NAHAD
HOSE SAFETY INSTITUTE | Safety, Quality & Reliability

INTRODUCTION TO HYDRAULIC PUMPS

NAHAD
THE ASSOCIATION FOR HOSE AND ACCESSORIES DISTRIBUTION

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The Guidelines incorporate pressure recommendations, corrosion recommendations and temperature recommendations published by hose and coupling manufacturers and others. NAHAD has not independently tested or verified these recommendations and specifically disclaims all liability, direct or indirect, for these recommendations.

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Attributes – Images & Terms

NAHAD would like to acknowledge that the images of a Hydraulic Gear Pump (page 5), Vane Pump (page 6), and Piston Pump (page 7) are attributed to IQS® Directory (https://www.iqsdirectory.com/articles/hydraulic-pump.html), accessed January 2023. The Hydraulic Pump Terms (page 14) are attributed to IQS® Directory (https://www.iqsdirectory.com/hydraulic-pumps/), accessed January 2023.

Section 1 - Scope

This Guide is designed to provide a basic understanding of hydraulic pumps to ensure the proper selection and fabrication of hose assemblies critical to ensure maximum efficiency and effectiveness of these units. This document supplements the NAHAD Hose Safety Institute Handbook © and the Hydraulic Hose Fabrication Guide, which should be referenced for additional information related to the fabrication of hoses to fit Hydraulic Pumps.

This Guide is for NAHAD Members who are not hydraulic experts but who provide hose/hose assemblies to customers who use hydraulic pumps. Those who would benefit most from this content: Outside Sales, Customer Service, Fabrication Personnel.

Section 2 – Learning Objectives

After reading this Guide, the learner should be able to:

- Define the most important questions to ask to ensure proper hose and fitting selection.
- Describe the three types of hydraulic pumps for both mobile and industrial applications.
- Understand the special considerations for correct fabrication and installation of hoses for hydraulic pump systems.

Section 3 - What is a Hydraulic Pump

3.1 Definition

The hydraulic pump is the heart of any fluid power system converting mechanical energy to hydraulic energy, and then pumping it out into the system its tied to. The working principle of a hydraulic pump is the same for all the other pumps. Due to mechanical action, the pump creates a partial vacuum at the inlet. This causes the atmospheric pressure to force the fluid into the inlet of the pump. The pump then pushes the fluid into the hydraulic system.

A pump produces liquid movement or flow: it does not generate pressure. It produces the flow necessary for the development of pressure which is a function of resistance to fluid flow in the system.

3.2 Three Most Common Hydraulic Pumps – Mobile Applications

A mobile hydraulic pump application applies to any machine driven by an engine and electric powered.

3.2.1 Gear Pumps ($)

Description: Internal gear pumps and external gear pumps are the two main types of hydraulic gear pumps. Pumps with external gears have two spur gears, the spurs of

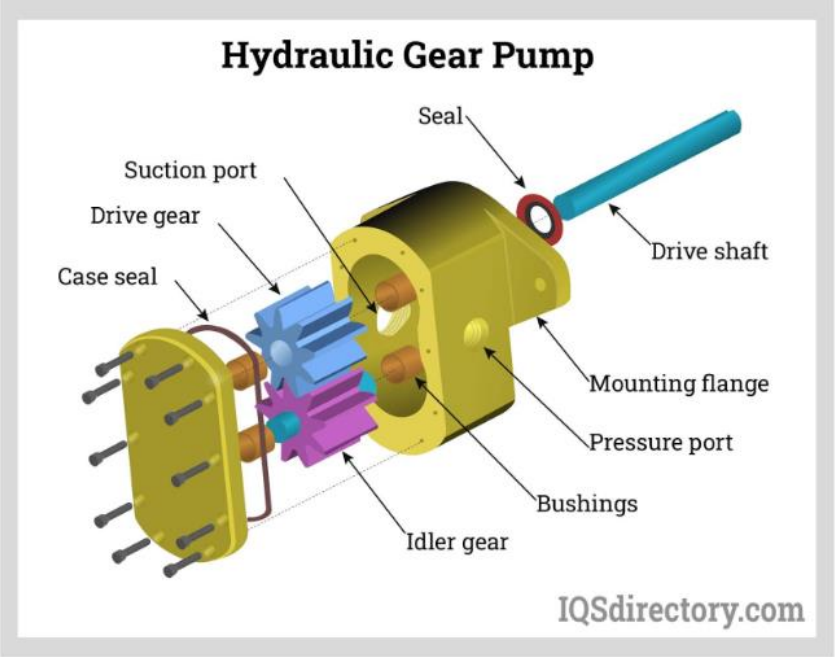
which are all externally arranged. Internal gear pumps also feature two spur gears, and the spurs of both gears are internally arranged, with one gear spinning around inside the other.

Both types of gear pumps deliver a consistent amount of liquid with each spinning of the gears. Hydraulic gear pumps are popular due to their versatility, effectiveness, and fairly simple design. They are commonly used in lower pressure mobile applications.

