

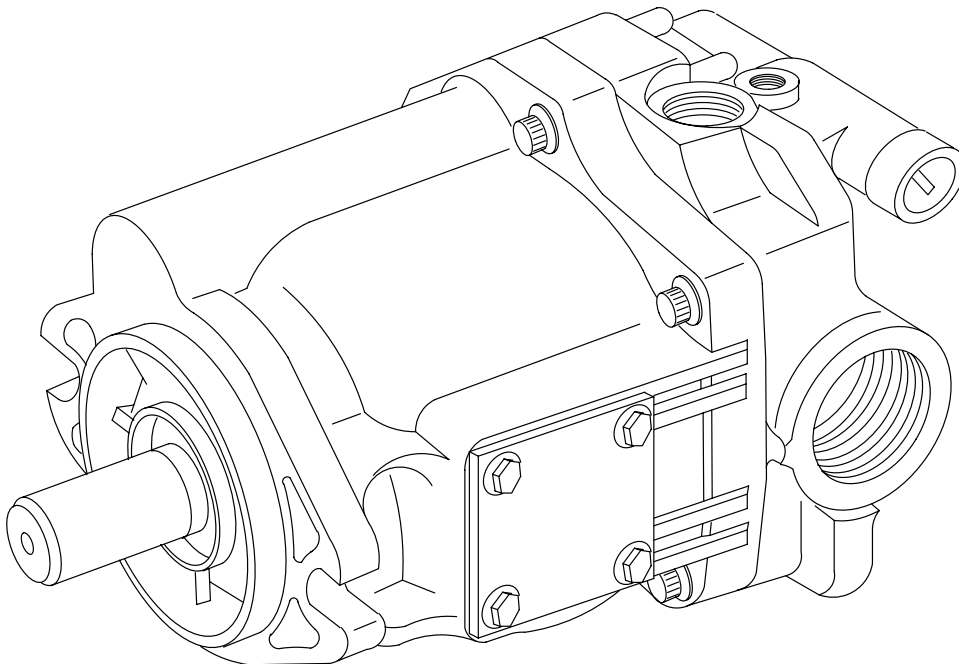
Vickers®

# Piston Pumps



## Overhaul Manual

PVE Variable Pump  
12–21 USgpm capacity at 1800 rpm



**VICKERS**

Released 8/1/90

# Table of Contents

Section	Page
I. Introduction	3
A. Purpose of Manual	3
B. General Information (Related Publications/Model Code)	3
II. Description	6
A. General	6
B. Application	6
III. Principles of Operation	7
A. Piston Pump	7
B. Compensator (Flat Cut-Off Type - "C")	7
C. Compensator (Remote Control Type - "CG")	7
D. Compensator (Load Sensing Type - "CV")	8
E. Compensator (Load Sensing with Pressure Limiting - "CVP", "CVPC", "CVPD")	10
IV. Installation and Operating Instructions	12
A. Installation Drawings	12
B. Mounting and Drive Connections	12
C. Shaft Rotation	12
D. Piping and Tubing	12
E. Hydraulic Fluid Recommendations	12
F. Overload Protection	13
G. Start-up	13
V. Service and Maintenance	14
A. Service Tools	14
B. Inspection	14
C. Adding Fluid to the System	14
D. Adjustments	14
E. Lubrication	14
F. Replacement Parts	16
G. Troubleshooting	17
VI. Overhaul	18
A. General	18
B. Disassembly	18
C. Inspection, Repair and Replacement	18
D. Assembly of Compensator	23
E. Removal and Disassembly of Rotating Group	23
F. Inspection, Repair and Replacement	24
G. Assembly of Housing Parts	26
H. Disassembly of Valve Block	28
I. Inspection, Repair and Replacement	28
J. Assembly of Valve Block	28
K. Shaft Bearing Preload Adjustment	29
L. Final Assembly of PVE Series Pump	29
VII. Test Procedure	30
A. Test Conditions	30
B. Preliminary Check	30
C. Preliminary Set-Up	30
D. Performance Test	30
E. Performance Test of Piston Pump with "C" Compensator Control	30
F. Performance Test of PVE 12/19/21 Piston Pump with "CG" Compensator Control	31
G. Performance Test of PVE 12/19/21 Piston Pump with "CV", "CVP", "CVPC" and "CVPD" Compensator Control	32
H. Load Sensing Control Test	32

# Section I – Introduction

## A. Purpose Of Manual

This manual describes operational characteristics and overhaul information for the PVE12, 19(\*) and the PVE21(\*)-\*\* variable displacement piston pumps. The information contained herein pertains to the latest design series as listed in Table 1.

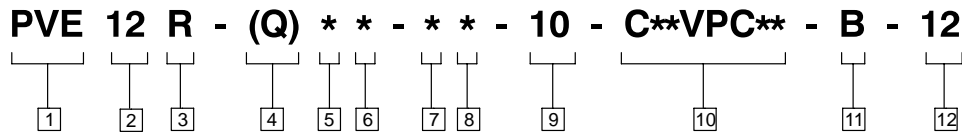
Model Series	Parts Drawing	Installation Drawing
PVE12	M-2853-G	—
PVE19	M-2841-S	322C
PVE21		

Table 1.

## B. General Information

1. **Related Publications** - Service parts information and installation dimensions are not contained in this manual. The parts and installation drawings listed in Table 1 are available from authorized distributors or sales engineers.

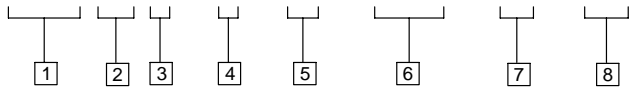
2. **Model Codes** - Variations within each basic model series are covered in the model code. Table 2 shows a complete breakdown of the model codes covering these units. Service inquiries should always include the complete model code number as stamped on the mounting flange.



<p><b>1</b> Pump, Variable Displacement, Inline Piston, E-Series</p> <hr/> <p><b>2</b> Flow Rating USgpm @ 1800 rpm</p> <hr/> <p><b>3</b> Shaft Rotation (Viewed from shaft end) R – Right hand (clockwise) L – Left hand (counterclockwise)</p> <hr/> <p><b>4</b> Noise Level Rating Blank – Standard Unit Q – Industrial Quieter 1800 rpm @ 207 bar (3000 psi)</p> <hr/> <p><b>5</b> Mounting Flange B – SAE B 2 bolt</p> <hr/> <p><b>6</b> Input Shaft Type 1 – SAE B Straight keyed 2 – SAE B Splined</p> <hr/> <p><b>7</b> Port Configuration E – End ported, SAE O-ring M – End ported, metric O-ring (per ISO 6149)</p> <hr/> <p><b>8</b> Shaft Seal S – Standard shaft seal N – No shaft seal</p>	<p><b>9</b> Design</p> <hr/> <p><b>10</b> Control Options (** = Pressure setting in tens of bars) C** – Pressure compensator Max. setting 207 bar (3000 psi) Range 02-21 bar C**VP** – Pressure &amp; load sensing Pressure compensating (see C**) Load sensing (see CV**) C**VPC** – Pressure and load sensing Pressure compensating (see C**) Load setting 24 bar (350 psi) Range 17-31 bar (251-450 psi) C**VPD** – Pressure &amp; load sensing Pressure compensating (see C**) Load setting 41 bar (600 psi) Range 32-45 bar (451-650 psi) Same as C** except with max. adj. stop. Pressure compensation with remote control (see C**) Electric dual range com- pensation Same as CD except with max. adj. stop</p>	<p><b>10</b> Control Options (Con't) (** = Pressure setting in tens of bars) CC** - Same as C** except with max. adj. stop. CG** - Pressure compensation with remote control (see C**) Electric dual range com- pensation CD - Same as CD except with max. adj. stop CCD - max. adj. stop</p> <hr/> <p><b>11</b> Control Bleed Down Blank – C, CC, CG, CD, CCD B – Bleed down orifice (CVP &amp; CVPC) P – Plug (no orifice) (CVP &amp; CVPC)</p> <hr/> <p><b>12</b> Control Design</p>
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Table 2. Model Code Breakdown

**PVE \*\* \* - \* - \*\* - C\*\*\* - 1\* - \*\*\***



**1** Pump, Variable Displacement, Inline Piston, E-Series

**2** Flow Rating  
USgpm @ 1800 rpm  
19 – 19 USgpm  
21 – 21 USgpm

**3** Shaft Rotation  
(Viewed from shaft end)  
R – Right hand (clockwise)  
L – Left hand (counterclockwise)

**4** Input Shaft Type  
1 – SAE B Straight keyed  
2 – SAE B 15 tooth splined  
9 – SAE B 13 tooth spline

**5** Pump Design

**6** Control Options  
(\*\* = Pressure setting in tens of bars)

C-10 – Pressure compensated (PVE19, 250-3000 psi)  
(PVE21, 250-2700 psi)

CG-10 – Remote control pressure compensator adjustable from 350-3000 psi using and external relief valve.

