CROSS FLUID POWER

P.O. Box 18508

Greensboro, N.C. 27419-8508

HYDRAULIC POWER UNIT MANUAL

CROSS
Fluid Power

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INITIAL START-UP OF HYDRAULIC POWER UNIT

1. Before starting the electric motor or motors on the power units, for any reason, the following should be done:

   A. Be sure to fill the reservoir to the proper level with the recommended hydraulic fluid. See data sheet, Page 7.

   B. Check to see if pump or pumps have case drain connections and with clean hydraulic fluid fill the pumps. Case pressure should never exceed 5 PSI under operating conditions.

   C. Check the alignment of the flexible coupling. The alignment should be checked with an indicator or straight edge and adjustments made if necessary (maximum misalignment is .005 inch). This is not necessary on units with pumps mounted directly on the motor.

   D. Determine that all fittings are properly secured.

2. Connect the motor to the proper electrical source. Check the motor nameplate for proper wiring of dual voltage motors. Jog the motor to check rotation. Polyphase motors are bi-directional and proper rotation can be established by reversing any two power leads.

3. Establish the prime on the pump by the following steps:

   A. Adjust the relief valve to the minimum pressure setting. (On pressure compensated piston pumps, adjust the pressure compensator to the minimum setting.)

   B. Jog the electric motor several times.

   C. If pump fails to prime, loosen one of the pressure line joints to bleed off trapped air. (This is not necessary on units equipped with air bleed valve ABT-03-10.)

   D. The use of open center valving allows the pump on initial start-up to clear itself of air and draw an oil prime immediately. When this valving arrangement exists, there are no further precautions necessary to insure pump priming.

4. After the pump is primed, the pressure should be adjusted to suit the system requirements. It is important to note that it is necessary for the pump to be operated against a blocked system when making pressure adjustments.

5. Air trapped in a hydraulic system will cause spongy operation. After the pump has been running for a short period of time, the machine should be cycled several times to purge air from the system. (The fluid level should be checked several times at this time as it may be necessary to add more fluid to maintain the proper level.) It may be necessary to bleed air at the actuators.

6. After the first few hours of operation, any foreign material from the system plumbing will be flushed to the reservoir. It is good practice to drain and replace the initial oil filling and to clean the reservoir and suction strainer. Also, replace return filter element.

7. After the hydraulic system has been running under actual operating conditions for at least one day, the following checks should be made and subsequent corrections made if necessary:

   A. Check all pipe and tubing joints and system components for external leakage.

   B. Check temperature of fluid. To obtain optimum service life from both the oil and the hydraulic system, operate between 120° (49°C) and 130° (54°C), but 150° (66°C) normally is the maximum oil temperature recommended.

   C. Check system pressure to insure that you are operating at the lowest possible level.

   D. Check level of reservoir oil.

   E. Check system for spongy operation and bleed air if necessary.

8. At least once a year or every 4,000 operating hours, the reservoir, suction strainer and air vent filter should be cleaned and all return filter elements should be replaced.

HYDRAULIC FLUID AND TEMPERATURE RECOMMENDATIONS FOR INDUSTRIAL MACHINERY

UNIT TYPE	VISCOSITY	OIL TYPE
Inline Piston (Pumps & Motors)	● Viscosity Grades: 32-68 cSt (150-315 SUS) @ 40° C. (104° F.) Running: 13-54 cSt (70-250 SUS) At Start Up: 220 cSt (1000 SUS) Max.	Antiwear type industrial hydraulic oils or automotive crankcase oils having letter designations "SC", "SD", "SE" or "SF". Per SAE J183 FEB80.
Angle Piston Vane (Except MHT) Gear (Pumps & Motors)	● Viscosity Grades: 32-68 cSt (150-315 SUS) @ 40° C. (104° F.) Running: 13-54 cSt (70-250 SUS) At Start Up: 860 cSt (4000 SUS) Max.	
◆ MHT (High Torque/ Low Speed Vane Motors)	● Viscosity Grades: 32-68 cSt (150-315 SUS) @ 40° C. (104° F.) Running: 13-54 cSt (70-250 SUS) At Start Up: 110 cSt (500 SUS) Max.	
HAS Drives (Hydraulic Adjustable Speed Drives)	● Viscosity Grades: 68 cSt (315 SUS) @ 40° C. (104° F.)	SAE 20-20W. Automotive crankcase oils designated "SC", "SD", "SE" or "SF" or antiwear type industrial hydraulic oils.

cSt: Centistokes

SUS: Saybolt Universal Seconds

◆ Adhere to the oil recommendations for MHT units rather than the pumps involved.

● Viscosity Grades are the standard viscosity grades listed in ASTM D-2422 titled "Viscosity System for Industrial Fluid Lubricants", but any intermediate viscosity is acceptable.

SELECTION OF VISCOSITY GRADES

Use the following tabulation to determine the temperature extremes between which the viscosity grades can be used to remain within Vickers start-up and running viscosity range recommendations.

The SAE 10W grades fall between the 32 cSt (150 SUS) and 46 cSt (215 SUS) grades and the SAE 20-20W approximates the 68 cSt (315 SUS) grade.

VISCOSITY GRADE 40° C. (104° F.)	START UP 860 cSt (4000 SUS)	START UP 220 cSt (1000 SUS)	START UP 110 cSt (500 SUS)	RUNNING 54 cSt (250 SUS) Max.	RUNNING 13 cSt (70 SUS) Min.
32 cSt (150 SUS)	−12° C. (11° F.)	6° C. (42° F.)	14° C. (58° F.)	27° C. (80° F.)	62° C. (143° F.)
46 cSt (215 SUS)	− 6° C. (22° F.)	12° C. (54° F.)	22° C. (72° F.)	34° C. (94° F.)	71° C. (159° F.)
68 cSt (315 SUS)	0° C. (32° F.)	19° C. (66° F.)	29° C. (84° F.)	42° C. (108° F.)	81° C. (177° F.)

