

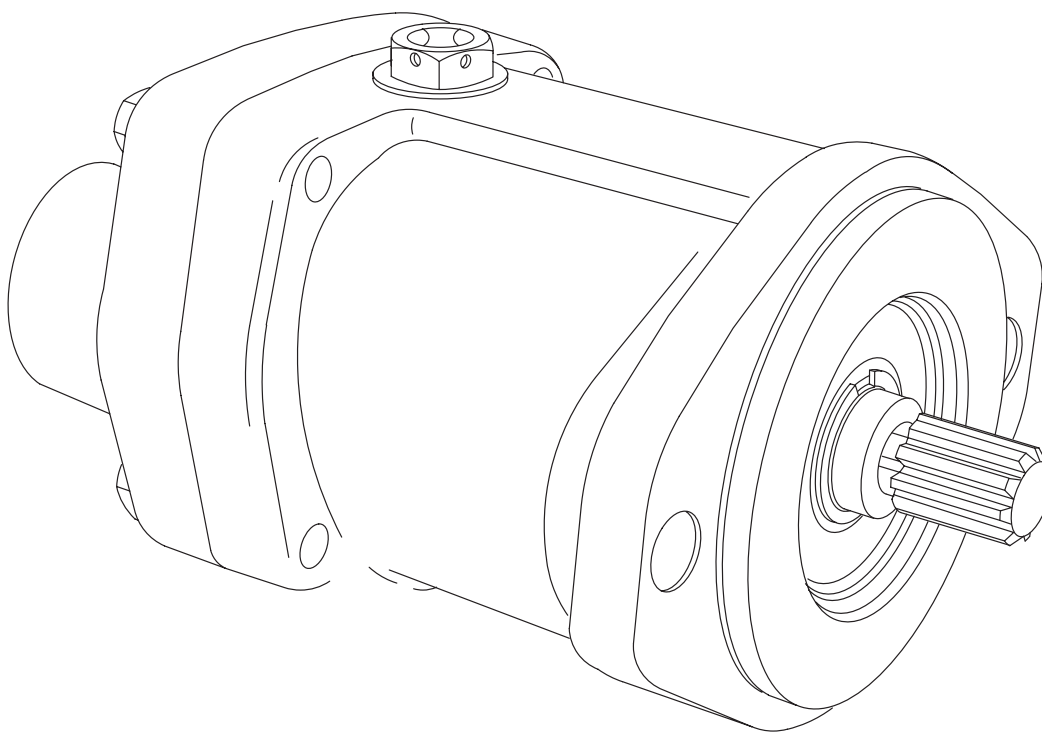
# Piston Motors

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## In-line Piston Motors

M-MFB & M-MVB Series



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# Section I – Introduction

## A. Purpose of Manual

The purpose of this manual is to describe the basic operational characteristic and to provide service and overhaul information for Vickers Fixed and Variable Delivery In-line Piston Motors. Models included in this series are listed in Table 1. Information contained in this manual pertains to the latest designs. Earlier designs are covered only to the extent of their similarity to present equipment.

## B. General Information

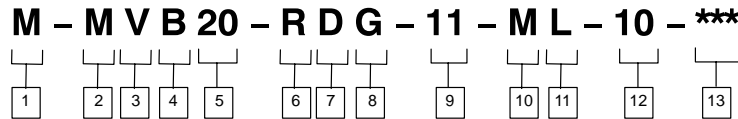
**Related Publications** – Service parts information and installation dimensions are not contained in this manual. The installation drawings and parts catalogs listed in Table 1 are available from Vickers.

**Model Codes** – There are many variations within each basic model series, which are covered by variables in the model code. Table 2 is a complete breakdown of the code covering these units. Service inquiries should always include the complete unit model number, which is stamped on the nameplate.

Model	Installation Drawing	Parts Catalog
M-MFB5, 6	M-289420	M-2761-S
M-MFB10, 15		M-2762-S
M-MFB20, 29		M-2764-S
M-MFB45		M-2764-S
M-MVB5 M-MVB10 M-MVB20	Contact Vickers sales engineers for information on variable displacement motors.	

Table 1. Installation Drawings and Parts Catalogs

## Model Code



<p><b>1 Mobile release</b></p>	<p><b>6 Rotation</b> (viewing from shaft end) R – Right hand L – Left hand U – Either direction</p>	<p><b>10 Control type</b> (variable motors only) C – Pressure compensator (250-3000 psi range) The compensator is adjusted to the minimum setting at the factory. M – Lever D – Stem servo</p>
<p><b>2 Motor</b></p>	<p><b>7 Yoke travel</b> (variable motors only) S – One side of center</p>	<p><b>11 Lever control location</b> (lever models only) L – Left hand side-viewing shaft end; omit for right hand side as shown on installation data.</p>
<p><b>3 Delivery type</b> F – Fixed displacement V – Variable displacement</p>	<p><b>8 Shaft type</b> G – SAE splined shaft * – Omit for straight keyed shaft</p>	<p><b>12 Control design numbers</b> (Variable motors only; omit for fixed motors) Design numbers subject to change. Installation dimensions remain as shown for design numbers 10 thru 19.</p>
<p><b>4 Motor type</b> In-line piston</p>	<p><b>9 Motor design numbers</b> Design numbers subject to change. Installation dimensions remain as shown for design numbers 10 thru 19.</p>	<p><b>13 Special features suffix</b></p>
<p><b>5 Delivery</b> GPM rating at 1800 RPM</p>		

Table 2. Model Code

# Section II – Description

## A. General

In-line motors are of the axial piston, positive displacement type and include both fixed and variable (adjustable) displacement motors capable of high pressure operation. Drive speeds vary with the model, type of fluid used and circuit application.

valve plate. The variable displacement units incorporate a mechanism which governs the angle of the swash plate and consequently controls the stroke length of each piston as the cylinder block and drive shaft rotate. The valve plate subassembly also serves as the back cover of the entire unit and includes the inlet and outlet ports. A bearing in the cover and one in the housing support the drive shaft.

## B. Assembly and Construction

The assembly of typical fixed and variable displacement units together with their ASA symbols are shown in Figure 1. As illustrated, the major components of the fixed in-line unit are the housing, drive shaft, rotating group, swash plate and

## C. Application

The installation drawings give the nominal motor performance characteristics and limits. For applications outside of the given limits the mobile sales application engineer should be consulted.