CV-10 – Load sensing PVE19/21

CVP-12 – Load sensing (160 psid) with pressure compensation PVE 19/21

CVPC-12 – Load sensing (350 psid) with pressure compensation PVE 19/21

**7** Control Design

**8** Special Suffix

Table 2. Model Code Breakdown (Con't)

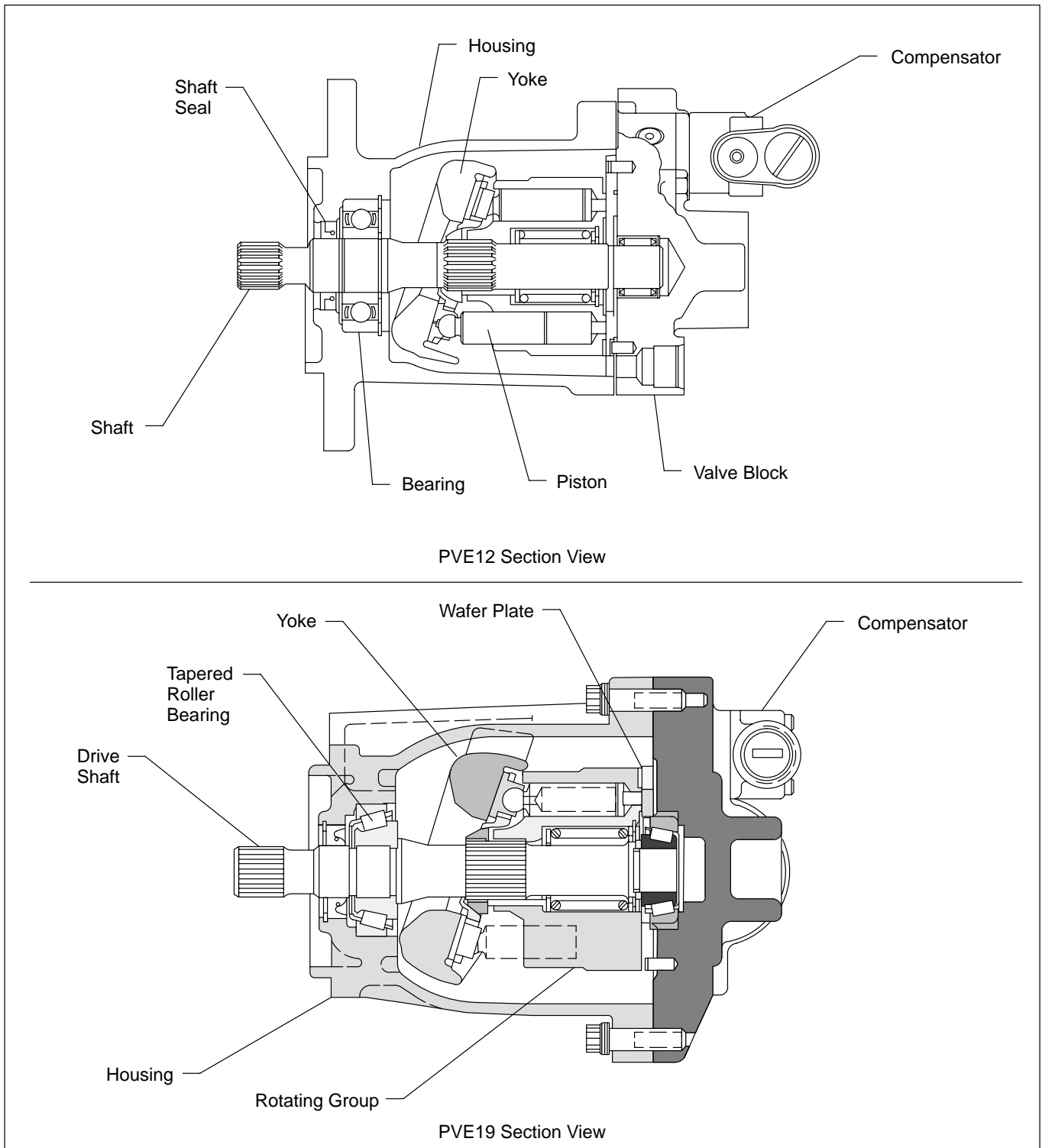


Figure 1. Sectional Views of the PVE Pumps

# Section II – Description

## A. General

Assembly of a typical pump package is shown in Figure 1.

Six types of compensator subassemblies are used with the PVE series pumps. Refer to Section III for principles of operation. See Model Code for pressure settings.

1. Compensator (C), (Flat Cut-Off Type): A pump using this compensator will maintain a constant load pressure for all values of flow within the capacity of the pump.

2. Compensator (CG), (Remote Control Type): This compensator is similar to the “C” type compensator except the compensator is controlled by a remote hydraulic source such as a relief valve.

3. Compensator (CV), (Load Sensing Type): A load sensing compensator provides flow at a pressure equal to that required by the load plus a constant value used as a pressure drop across a metering valve. The pump will change its flow with changes in size of the metering valve orifice. The pump and compensator together provide a constant flow source for the load, at a pressure established by the requirements of the load, hence the title “Load Sensing”.

4. Compensator (CVP), (Load Sensing Pressure Limiting Type): The CVP control is a combination of the standard flat cut-off compensator (C) and the load sensing compensator (CV). The load sensing compensator controls flow to the load across an external valve orifice. If pressure build-up exceeds the flat cut-off compensator setting, the flat cut-off compensator overrides the load sensing compensator and lowers the flow to prevent excessive pressure build-up at the pump.

5. Compensator (CVPC), (Load Sensing Pressure Limiting Type): This compensator is the same as the “CVP” compensator except the load sensing spring is heavier. The heavier spring provides a slightly higher pressure differential (160 $\Delta$ P vs. 350 $\Delta$ P) across the external valve orifice. See Figure 5.

6. Compensator (CVPD), (Load Sensing, Pressure Limiting Type): Same as “CVPC” except with higher pressures.

## B. Application

Pump ratings in USgpm as shown in the model coding are at 1800 rpm. For ratings at other speeds, methods of installation and other application information, contact an authorized distributor or sales engineer.



### CAUTION

*A relief valve must be provided in the external circuit to prevent excessive pressure build up at the pump.*

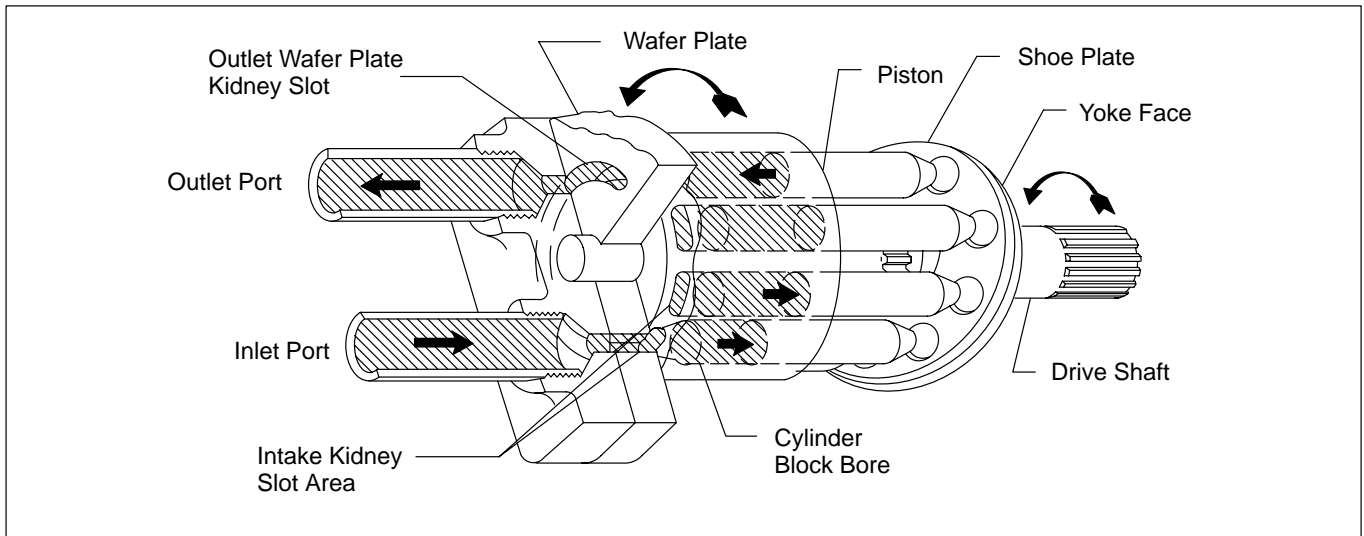


Figure 2.

# Section III – Principles of Operation

## A. Piston Pump

Rotation of the pump drive shaft causes the cylinder block, shoe plate and pistons to rotate. See Figure 2. The piston shoes are held against the yoke face by the shoe plate. The angle of the yoke face imparts a reciprocating motion to each piston within the cylinder block. Inlet and outlet ports connect to a kidney slotted wafer plate. As the pistons move out of the cylinder block, a vacuum is created and fluid is forced into the void by atmospheric pressure. The fluid moves with the cylinder block past the intake kidney slot to the outlet (pressure) kidney slot. The motion of the piston reverses and fluid is pushed out the cylinder block into the outlet port.

## B. Compensator (Flat Cut-Off Type)

A flat cut-off compensated pump will maintain a constant load pressure for all values of flow within the capacity of the pump providing the load is sufficient to build up pressure.

A step by step description of the flat cut-off type compensator control follows. Refer to Figure 3 throughout this discussion.

When a no load condition exists, the pump will deliver maximum flow at zero pressure. As the actuator load increases, pressure will rise; however, flow will remain at maximum until pressure reaches the compensator spring setting (cracking pressure). As a further increase in load occurs, system pressure will cause the compensator spool to move against the compensator spring, metering flow to the yoke stroking piston. The yoke stroking piston then moves the yoke to reduce flow. As flow is reduced, system pressure reduces slightly causing the compensator spool to return to the null position. At null, flow to the yoke stroking piston stops. Movement of the yoke will stop and the flow will stabilize at a reduce value. If the load were to continue to increase, the pump flow will reduce to zero (0) and a deadhead pressure condition would exist. The pressure differential needed to cause the compensator spool to change from maximum flow (cracking pressure) to zero flow (deadhead pressure) is approximately 50 to 150 PSI.

Pump outlet flow is proportional to the control range from cracking pressure to deadhead pressure. (i.e. If cracking pressure is 2900 PSI (max. flow) and deadhead pressure is 3000 PSI (min. flow), a pressure of 2950 PSI would be equal to 1/2 maximum flow.)

If the load decreases, pressure will decrease proportionally and the compensator spring will move the spool down, opening the yoke stroking piston to case drain. As fluid is metered from the yoke stroking piston, the yoke spring will stroke the yoke to increase flow. The increase in flow causes a proportional increase in system pressure. The increase in system pressure returns the compensator spool to a null position and flow from the yoke stroking position will stop; simultaneously, movement of the yoke will stop. The flow will stay constant until another change of load occurs.