Applications: Lower efficiency, lower duty cycle.

Markets:

- Truck Equipment (mounted)
- Construction (cranes, air compressors, dump trucks)
- Oil and Gas (lube applications)
- Forestry (auxiliary functions)



3.2.2 Vane Pumps ($$)

Description: Vane pumps are positive displacement pumps that maintain a constant flow rate under varying pressures. It is a pump that self-primes. It is referred to as a "vane pump" because the effect of the vane pressurizes the liquid.

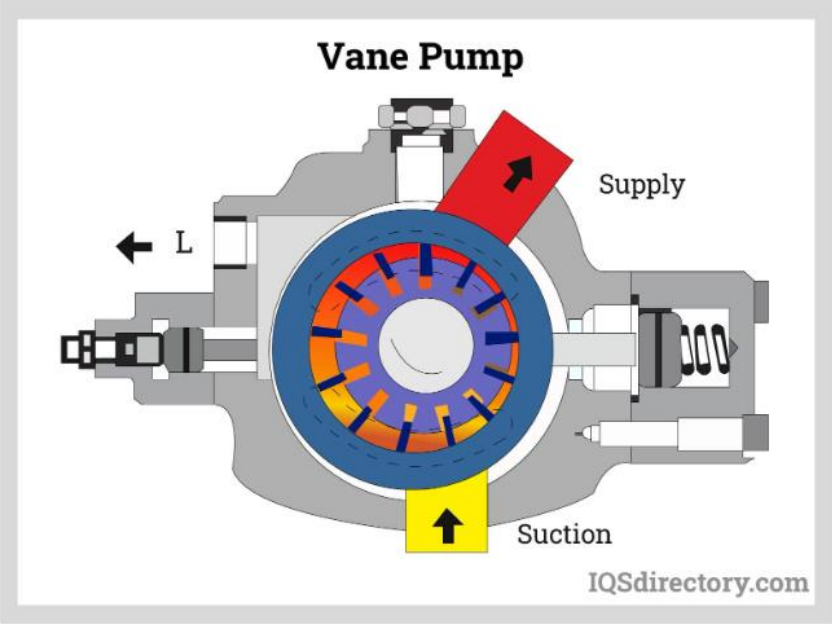
This pump has a variable number of vanes mounted onto a rotor that rotates within the cavity. These vanes may be variable in length and tensioned to maintain contact with the wall while the pump draws power. The pump also features a pressure relief valve, which prevents pressure rise inside the pump from damaging it.

Vane pumps are commonly used for industrial applications. Seldom used in mobile applications.

Applications: Medium efficiency and pressure, lower noise level and super-charged circuitry (power steering). Best suited to handle moderately viscous fluids and best suited for lower viscosity applications such as gas, oil, solvents, and water.

Markets:

- Oil and Gas (auger drives, centrifugal drives)
- Skid Steer (propelled functions)
    - Bobcat, John Deere



3.3.3 Piston Pumps ($$$)

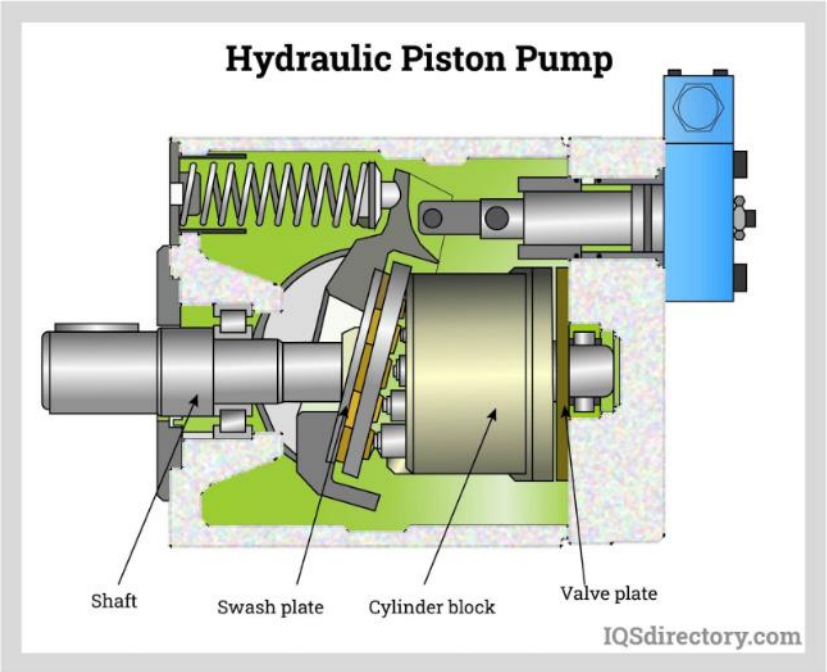
Description: Hydraulic piston pumps transfer hydraulic liquids through a cylinder using plunger-like equipment to successfully raise the pressure for a machine, enabling it to pull, lift, and push heavy loads. Hydraulic piston pumps are common due to their capability to enhance energy usage productivity.