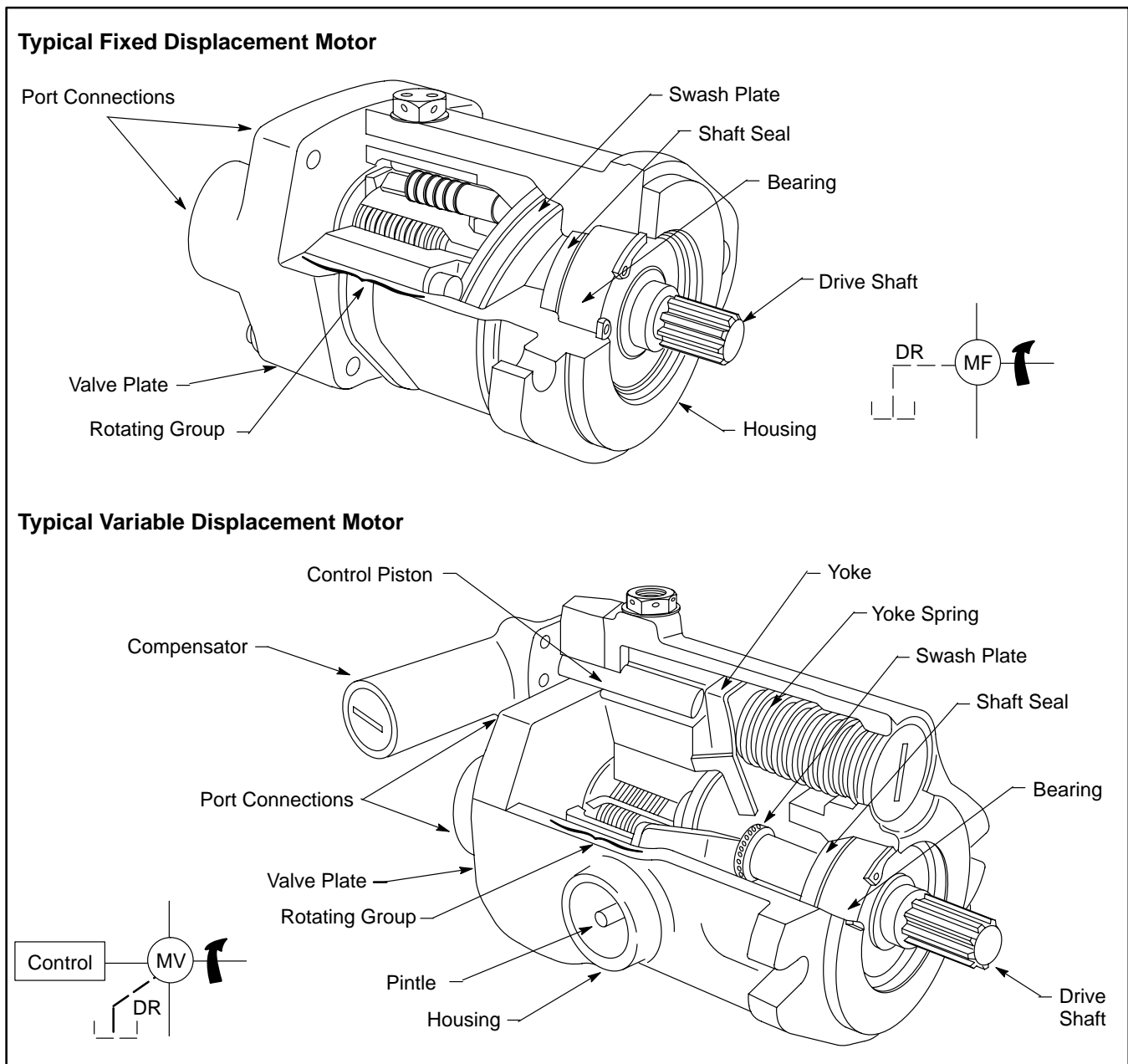


Figure 1.

# Section III – Principles of Operation

## A. General

Although nearly identical in design, pumps and motors operate essentially in reverse of each other; the pump forcing fluid through the system as it rotates, the motor being rotated by the fluid. Variable displacement units are constructed so that the angle of displacement (angle of the swash plate to the drive shaft axis) can be varied by changing the yoke position.

Motors are positive displacement units which are capable of producing a variable torque and speed. Motor speed is a function of the input fluid volume. Torque is generated by the pressure drop across the motor. Maximum torque is limited by system relief valve setting. On a variable displacement motor, the angle of the swash plate affects the speed and torque.

In operation, the inlet fluid is forced into the cylinder bores which are open to the inlet port (see Figure 2). The remaining cylinder bores are either open to the outlet port or blocked by the valve plate. Because the piston travel is limited by the swash plate, a component of the counter-force at the contact point of the piston shoe and swash plate causes the cylinder block to move in a rotary direction.

When the pistons move over the outlet port, the fluid discharges and returns to the reservoir or system. Rotation is reversed by reversing the fluid supply to the motor.

Motors are used for continuous, intermittent, or continuously reversing service. They can be stalled indefinitely under load without damage when protected by a relief valve and heat exchanger.

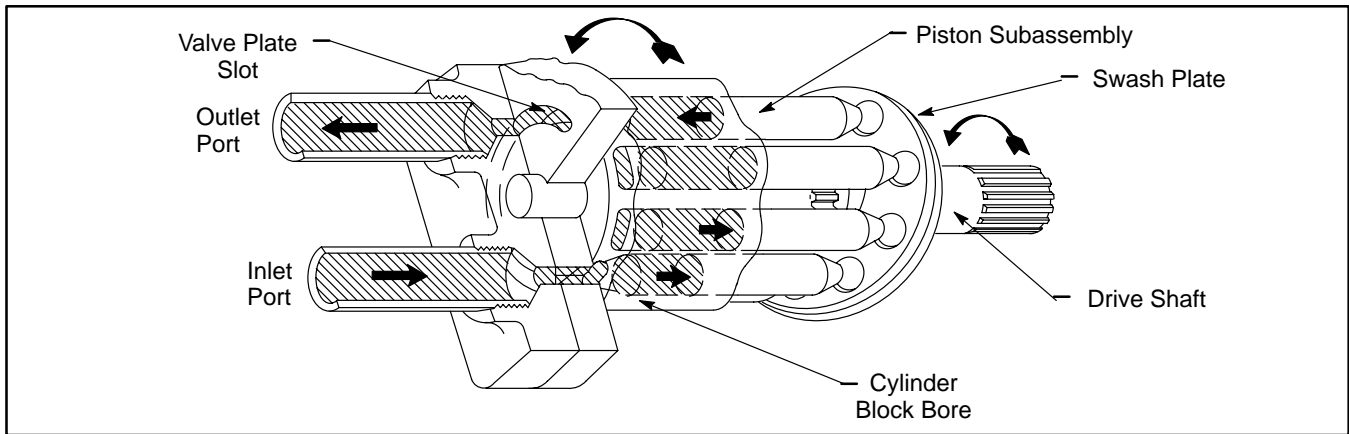


Figure 2.

