inadequate corrosion protection
- Incorrect material selection

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Hose/fitting separation

- Compression set of hose material
- Loss of compression pressure on hose
- Overload – pressure
- Overload – mechanical
- Mismatched components
- Poor assembly practices

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Outer layers of hose penetrated

- Abrasion damage to hose by foreign material
- Hoses rubbing together
- Inadequate hose cover material
- Environment (for example ozone, UV)

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Delamination of inner hose

- Excessive vacuum conditions
- Prolonged vacuum conditions
- Material degradation
- Incorrectly selected hose causing too high a velocity

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- Fatigue failure of reinforcing mesh
- Cyclic/random bending of hose
- Cyclic/random pressure changes

- Vibration
- Cyclic loading of hoses can damage hose components even when motion seems relatively small.
- Hoses having bulges or getting wet surface to be immediately replaced.
- Hose rupture valve may be provided near the actuator for enhanced safety in case of hose failure.

- Extreme Pressure Fluctuations
- Pressure surges above the hose working pressure will damage hose components.
- Abrasion and Cuts
- Wear against other hoses or objects will wear off the outer cover and lead to corrosion of the reinforcing mesh.

Fluid Spray Can Ignite

Hose Checks- Inspections

Precautions

- Always wear safety glasses.
- Keep appendages clear from moving parts.
- Don't wear loose-fitting clothing.
- Make sure equipment is securely mounted and connected.

First Use

- Pressure test new hydraulic equipment to 1.5 times working pressure, using a low energy pressure device such as a hand operated or low energy pump, before first off startup

Hose Assembly Inspection

- Visually inspect for:
- Hose cover damage
- Stiffness or hardness of the hose
- Changes in color
- Cover blisters
- Kinked or flattened hose
- Damaged hose reinforcement
- Damaged or leaking end terminations

- Leakage –
- Warning: NEVER inspect a hose for leaks by running your hand over it while it is under pressure or contains the material being transferred.

Component Inspection

- Style or type
- Cleanliness
- Loose covers
- Nicks
- Size
- Inside obstructions
- Visible defects
- Damage
- Length
- Blisters
- Burrs

Hose Checks

Look for high-quality materials when sourcing, fitting, using, maintaining, and replacing hose.

Make sure to tighten all fittings to the correct tension.

Use hose whipchecks wherever possible.

Replace hoses and fittings well before their expiry date.

Regular inspection for early damage detection and good maintenance practice.

Ensure staff receive professional training

NEVER check for leaks with hands!

Inspection During Repair / Maintenance / Shutdown

- Visually inspect for leakage - Always conduct close inspection of the hose when pressure is released and the hose does not contain potentially dangerous material.
- Inspect hose tube for hardness, color change, cracks, blisters, erosion, etc.
- Inspect end termination for cracks, leaking gaskets and missing parts such as cam arms

Hose Inspection Hazards

- Hose burst in one or more places along the length of the hose.
- Exceeded the rated working pressure. Hose twisted during attachment to ports during application, causing gaps in the reinforcement.
- Check pressure output of system. Use a hose with a higher pressure rating. Use swivel couplings.

- Hose tube swells or deteriorates, blocking material flow or causing a leak.
- Hose tube is not compatible with material being conveyed and/or temperature.
- Identify the material and the temperature at which the system operates.

Hose Inspection Checklist

- Visual evidence of leaks along the hose or around the hose ends
- Degraded hose, hard, stiff, charred, blistered, soft, heat cracked
- Exposed, damaged, corroded or broken outer wire braid
- Corrosion, may be identified by small lumps in the hose

- Wear and abrasion
- Bulges, blistered, soft, degraded or loose outer covers
- Outer cover sheath damage, cuts in the hose cover or cracked and heat affected
- Kinked, crushed, flattened or twisted hose
- Wrong bend radius

- Incorrect hose routing
- Incorrect length of hose
- Permanent or physical damage to the hose or hose ends, kinked crushed or flattened hose
- Hoses too close to heat sources
- Hoses tangled with moving parts