A hydraulic hand pump energized by a hand or foot pedal can convert a force of 4.5 pounds into a load-moving force of 100 pounds. Electric hydraulic pumps can attain pressure reaching 4,000 PSI. Because capacities vary so much, the desired usage pump must be carefully considered. Several other factors must also be considered. Standard and custom configurations of operating speeds, task-specific power sources, pump weights, and maximum fluid flows are widely available.

Piston pumps are commonly used in high-pressure and high efficiency applications.

Applications: High pressure, high efficiency and can provide variable flow as needed.

Market: Virtually every application, every market.



3.4 Three Most Common Hydraulic Pumps – Industrial Applications

An industrial hydraulic pump application applies to any pump that is hardwired and electric in nature; within a closed area tied to an electrical source.

3.4.1 Gear Pumps

Description: Gear pumps use the actions of rotating cogs or gears to transfer high viscosity fluids in hydraulic applications. They are used in lower pressure mobile applications but can be found in industrial applications.

Applications: Lower efficiency, lower duty cycle.

Commonly Use:

- General fluid transfer.
- Lube Skids. Pump-based lube systems use on-demand air pressure to push or pull fluids at certain ratios.
- Kidney Loop. Contains a motor, a pump and a filter to form an independent filtration unit.

3.4.2 Vane Pumps

Description: Most vane pump applications are found in industrial applications.

Applications: Medium efficiency and pressure, lower noise level and super-charged circuitry.

Commonly Used: As the main system pump for industrial power units.

3.4.3 Piston Pumps

Description: Piston pumps are commonly used in high-pressure and high efficiency applications.

Applications: High pressure, high efficiency and can provide variable flow as needed. Commonly found in virtually every application, every market.

Section 4 - Importance S.T.A.M.P.E.D.

S.T.A.M.P.E.D. is an acronym and stands for the seven major information areas required to provide a quality hose assembly for the customer. The proper hose/hose connections for hydraulic pumps are based on their type and use function. Pay particular attention to Size, Application, Material, and Pressure:

S stands for SIZE; I.D., O.D. and length
(System flow: GPM or LPM)
T stands for TEMPERATURE of the material conveyed and environmental
A stands for the APPLICATION, the conditions of use
(Bend radius requirements; Flexibility)
M stands for the MATERIAL being conveyed, type and concentration
(Fluid type: ISO viscosity grade, water glycol/hydraulic oil are some examples)
P stands for the PRESSURE to which the assembly will be exposed
(Pressure requirements: PSI or BAR)
E stands for ENDS: style, type, orientation, attachment methods, etc.
D stands for DELIVERY details; testing, quality, packaging, and delivery requirements

Note: See Appendix A for full S.T.A.M.P.E.D. detail.

4.1 Identify the Hose Function

Systems could have hoses that need to effectively perform one or more of these functions:

- **Suction lines**: connected between the reservoir and the pump inlet.
- **Pressure lines**: connected at the outlet of the pump and will feed back to the main control valve.
- **Return line**: will flow from the main control valve to the reservoir, through filtration and/or cooling.
- **Case drains** – (where applicable): most commonly used on piston pumps, (internal lubrication oil for the pump that goes back to the reservoir below fluid level, unrestricted.)

Section 5 - Considerations for Pump Hose Fabrication and Installation

5.1 Fabrication Requirements

Flange connections are typically used high pressure applications and in large OD applications. They connect ports directly to tubes and hoses without having to use threaded connectors or adapters and work well in hard-to-reach areas where flexibility is required.

SAE J518 is commonly used worldwide to connect large sizes of hose and tubing (3/4" to 3" in fluid power systems. An O-ring, inserted into a ring grove in the flange head seals on a smooth face female port, and is held in place by two clamp halves (or one-piece clamp) which are held tight by four bolts located in a rectangular pattern.

SAE J518 flanges come in two pressure classes:

- Standard Series, Code 61, which goes to 3,000 psi
- Hight Pressure Series, Code 62, where all the sizes are rated at 6,000 psi.

SAE J518 is interchangeable with ISO 6141, DIN 20066, and JIS B8363, except for the bolt sizes.

Below is an example of the Code 61 and Code 62 Bolt Flange.