If the load continues to decrease, pump flow will continue to increase, holding the outlet at compensator cracking pressure. When maximum flow is reached (max. stroke), a maximum flow and a maximum pressure condition exists. A further decrease in load will lower the outlet pressure until a final theoretical condition of maximum flow and zero pressure is obtained.

## C. Compensator (Remote Control - "CG")

This compensator allows the operator to change the pressure setting through the use of a remote control valve. The "CG" compensator has the same performance characteristics as the "C" type compensator.

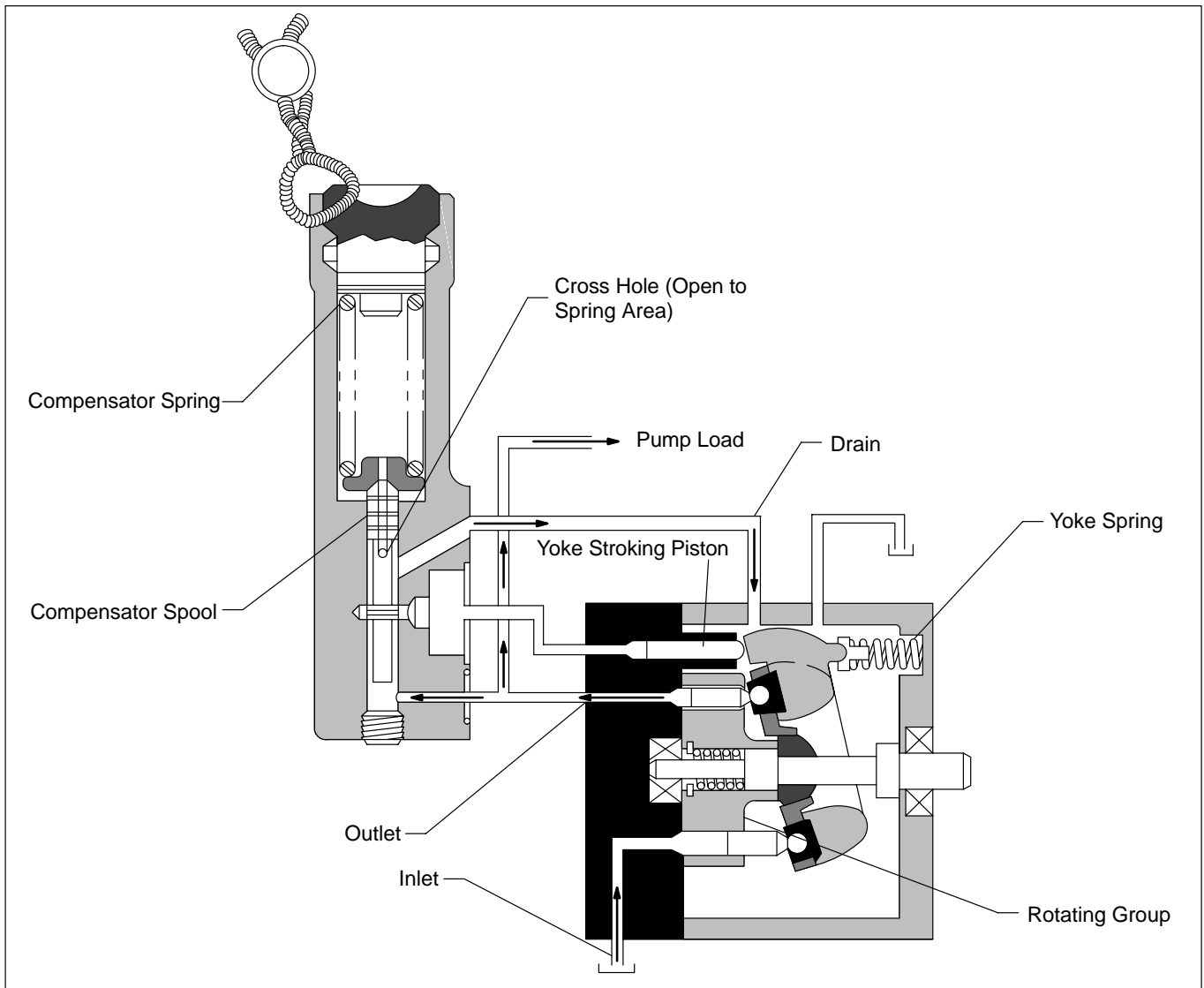


Figure 3. Flat Cut-Off Compensator

## D. Compensator

(Load Sensing Type - "CV")

### Application

A frequent application of pressure compensator pumps is to supply servo valves or mechanically operated metering valves, whose function is to control flow to a hydraulic actuator (cylinder or motor).

In such circuits it is often desirable that flow be proportional only to an external valve spool position. This requires a constant pressure drop across the external valve. (NOTE: Flow through a valve varies with pressure drop as well as with valve spool position.)

Pumps incorporating the load sensing feature have a constant flow characteristic: Flow is constant regardless of the load pressure.



**CAUTION**

*A relief valve must be used to prevent outlet pressure from exceeding pump ratings if the load is excessive.*

### Minimum Pump Pressure

The minimum outlet pressure developed by the pump (no load) is a function of the compensator spring force versus the yoke spring force, whichever is greater. (Please note that external valve spool position (orifice size), has nothing to do with the minimum outlet pressure of the pump). The orifice size controls pump rate of flow only. The minimum outlet pressure will be constant for all settings of the valve spool orifice and is considered the pressure drop across the orifice ( $\Delta P$ ).



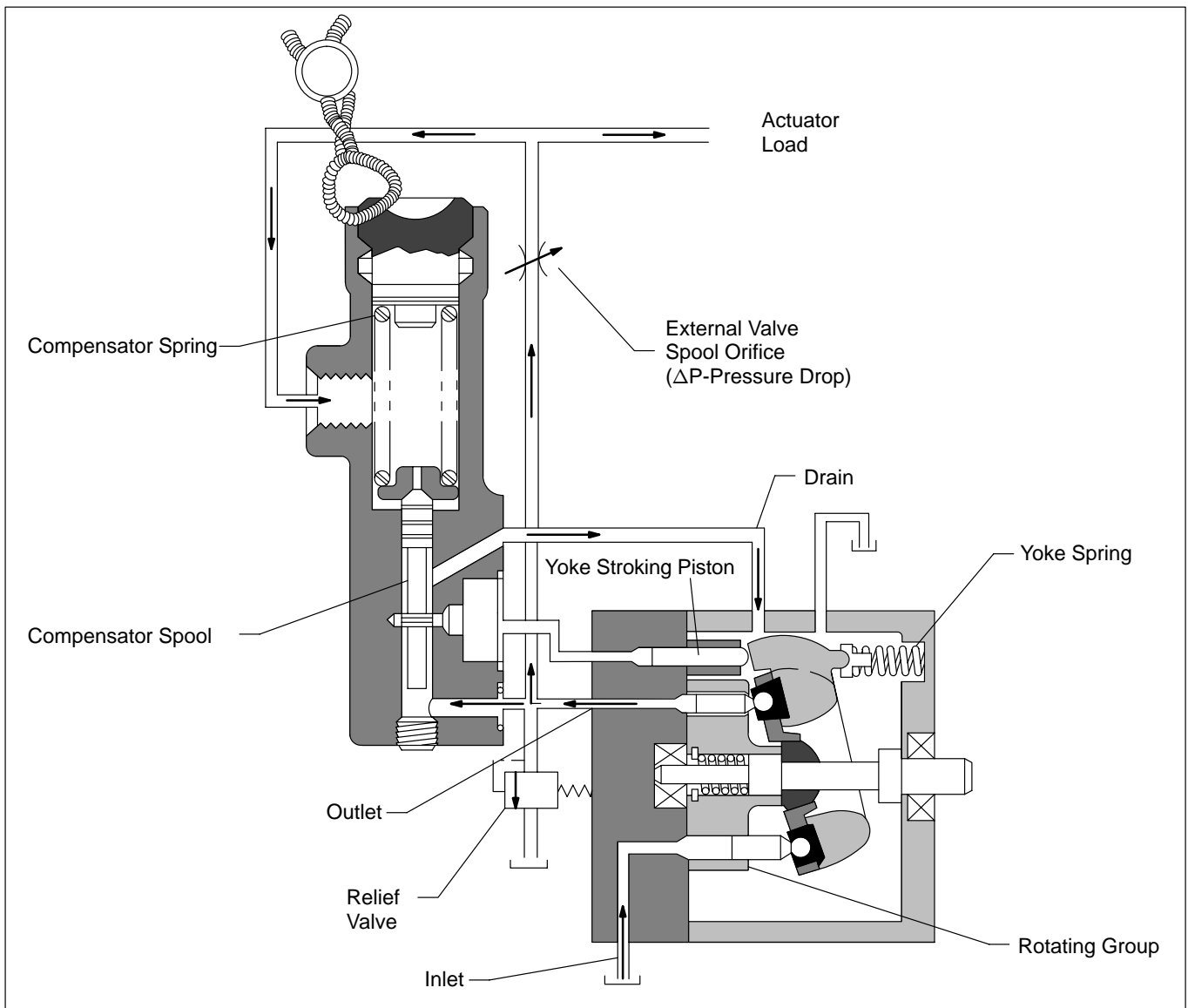


Figure 4. Load Sensing Compensator (CV).

### Circuit Operation At Minimum Pressure

Refer to Figure 4 during the following description. Assume a no load condition.

The pump load consists of the pressure drop across the valve spool orifice ( $\Delta P$ ), plus the pressure developed by the work being performed at the actuator. (In this case the actuator is unloaded and only the pressure drop across the valve spool orifice ( $\Delta P$ ) will be considered.)