- Cracked, damaged, or badly corroded hose ends or adaptors
- Unsecured or loose hoses and fittings
- Fitting thread is damaged
- Inspection of staples (broken, twisting, cracked or "walking out")

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- Hose exceeding shelf life before installation
- Hose exceeding designed service life
- Other sign of deterioration

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Hoses

- Hose dates are within predicted life limits, typically 5-7 years
- Particular care of hoses that retain load pressure and the consequence of their failure would be a dangerous falling load

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Hose Discarding Strategy

a) Inspection and assessment to discard
- excessive mechanical damage (such as abrasion, cuts, crushing etc.),
- corrosion (of both fittings and hose wire reinforcement)
- degradation (age, chemical, cracking, overheating, fatigue etc)

b) Catastrophic in-service failure
- leakage
- burst
- hose/hose end separation
- pinholes

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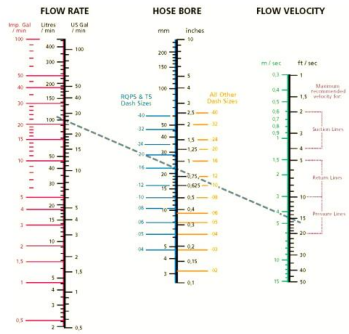
Fluid Nomogram



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Inspection Kit

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Hose Testing

Inspection – testing Hoses / couplings

- All hose and couplings should be hydrostatic tested at regular intervals.
- The hose should be at room temperature.
- The testing area should be clean and dry.
- Lay the hose out straight to its full length.
- Place the hose on rollers. This allows the hose to be moved while under pressure.
- Restrain the hose if there is danger of uncontrolled movement during the test

- Conduct a visual inspection.
- Look for cuts, gouges, bulges, soft spots, coupling slippage or any other signs of wear.
- A hose which does not pass a visual inspection should be replaced.
- A hose which does pass a visual inspection is then connected to a test pump and the free end is fitted with a quick-opening valve.

- Elevate the free end and fill the hose with water from the pump.
- Always use water. Never test with flammable or corrosive fluids, solvents or compressed gas. Can be used only after good drying

- As the hose fills with water, bleed the air out through the open valve.
- Close the valve and lower it to the ground when all the air is out.
- It is imperative to pressure test the hose at the proper pressure.
- Drain the hose and allow it to dry before returning it to service.

- Test hydrostatic pressure –
- Always use water for pressure testing. Never use other materials, including air or gas.
- This is essential for hoses used in hazardous applications such as chemical, steam, petroleum and compressed gas transfer.

Hydrostatic Test - Hose

- Hose should be at room temperature.
- Testing area should be clean and dry.
- Lay the hose out straight to its full length.
- Place the hose on rollers. This allows the hose to be moved while under pressure.
- Restrain the hose if there is danger of uncontrolled movement during the test.
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- Use swivel couplings.
- Check tube swells or deteriorates, blocking material flow or causing a leak.

- Do not use Hose tube is not compatible with material being conveyed and/or temperature.
- Identify the material and the temperature at which the system operates.

Filters

Filter

- Filters are used in hydraulic systems to remove these foreign particles and to purify the fluid.
- Metals, Fibers, Silica, Elastomers and Rust
- It is important to clean or replace the filter at regular intervals.
- Otherwise, the pressure of the hydraulic fluid gets reduced and will result in other issues.

Different Sizes- Filters

Breather

Filter Module

Filter Working

- As a result of continuous operation, the deposits of dirt particles at the inlet of filtration element will generate a pressure differential between the inlet and outlet of the filter.
- Bypass relief valve senses this pressure difference, the valve will open and pass the fluid directly from inlet to outlet port by sending an indication to replace/clean the filter

Filter Module

- Fluid to enter and filtered fluid to exit.
- Filter bowl threaded with the filter head
- Element is considered as the most important component that holds the filter media for removing contaminants.
- Bypass valve can be a relief valve that opens for the direct flow of hydraulic fluid if the filter contains increased dirt deposits.