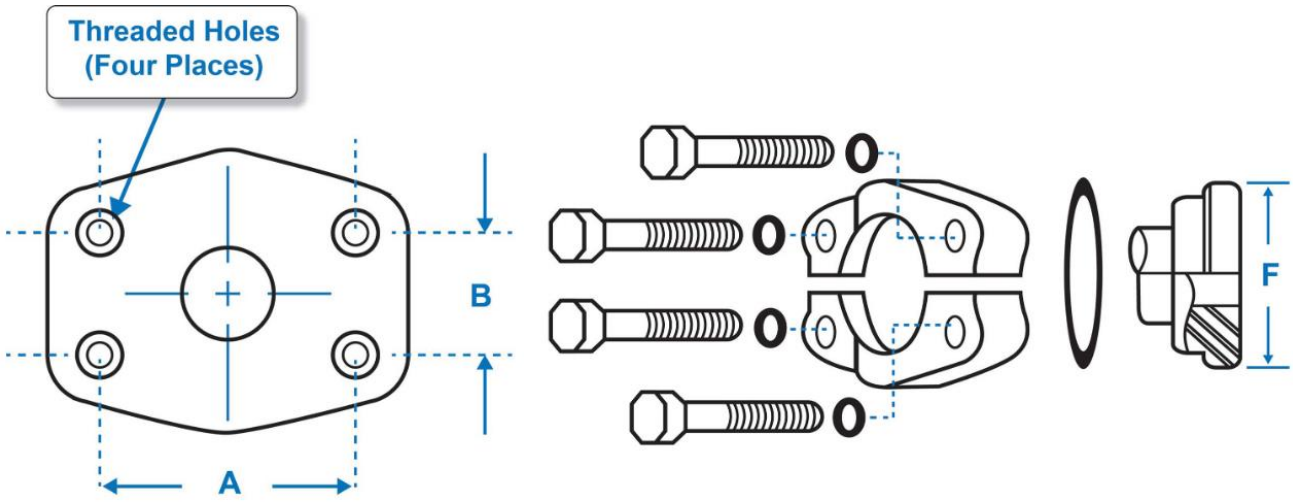


Image Resource: New Line Hose & Fittings

For more detailed information related to hose measurements, threaded fittings: SAE, NPT, or BSPP, correct pressure rating and pressure testing consult the NAHAD Fabrication Guide - Hydraulic Hose, v 3.0.

5.2 Bend Radius Considerations; Installation - Hose Routing

Overall, follow the Best Practices and Guidelines as found in the HSI Handbook for Design and Specification of Hose Assemblies as well as the HSI Fabrication Guide for Hydraulic Hose. Specifically, pay attention to:

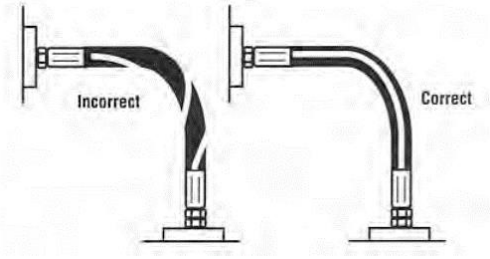
5.2.1. **Bend Radius**. Flexibility and minimum bend radius are important factors in hose design and selection if it is known that the hose will be subjected to sharp curvatures in normal use. When bent at too sharp an angle, hose may kink or flatten in the cross-section. The reinforcement may also be unduly stressed or distorted and the hose life compromised.

5.2.2. **Hose Routing**. When planning the hose routing use the following practices for optimum performance and more consistent and predictable service life. Routing at less than minimum bend radius, will reduce the service life of the hose and/or cause premature hose failure. Use the static or dynamic minimum bend radius according to service conditions. Sharp bends at the hose to fitting juncture should be avoided

Hose assemblies subject to movement while operating should be installed in such a way that flexing occurs in the same plane.

Hose assemblies shall not be installed or operated in a twisted or torqued condition. Swivel fittings or a lay line may be used to aid in torque-free installation. Also flanged hose assemblies should ideally have one end secured with a floating flange.

Flange to flange bolt hole alignment is critical for proper installation.



5.3 Cleanliness & Cleaning Methods

Components for any hydraulic system must be thoroughly cleaned and free of any debris or particles that could adversely impact the overall system.

The customer's cleanliness requirement and the specific application will dictate the required level of cleanliness and cleaning method. The only sure way to know if you are meeting a specific ISO or SAE cleanliness code is testing.

1. Projectiles (most effective): The projectile cleaning method requires clean, dry compressed air or an inert gas source such as nitrogen as the propellant. A pneumatic launcher is then used for propelling the projectile through the hose or

hose assembly. A virgin polyurethane foam projectile wipes the tube wall clean and pushes contamination out of the assembly.

2. Air Blow (least effective): Clean dry air can be used to blow loose particles of contamination from the hose or hose assembly. Long lengths of hose or hoses with inside diameters of more than a ½" may present a problem when using air only as the cleaning method.

3. Fluid Flushing (effective but not readily available): Clean fluids that are compatible with the hose and tube stock can be flushed through the assembly to remove contamination. A flushing system that provides a high turbulent flow is desirable to make sure that the contamination is removed from the tube wall. The fluid flushing system should have filtration to ensure that the flushing fluids are clean. After flushing the hose assembly will then need to have the flushing fluid removed and the tube should be dry.