## B. Fixed Displacement Motors

Since the swash plate angle in fixed displacement motors is not variable, the output speed is determined by motor size and the volume of input oil.

## C. Variable Displacement Motors

Variable displacement is affected by altering the angularity between the swash plate and the drive shaft axis as shown by views A, B and C in Figure 3.

The pressure compensator is a spring-biased, pressure actuated, three-way valve incorporated onto the valve plate.

The operation of the compensator is such that when the system pressure (motor inlet) reaches a pre-set value, determined by the compensator spring setting, the valve moves to regulate the control pressure acting on the actuating piston. As the force produced by the actuating piston overcomes the force of the opposing springs, the swash plate angle moves toward the minimum displacement position, view C. The amount of angular movement of the swash plate (i.e., displacement change) is determined by system pressure. Equilibrium is achieved when the new displacement (i.e., motor torque) matches the system requirement.

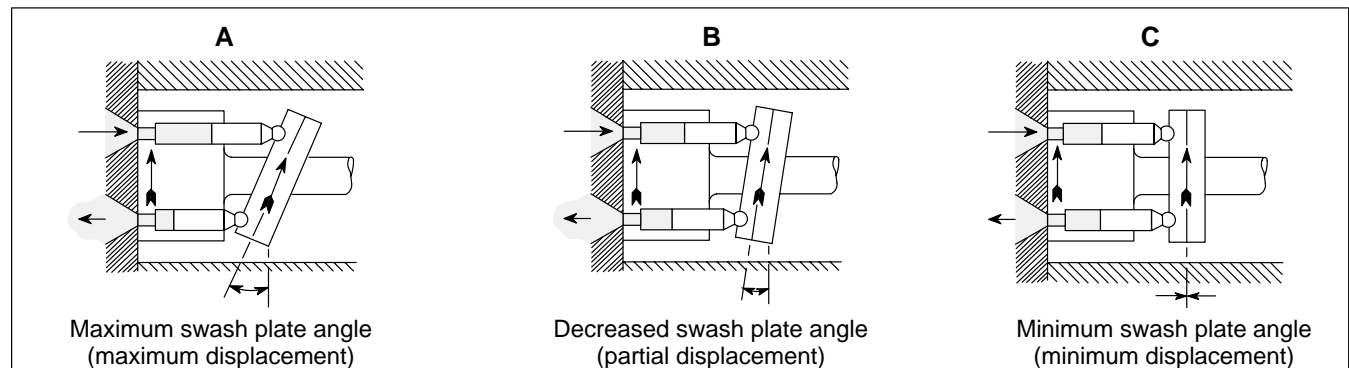


Figure 3.

# Section IV – Installation and Operating Instructions

## A. Installation

Installation drawings shown in Table 1 should be consulted for installation information.

## B. Drive Connections



### CAUTION

*Motor shafts are designed to be installed in flexible couplings with a slip fit or very light tap. Pounding can injure the bearings. Shaft tolerances are shown on pump installation drawings. (See Table 1.)*

1. **Direct Drives** – Care must be exercised when mounting the motor so that the pilot diameter fits properly into the mating section of the prime mover (see Figure 4). The pilot should not be forced into the mating part under any condition. Care should be exercised in tightening all flange mounting screws to prevent misalignment of shaft connections.

Shaft alignment is critical. Displacement or angularity can cause shaft breakage or bearing problems quickly, due to overloading.

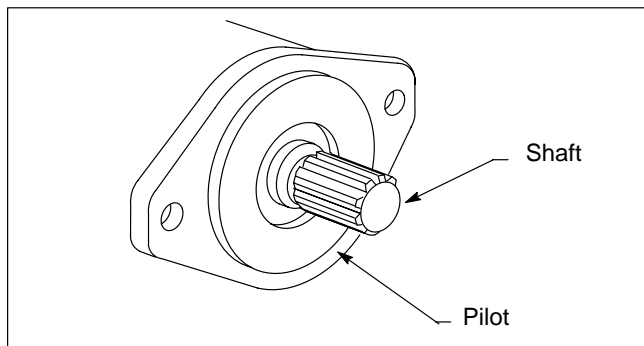


Figure 4.

2. **Indirect Drives** – For indirect drive applications the magnitude of side force, shown on the installation drawings (Table 1) relative to the mounting face must not exceed the indicated value at rated speed and pressure. For combined thrusts and side loads or other speeds and pressure, consult your local Vickers application engineer.

## C. Mounting

Mounting position is unrestricted. An unrestricted housing drain line must be connected from the upper-most drain port directly to the reservoir in such a manner that the housing remains filled with oil at all times. The drain line should be at least full size, or oversize depending upon its length. Proper drain line size will prevent a build-up of housing pressure and also allows oil to flow freely into the motor housing under certain severe operating conditions. No other drain line should tie into the housing drain line.

The housing drain line connection to the reservoir must be submerged in oil at all times. If the drain line is above the oil level, damage to the unit may result due to air being drawn into the motor.

If motor mounting will not permit the housing drain line connection to be at the highest point, the drain line should be rigid, such as metal pipe or tubing. Loop the drain line above the highest point of the motor (as shown in Figure 5) to prevent the oil from siphoning or draining from the housing during shut-down periods.

Before initial start-up, fill the motor housing with oil through the uppermost drain port. The housing must be kept full to provide internal lubrication.

### NOTE

Pipe threaded ports on the valve plate are not available because of valve plate distortion. Plumbing should be attached in a manner that will not cause valve plate distortion.

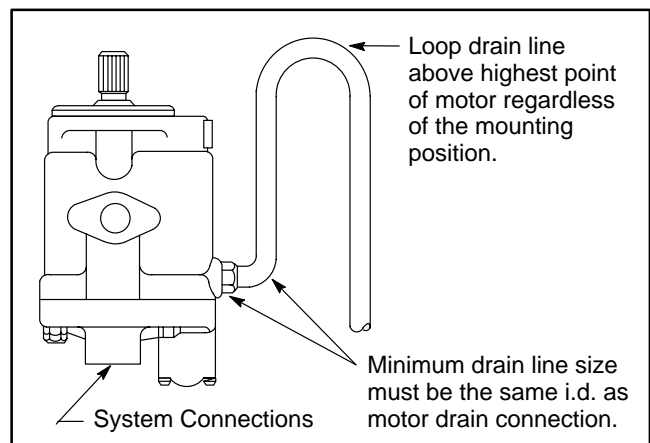


Figure 5.