- Generally, the filter units are installed in pressure and return lines to prevent damage of major components
- Reservoir filters- suction filter and return filter- Pressure Filter
- Line filters
- Off-line filters (kidney filter)
- Selected based on pressure rating

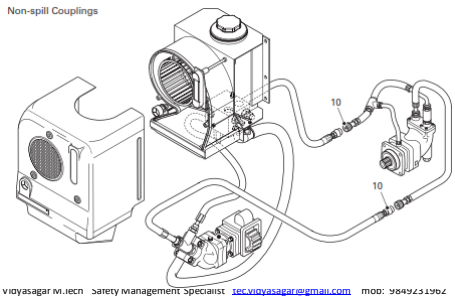
Filter Cleaning

- Air breather
- Magnet separators
- Oil filling ports

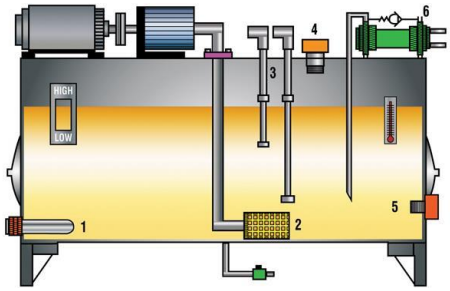
Reservoir-Fluid Sump- Hydraulic Power Pack

Hydraulic Power Unit (or Pack)

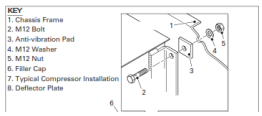
- Micro-power pack units
- Mini power pack units
- standard hydraulic power pack units
- Hydraulic power unit stations

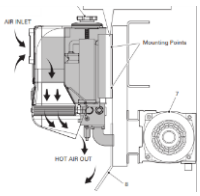


- Reservoir/Sump
- Do not weld on a hydraulic reservoir/sump without emptying the oil.
- Ensure all vents (air breather & hatch plate) should be opened. For any maintenance/ cleaning job to release entrapped gases.
- Ensure no chocking of the air breather. Inspect and replace faulty breathers.



Oil Cooler- Heat Exchanger





Reservoir Temperature

- A temperature sensing device should be installed in the reservoir with Alarm

Air Trapped- Hydraulic Reservoir

- Air trapped inside the fluid will cause problems like aeration.
- Reservoir is designed in such a way to remove trapped air and to cool the pressurized fluid.
- Also, extra space is provided in the system to avoid overfilling as a result of oil expansion.

- A rim at the filler neck of most of the reservoir is the maximum limit for filling.
- Another method to prevent overfilling include checking the fluid level using a glass or plastic sight gage, a tube, or a dipstick.
- Reservoirs are placed at the highest point of the hydraulic system to provide maximum gravity/force to the flow

Hydraulic Pump

- Converts mechanical energy from a prime mover (electric motor) into hydraulic (pressure) energy.
- Pressure energy is used then to operate an actuator. Pump pushes on a hydraulic fluid and create flow.
- Combined pumping and driving motor unit is known as hydraulic pump.

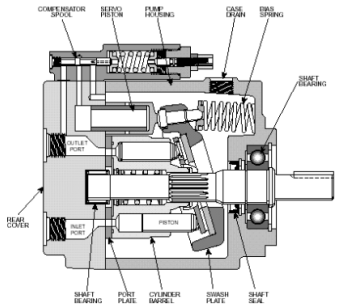
Hydraulic Pump

- Pump is considered as the heart of every hydraulic system.
- Pump is a component that converts the mechanical energy of fluids to hydraulic energy.
- Hand pumps and power driven pumps are the two categories of hydraulic pumps.

- Power driven pumps are commonly used in the hydraulics industry.
- Hand pumps are suitable for emergency conditions, where the power pumps fail.
- Piston pumps
- Gear pumps
- Vane pumps

- **Positive Displacement Pumps**
- Fluid flows with a constant speed neglecting the pressure on the inlet
- Non-positive Displacement Pumps/ Dynamic Pumps

Pump



Pump Maintenance

- Pump
- Put off the motor power from MCC and lock out & Tag out. Obtain permit to work as per plant procedures.
- Close the suction & delivery valve and lock out & Tag out.
- Drain the pump casing and depressurize (ensure zero pressure).