GENERAL DATA

Oil in hydraulic systems performs the dual function of lubrication and transmission of power. It constitutes a vital factor in a hydraulic system, and careful selection of it should be made with the assistance of a reputable supplier. Proper selection of oil assures satisfactory life and operation of the system components with particular emphasis on hydraulic pumps and motors. Any oil selected for use with pumps or motors is acceptable for use with valves.

Some of the factors especially important in the selection of oil for use in an industrial hydraulic system are:

(1)The oil must contain the necessary additives to ensure high antiwear characteristics. Not all hydraulic oils contain these in sufficient amounts.

(2)The oil must have proper viscosity to maintain adequate sealing and lubricating quality at the expected operating temperature of the hydraulic system.

(3)The oil must have rust and oxidation inhibitors for satisfactory system operation.

Two specific types of oil meet the requirements of the modern industrial hydraulic systems:

(1)Antiwear type industrial hydraulic oils. A new generation of industrial oils containing adequate quantities of antiwear compounds is recommended by Vickers for general hydraulic service. These oils are generally developed and evaluated on the basis of pump wear tests such as ASTM-D2882. These oils offer superior protection against pump and motor wear and the advantage of long service life. In addition, they provide good demulsibility as well as protection against rust.

(2)Automotive type crankcase oils having letter designation "SC", "SD", "SE" or "SF" per SAE J183 FEB80.

The above classes of oils in the 10W and 20-20W SAE viscosity ranges are excellent for severe hydraulic service where there is little or no water present. The only adverse effect is that the "detergent" additive tends to hold water in a tight emulsion and prevents separation of water, even on long time standing. It should be noted that very few water problems have been experienced to date in the use of these crankcase oils in machinery hydraulic systems. Normal condensation has not been a problem.

Over the years, Vickers hydraulic oil recommendations have been based on oils that (1) provide adequate wear protection, (2) have proper viscosity and (3) are sufficiently stable to withstand the chemical, thermal, and mechanical stresses of severe hydraulic service. There are many engine oils that are outside of the SC, SD, SE, and SF classes that meet the above basis of recommendation with lower concentrations of some of the less critical additives (such as the detergent-dispersants) and result in lower costs.

With these oils it is highly desirable to have data from pump wear tests similar to ASTM-D-2882. In exceptional cases where the requirements of speed, pressure, temperature and ambient conditions exceed the recommendations for industrial machinery, please refer to the oil recommendations M-2950-S for Mobile hydraulic equipment.

VISCOSITY

Viscosity is the measure of resistance to flow. The selection of a hydraulic oil of a specific viscosity range must be based on the needs of the system, limitations of possible critical components, or proper performance of specific types of units. Vickers recommends that certain maximum and minimum viscosity ranges of the oil at start-up and during running be maintained. (See chart.) Very high viscosities at start-up temperatures can cause noise and cavitational damage to pumps. Continuous operation at moderately high viscosities will tend to hold air in suspension in the oil while passing through the reservoir which can cause noise and early failure of pumps, motors and erosion of valves. Low viscosities result in decreased system efficiency and impairment of dynamic lubrication.

Choose the proper oil viscosity for your particular system so that over the entire temperature range encountered, the start-up viscosity and the running viscosity range shown in the chart is met. This is important, and assurance should be obtained from your oil supplier that the viscosity of the oil being used will not be less than the minimum recommended at maximum oil temperature encountered.

A number of antiwear hydraulic oils containing polymeric thickeners (V.I. improvers) are available. The temporary and permanent viscosity loss of some of these oils at operating temperature may be sufficient to affect the life and performance of components. Be certain you know the extent of loss of viscosity of polymer containing oils under hydraulic service before using them so that you do not operate below the recommended minimum viscosity.

TEMPERATURE

To obtain optimum service life from both the oil and the hydraulic system, operate between 49° C. (120° F.) and 54° C. (130° F.), but 66° C. (150° F.) normally is the maximum oil temperature recommended. Vickers HAS Drives operate at a slightly higher temperature, but this is permissible because of the component design.

MHT Motors are permitted to operate at higher temperatures, but this is permissible by meeting special application requirements. Pumps can be approved to operate MHT Motors at these higher temperatures. Contact your Vickers Representative for recommendations.

CLEANLINESS

Thorough precautions should always be observed to insure that the hydraulic system is clean:

(1) Clean (flush) entire system to remove paint, metal chips, welding shot, lint, etc.

(2) Filter each change of oil to prevent introduction of contaminant into the system.

(3) Provide continuous oil filtration to remove sludge and products of wear and corrosion generated during the life of the system.

(4) Provide continuous protection of system from entry of airborne contamination by proper filtration of air through breathers.

(5) During usage, proper oil filling of reservoir and servicing of filters, breathers, reservoirs, etc. cannot be over emphasized.

(6) Refer to installation data for recommended filtration.

SOUND LEVEL

Noise is only indirectly affected by the fluid selection, but the condition of the fluid is of paramount importance in obtaining the optimum reduction of system sound levels.

Some of the major factors affecting the fluid conditions that cause the loudest noises in a hydraulic system are:

1. Very high viscosities at start-up temperatures can cause pump noises due to cavitation.
2. Running with a moderately high viscosity fluid will impede the release of entrained air. The fluid will not be completely purged of such air in the time it remains in the reservoir before recycling through the system.
3. Aerated fluid can be caused by ingestion of air through the pipe joints of inlet lines, high velocity discharge lines, cylinder rod packings, or by fluid discharging above the fluid level in the reservoir. Air in the fluid causes a noise similar to cavitation.
4. Contaminated fluids can cause excessive wear of internal pump parts which may result in increased sound levels.
5. Systems using water based fluids are susceptible to noise created by vaporization of the fluid if excessive vacuums and temperatures are encountered.

FIRE RESISTANT FLUIDS

Hydraulic systems using fire resistant fluids require special engineering consideration.

Proper design, operation and maintenance of fluid power systems is of paramount importance to obtain the optimum performance of fire resistant fluids such as synthetics, water glycol, and water in oil emulsion types.