Section 6 - Maintenance & Safety

Drawback of Hydraulic Pumps:

- Hydraulic liquid that leaks in hot areas may catch fire.
- Hydraulic lines that burst may cause serious injuries.
- Hydraulic liquids can be corrosive.
- Scheduled detailed inspections should be frequent; visual inspection of hoses and connections should be ongoing.
- The system must be shut down immediately if it goes above the rated operating temperature, pressure rapidly declines, or stops working.

As a Distributor, this is where you can add value:

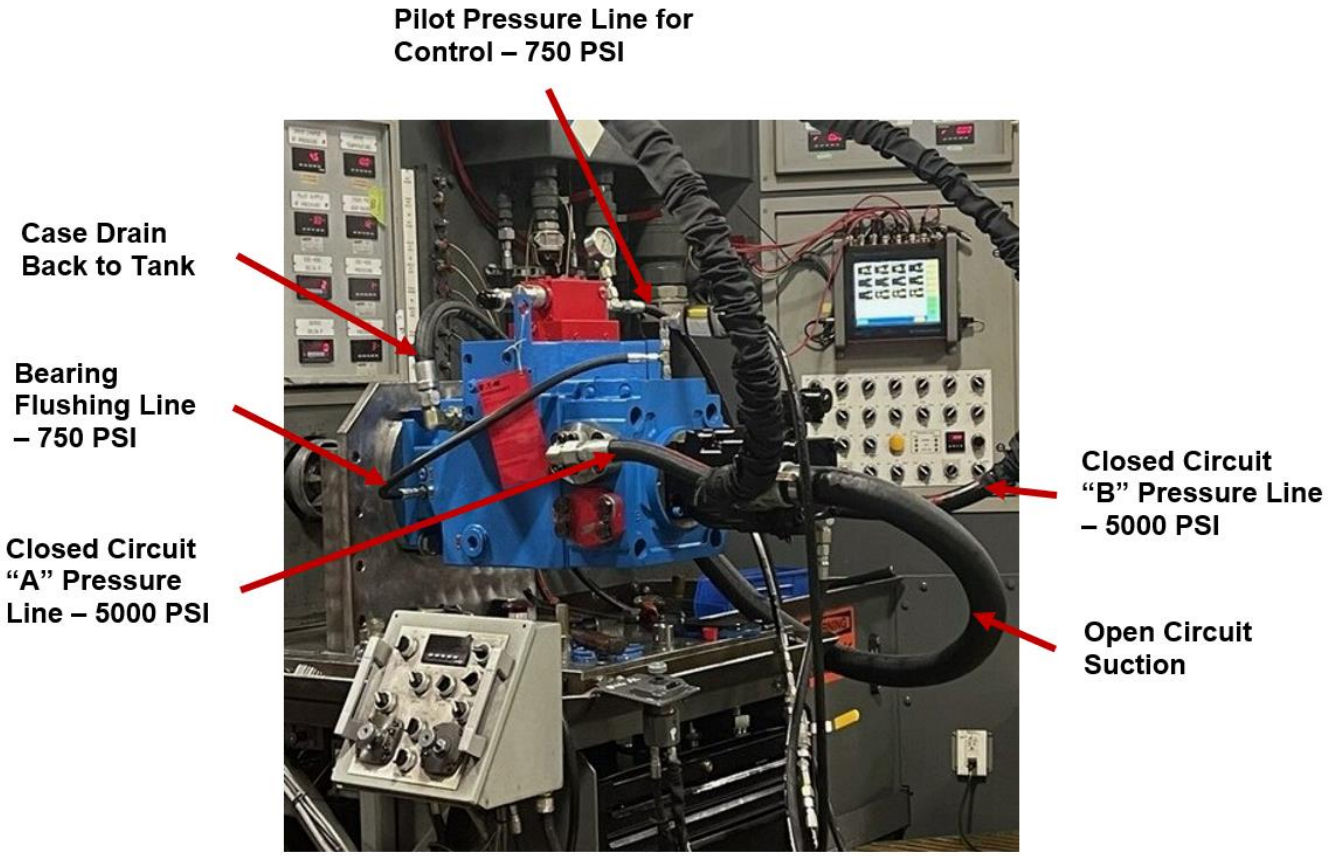
- Work with your clients to create a comprehensive Safety and Preventative Maintenance Program if they don't already have one. Review their current policy to ensure they have all their bases covered.

- Do periodic check-ins with your clients and ask to review relevant reports so any potential issues can be identified and solved before they become a problem.

Use the HSI *Roadmap to Developing a Safety & Preventative Maintenance Program* as a resource.

Section 7 - How Hydraulic Pumps Work

7.1 Closed Circuit Piston Pump



7.2 - Function of Hydraulic Pump Hose

1. Pilot Pressure Line for Control: Connected at the outlet of the pump and will feed back to the main control valve.
2. Case Drain: (where applicable): most commonly used on piston pumps, (internal lubrication oil for the pump that goes back to the reservoir below fluid level, unrestricted.) Low pressure, typically less than 100 PSI.
3. Bearing Flushing Line: Unique to this application. Lubing the bearings in this pump application.
4. Closed Circuit "A" Pressure Line: High pressure line upwards of 6,500 PSI
5. Closed Circuit "B" Pressure Line: High pressure line upwards of 6,500 PSI
6. Open Circuit Suction: connected between the reservoir and the pump inlet.