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

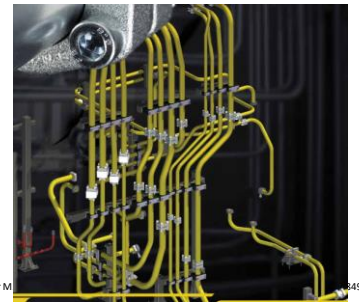
- Entrapped air to be released from delivery line
- Before start of motor, ensure correct direction of motor rotation.
- Before installing a new pump, check pressure rating of pump.
- Its pressure rating should be higher than the required system pressure.

- 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.

- Flushing circuit for the pump, if available, should be kept on prior to switching on the pump.
- Relief Valve Pressure should always be set 20-30 bar more than the Pump compensator setting.

Tubing and Fittings

Hydraulic Piping



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- Piping Material-specification
- Velocity Criteria
- Fittings and Flanges Appropriateness
- Hoses and Couplings
- Pipe Supports and Clamps
- Cleanliness and Flushing Techniques- Tools

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Hydraulic Tubing & Piping

- Hydraulic tubes and pipes have the same function of hydraulic hose.
- Transfer fluid between the components of the hydraulic system.
- A pipe/tube is a tubular section or hollow cylinder that will allow the passage of hydraulic pressure.

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- Due to its rigid nature, such connections require more space and installation time.
- Both tubes and pipes are interchangeable.

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- Pipes & fittings
- 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.

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- 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.
- Distance between two clamps should not be greater than 1.5 m.

- For pipe joints up to 38 mm OD pipe, weld-nipple type fittings(24 deg)/ walform fittings with 'O'-ring shall be used.
- 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.

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

Max. Distance between Pipe Supports

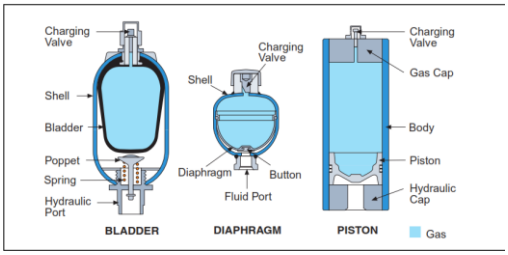
Pipe outside diameter mm	Maximum distance between supports m
⩽ 10	1
> 10 and ⩽ 25	1,5
> 25 and ⩽ 50	2
> 50	3

Accumulator

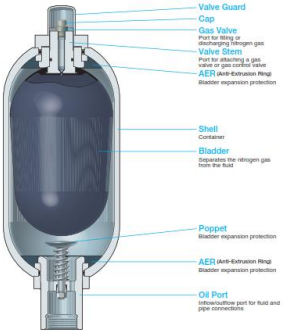
Accumulator

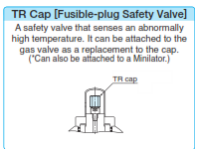
- Energy Accumulation
- Shocks absorption
- Pulse Dampening
- Impact Absorption
- Thermal Expansion Compensation
- Leak Compensation
- Minimize the noises and pulsations.
- Transfer Barrier

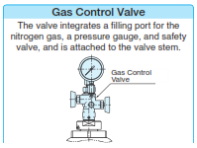
- Bladder type
- Diaphragm type
- Piston type
- Spring type
- Weight loaded type
- Miniature
- Expansion Tank