## D. Shaft Rotation

The rotation of Vickers motors are always viewed from the shaft end of the motor as shown in Table 2.

## E. Hydraulic Tubing

1. The number of bends in tubing must be kept to a minimum to prevent excessive turbulence and friction of oil flow (contributing to system inefficiency).

2. Tubing must not be bent too sharply. The recommended minimum radius for bends is three times the inside diameter of the tube.

3. To minimize flow resistance and the possibility of leakage, only as many fittings and connections as are necessary for proper installation should be used.

4. All tubing must be thoroughly cleaned before installation. Recommended methods of cleaning are wire brushing and pickling.

## F. Hydraulic Fluid Recommendations

1. **Oil Type** – Oils used in hydraulic systems perform the dual function of lubrication and transmission of power. Oil must be selected with care and with the assistance of a reputable supplier.

Crankcase oils meeting or exceeding the “Five Engine Test Sequence” for evaluating oils for API (American Petroleum Institute) service MS (Maximum Severity) best serve the needs of mobile hydraulic systems. These engine sequence tests are adopted by the Society of Automotive Engineers, American Society for Testing Materials and Automotive Engine Builders. The MS classification is the key to selection of oils containing the type of compounding that will extend the operating life of the hydraulic system. Oils meeting diesel engine requirements, DG through DS classifications, may or may not have the type of compounding desired for high performance hydraulic systems.

Table 3 summarizes the oil types (viscosity and service classification) that are recommended for use with Vickers equipment. This selection is most important and should be made with considerable care.

For moderate service applications use oil in accordance with specifications shown in Table 3. For high speed, high pressure applications or speeds below 100 rpm at high pressure, use one viscosity heavier oil.

Good oils are the most economical. Specifications can be set up which will indicate, to a limited degree, the characteristics essential in a good hydraulic oil. These are listed herein and should be checked with the oil manufacturer prior to its use.

Hydraulic System Operating Range (Min. to Max.)	SAE Viscosity	API Service Classification
0°F to 180°F	10W	MS
15°F to 210°F	20-20W	MS
32°F to 230°F	30W	MS
0°F to 210°F	10W-30	MS

Table 3.

2. **Operating Temperatures** – The temperature ranges for each grade of oil are satisfactory if suitable speed control procedures are followed for low temperature start-up conditions and if sustained operation is avoided at the upper temperature limits. Operation in excess of these temperatures results in increased wear of the system components and causes rapid deterioration of the oil. For optimum operation, a maximum oil viscosity of 4000 SSU at the temperature start-up condition and a minimum oil viscosity of 60 SSU for the sustained high temperature operating condition are recommended.

3. **Viscosity** – Viscosity is the measure of fluidity. The oil must have sufficient body to provide adequate lubrication and sealing effect between working parts of pumps, valving, cylinders, etc. but not enough to cause pump intake cavitation or sluggish valve action. Viscosity recommendations must at best be a compromise which takes into consideration the working temperature range, the type of hydraulic equipment used and the class of service. Refer to Table 3.

4. **Viscosity Index** – The viscosity index is a measure of the rate at which temperature changes cause a change in oil viscosity. It is very desirable that the oil viscosity remain as nearly constant as possible under the wide range of temperature conditions encountered in operating mobile and construction machinery. The viscosity index (V.I.) of hydraulic oil should be not less than 90 for this type of service.

5. **Additives** – Research has developed a number of additive agents which materially improve various characteristics of oils for hydraulic systems. They may be selected for compounding with a view toward reducing wear, increasing chemical stability, inhibiting corrosion, depressing pour point and improving the anti-foam characteristics. Proper use of additive agents requires specialized knowledge, and they should be incorporated by the oil manufacturer only, as serious trouble may otherwise result.

Most companies have several brands of crankcase oils of somewhat varying formulation that will meet the API service classification of MS. The more desirable of these oils for hydraulic service will contain higher amounts of the type of compounding that avoids scuffing and wear of cam lobes and valve lifters. These oils will also be formulated to be stable under oxidative conditions and when in contact with small amounts of moisture. There should also be reasonable protection against rust to any ferrous materials submerged in the oil or covered by the oil film.

6. **Cleanliness** – Thorough precautions should be taken to filter the oil in the entire hydraulic system prior to its initial use to remove paint, metal chips, welding slag, lint, etc. If this is not done, damage to the hydraulic system will probably result. In addition, continuing filtration is required to remove sludge and products of wear and corrosion, throughout the life of the system.

Precautions should be taken in the design of hydraulic circuits to assure that a means is provided to keep the oil clean. This can best be accomplished by the use of a 25 micron full-flow filter or a 10 micron by-pass filter plus a micron filter type air breather or sealed reservoir.

7. **Miscellaneous** – The performance of hydraulic valves and cylinders is less affected by the lubricating quality of the oil, and, therefore, selection of the oil is less critical than for pumps and motors. It is always good practice, however, to use the best quality oil available for all components.

## G. Overload Protection

A relief valve must be installed in the system to protect components from excessive pressure. The setting of the relief valve depends on the work requirements of the system and the maximum pressure ratings of system components.

### NOTE

Do not allow system pressure to exceed motor rating due to valving configurations.

## H. Starting and Priming

### NOTE

In most cases “break in” is not a problem but when it is, it can be compared with new engines, gear boxes and other products. A by-product of “break in” is self generated dirt. Generous filters and good filter maintenance are required to be sure a unit is “broken in” and not “broken up”.

### 1. Precautions

- Make sure the reservoir air cleaner is clean and of ample size to handle the system breathing requirements.
- Make certain the hydraulic system is clean and free of dirt, metal chips, paint, welding slag and foreign material. System filtration should be 25 microns or finer.
- Make sure all inlet and system return line fittings are tight so that air is not drawn into the system.

d. Make sure the system is full of oil. Most of the MS crankcase oils will serve the needs of inline motor applications (refer to fluid recommendations in Section IV, H).

e. Make sure shaft rotation direction and coupling alignment are correct.