For general information on the properties, characteristics, application and use of fire resistant fluids consult the "ANSI B93.5-19**–Standard Practice for Use of Fire Resistant Fluids for Fluid Power Systems."

For applications using fire resistant fluids consult your current catalog data for the specific component being used, or contact your local Vickers representative for assistance.

LOW VISCOSITY–HIGH WATER BASED FLUIDS (HWBF)

Low viscosity hydraulic fluids containing 90 to 95% water are known as "High Water Based Fluids" (HWBF).

For specific applications of High Water Based Fluids (HWBF), such as "soluble oil in water emulsions" and "synthetic solutions", consult your Vickers representative.

TYPES OF "HIGH WATER BASED FLUIDS" (HWBF)

There are three major types of HWBF being used today:

Oil-in-Water (O/W) Emulsions/Microemulsions: An oil-in-water emulsion containing a 5% concentration of soluble oil is recommended. (A 6 to 10% concentration is preferred). The soluble oil should be a stable, high quality, heavy duty type soluble oil additive, which includes emulsifiers, antiwear additives, rust and, oxidation inhibitors, vapor phase inhibitors and bactericides. The minute droplets of oil are dispersed throughout the water, forming a milky oil-in-water emulsion. The average droplet size of microemulsions is smaller than that of ordinary O/W emulsions and have a translucent appearance.

Synthetic Solutions: A synthetic solution containing 5% soluble additives is recommended. (A 6 to 10% concentration is preferred). The soluble additives include antiwear agents, rust and oxidation inhibitors, vapor phase inhibitors and bactericides. The soluble additives are dissolved in the water, forming a true clear solution. Dyes are sometimes added to make the fluid more visible.

Semi-Synthetics: This type is a mix of both O/W emulsion and synthetic solution. These can also be used at concentrations of 5 to 10%.

GENERAL DATA

To assure an effective emulsion or solution, the water should not have excessive hardness or have an acid nature, and it should be distilled or deionized water with less than 300 parts per million hardness.

Hard water containing excessive mineral content, such as calcium, may cause deposits in the hydraulic system or result in additive separation or emulsion breaking.

Oil-in-water emulsions preparation is more exacting. When preparing the mixtures, the soluble oil should always be added to the water while maintaining good fluid agitation. The water should never be added to the soluble oil. Do not mix soluble oil brands.

Proper maintenance of HWBF requires periodic testing for pH and soluble oil or soluble additive concentration. The pH should be maintained at 8.0 - 9.5 in accordance with the supplier's recommendation. If the pH number exceeds these limits, discard the fluid. Always use a premixed fluid to replenish the system.

The recommended storage or operating temperature range of HWBF is 4^{o} C. (39^{o} F.) to 49^{o} C. (120^{o} F.), unless otherwise specified by the fluid supplier.

COMPONENTS

Pumps: Vickers' standard "B" series inline piston pumps are approved for use with a suitable HWBF at 1200 RPM and 1000 PSI. Some "B" series models are approved for select applications operating at higher pressures and speeds. These pumps carry the "F6" designation.

Vickers' standard vane and gear type pumps and motors are not approved for HWBF. Special vane pumps have been developed and are approved for use with suitable HWBF at 1000 PSI and 1200 RPM. These pumps carry the "F6" designation.

Valves: Many standard Vickers valves and controls can be used successfully with suitable HWBF at less than 1000 PSI. Consult your Vickers representative.

Some Vickers valves and controls are approved for select applications operating at higher pressures. These units carry the "F6" designation.

Filters: Vickers' standard indicating type inlet filters and tank line filters are approved with HWBF.

A reduction of predicted life of hydraulic components should be expected when using HWBF.

OIL STORAGE & HANDLING

GENERAL

A number of the Mobile Hydraulic Hints outline methods for reducing contamination in the system at assembly and after the system is running. Following these procedures is absolutely necessary to the proper operation of any hydraulic system or component. But none of these procedures will do the job if contaminated fluid is added to the system to begin with.

Refiners of hydraulic oils take particular care to prevent contamination of any sort from entering the oil up to the time of delivery. It is just as important to exercise care in preventing contaminants from entering after its delivery, and during storage and handling. This bulletin provides instructions for this purpose.

STORAGE

Care must be taken from the minute oil is delivered to keep it clean. The first step is selecting a clean, dry spot for storage. Store the drums on their sides and cover them to prevent dust accumulation.

To avoid condensation in storage, drums must be protected against sudden temperature changes and should be kept full. Water collecting on the top of a drum will seep through the plug and into the oil. Water in hydraulic oil will reduce reliability and service life, regardless of the manufacturer's claims of the oil's ability to function with water contamination.

HANDLING

Before opening a drum, wipe the top carefully so that dirt will not fall into the oil. If, by chance, dirt does get into the oil, make sure the oil is cleaned before using. Most large particles can be removed by straining through a 100-mesh screen. Remove the remaining dirt by allowing it to settle in the oil. Using only the clean oil from the top of the container may waste some oil, but it could prove to be very worthwhile in keeping the system clean.

If equipment is available, filter or centrifuge the oil. Remember, however, that active earth types of filters (such as Fullers Earth) remove oil additives. Consult your oil company representative or filter manufacturer if you're not sure.

When drawing oil out of storage, make certain it is carried from storage point to use in clean, covered containers. If the oil drawn out of storage is not used immediately, make sure it is kept tightly covered.

FILLING

Before removing filler cap to add oil to a hydraulic system, wipe off the fill plug and the filler nozzle with a clean, lint-free cloth. The safest way to pour oil from a container into a reservoir is to use a 10-micron filter on the filler nozzle. It is especially important at this point to watch for metallic chips, bits of waste, and other contaminants that may cause damage to the hydraulic system. The reservoir should be tightly closed after filling the system.

CONCLUSION

Dust, water, lint or contaminants of any kind can seriously impair the operation of a hydraulic system. Following the simple rules outlined in this bulletin can prevent such material from contaminating hydraulic oil. A preventative maintenance program aimed at keeping oil clean can pay off.