Flow is restricted through the valve spool orifice and develops a pressure at the outlet of the pump. This pressure is applied to the lower end of the compensator spool. Initially, the compensator spring is holding the spool in the down position and the yoke is at maximum delivery position. When the pump is started, the increasing flow increases pressure at the lower end of the compensator spool and the compensator spool opens pressure to the yoke stroking piston. The yoke then strokes to a lower flow, lowering the pressure drop across the external valve orifice. When pressure reaches  $\Delta P$ , the compensator spool will null. At this time, the stroking piston will remain stable until the external valve spool orifice is changed. (See Figure 4.)

### External Valve Spool Orifice Size Reduced

If the external valve spool orifice is reduced in size, pressure at the pump outlet will rise proportionally causing the compensator spool to move against the compensator spring. When the compensator spool moves far enough to open the yoke stroking piston to pump outlet pressure, the yoke stroking piston will move the yoke to a lower flow setting.

The compensator senses pressure at the downstream side of the external valve spool orifice and compares this pressure to the pump outlet pressure. The compensator then adjusts the yoke to a flow which holds a constant pressure drop ( $\Delta P$ ) across the external valve spool orifice.

The pressure developed at the pump outlet is a summation of the pressure drop across the external valve spool orifice and the actuator load pressure. As the actuator load pressure increases, the increase is reflected directly back to the pump outlet. Since the compensator monitors the difference between pump outlet pressure and actuator load pressure, and this difference ( $\Delta P$ ) does not change with load variations, flow from the pump will stay constant.

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### External Valve Spool Orifice Size Increased

If the external valve spool orifice size is increased, pump outlet pressure will decrease, lowering force against the compensator spool. (See Figure 4.) The compensator spring causes the spool to move, opening the yoke stroking piston to case drain. As fluid is metered from the yoke stroking piston, the yoke spring force strokes the yoke to a higher flow. The increase in flow through the external valve spool orifice establishes once again the constant pressure drop ( $\Delta P$ ). With differential pressure ( $\Delta P$ ) across the external valve orifice, the compensator spool nulls. Flow from the yoke stroking piston stops, and the pump flow rate stabilizes at a higher value.

Operation of the load sensing compensator is such that as the load pressure varies, the pump outlet pressure will follow the variations, holding a constant pressure drop ( $\Delta P$ ) across the external valve spool orifice, and a constant flow through the external valve and actuator. Pump flow will change only with changes in external valve spool orifice size.

## E. Compensator (Load Sensing with Pressure Limiting “CVP”, “CVPC”, “CVPD”)

As expected from the above title, these units are a combination of the flat cut-off and load sensing compensators.

The load sensing portion functions at pressures below the flat cut-off compensator setting and provides a constant flow characteristic. If pressure exceeds the flat cut-off compensator setting, the yoke will stroke to zero flow at maximum pressure lowering the horsepower requirements for holding circuits and protecting the pump. Refer to Figure 5 throughout the following circuit explanation.

Assume an actuator load that is increasing gradually. Also, assume the pump outlet pressure is lower than the flat cut-off compensator cracking pressure. As actuator load pressure increases, the load sensing compensator spool senses the difference between pump outlet pressure and actuator load pressure. As long as the difference between the pump outlet pressure and the actuator load pressure ( $\Delta P$ ) is constant, flow to the load will stay constant. As pressure rises across the load, leakage will increase in the pump and load. The load sensing portion of the compensator adjusts pump outlet flow to compensate for leakage while providing a constant flow through the valve spool orifice.

The pump outlet pressure continues to increase until the flat cut-off compensator spool reaches cracking pressure. The flat cut-off compensator spool then meters flow to the yoke stroking piston. The yoke stroking piston starts moving the yoke to reduce flow while holding the outlet pressure at compensator cracking pressure. This action continues until the pump is fully compensated (zero flow and maximum pressure).

### Standby Operation Feature

Standby defined: When the external valve spool is shifted to zero flow, the circuit is placed in standby.

The small fixed orifice located in the compensator body provides a decompression feature for the load circuit during standby operation. The decompression feature allows the pump to stroke to zero flow and minimum pressure ( $\Delta P$ ), if the load is blocked and the external valve spool orifice is closed. (Refer to Figure 5.)

The circuit functions as follows:

Assume the pump is at zero flow with maximum pressure to the load. The flat cut-off compensator spool will be in the up position (compressing the spring) and the load sensing spool will be in the down position due to actuator load pressure plus the spring force. If the external valve spool orifice is closed at this time, fluid under pressure will be trapped in the load circuit and will hold the load sensing spool in the down position. This will keep the pump outlet pressure at flat cut-off compensator cracking pressure (a power loss since no work is being performed at this time). To prevent this condition from continuing, the small orifice meters the fluid trapped in the load back through the flat cut-off compensator spool to case drain. The actuator load pressure will decrease gradually causing the load sensing spool to open pressure to the yoke stroking piston, bypassing the flat cut-off compensator. As the actuator load pressure reduces, the pump outlet pressure will reduce until minimum pump pressure is obtained. When the minimum flow/minimum pressure condition occurs, the pump is considered to be in standby. During standby, the CVP(C) control reduces the input power well below that of a standard “C” type compensator. This provides an increase in system efficiency and reduces the cost of operation.

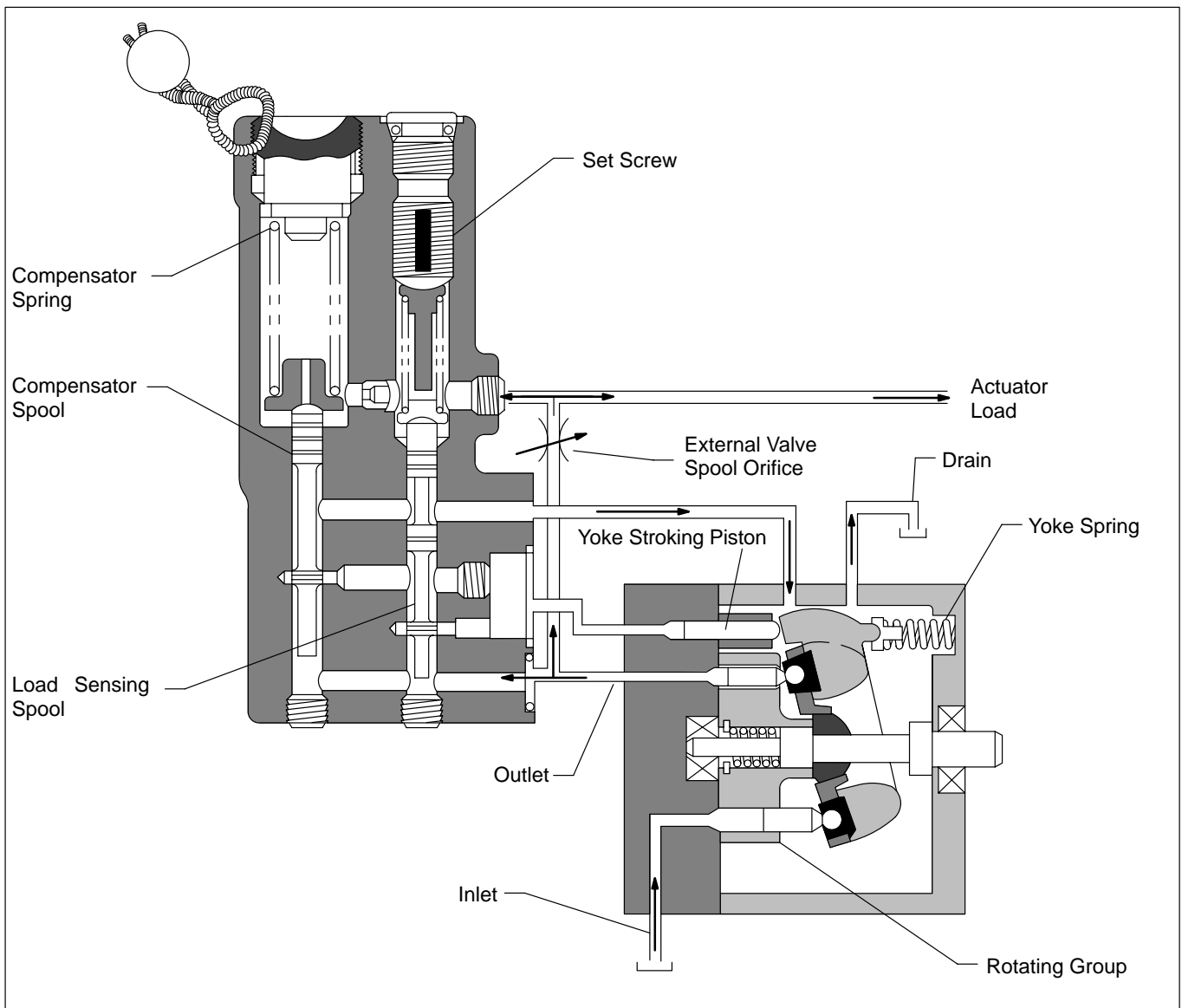


Figure 5. Load Sensing Pressure Limiting Compensator (CVP, CVPC, CVPD)

# Section IV – Installation and Operating Instructions

## A. Installation Drawings

The installation drawing listed in Table 2 will show installation dimensions and port locations.

## B. Mounting and Drive Connections



**CAUTION**

*Pump shafts are designed to be installed in couplings with a slip fit. Pounding can injure the bearings. Shaft tolerances are shown on the installation drawing. (See Table 1.)*

1. **Direct Mounting** - A pilot on the pump mounting flange (Figure 6) assures correct mounting and shaft alignment. Make sure the pilot is firmly seated in the accessory pad of the power source. Care should be exercised in tightening the mounting screw to prevent misalignment.