### CAUTION

*Be absolutely sure the housing is full of oil before starting. Fill the housing with system fluid through the uppermost drain port.*

f. Bleed the motor outlet line until a clear stream of oil results with no air bubbles present. This is best accomplished by loosening an inlet fitting next to the motor. Slowly extend and retract all hydraulic cylinders in the circuit and again bleed the inlet line. It may be necessary to bleed the circuit several times in order to remove all the air trapped in the circuit.

If the air is not expelled from the circuit after several attempts, check the inlet lines to the motor to make sure all the fittings are tight. When a hose is used for the inlet line for the pump, it is not uncommon for it to leak where it is attached to the fitting and allow air to be drawn into the system.

g. Allow the unit to run at minimum operating speed for as long as possible while checking the system for leaks and bleeding air out of the lines. *Do not remove the compensator adjustment plug while the motor is in operation.*

## Section V – Service, Inspection and Maintenance

### A. Service Tools

Special tools required for these units are a shaft seal driver and a bearing puller of suitable size. The seal driver can be made from round stock machined as shown in Figure 6.

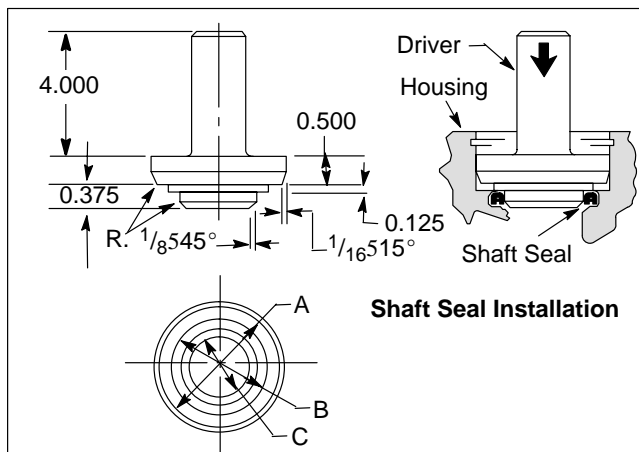


Figure 6.

### B. Inspection and Service

Periodic inspection of the fluid condition and tube or pipe connections can prevent both time consuming breakdowns and unnecessary repairs.

Since motors depend on the fluid in the system for internal lubrication, clean fluid is important to service life. If the fluid becomes contaminated, thoroughly drain the system and clean the reservoir before new fluid is added. Insure that all hydraulic connections are kept tight. In a pressure line, a loose connection permits the fluid to leak out. If the fluid level becomes so low as to uncover the inlet pipe opening in the reservoir, extensive damage to the pump may result. In the suction or return lines a loose connection will permit air to be drawn into the system resulting in noisy or erratic operation or motor breakdown, also “spongy” operation.

Motor Size	Dimensions in Inches		
	A	B	C
5 USgpm	2.043	1.625	0.968
10 USgpm	2.437	2.062	1.375
20 USgpm	3.145	2.375	1.750



Check and replace filter elements periodically. A clogged filter element results in a higher pressure drop, forcing particles through the filter which would ordinarily be trapped, or causing the by-pass to open resulting in a partial or complete loss of filtration.

### C. Adding Fluid to the System

When hydraulic fluid is added to replenish the system, it should always be poured through a micron filter. If such a filter is not available, a funnel with a fine wire screen (200 mesh or better) can be used.

It is important that oil be clean and free of all substance which will cause improper operation and excessive wear of any unit in the system.

### D. Lubrication

Internal lubrication is provided by system oil flow, except main bearing which must be packed 1/3 full of high temperature grease when unit is rebuilt.

### E. Replacement Parts

Only genuine parts manufactured or sold by Vickers, Incorporated should be used as replacement parts for these motors. They are shown in the parts catalogs listed in Table 1. Copies are available on request.

### F. Adjustments

No periodic adjustments are required, other than to maintain proper shaft alignment with the driving medium.

### G. Troubleshooting

The cause of improper functioning in a hydraulic system is best diagnosed with the use of proper and adequate testing equipment and a thorough understanding of the complete hydraulic system.

A hydraulic motor exhibiting an excessive increase in heat or noise is a potential failure. When either of these conditions are noticed, immediately shut down the machine, locate the trouble and correct it.

Table 4 lists some of the common difficulties found in hydraulic components and systems, their probable cause and remedies.

TROUBLE	PROBABLE CAUSE	REMEDY
Motor shaft not turning or not developing sufficient speed or torque.	System overload relief valve set too low to permit necessary pressure.	Check pressure and increase relief valve setting, but not above recommended maximum.
	Excessive work load.	Check circuit design.
	Valve plate and cylinder block surface scored by abrasive in hydraulic fluid.	Check external leakage at drain port. Remove motor for lapping of valve plate and cylinder block surfaces or installation of new parts. Flush system with clean oil. Minor defects can be removed by lightly stoning the surface, however, any lapping should not exceed 0.0002 inches. The surface is hardened and excessive lapping will remove this hardened surface. If the wear or damage is extensive, replace the valve plate.
Motor turning in wrong direction.	Pump or other components in system not functioning properly.	Check directional control and pump stroke position.
	Incorrect connection.	Check circuit and connect correctly.
External leakage from motor.	Worn seal or gaskets.	Install new seal and/or gaskets.
	Gaskets leaking due to improperly connected reservoir drain.	Connect drain line directly to reservoir below the fluid level.
Speed fluctuations with constant input flow.	Irregular wear between valve plate and cylinder block.	Lap valve plate and cylinder block. Minor defects can be removed by lightly stoning the surface, however, any lapping should not exceed 0.002 inches. The surface is hardened and excessive lapping will remove this hardened surface. If the wear or damage is extensive, replace the valve plate.

Table 4. Troubleshooting Chart



## B. Disassembly

All models are disassembled in the same general sequence as shown in the exploded views of Figures 7 and 8.

1. **Valve Plate** – On pressure compensated models, remove the compensator body first to permit removal of the valve plate retaining bolts. Remove the valve plate from the unit. A commercially available bearing puller should be used for removal of the valve plate bearing if it is to be replaced.

2. **Rotating Group Removal** – Turn the rotating group slightly to free it from the swash plate. Tilt the housing and remove the rotating group. Care should be taken to prevent the separation of the cylinder block from the rotating group during removal from the housing.

3. **Rotating Group Disassembly** – Lift the piston and shoe sub-assemblies from the cylinder block. Keep the pistons from striking hard objects during handling of the rotating group sub-assembly.