Vickers equipment is designed to prevent dirt from entering the hydraulic system during operation. Nevertheless, it is to your advantage to study your own operating conditions and initiate practices to ensure contamination-free system operation.

MAINTENANCE OF HYDRAULIC FLUID IN THE SYSTEM

Hydraulic Fluid Changes

Good maintenance procedures make it mandatory to keep the hydraulic fluid clean. A daily/weekly or monthly log should be kept on the hydraulic fluid condition.

No hard and fast rule can be established for changing the fluid because of the great variety of operating conditions. However, we do know that when filter elements are replaced frequently, service life of a system increases. Periodic testing of the fluid by the supplier is recommended to confirm suitability for continued use and to establish the correct fluid and filter element replacement interval.

Some of the considerations affecting hydraulic fluid life are: operating temperature, type of service, contamination levels, filtration, and the chemical composition of the fluid.

Fluid Recommendations

The basic recommendations for fluid are stipulated in bulletin page 7. The fluids recommended by this bulletin give the assurance of adequate wear protection and excellent chemical stability under the most adverse operating conditions.

On mobile applications, the viscosity grade of the fluid should be changed in spring and autumn as is done with automobile engines. Hydrostatic transmissions and control mechanisms may require a different viscosity fluid.

Draining The System

The system should be started and fluid heated before draining. This will lower the time it takes to drain the system and allow impurities suspended in the fluid to be removed. It is desirable to remove all fluid from the system. Bleeding of the fluid at the lowest point in the system will help in most cases.

Systems which have accumulated deposits that were not removed during draining must be flushed with a light viscosity fluid. The fluid should contain a rust inhibitor to protect metal surfaces against rust formation after draining.

When hydraulic fluid is added to replenish the system, it should be pumped through a 25 micron filter. If such a filter is not available, a funnel with a fine wire screen (200 mesh or finer) can be used. It is important that fluid be clean and free of all substances which will cause improper operation.

FLUID CONTAMINATION/AERATION—CAUSES AND EFFECTS

CONTAMINATION

A contaminated system can be the result of several factors: system design inadequate, poor maintenance of the system, poor housekeeping of the system and adverse operating conditions

A. System Design Inadequate

1. Reservoirs which cannot be cleaned.

2. Breathers that permit abrasives, inherent in the atmosphere to enter the system.

3. Poor cylinder packing design (no wiper to clean dirt from the piston rod).

4. Improper piston rod design (piston rods with poor wear characteristics).

5. Improper valving (anti-cavitation checks omitted from cylinder circuits with rapid drop characteristics).

6. Failure to provide adequate filteration.

B. Poor Maintenance of the System

1. Improper and unclean practices when adding fluid to the system.

2. Failure to clean breathers.

3. Failure to change pitted cylinder rods and worn cylinder packings.

4. Failure to use good cleanliness practices when changing system components.

5. Failure to change filter cartridges and/or fluid at proper intervals.

6. Failure to purge debris from the system after a pump failure.

C. Poor Housekeeping of the System

Surgical cleanliness is not required, however, ordinary clean practices during assembly will pay off in increased service life of the equipment.

Excessive and improper use of pipe thread sealer on lines and gaskets in the system can cause pump failures. This is especially true when a type of sealer is used that hardens.

Another source of contamination is fittings, hoses and lines which are received from a vendor uncapped. The use of brazed or welded fittings, and unpickled steel plating can also contribute to the contamination.

Vickers data sheet 1221-S covering the preparation of pipes, tubes and fittings should be referred to and followed. This will lower the possibility of premature failure due to contamination of the system.

D. Adverse Operating Conditions

From experience, we have found that machines used in a very dusty atmosphere and in windy areas require special components. For example, heavy duty breathers, chrome plated piston rods, plus frequent changes of the filter cartridges are also required.

Effects of Contamination

Contamination affects all types of hydraulic equipment adversely. Precision high tolerance parts are very susceptable to the effects of contamination. Dirty fluid causes wear which accelerates leakage and the development of heat in a system. Heat lowers the lubricity of a hydraulic fluid and causes additional wear.

If a hydraulic pump or motor should fail, the system becomes contaminated. Remove the unit for repair. The reservoir must be drained, flushed and cleaned. All hoses, lines, cylinders and valves should be inspected for wear and particles of the unit that failed. Flush all components of the complete system to remove metallic particles.

Replace filter elements. Dispose of the fluid removed from the system and fill the reservoir with clean hydraulic fluid. Install a new or rebuilt unit and start-up the system. Allow the system to run for a period of time to verify normal operation. Filter elements should be changed after 40 or 50 hours of operation. This guarantees that the system is essentially clean and free of any residue of the failed unit.

A very good reference catalog on contamination is available from Vickers called "Effective Contamination Control in Fluid Power Systems". This catalog describes types and sources of contamination, effects of types and sizes of particles, specifying contamination levels, selecting a filter, locating a filter, design steps and worked examples and fluid sampling and analysis.

AERATION (air bubbles in the fluid)

Causes

The following are candidates for the formation of air in a system.

A. Leaking inlet lines.

B. Control valve "O" rings leaking.

C. Shaft seal leakage.

D. Leaking cylinder packings caused by cavitating cylinders.

E. Turbulence or sloshing in the reservoir.

F. Vortexing fluid in the reservoir.

G. Release of air suspended within the fluid.

Effects

Aeration can be in many forms: large bubbles, foam or in various degrees of suspension. It usually causes pump noise (cavitation). Small bubbles cause extreme and rapid ring wear, with corresponding vane tip wear. Larger bubbles cause vanes to collapse and pound. This pounding effect develops rippling in the ring and the ring will have a dull appearance. This is more apparent on straight vane rings which are hardened cast iron. With extreme aeration cases, the wear is so rapid that a ring and vanes can be destroyed within an hour. In many cases, a large step will be worn in the ring contour at the pressure quadrant. When the step reaches a depth where the vane extends and locks, the vane and/or ring will break. Also, the shaft can break where it enters the rotor if the torque is great enough.