Open Circuit Pumps: The flow path is always back to tank.
Closed Circuit Pumps: The flow path is continuous between the pump and the actuator.

NOTE: The images below illustrate hose line connections and function for this particular manufacture/model pump. Other manufacture/model pumps have the same or similar elements and lines; however, the location of those connections can vary from pump to pump.

7.3 - Piston Pumps

Image A:

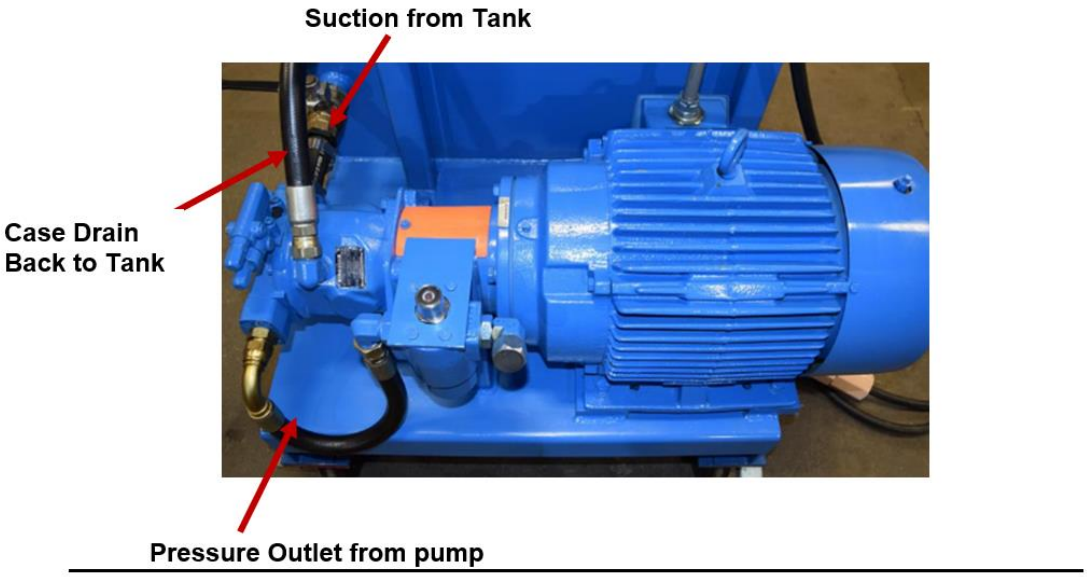
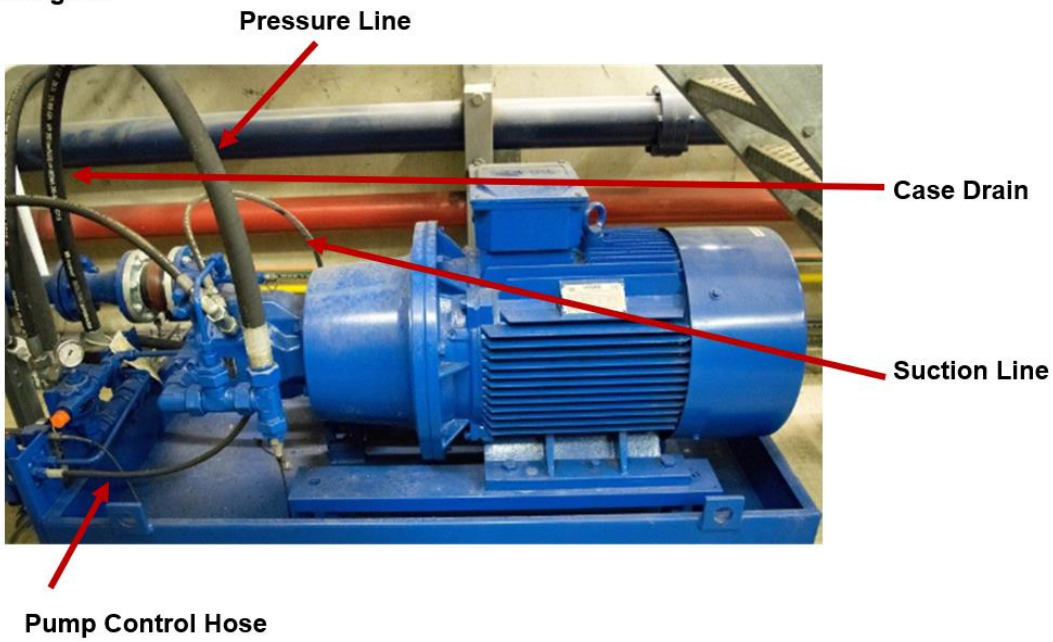
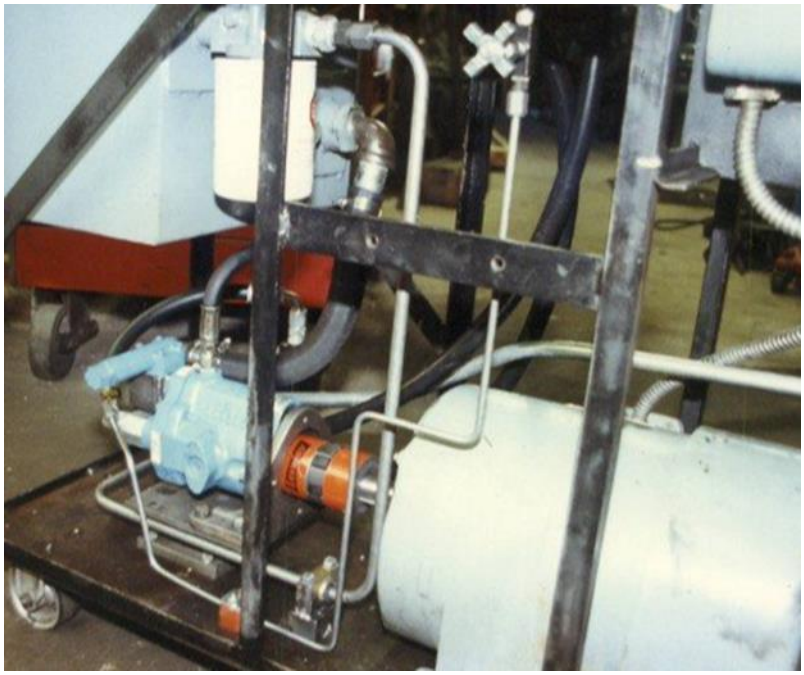