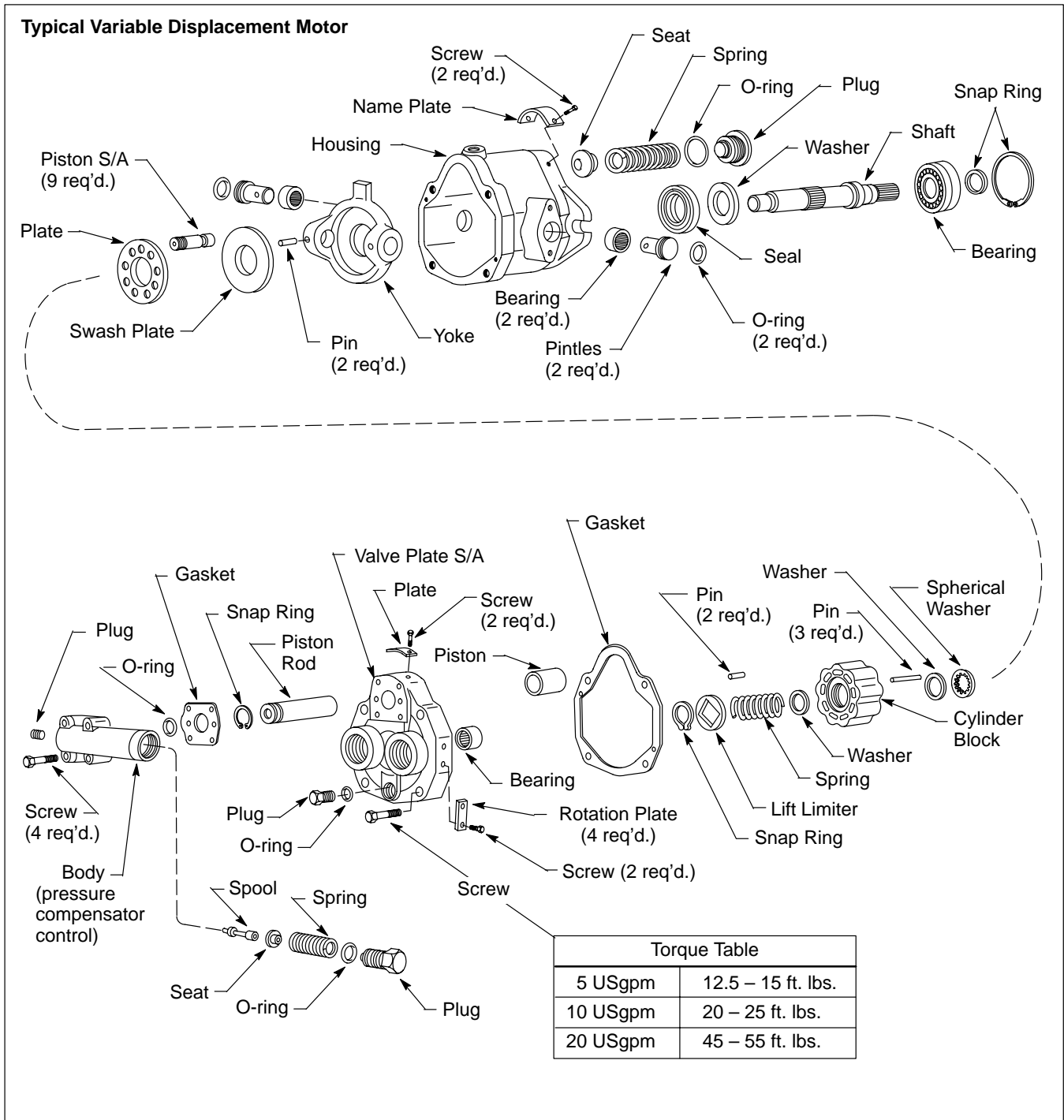


Figure 8.



**WARNING**

*If the spring and washer are to be removed from the cylinder block, follow the procedure outlined in Figure 9 to prevent bodily injury from the sudden release of the cylinder block spring.*

**4. Swash Plate Removal** – The swash plate outside diameter is smaller than the inside diameter of the recess in the yoke. A properly seated swash plate can be freely rotated with the fingertips. Removal, however, might be slightly difficult due to oil suction under the swash plate. Rotate the swash plate and pull out evenly from the yoke.

**5. Drive Shaft Removal** – Remove the retaining snap ring with snap ring pliers. Tap the end of the drive shaft with a soft tip hammer to free the shaft and bearing from the housing. It may be necessary to use a commercial bearing puller to remove the main bearing from the housing. Removal of these bearings often destroys them and replacement parts should be available prior to removal.

**6. Yoke Removal** – Figures 10 and 11 illustrate the procedure for removal of the yoke from a variable displacement unit. Yokes of the smaller units are similar in design to the larger units. Only the methods of retaining are different.