Cures

A. Leaking Inlet Lines

1. Pipe threaded fittings can be porous. Use an approved type of pipe thread sealer on all pipe threads.

2. If the pump inlet flange surface is rough, scored or mutilated, air leakage past the "O" ring seal can result.

With any of the above defects, air can be pulled into the system.

B. Control Valve "O" Rings Leaking

"O" rings are used to seal against port leakage in many control valves. These seals can be checked by applying heavy grease around the part to be checked. If the noise stops, the trouble has been located and repair can be initiated.

On systems which have been operating at excessive high temperatures, the "O" rings can harden and take a set. If this occurs, air leakage can result. This is true not only in a pump, but also in the rest of the components of the system. Another factor enhancing air leakage is the actual fluid composition. Fluids which have a high sulphur content tend to accelerate "O" ring hardness. This is one of the principle reasons for keeping system operating temperatures down. Normal operating temperature of a system is 90° above ambient. When operating temperatures are in excess of this value, trouble may result. Maximum operating temperatures should be checked at the pump outlet port.

C. Shaft Seal Leakage

Most vane pumps are internally drained. The shaft seal cavity is connected to the pump inlet. Excessively high inlet vacuums can cause air leakage at the shaft seal. The maximum vacuum measured at the pump inlet should not exceed five inches of mercury.

Shaft misalignment can increase the probability of air leakage past the shaft seal. Universal jointed couplings or splined couplings can cause seal leakage if not properly aligned. Straight (direct) couplings should never be used.

The use of the wrong type of tools can cause distortion or mutilation of a shaft seal at installation. The outer diameter of the shaft should be lightly polished before installation to remove any burrs or roughness in the area of the shaft seal.

Shaft seals must be made of the correct material for a given application. A material that is not compatible with system fluid can deteriorate and result in a leakage problem.

D. Leaking Cylinder Packings Caused By Cavitating Cylinders

On applications where a rapid raise and lower cycle is experienced, air can enter the system through a cylinder rod seal. Vacuums in excess of 20 inches of mercury have been recorded in systems without anti-cavitation check valves. This is enough to force dirt particles past the shaft seal into the system with the air. An anti-cavitation check will allow flow from the reservoir to enter the rod area of the cylinder during a vacuum condition. Anti-cavitation checks should always be used to prevent a high vacuum condition from developing. This will lower the possibility of fluid contamination through the rod seal of a working cylinder.

E. Turbulence or Sloshing in the Reservoir

Return lines, if improperly located, can cause turbulence and aeration. Return lines emptying above the fluid level cause bubbles to form in the system. Return lines should always be terminated below the fluid level. Reservoir must be deep enough to prevent aeration.

F. Vortexing Fluid in the Reservoir

If the fluid level in the reservoir is low and the inlet demand is great, a vortex condition can develop which pulls air into the pump inlet. In a hydraulic system, vortexing is normally the result of low fluid or poor reservoir design.

One of the best ways of curing a vortex problem is to place an anti-cavitation plate over the outlet of the reservoir. This is a common piece of sheet metal at least ⅛ inch thick set over and above the outlet opening. This plate will allow flow into the outlet from a horizontal direction and effectively extends and enlarges the reservoir opening. This prevents the vortex condition from developing.

F. Release of Air Suspended within the Fluid

There is considerable air suspended in cold hydraulic fluid. As the fluid warms, air is released into the system. A reduction of fluid pressure will also release air out of suspension. A simple relief valve poppet can create an orifice that increases velocity of the fluid and lowers its pressure. The reduced pressure condition releases air out of suspension into the system. Relief valves should be returned below the fluid level of the reservoir as far from the reservoir outlet as possible. This allows time for the air released by the relief valve to be removed before leaving the reservoir and entering the inlet area of the pump.

In some cases, special return line configurations are needed, or air bleed valves used, to remove air from the system.

Trouble Shooting Guide
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SECTION I - INTRODUCTION

1-1. GENERAL. The trouble shooting charts and maintenance hints that follow are of a general system nature but should provide an intuitive feeling for a specific system. The more general information is covered in the immediately following paragraphs. Effect and probable cause charts appear in Section II.

1-2. SYSTEM DESIGN. There is, of course, little point in discussing the design of a system which has been operating satisfactorily for a period of time. However, a seemingly uncomplicated procedure such as relocating a system or changing a component part can cause problems. Because of this, the following points should be considered:

A. Each component in the system must be compatible with and form an integral part of the system. For example, an inadequate size filter on the inlet of a pump can cause cavitation and subsequent damage to the pump.

B. All lines must be of proper size and free of restrictive bends. Undersize or restricted line results in a pressure drop in the line itself.

C. Some components must be mounted in a specific position with respect to other components or the lines. The housing of an in-line pump, for example, must remain filled with fluid to provide lubrication.

D. The inclusion of adequate test points for pressure readings, although not essential for operation, will expedite trouble-shooting.

1-3. KNOWING THE SYSTEM. Probably the greatest aid to trouble-shooting is the confidence of knowing the system. Every component has a purpose in the system. The construction and operating characteristics of each one should be understood. For example, knowing that a solenoid controlled directional valve can be manually actuated will save considerable time in isolating a defective solenoid. Some additional practices which will increase your ability and also the useful life of the system follow:

A. Know the capabilities of the system. Each component in the system has a maximum rated speed, torque, or pressure. Loading the system beyond the specifications simply increases the possibility of failure.

B. Know the correct operating pressures. Always set and check pressures with a gauge. How else can you know if the operating pressure is above the maximum rating of the components? The question may arise as to what the correct operating pressure is. If it isn't correctly specified on the hydraulic schematic, the following rule should be applied:

The correct operating pressure is the lowest pressure which will allow adequate performance of the system function and still remain below the maximum rating of the components and machine.

Once the correct pressures have been established, note them on the hydraulic schematic for future reference.