2. Indirect drive is not recommended for these pumps without engineering approval.

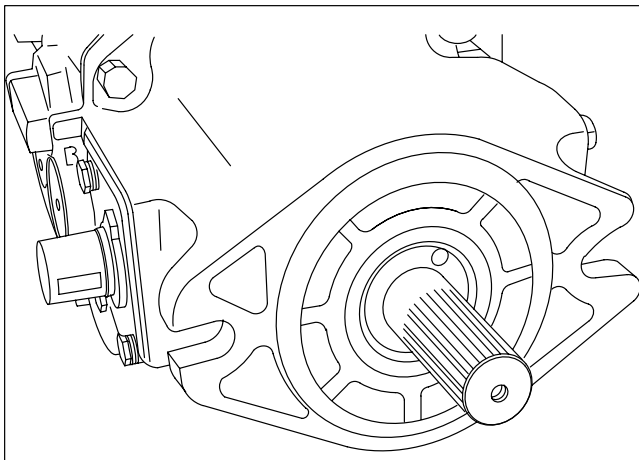


Figure 6. Pump Pilot Flange.

## C. Shaft Rotation

Rotation is determined as viewed from the shaft end of the pump. A pump made for left-hand rotation is identified by an "L" and right-hand by an "R" in the model code. (See Table 2.) An arrow stamped on the mounting flange indicates the correct rotation.



**CAUTION**

*NEVER drive a pump in the wrong direction of rotation. Seizure may result causing expensive repairs.*

## D. Piping and Tubing

1. All pipes and tubing must be thoroughly cleaned before installation. Recommended methods of cleaning are sand blasting, wire brushing, and pickling.

### NOTE

For instructions on pickling, refer to instructions sheet 1221-S.

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

3. The number of bends in tubing should be kept to a minimum to prevent excessive turbulence and friction of oil flow. Tubing must not be bent too sharply. The recommended radius for bends is three times the inside diameter of the tube.

## E. Hydraulic Fluid Recommendations

### General Data

Oil in a hydraulic system 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 system components with particular emphasis on hydraulic pumps. Any oil selected for use with pumps is acceptable for use with valves or motors.

Data sheets for oil selection are available from any authorized distributor or sales engineer.

Oil Recommendations noted in the data sheet are based on our experience in industry as a leading hydraulic component manufacturer.

Where special considerations indicate a need to depart from the recommended oils or operating conditions, contact an authorized distributor or sales engineer.

### Cleanliness

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

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

2. Filter each change of oil to prevent introduction of contaminants 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 sealing the system and/or by proper filtration of the air.

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

6. Thorough precautions should be taken by proper system and reservoir design to insure that aeration of the oil will be kept to a minimum.

## Sound Level

Noise is only indirectly affected by the fluid selection, but the condition of the fluid is of paramount importance in obtaining 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.

## F. Overload Protection

Relief valves limit pressure in the system to a prescribed maximum and protect components from excessive pressure. The setting of the relief valve depends on the work requirements of the system components.

## H. Start-Up

Before starting pump the case *MUST* be filled with clean hydraulic fluid.

With a minimum drive speed of 650 rpm, a pump should prime almost immediately if provision is made to initially purge the air from the system.

Failure to prime within a reasonable length of time may result in damage due to lack of lubrication. Inlet lines must be tight and free from air leaks. However, it may be necessary to crack a fitting on the outlet side of the pump to purge trapped air.

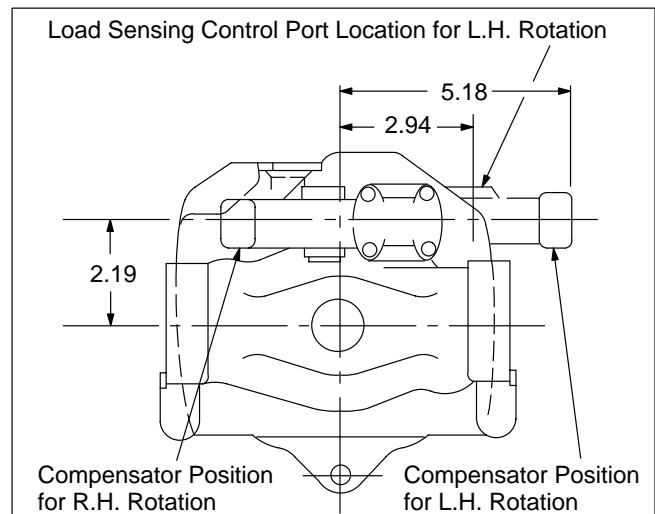


Figure 7. C/CV/CVP Compensator Positions for Right and Left Hand Shaft Rotation

# Section V – Service and Maintenance

## A. Service Tools

The following standard tools for overhauling the piston pump are shown in Figure 8.

### Standard Tools and Equipment:

1. Torque wrench with short extension and sockets
2. 1" micrometer
3. 1" depth micrometer
4. External Truarc pliers
5. Internal Truarc pliers

In addition to the above tools, an arbor press is required to service bearings, etc. Maintenance of this unit is intricate and should not be attempted without the proper tools.

### Special Tools:

Special tools are shown in Figures 9, 10, 11 and 12.

## B. Inspection

Periodic inspection of the fluid condition and tube or piping connections can save time consuming breakdowns and unnecessary parts replacement. The following should be checked regularly:

1. All hydraulic connections must be kept tight. A loose connection in a pressure line will permit 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 can result. In suction or return lines, loose connections permit air to be drawn into the system resulting in noisy and/or erratic operation.

2. Clean fluid is the best insurance for long service life. Therefore, the reservoir should be checked periodically for dirt or other contaminants. If the fluid becomes contaminated the system should be drained and the reservoir cleaned before new fluid is added.

3. Filter elements also should be checked and replaced periodically. A clogged filter element results in a higher pressure drop. This can force particles through the filter which would ordinarily be trapped or can cause the by-pass to open, resulting in a partial or complete loss of filtration.

4. Air bubbles in the reservoir can ruin the pump and other components. If bubbles are seen, locate the source of the air and seal the leak. (See Table 3).

5. A pump which is running excessively hot or noisy is a potential failure. Should a pump become noisy or overheated, the machine should be shut down immediately and the cause of improper operation corrected.

## C. Adding Fluid to the System

When hydraulic fluid is added to replenish the system, it should always be poured through a 10 micron (absolute) or better filter.

It is important that the fluid be clean and free of any substance which could cause improper operation or wear of the pump or other hydraulic units. Therefore, the use of cloth to strain the fluid should be avoided to prevent lint from getting into the system.

## D. Adjustments

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

## E. Lubrication

Internal lubrication is provided by the fluid in the system. Lubrication of the shaft couplings should be as specified by their manufacturers. Coat shaft splines with a dry lubricant (Molycoat or equivalent) to prevent wear.

## F. Replacement Parts

Reliable operation throughout the specified operating range is assured only if genuine manufacturer's parts are used. Sophisticated design processes and materials are used in the manufacture of these parts. Substitutions may result in early failure. Part numbers are shown in the parts service drawings listed in Table 2.

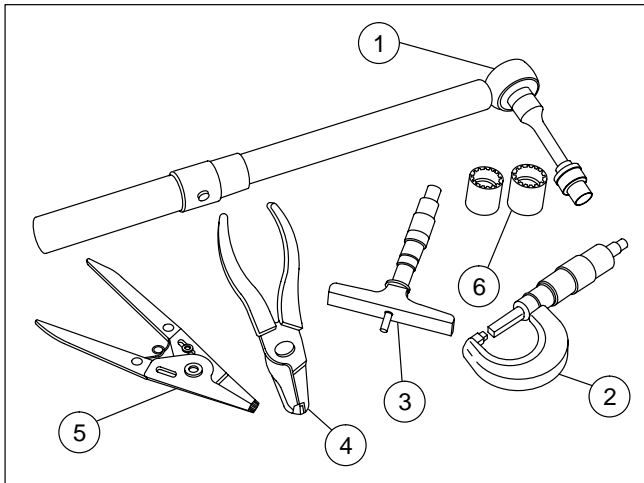


Figure 8. Standard Tools.

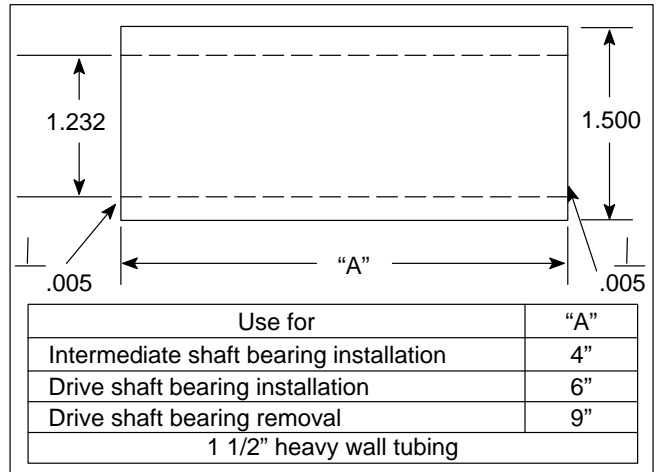


Figure 9. Special Shaft Bearing Removal and Installation Tools.