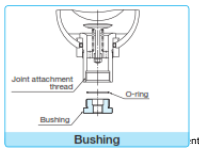


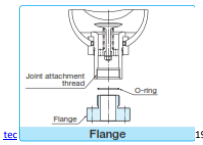
Accumulator



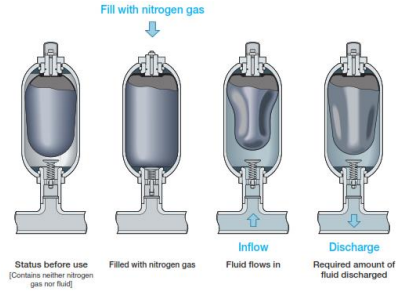


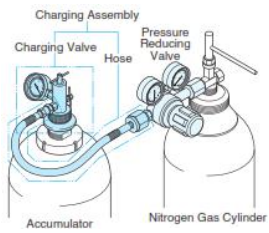






Stages of Accumulator Use





Issues
LOTO
Cylinder Pressure Reducing / Regulation
Connections- Integrity-To Cylinder - Accumulator
Gas Inertness- Dry Nitrogen
No Oxygen at any cost
Adopters Issues
Permeation of Bladder
OEM Recommendations
SOP for Pre-Charging- Topping is essential- Competency and Experience

Nitrogen Charging Issues

- N_2 Charging- Bladder
- 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 minimesh point of accumulator safety block.

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- Pump should be off and positive isolated. In let valve should be closed and locked.
- Drain valve of accumulator should be open during charging.
- Gas pressure must be discharged while attempting to dismantle an accumulator.
- Replacement of components to be done after checking their rating and capability.

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- 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.

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Hydraulic Accumulators

- Hydraulic accumulators should be securely installed and protected from damage by falling objects.
- Attachments to the accumulator should be by means of a minimal length adapter and flexible hose for mobile plant.

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- Fittings should be located or otherwise guarded to provide mechanical protection against operational and maintenance damage
- e.g., Rock damage or stepping onto components during maintenance etc.

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- A means (e.g. bleed valve) should be fitted to allow service personnel to quickly deplete pressure.
- The fluid should return to tank and the tank depressurised.
- A means for service personnel to relieve gas pressure safely in a gas-charged accumulator(s) should be provided.

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- A means of diffusing pressure (e.g. relief valve) should be provided between the manual gas charging circuit and gas-charging accumulators.
- Spring type accumulators should be labelled with a warning informing the content is under spring pressure.

Cylinder Valve-Standard-Risk of Interchangeability

- Nitrogen Cylinder outlet
  - G ¾ A RH

IS 3224 Nitrogen Cylinder Outlet Valve is of ¾ A RH Female Threads

Oxygen Cylinder Outlet
G 5/8 RH

IS 3224, the Oxygen cylinder outlet valve is of 5/8"RH Female Threads).

Hydraulic Seals

Hydraulic Seals

- Seals prevent leakage of hydraulic fluids.
- Static seals are used in between parts, that doesn't require motion.
- Piston seals, rod seals are examples for dynamic seals.

Hydraulic Seals

- Hydraulic seals are usually non-metallic, quite soft rings made out of materials like
- Rubber
- PTFE
- Polyurethane (PU)

Seal Failures

- Seal Abrasion
- Seal Extrusion
- Dieseling
- Hydrolysis
- Swelling
- Side Loading
- Dry Running

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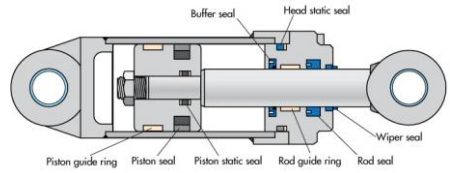

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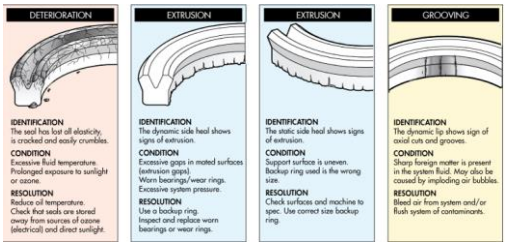

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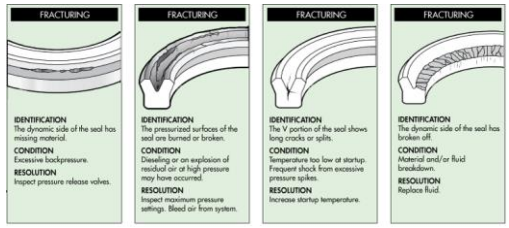