C. Know the proper signal levels, feedback levels, and dither and gain settings in servo control systems. If they aren't specified, check them when the system is functioning correctly and mark them on the schematic for future reference.

1-4. DEVELOPING SYSTEMATIC PROCEDURES. Analyze the system and develop a logical sequence for setting valves, mechanical stops, interlocks, and electrical controls. Tracing of flow paths can often be accomplished by listening for flow in the lines or feeling them for warmth. Develop a cause and effect troubleshooting guide similar to the charts appearing in Section II. The initial time spent on such a project could save hours of system down-time.

1-5. RECOGNIZING TROUBLE INDICATIONS. The ability to recognize trouble indications in a specific system is usually acquired with experience. However, a few general trouble indications can be discussed.

A. Excessive heat means trouble. A mis-aligned coupling places an excessive load on bearings and can be readily identified by the heat generated. A warmer than normal tank return line on a relief valve indicates operation at relief valve setting. Hydraulic fluids which have a low viscosity will increase the internal leakage of components resulting in a heat rise. Cavitation and slippage in a pump will also generate heat.

B. Excessive noise means wear, mis-alignment, cavitation or air in the fluid. Contaminated fluid can cause a relief valve to stick and chatter. These noises may be the result of dirty filters, or fluid, high fluid viscosity, excessive drive speed, low reservoir level, loose intake lines, or worn couplings.

1-6. MAINTENANCE. Three simple maintenance procedures have the greatest effect on hydraulic system performance, efficiency, and life. Yet, the very simplicity of them may be the reason they are so often overlooked. What are they? Simply these:

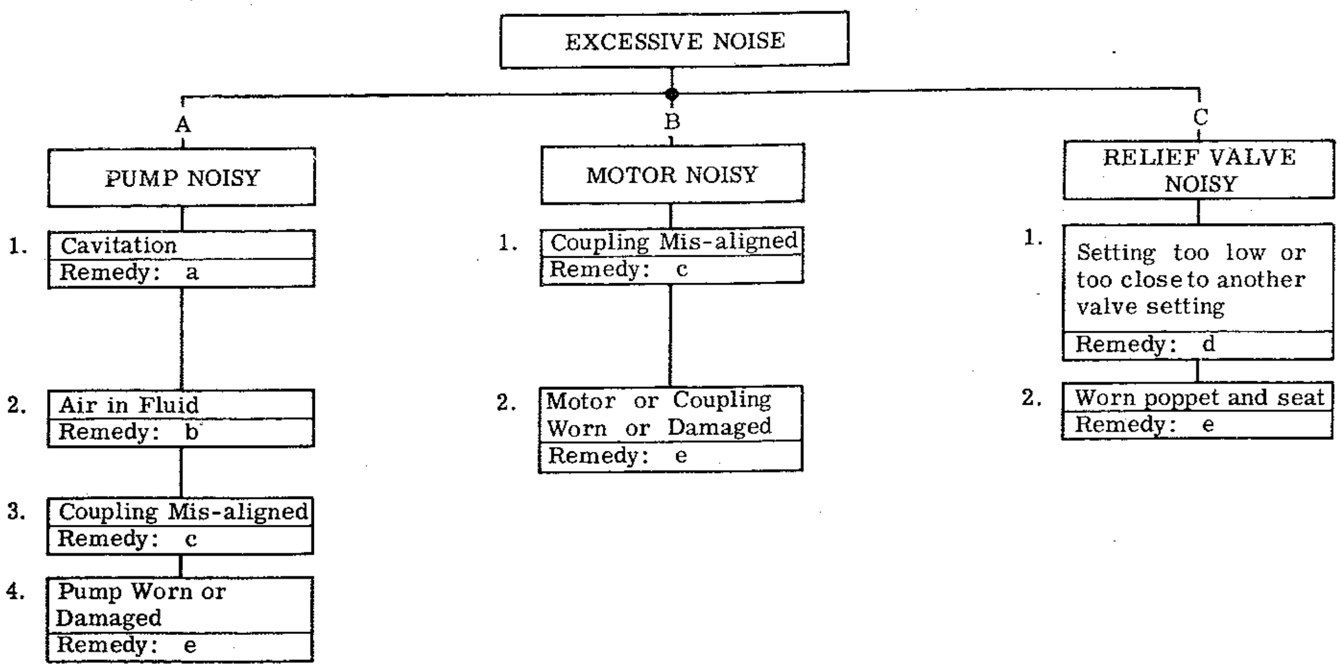
A. Maintaining a clean sufficient quantity of hydraulic fluid of the proper type and viscosity.

B. Changing filters and cleaning strainers.

C. Keeping all connections tight, but not to the point of distortion, so that air is excluded from the system.

SECTION II - TROUBLE-SHOOTING GUIDES

2-1. The following charts are arranged in five main categories. The heading of each one is an effect which indicates a malfunction in the system. For example; if a pump is exceptionally noisy, refer to Chart I titled EXCESSIVE NOISE. The noisy pump appears in Column A under the main heading. In Column A there are four probable causes for a noisy pump. The causes are sequenced according to the likelihood of happening or the ease of checking it. The first cause is cavitation and the remedy is "a". If the first cause does not exist, check for cause number 2, etc.