Image B:



7.4 Hose vs Tube – Attributes of Each



Hose	**Tube**
Absorbs Shock	Longevity
Allows Mounting Flexibility (Tight spots; bends)	Aesthetic Presentation
Easier to Replace	Required to be Fixed in Place
Lower Cost	

Section 8: Hydraulic Pump Terms

Cavitation: A circumstance that occurs in pumps when existing space is not filled by available fluid. Cavitation will deteriorate the hydraulic oil and cause erosion of the inlet metal.

Closed-Center System: A system in which the pump continually operates against a load, even in the neutral condition.

Displacement: The amount of liquid transferred from the inlet of the pump to the outlet in a single revolution. Displacement can be fixed or variable.

Flow Rate: The amount of liquid volume that passes a given point in a given time. Flow rate is commonly measured in gallons per minute (gpm).

Head: Vertical distance measured between two stages in a liquid.

Hydraulic Actuator: The piece of machinery that receives pressure from the energized fluid and then converts it to motion and mechanical force. Typically, linear (cylinder) or rotary (motor).

Hydraulic Hoses: A flexible means of connecting hydraulic components.

Hydraulics: The science dealing with the transmission of force through the medium of a contained fluid.

Oil: A slippery and viscous liquid that is not miscible with water. Oil is often used in conjunction with hydraulic systems because it cannot be compressed.

Open-Center System: A system in which the yield of the pump has a free-flow passageway back to the reservoir, while in the neutral condition.

Piston: A device used for converting hydraulic power to mechanical energy. In hydraulic pumps, the piston is responsible for pushing down and pulling up the ram.

Pump: A mechanical device that transports liquids and gases by suction or pressure.

Resistance: In hydraulics, the condition engendered by an obstruction or restriction in the flow path.

Seal: A fastener designed to provide a perfect and tight closure. Seals prevent environmental materials from contaminating hydraulic assemblies.

Velocity Pressure: Pressure in a hydraulic system caused by kinetic energy.

Appendix A: S.T.A.M.P.E.D. In Detail

The S.T.A.M.P.E.D. acronym stands for the seven major information areas required to provide a quality hose assembly for the customer.

S stands for **SIZE**; I.D. and length; any O.D. constraints

- Overall length should be specified to include fittings.
- Tolerances need to be specified if special requirements exist.