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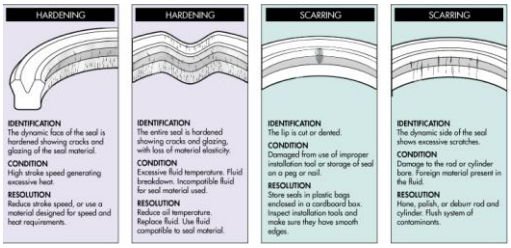

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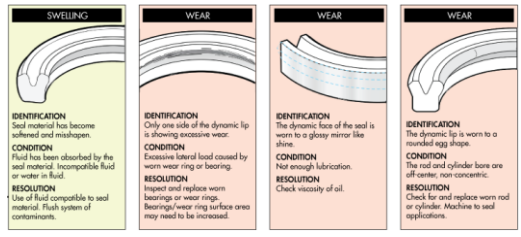

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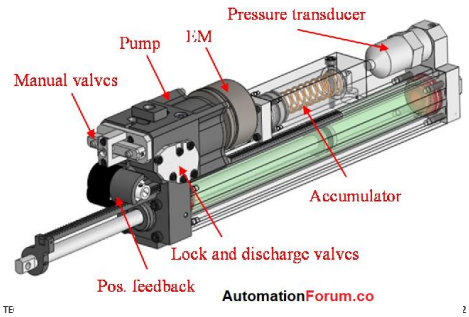
Hydraulic Actuators

Hydraulic Actuators (Motor)

- Hydraulic actuators convert hydraulic energy into mechanical energy.
- Cylinders and motors two type of actuating devices.
- The hydraulic cylinders produce a unidirectional force -linear motion actuators

Actuator

- A rotary actuator produces torque and rotating motion.
- It is more commonly called a hydraulic motor or motor.
- Valves are used in hydraulic systems to control the operation of the actuators.



- Actuator (hydraulic cylinder/motor):
- Removal of Old actuator.
- Ensure that the load attached to the actuator is mechanically secured.
- 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.

- 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.

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

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- Fix the hose connection and after proper tightening and bleeding of entrapped air during cylinder trial only, leave the work place.
- Hydraulic Motor should always be started with casing filled with fluid.
- Ensure there is no pressure inside actuator, especially if there is pilot operated check valve or counter balance valve in the lines

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

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- Valves: Removal of old valve
- Ensure 100 % positive isolation & depressurization of P,T,A,B line before opening of any hydraulic valve.
- 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.

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- Fixing of new valve
- 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.)
- After replacement of O-ring / valve, start tightening of valve mounting bolt (cross wise).

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- 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.
- 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.

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- 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.

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- Pressure relief valves incorporated into the hydraulic system will avoid pressure build-ups during use.
- Keep these valves clean and test them periodically to ensure correct operation.
- While working on spring loaded valves take precaution to ensure that no spring back action takes place.

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

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Pressure Measurement

- Permanently installed pressure gauges shall be protected by a pressure limiter or gauge isolator.
- The upper limit of the pressure gauge range should exceed the maximum working pressure by not less than 25%.
- Pressure damping devices should not be an integrated part of pressure transducers.

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Fire Hazard

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Fire Hazard of Hydraulic Systems

- Hydraulic oils are not generally considered a serious fire hazard, because they have high ignition temperatures
- Hydraulic systems are highly pressurised- flames from a hydraulic oil fire can spread over dozens of metres
- But spraying hydraulic oil will burn just as fiercely as other hydrocarbons.
- Hydraulic fluid has been a factor in many fires

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Fire Prevention-Protection

- Depends Upon
- Hydraulic fluid type.
- Piping system design, operation and maintenance.
- Systems interlock design.
- Housekeeping.
- Automatic Detection- fire protection system design.

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- Hydraulic fluids systems can range in pressure from 14 to 700 bar
- Drain the areas to a safe location or provide curbs around the equipment to contain the fluid
- Convert existing hydraulic systems to less flammable hydraulic fluid systems with consent of OEM

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- Keep all hydraulically operated equipment and surrounding areas clean and free of fluid residue and combustible material
- For large central systems, and whenever practical, use detachment or shielding to protect electrical equipment from possible fires

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- Shield any equipment that cannot be remotely located
- Provide automatic sprinklers in all areas containing hydraulically operated equipment, hydraulic
- systems, or hydraulic piping.
- Sprinkler systems should extend to all areas, including pits that would be damaged by hydraulic fluid release or hydraulic fluid fire.
- In general, automatic sprinkler protection should extend not less than 15 min all directions from the hydraulic equipment and hydraulic fluid piping.