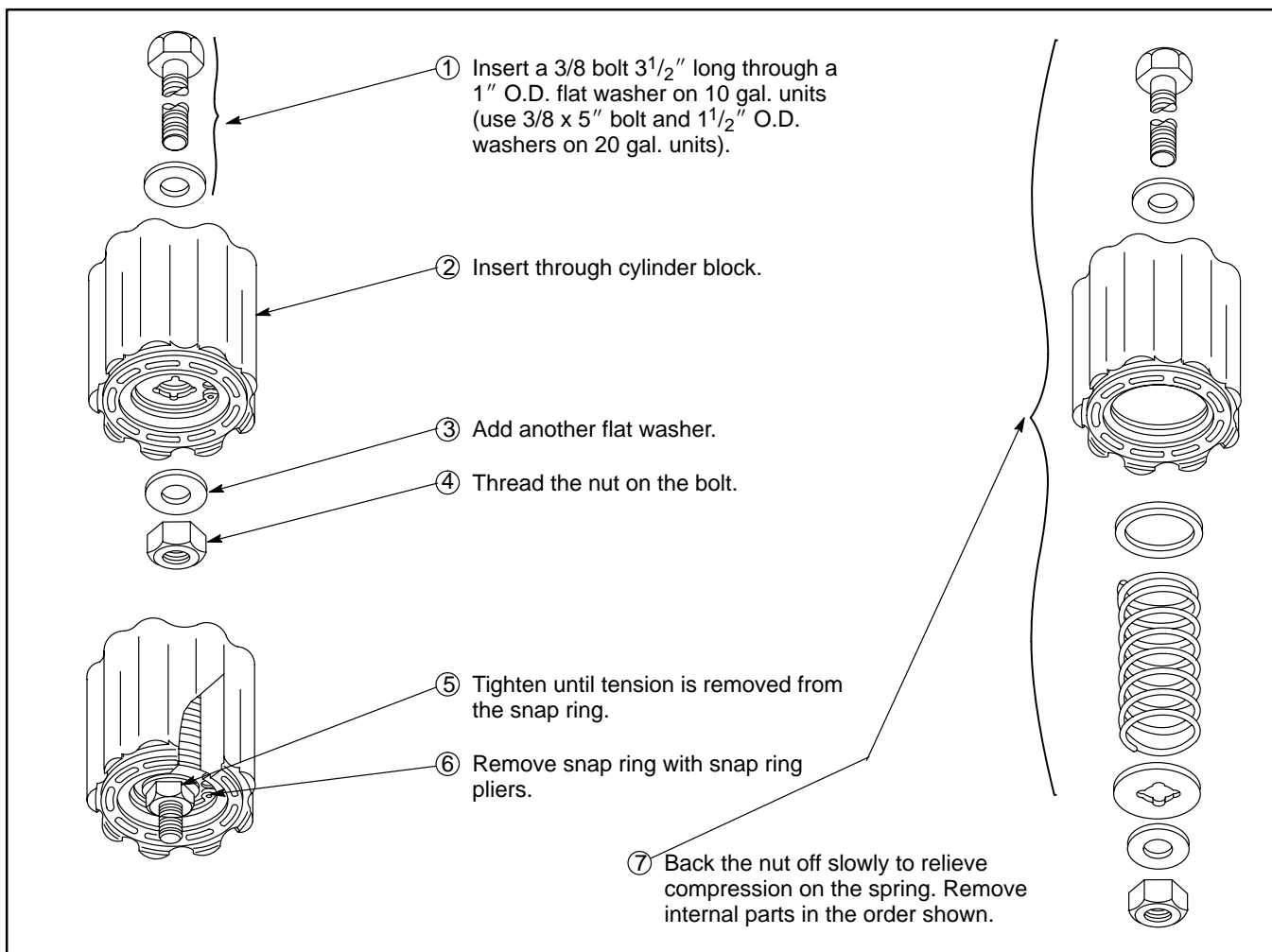


Figure 9.

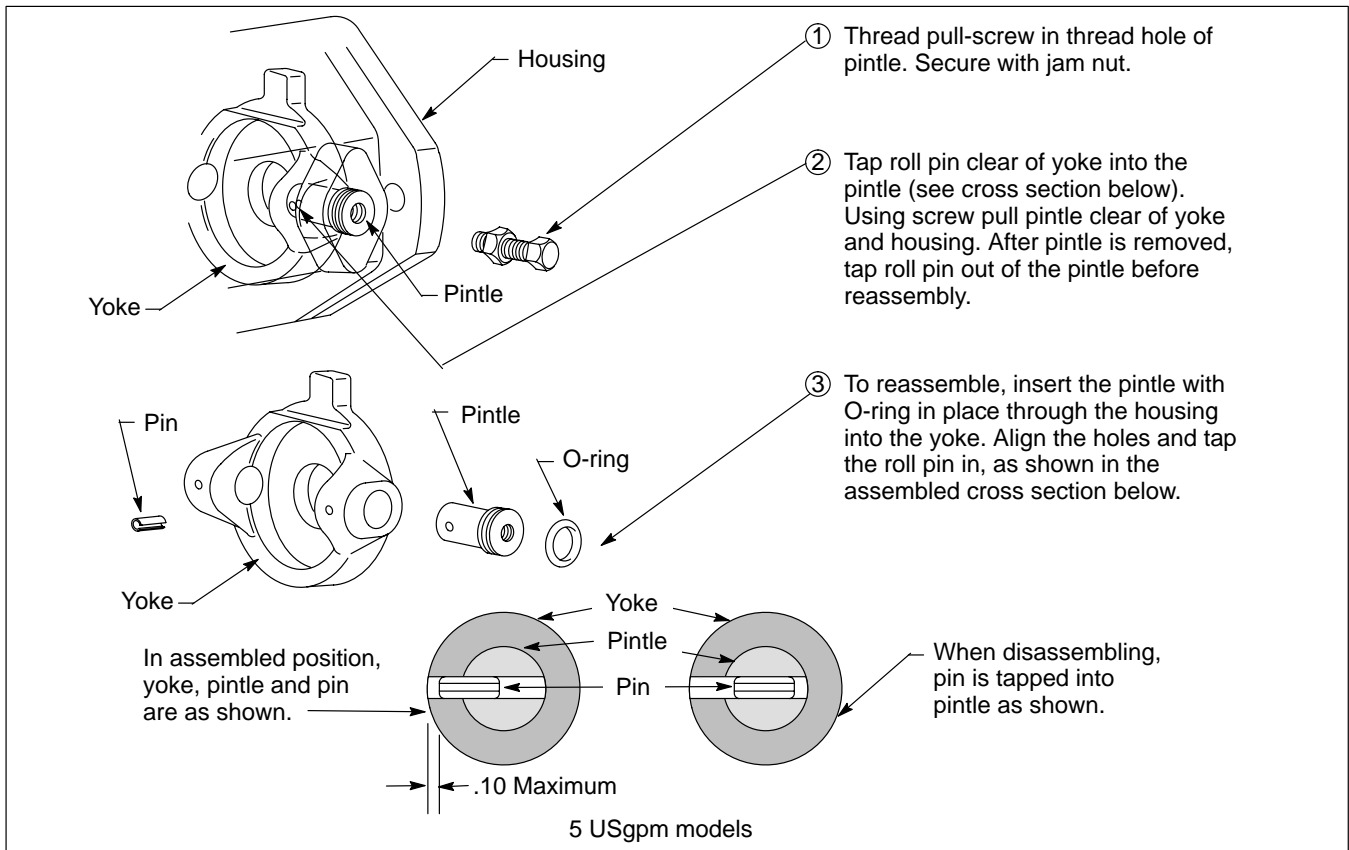


Figure 10.