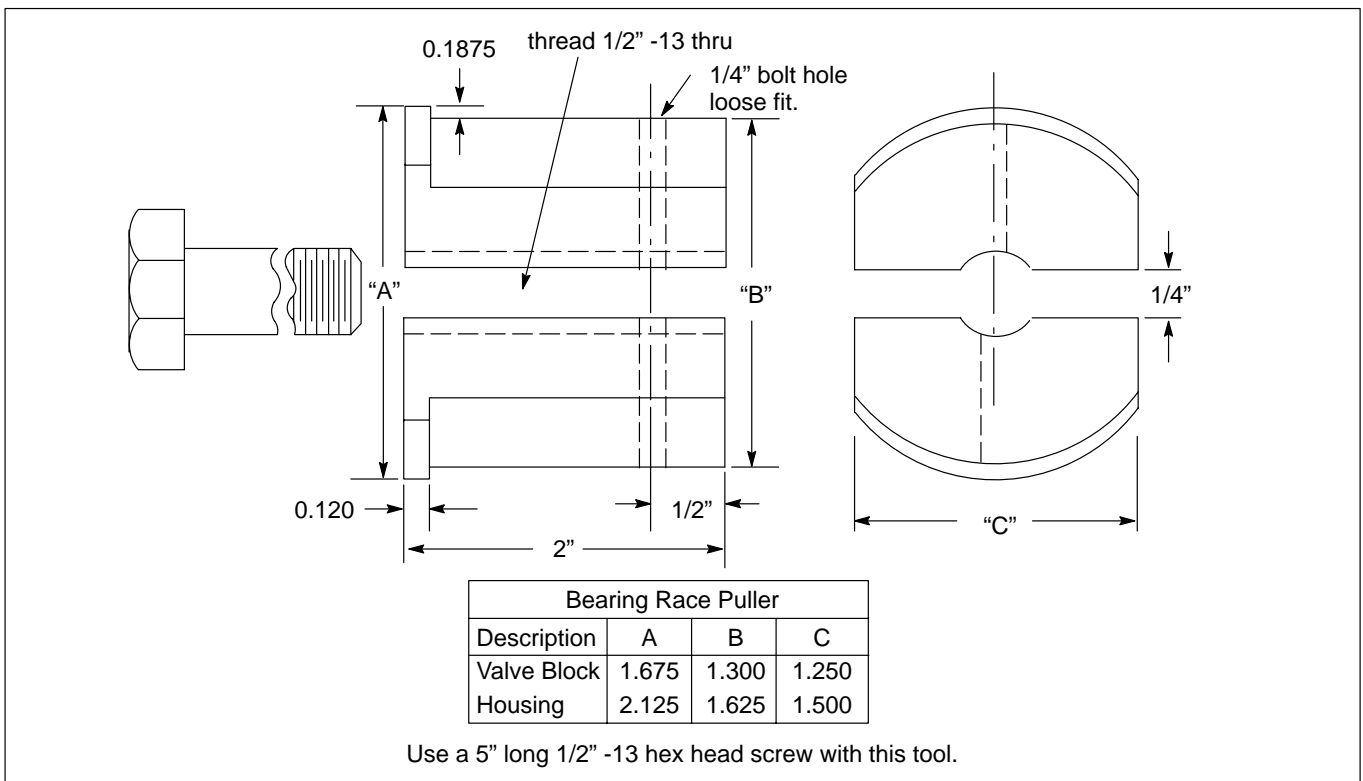


Figure 10. Bearing Race Removal Tools.

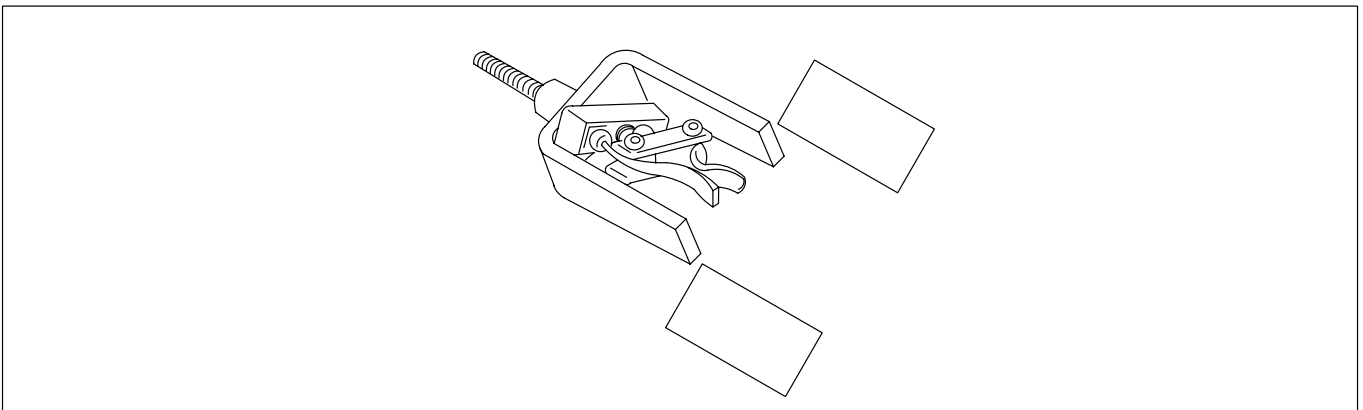


Figure 10a. Bearing Race Removal Tools.

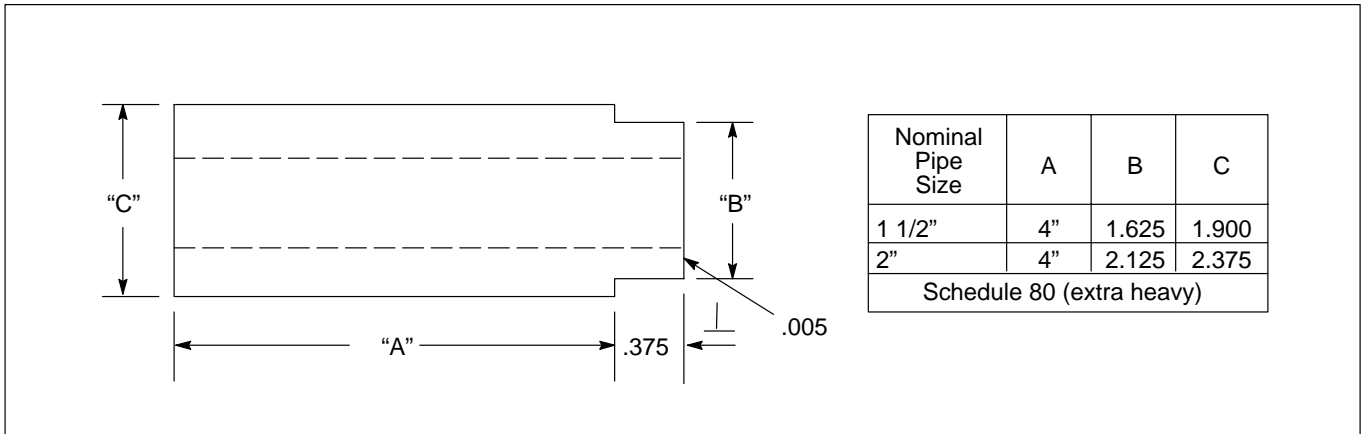


Figure 11. Special Bearing Race Installation Tools.

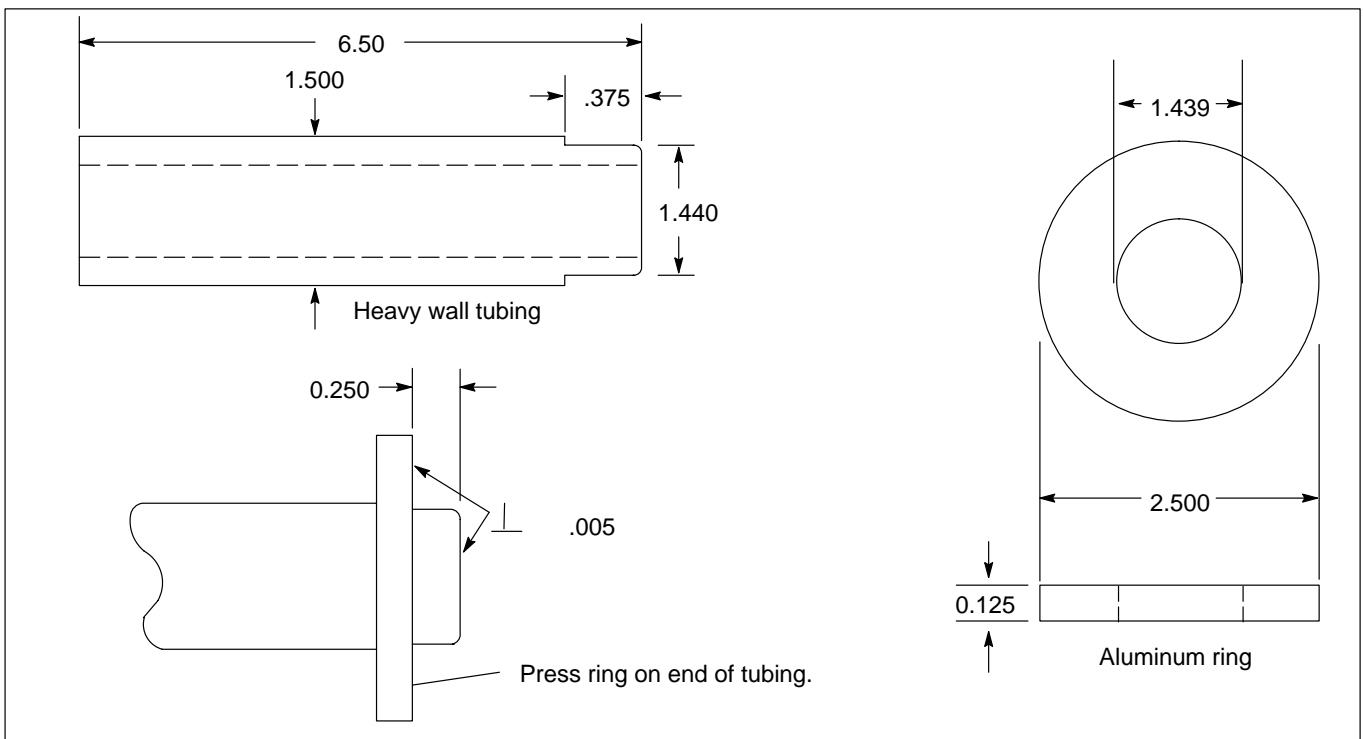


Figure 12. Shaft Seal Driver.

## F. Replacement Parts

Reliable operation throughout the specified operating range is assured only if genuine manufacturer's parts are used. Sophisticated design processes and materials are used in the manufacture of these parts. Substitutions may result in early failure. Part numbers are shown in the parts service drawings listed in Table 2.