REMEDIES:

a. Any or all of the following: Replace dirty filters - Wash strainers in solvent compatible with system fluid - Clean clogged inlet line - Clean reservoir breather vent - Change system fluid - Change to proper pump drive motor speed - Overhaul or replace supercharge pump - Fluid may be too cold

b. Any or all of the following: Tighten leaky inlet connections - Fill reservoir to proper level (with rare exception all return lines should be below fluid level in reservoir) - Bleed air from system - Replace pump shaft seal (and shaft if worn at seal journal)

c. Align unit and check condition of seals, bearings and coupling

d. Install pressure gauge and adjust to correct pressure

e. Overhaul or replace

EXCESSIVE HEAT

A	B	C	D
PUMP HEATED	**MOTOR HEATED**	**RELIEF VALVE HEATED**	**FLUID HEATED**
1. Fluid heated Remedy: See column D	1. Fluid heated Remedy: See column D	1. Fluid heated Remedy: See column D	1. System pressure too high Remedy: d
2. Cavitation Remedy: a	2. Relief or unloading valve set too high Remedy: d	2. Valve setting incorrect Remedy: d	2. Unloading valve set too high Remedy: d
3. Air in fluid Remedy: b	3. Excessive load Remedy: c	3. Worn or damaged valve Remedy: e	3. Fluid dirty or low supply Remedy: f
4. Relief or unloading valve set too high Remedy: d	4. Worn or damaged motor Remedy: e		4. Incorrect fluid viscosity Remedy: f
5. Excessive load Remedy: c			5. Faulty fluid cooling system Remedy: g
6. Worn or damaged pump Remedy: e			6. Worn pump, valve, motor, cylinder or other component Remedy: e

REMEDIES:

a. Any or all of the following: Replace dirty filters - Clean clogged inlet line - Clean reservoir breather vent - Change system fluid - Change to proper pump drive motor speed - Overhaul or replace supercharge pump

b. Any or all of the following: Tighten leaky inlet connections - Fill reservoir to proper level (with rare exception all return lines should be below fluid level in reservoir) - Bleed air from system - Replace pump shaft seal (and shaft if worn at seal journal)

c. Align unit and check condition of seals and bearings - Locate and. correct mechanical binding - Check for work load in excess of circuit design

d. Install pressure gauge and adjust to correct pressure (Keep at least 125 PSI difference between valve settings)

e. Overhaul or replace

f. Change filters and also system fluid if of improper viscosity - Fill reservoir to proper level

g. Clean cooler and/or cooler strainer - Replace cooler control valve - Repair or replace cooler

INCORRECT FLOW

A. NO FLOW

1. Pump not receiving fluid
   Remedy: a
2. Pump drive motor not operating
   Remedy: e
3. Pump to drive coupling sheared
   Remedy: c
4. Pump drive motor turning in wrong direction
   Remedy g
5. Directional control set in wrong position
   Remedy: f
6. Entire flow passing over relief valve
   Remedy: d
7. Damaged pump
   Remedy: c
8. Improperly assembled pump
   Remedy: e

B. LOW FLOW

1. Flow control set too low
   Remedy: d
2. Relief or unloading valve set too low
   Remedy: d
3. Flow by-passing thru partially open valve
   Remedy: e or f
4. External leak in system
   Remedy: b
5. Yoke actuating device inoperative (variable displacement pumps)
   Remedy: e
6. RPM of pump drive motor incorrect
   Remedy: h
7. Worn pump, valve, motor, cylinder, or other component
   Remedy: e

C. EXCESSIVE FLOW

1. Flow control set too high
   Remedy: d
2. Yoke actuating device inoperative (variable displacement pumps)
   Remedy: e
3. RPM of pump drive motor incorrect
   Remedy: h
4. Improper size pump used for replacement
   Remedy: h

REMEDIES:

a. Any or all of the following: Replace dirty filters - Clean clogged inlet line - Clean reservoir breather vent - Fill reservoir to proper level - Overhaul or replace supercharge pump