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- Turbine, compressor and generator hydraulic systems may require water-spray protection. Design fire protection for these systems in accordance with NFPA 850, NFPA 851 and NFPA 15

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- System Interlocks- Fire Safety
- Hydraulic systems have a variety of controls, transducers and interlocks to provide alarms or relief paths to sumps, to bypass pumps or to otherwise keep system pressure within design limits.

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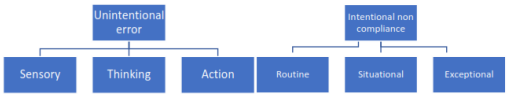
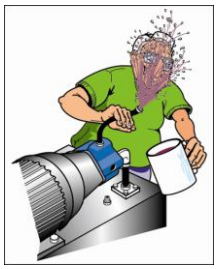
- Housekeeping for Fire Safety
- Provide drip pans under seals and joints where leakage cannot be eliminated.
- Use curbs or dikes to contain spills in areas where spills are likely.
- Fully depressurize, isolate, lock out and, if possible, drain any portion of the system that is to be opened.
- Leakage from high pressure lines may atomize and spread far from the leak

- Anti vibration pads to be periodically & replaced , if required.
- Install a Fire Extinguisher (Dry Chemical or Foam- CO2-with Limitation) near the hydraulic system.
- Oil Cellar must have fire hydrant lines as per standard (IS 3844:1989) .

Human Factors



Improper Method of Work



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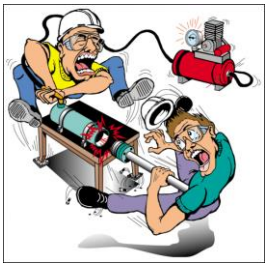
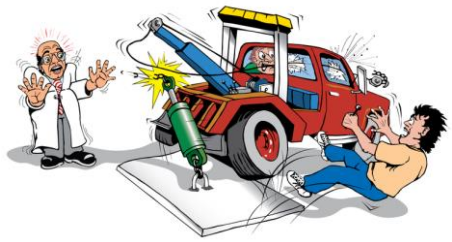


Bursting

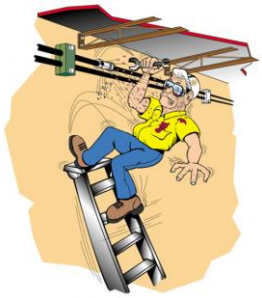


Fluid Power System Design- Maintenance Hazards- Case

Case-Maintenance

- Mr X was standing on a stepladder, tightening a leaking hydraulic connector in a steel fluid line that was affixed to a wall approximately 12 ft above the floor.
- He purposely left the power unit running because he wanted the hydraulic system to be at maximum pressure — that way, he could see if and when the leak stopped as he tightened the connector.

- Connector unexpectedly failed.
- High-pressure hydraulic oil burst from the broken connector, striking him in the face and chest,
- X lost his grip on the ladder, and fell to the concrete floor below.
- He died as a result of the injuries he sustained from the fall
- Such actions were practiced quite routinely in the plant.



Avoidable

- Could have continually lock out and de-energize, and then re-start and re-energize to accomplish, what appears to be the simple task of tightening a leaking connector.
- Understanding Hazard
- Training
- Torque Assessment
- Isolation and Attempt
- Additional Effort

Case - Add-On

- Adding an additional implement to an existing machine
- New cylinder and a New directional control valve added
- In Series rather than in Parallel
- This resulted in tremendous Increase in pressure
- System could not withstand pressure

Pressure Measurement Errors / Failures

- Vibration & Pulsation
- Extreme temperature
- Moisture content
- Overpressure and pressure spikes
- Clogging
- Corrosion
- Inappropriate usage

PPE

PPE+ Standard+ Upkeep

PPE

- Safety helmet
- Hearing protectors
- Protective goggles
- Face-protection visor
- Protective suit (waterproof)
- Protective gloves (waterproof)
- Safety boots (waterproof)

Specific PPE

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

PPE

- Full face shields and safety goggles (double eye protection) are to be worn for high impact potential activities.
- Whip cords (hose chockers) certified for high pressure hydraulics, are used for all coupling joins.
- Ensure all hoses are visually inspected before use.
- Dispose of damaged hoses and couplings.