## G. Troubleshooting

Table 3 lists the common difficulties experienced with piston pumps and hydraulic systems. It also indicates probable causes and remedies for each of the troubles listed.

TROUBLE	PROBABLE CAUSE	REMEDY
Excessive pump noise.	Low oil level in the reservoir	Fill reservoir to proper level with the recommended transmission fluid. <i>DO NOT</i> over fill transmission or damage may result.
	Air in the system	Open reservoir cap and operate hydraulic system until purged.  "Bleed" hydraulic lines at highest point downstream of auxiliary pump and while system is under pressure.
	Vacuum condition	Check inlet (suction) lines and fittings for air leaks.  Check auxiliary pump function.
	Oil too thick	Be certain correct type of oil is used for refilling or adding to the system.
	Cold weather	Run hydraulic system until unit is warm to the touch and noise disappears.
Pump overheating	Internal leakage	If established that excessive internal leakage is evident, return vehicle to maintenance shop for evaluation and repair.
	Heat exchanger not functioning	Locate trouble and repair or replace.
	Fluid level low	Add oil to operating level.
System not developing pressure	Relief valve open Compensator misadjusted	Replace one or both. Do not attempt to repair cartridges, they are factory assembled and preset.  Return vehicle to maintenance shop for repair of hydraulic system.
	Loss of fluid internally (slippage)	
Loss of fluid	Ruptured hydraulic lines	Check all external connections, tubing and hoses. Tighten connections, replace ruptured tube or hose.
	Loose fittings	
	Leaking gaskets or seals in pump or circuit	Observe mating sections of hydrostatic transmission for leaks. Replace seals or gaskets if possible.  Replace seals or gaskets if possible.
Miscellaneous	Sheared shaft key	Locate and repair.
	Disconnected or broken drive mechanisms	

Table 3. Troubleshooting Chart

# Section VI – Overhaul

## A. General



### CAUTION

*Before breaking a circuit connection, make certain that power is off and system pressure has been released. Lower all vertical cylinders, discharge accumulators, and block any load whose movement could generate pressure.*

After removing the pump from the system and before disassembly, cap or plug all ports and disconnected hydraulic lines. Clean the outside of the unit thoroughly to prevent entry of dirt into the system.



### CAUTION

*Absolute cleanliness is essential when working on a hydraulic system. Always work in a clean area. The presence of dirt and foreign materials in the system can result in serious damage or inadequate operation.*

Periodic maintenance of the pump will generally not require disassembly to the extent described here. However, the sequence can also be used as a guide for partial disassembly. In general, disassembly is accomplished in the item number sequence shown in Figure 13. Special procedures are included in the following steps.

### NOTE

Discard and replace all O-Rings, gaskets, and shaft seals removed during disassembly.

## B. Disassembly

Removal and Disassembly of the Compensator S/A

a. Remove four screws (1) that hold the compensator S/A to valve block (26) and pull the compensator away from the valve block.

b. Remove compensator gasket (2) and O-Ring (3) from body (11) of compensator S/A.

c. Remove lockwire (4), plug (5) and O-Ring (7) (6 and 7 on the CV compensator).

d. Remove spring (8), seat (9), and spool (10) from the compensator body (11) and set aside for inspection.

e. Do not remove plug(s) (24) unless it is necessary for inspection of the bore.

### NOTE

The following steps concern only the CVP and CVPC compensator S/A.

f. Unscrew plug (12) and remove parts (13) through (18).

g. Remove plug (19) to gain access to orifice plug (20). Remove orifice plug (20). Do not remove check valve S/A (21) from body (11). Item (20) may or may not be an orifice. If the circuit has a bleed down, orifice (20) may be a plug.

h. Remove plug (22) and O-Ring (23).

i. Remove plug(s) (24) only if necessary to inspect the spool bore.

### NOTE

All parts must be thoroughly cleaned and kept clean during inspection and assembly. The close tolerance of the parts makes this requirement very important. Clean all removed parts using a commercial solvent that is compatible with the system fluid. Compressed air may be used in cleaning, but it must be filtered to remove water and contamination. Clean compressed air is particularly useful in cleaning the spool, compensator body, and valve block passages.

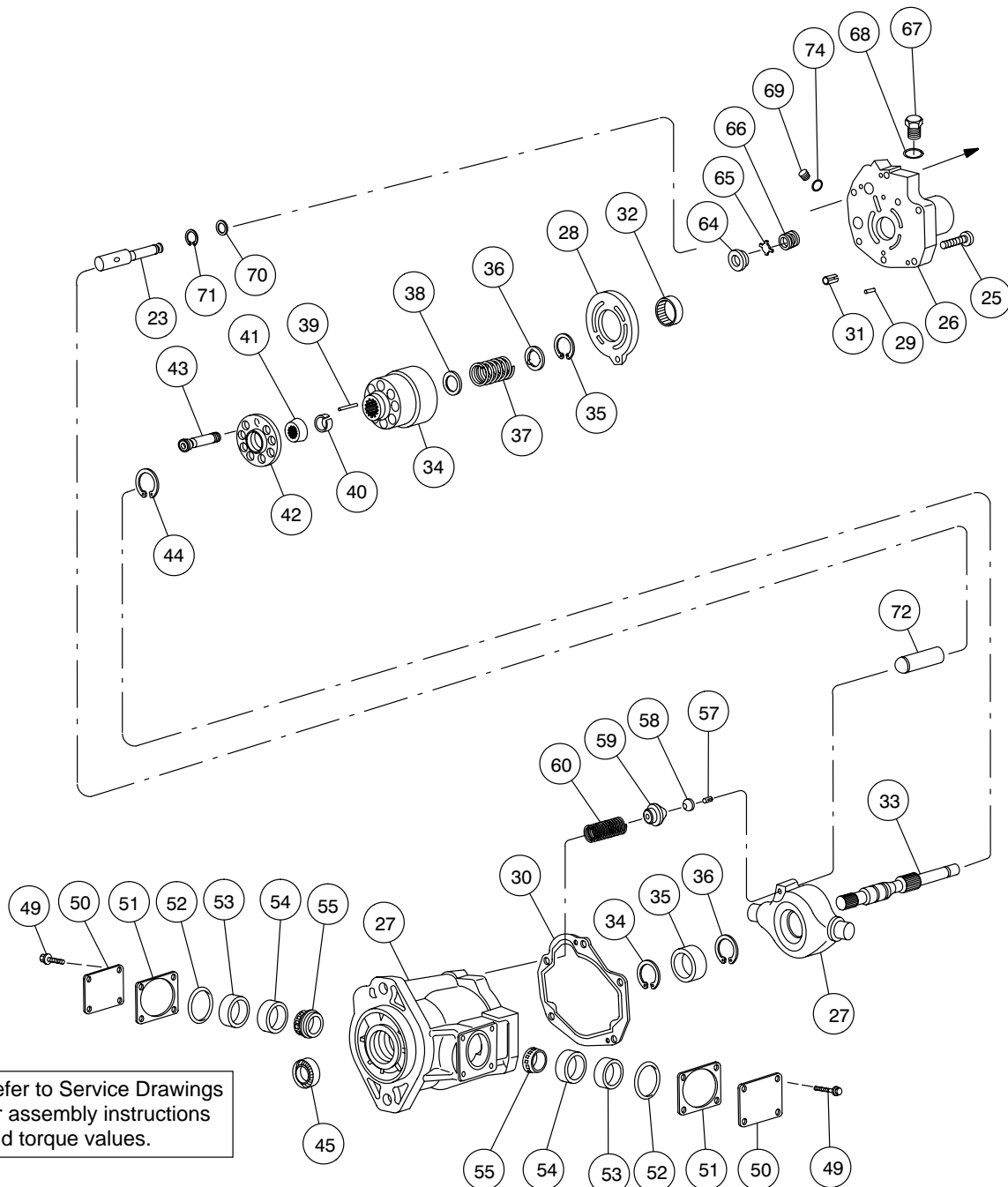
## C. Inspection Repair and Replacement

### NOTE

Replace all parts that do not meet the following specifications.

1. Inspect all components for excessive wear, erosion, and/or seizure.

2. Inspect plugs (5), (12), (19), (20), (22) and (24) for damaged threads, burrs, etc. Make sure orifice hole is open in plug (20). Replace if defective.



Item	Description	Qty	Item	Description	Qty	Item	Description	Qty
70	O-ring	1	27	Housing	1	51	Shim	2
71	Retaining Ring	1	73	Piston Rod	1	52	O-ring	2
25	Screw	5	72	Piston	1	53	Spacer	2
67	Plug	1	43	Piston & Shoe S/A	9	54	Bearing Race	2
68	O-ring	1	42	Shoe Plate	1	55	Bearing	2
69	Plug	1	41	Spherical Washer	1	56	Yoke	1
74	O-ring	1	40	Pin Retainer	1	57	Roll Pin	1
29	Pin	2	39	Pin	3	58	Seat	1
64	Seat	1	35	Retaining Ring	1	59	Seat	1
65	Valve	1	36	Spring Washer	1	60	Spring	1
66	Spring	1	37	Spring	1	44	Retaining Ring	1
31	Pin	2	38	Spring Washer	1	48	Shaft	1
32	Bearing	1	34	Cylinder Block	1	47	Retaining Ring	1
26	Valve Block	1	49	Screw	8	61	Bearing	1
28	Valve Plate	1	50	Cover	2	47	Retaining Ring	1
30	Gasket	1				45	Shaft Seal	1