I.D., O.D. and overall length of the assembly

- To determine the replacement hose I.D., read the layline printing on the side of the original hose. If the original hose layline is painted over or worn off, the original hose must be cut and inside diameter measured for size.
- The inside diameter of the hose must be adequate to keep pressure loss to a minimum, maintain adequate flow, and avoid damage to the hose due to heat generation or excessive turbulence.
- Length tolerances should be considered for all types of hose assemblies. See individual hose sections for specifics.
- Note: hoses with a large OD will likely require special handling.
- Flow Rate / Fluid Velocity - The flow rate of the system in conjunction with the inside diameter of the hose will dictate the fluid velocity through the hose. Please consult your hose supplier for specific recommended velocity ranges. Please note that suction line recommendations are different than pressure lines. Loading and unloading flow rate is impacted by the inside diameter of the hose**.**

T stands for **TEMPERATURE** of the material conveyed and environmental conditions

- Are there factors such as heat sources in the environment in which the hose will be used
- Continuous (average) and minimum and maximum temperatures have to be specified for both the environment and material conveyed
- Note if flame resistance or flammability will be an issue
- Sub-zero exposure: in subfreezing temperatures, care must be taken to keep water flowing through hoses; hoses may need to be flushed to remove ice crystals.
- There is a substantial pressure derating for both rubber and PVC hoses as the ambient temperature increases. Please contact manufacturer for details.
- Care must be taken when routing near hot manifolds and in extreme cases a heat shield may be advisable.
- Other things to consider - maximum intermittent ambient temperature, fluid temperature, ambient temperature, and maximum temperature.
- Maximum assembly working pressures will decrease as temperatures increase.

A stands for the **APPLICATION**, the conditions of use

- Configuration/routing (add a sketch or drawing if applicable)
    - is the hose hanging, laying horizontally, supported, unsupported (orientation and aspect of the hose)
    - what else is attached to the hose, any external load on the hose
    - bend radius requirements, flexibility
    - elongation considerations with working pressure
- Quantify anticipated movement and geometry of use requirements
- Intermittent or continuous service
- Indoor and outdoor use

- Unusual mechanical loads
- Excessive abrasion
- Electrical conductivity requirements
- Equipment type
- External conditions – abrasion, oil (specify type), solvents (specify type), acid (specify type and concentration), ozone, salt water, ultraviolet (UV) radiation (sunlight), geographic temperatures (e.g., Alaska vs. Louisiana)
- Hose now in use
    - Type of hose
    - Service life being obtained and description of failure or source of customer dissatisfaction
- strength and frequency of impulsing or pressure spikes
- non-flexing applications (static), flexing applications (dynamic)
- vacuum requirements
- Can also refer to Alloy when working with Metal Hose

M stands for the **MATERIAL or MEDIA** being conveyed, type and concentration

- Are there special requirements for this hose tube
    - Any special specifications (or agency requirements) that need to be considered (e.g., 3A, API, Proposition 65, USP Class VI, OSHA)
    - Will the material be continuously flowing, or sit in the hose for long periods of time (specify)
- Media velocity, flow rate
- Weight of media (specific gravity)
- Chemical name/concentration (MSDS/SDS)
- Solids, description and size
- Fluid Compatibility **-** Some applications require specialized oils or chemicals to be conveyed through the system. Hose selection must assure compatibility of the hose tube. In addition to the hose materials, all other components, which make up the hose assembly (hose ends, O-rings, etc…), must also be compatible with fluid being used. Depending on the fluid, your hose supplier may lower the maximum temperature or pressure rating of the assembly. When selecting any hose assembly, always consult your hose supplier's recommendations.
- Temperature of product
- Corrosivity of product; potential corrosiveness of mixed media (e.g., resulting from improperly cleaned hoses)
- Can also refer to motion when working with Metal Hose

P stands for the **PRESSURE** to which the assembly will be exposed

- System pressure, including pressure spikes. Hose assembly working pressures must be equal to or greater than the system pressure. Pressure spikes greater than the maximum working pressure will shorten hose life and must be taken into consideration.
- Temperature implications
- Vacuum considerations
- Maximum Operating Pressure - This is the maximum pressure that the system should be exposed to in normal operating conditions. For hydraulic hose assemblies, this pressure should be dictated by the relief setting of the system. Both the hose and hose end should not be rated to a pressure less than the maximum operating pressure of the system.

- Pressure Spikes - When a hydraulic system is subjected to a large load in a short period of time, the system pressure can overshoot the relief setting and exceed the maximum operating pressure. Frequent pressure spikes can reduce the life of hose assemblies. Please consult your hose supplier if there are multiple constructions which meet your application needs.
- Impulsing – exposure of the assembly to changing pressures over time
- Maximum assembly working pressures will decrease as temperatures increase.

E stands for **ENDS**; style, type, orientation, attachment methods, etc.

- Uncoupled or coupled hose; hose with built-in fittings
- Specify end style (see charts and pictures in Section 5)
- Materials and dimensions (steel, stainless, etc.) (Note: some applications such as potable water service require lead-free fittings)
- Conductivity requirements
- Specify attachment method – e.g., banded, crimped, swaged, etc.
- Consideration should be given to the lowest rated component (hose, fitting, and attachment) in determining overall MWP of the entire hose system.
- Specify impact of any pull forces, if vertical routing of hose assembly is anticipated

D stands for **DELIVERY** Details

- Specific to customer requirements
- Testing requirements
    - Certification and documentation requirements (e.g., Coast Guard)
- any special packaging requirements
- any special shipping requirements
- tagging requirements
- can also refer to Determined Overall Length when working with Metal Hose