b. Tighten leaky connections - Bleed air from system

c. Check for damaged pump or pump drive - replace and align coupling

d. Adjust

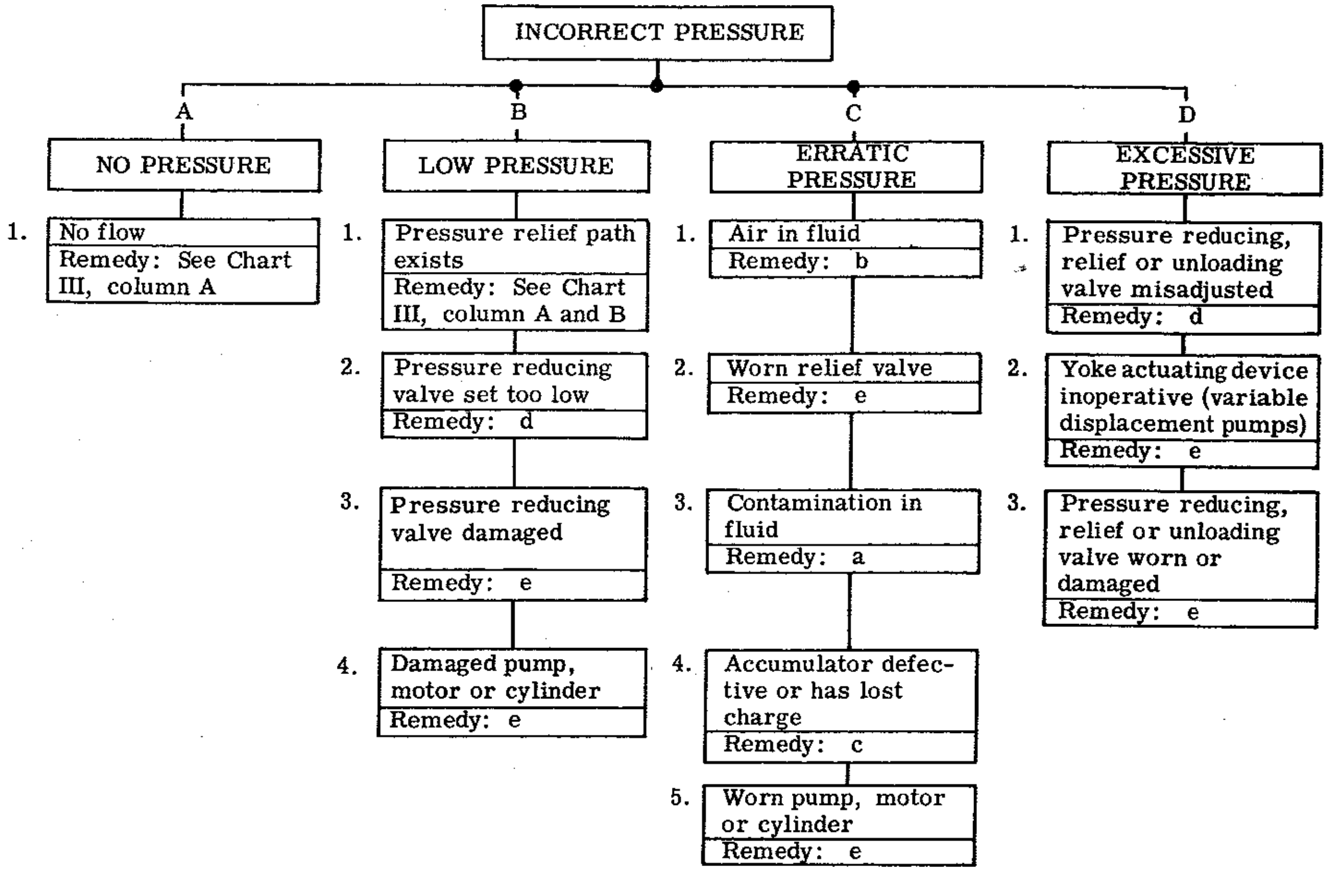
e. Overhaul or replace

f. Check position of manually operated controls - Check electrical circuit on solenoid operated controls - Repair or replace pilot pressure pump

g. Reverse rotation

h. Replace with correct unit

IV



REMEDIES:

a. Replace dirty filters and system fluid

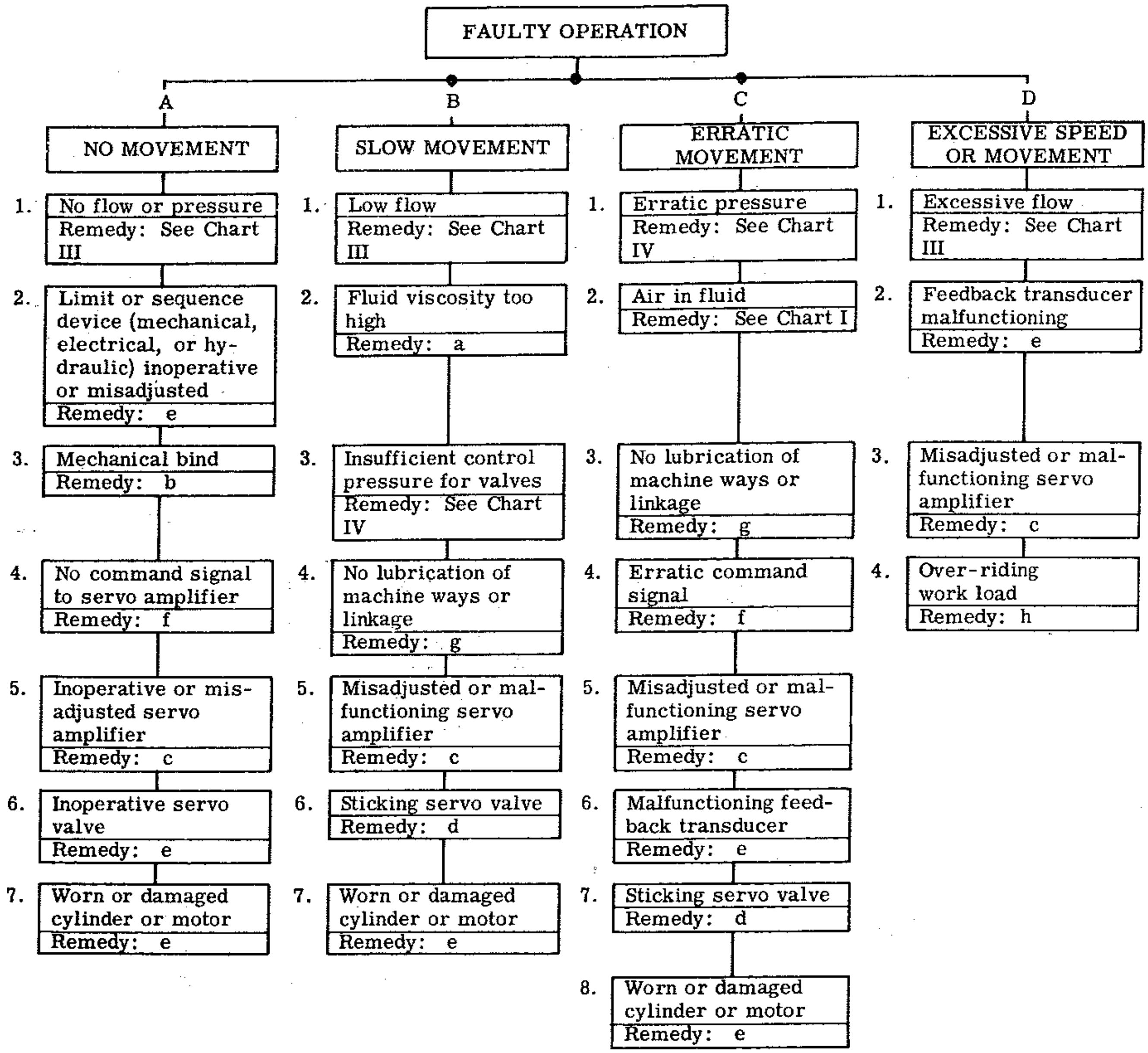
b. Tighten leaky connections (fill reservoir to proper level and bleed air from system)

c. Check gas valve for leakage - Charge to correct pressure - Overhaul if defective

d. Adjust

e. Overhaul or replace

V



REMEDIES:

- a. Fluid may be too cold or should be changed to clean fluid of correct viscosity
- b. Locate bind and repair
- c. Adjust, repair, or replace
- d. Clean and adjust or replace - Check condition of system fluid and filters
- e. Overhaul or replace
- f. Repair command console or interconnecting wires
- g. Lubricate
- h. Adjust, repair, or replace counterbalance valve.