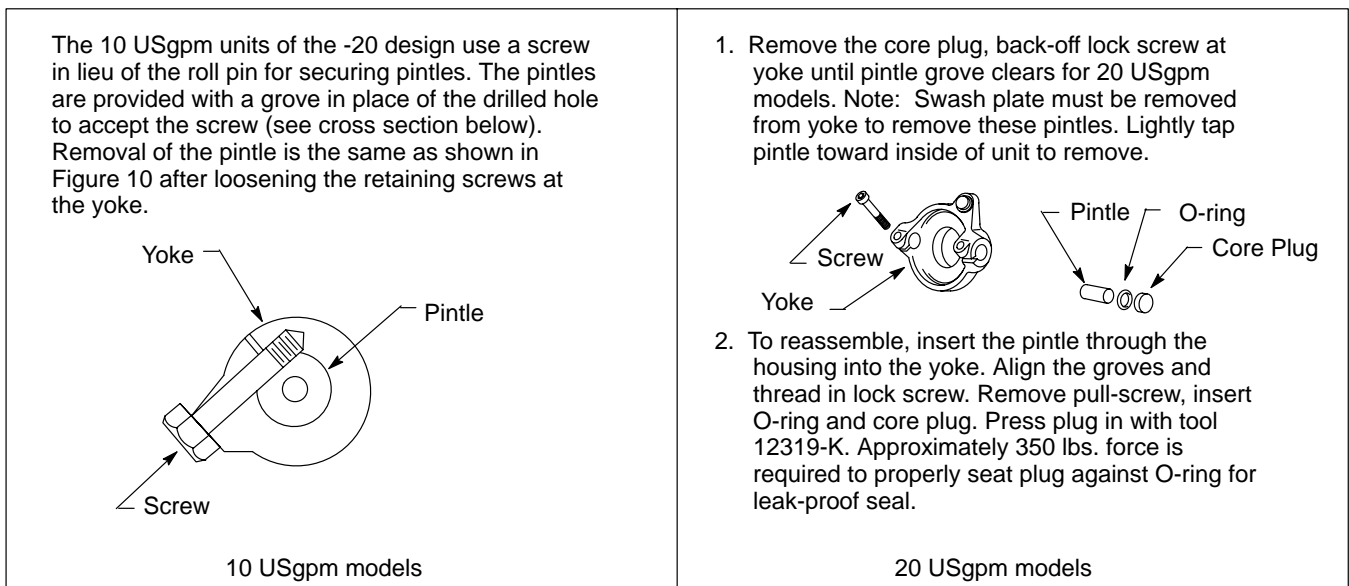


Figure 11.

## C. Inspection and Repair

Clean all parts thoroughly with a mineral oil cleaning solvent prior to inspection and after any lapping or machining operation.

1. **Valve Plate** – Inspect the flat surface which mates with the cylinder block for wear or scoring. Minor defects can be removed by lightly stoning the surface, however, any

lapping should not exceed 0.0002 inches. The surface is hardened and excessive lapping will remove this hardened surface. If the wear or damage is extensive, replace the valve plate.

2. **Rotating Group** – Inspect the bores and valve plate mating surface of the cylinder block for wear and scoring. Minor defects on valve plate mating face can be removed by lightly stoning the surface. If the defects cannot be removed by this method, the cylinder block should be replaced.

When conditions indicate that one or more piston and shoe sub-assembly should be replaced, all piston and shoe sub-assemblies in the unit should be checked as in Figure 12 to insure that all piston shoes ride properly on the swash plate. Variations greater than .001 of an inch from one shoe to another result in excessive internal leakage and shoe wear. At overhaul the replacement of all nine piston and shoe sub-assemblies in the unit, as well as the cylinder block, is recommended for maximum overhaul life.

If necessary, hand lap the shoes using a 400 A or 500 A emery paper (Tuff-Bak Durite Silicon Carbide) backed by a lapping plate. Good results may be obtained if the paper is dipped in kerosene and kept wet during polishing.

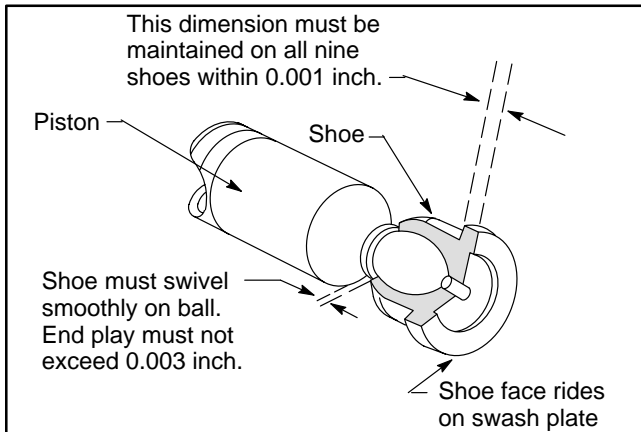


Figure 12.

3. **Swash Plate** – Inspect the swash plate for wear and scoring. If the defects are minor, stone the swash plate but do not remove more than 0.0004 of an inch. If wear or damage is extensive, replace the swash plate.

4. **Bearings and Drive Shaft** – Inspect all bearings for roughness or excessive play and replace if necessary. Inspect the shaft seal area of the shaft for scoring or wear. Replace the drive shaft if bent or wear is excessive.

## D. Assembly

Assembly is basically the reverse of disassembly. Install new gasket, seals, and O-rings when assembling the unit. A light film of clean hydraulic fluid will ease assembly and provide initial lubrication.

1. **Yoke** – Install the yoke in the housing as illustrated in Figures 10 and 11.

2. **Drive Shaft and Bearing** – Install a new shaft seal in the housing. Place the washer over the shaft seal. Assure that bearing is 1/3 to 1/2 filled with a good grade of high temperature ball bearing grease, then install the drive shaft and bearing in the housing. Secure the drive shaft bearing with the retaining ring.

3. **Swash Plate** – Install the swash plate chamfered edge toward shaft seal. It is important that the swash plate be properly seated in the yoke and can be freely rotated with the fingers.

4. **Rotating Group Assembly** – If the spring and washers were removed from the cylinder block, assemble them as shown in Figure 9.

Place the cylinder block face down on a smooth clean surface for ease of assembly. Insert the three pins in the cylinder block. Grease the back-up and spherical washers and place them on the pins. Put the nine piston and shoe sub-assemblies in the shoe plate. Carefully holding the shoe plate so that the pistons do not strike each other, align the pistons with the bores and maneuver them into place. The pistons must move freely in a lubricated block bore.

5. **Rotating Group Insertion** – Holding the cylinder block and shoe plate to keep the pins, washers and spherical washer intact, install the rotating group onto the drive shaft. Slight rotation during assembly will help align the spherical washer and cylinder block splines with those of the drive shaft.

6. **Valve Plate** – Replace the valve plate to body gasket if required and then install the valve plate with the retaining bolts. Install the compensator body on units containing the compensator feature.

## Section VII – Testing

Vickers application engineering personnel should be consulted for test stand circuit requirements and construction. If test equipment is available, the motor should be tested at recommended speeds and pressures shown on the installation drawing (see Table 1).

**Eaton**  
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