- For pressure ranges above 800 bar, the following personal protective equipment must be worn in addition:
- High-pressure protective gaiters -2,000 bar
- High-pressure apron -2,000 bar
- High-pressure hose protector -2,000 bar

- Hard hat can withstand 100 bar with **ANSI** Z89.1-1997
- **Face shields** – Clear shield nine inches deep by fifteen and one-half inches wide by 0.60 thick (ANSI Z87.1-1979 or equivalent).

Protective Overall Against High-Pressure Water Jets

High-pressure resistant	≤ 1000 bar
Size	48 (S)
Material	multilayer laminate
Type	breathable and waterproof (class 3 according to EN 343)
Standards / test principles	EN 343, EN 13034 (type 6), GS-IFA-P15
Test parameters according to GS-IFA-P15	**flat jet nozzle type B**
– Distance (nozzle – surface of test sample)	7.5 cm
– Angle (high-pressure water jet)	15 °
– Speed (feed)	0.5 m/s
– Quantity of water (high-pressure water jet)	22 l/min
– Pressure (high-pressure water jet)	1200 bar*

Fluid Power Glove has been specifically developed to protect service technicians against the dangers of fluid injections

- **Rubber steel-toed boots** – Knee length with ribbed steel shanks and heavy tread soles for nonslip traction (ANSI Z41.1-1967 or equivalent).

High Pressure Hoses

- Ensure all high pressure hydraulic hoses are sheathed to protect from abrasions, and provide protection in-case of failure, and hydraulic injection.
- Ensure operators are trained in good handling practices when using high pressure hydraulics.
- Lift slowly and check often.

- Ensure work is done on stable, flat surfaces. Avoid standing in the line of fire.
- Ensure the hoses do not kink and have a supported arc.
- The bending radius must be greater than 115mm.

Emergency Eye / Body Showers

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

Historical Information-Records-Importance

Life Cycle Safety Information

- Design specifications, performance and operational conditions
- Design documentation
- As built schematic
- Installation requirements
- Hazard identification and risk assessment documents

- Risk control methods
- Identification of all safety-critical systems and their safety category or integrity level
- Consultation records
- Commissioning and test results
- Maintenance records, safety inspections and test reports

- Change of procedures, monitoring, audit and review reports
- Reports of incidents, accidents and safety statistics
- Fluid system alterations.

Operative Environment

- Fluid medium properties e.g., fire resistance, mineral oil, water emulsion
- Ambient temperature range and fluid operating temperature
- Sources of vibration
- Contamination and dusty atmospheres
- Abrasive materials

- Corrosive environments (acidity/alkalinity/salinity)
- Likelihood and severity of fire
- Ventilation
- Ease/standards of maintenance
- Access for maintenance and use
- Explosive and combustible environments (e.g., coal dust, methane atmosphere).

Plant Synopsis

- System operating limits and capacities
- General arrangement drawings showing the physical dimensions
- Hydraulic and pneumatic circuit diagrams. Consider using colour to differentiate circuits
- Schematic and logic drawings of power and control facilities

- Detailed parts lists of all components including reorder codes
- Transport, storage and lifting requirements.

Design Data

- All purposes of the fluid power system
- Intended operations
- Intended service lifecycle of the system and its components
- Operating duty / cycle of the system and its components
- Functional specifications and control logic for control of the system

- Operating environment
- Maximum working pressures and temperatures
- Fluid types (specification) and cleanliness levels
- Emergency and safety requirements
- Information on residual risks and controls
- Procedures for servicing and maintenance.

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Any Questions- Points For Review

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