Figure 13. PVE19/21 Exploded View

Figure & Index No.	Description	Units per Assembly	Figure & Index No.	Description	Units per Assembly
1	Screw	4	46	Shaft Key	1
2 ▲	Gasket	1	47	Retaining Ring	1
3 ▲	O-Ring	1	48	Shaft	1
4	Lockwire and Seal	1	49	Screw	4
5	Adjusting Plug	1	50	Pintle Cover	2
6 ▲	Back-Up Ring	1	51	Shims (kit)	1
7 ▲	O-Ring	1	52 ▲	O-Ring	2
8	Spring (pressure limiter)	1	53	Bearing Spacer	2
9	Seat	1	54	Bearing Race	2
10	Spool (pressure limiter)	1	55	Bearing	2
11	Body (compensator)	1	56	Yoke	1
12	Plug	1	57	Roll Pin	1
13 ▲	O-Ring	1	58	Seat	1
14	Adjusting Screw	1	59	Seat	1
15	Seat	1	60	Spring	1
16	Spring (load sensing)	1	61	Bearing (shaft)	1
17	Seat	1	62	Bearing Race	1
18	Spool (load sensing)	1	63	Bearing Race	1
19	Plug	1	64	Seat (check valve)	1
20	Orifice Plug	1	65	Check Valve	1
21	Check Valve S/A	1	66	Spring (check valve)	1
22	Plug	1	67	Plug	1
23 ▲	O-Ring	1	68 ▲	O-Ring	1
24	Plug	2	69	Plug	1
25	Screw	6	70 ▲	O-Ring	1
26	Valve Block	1	71	Snap Ring	1
27	Housing	1	72	Piston	1
28	Wafer Plate	1	73	Piston Rod	1
29	Pin	1			
30 ▲	Gasket	1			
31	Roll Pin	2			
32	Bearing	1			
33	Bearing Spacer Kit	1			
34	Cylinder Block	1			
35	Retaining Ring	1			
36	Washer (notched)	1			
37	Spring	1			
38	Washer (pin)	1			
39	Pin	1			
40	Pin Retainer	1			
41	Spherical Washer	1			
42	Shoe Plate	1			
43	Piston and Shoe Subassembly	1			
44	Retaining Ring	1			
45	Shaft Seal	1			

## NOTE

- ▲ Indicated parts included in seal kit. Refer to parts drawing tabulated in Figure 2 for seal kit number and parts information.

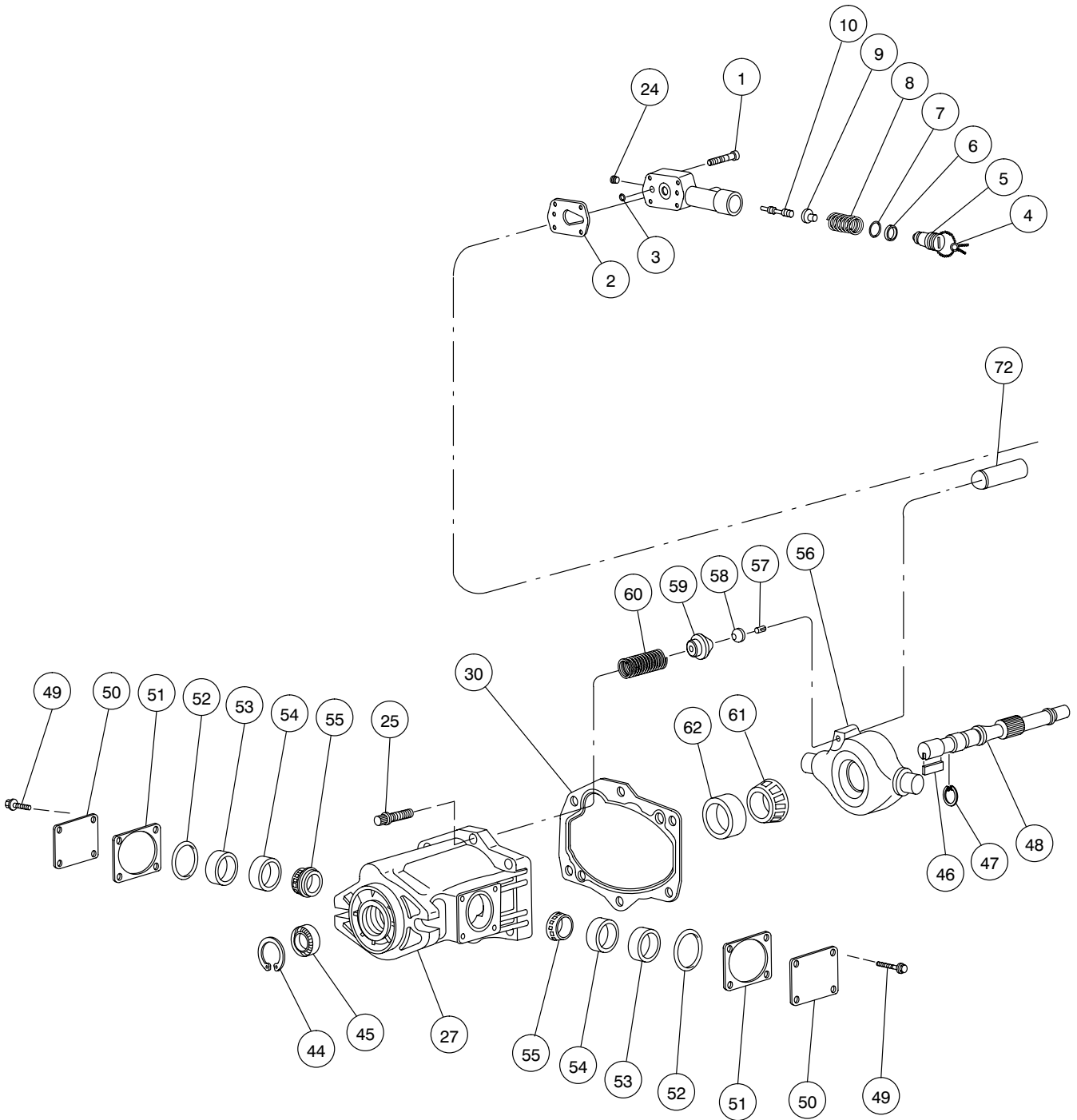
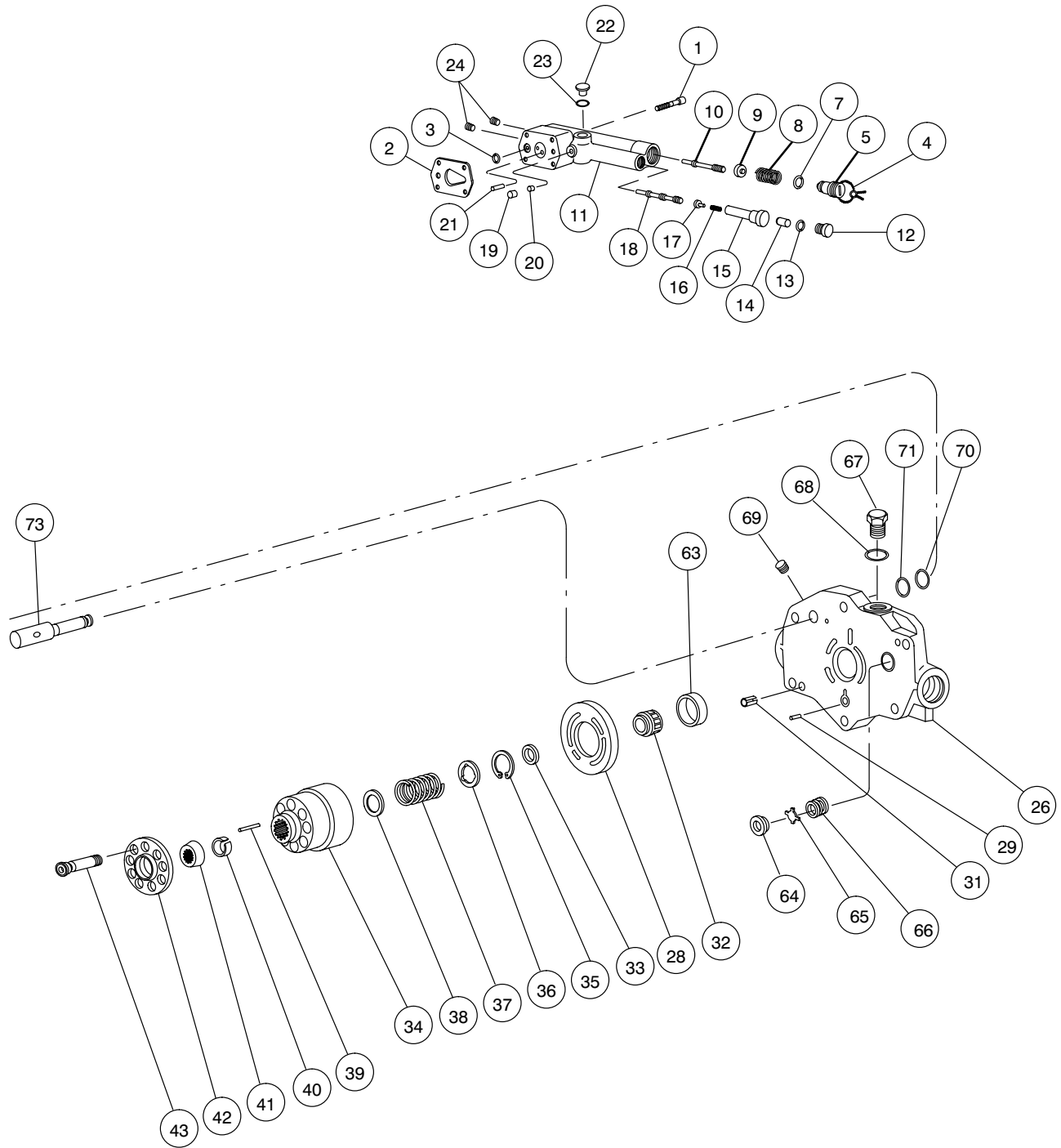


Figure 13. PVE19/21 Exploded View



3. Inspect spring (8) and (16) for wear and parallelism. Spring ends must be parallel. Replace if spring is warped or wear is evident.

4. Inspect seat (9) for wear in the area of spool contact.

5. Inspect spool (10) for excessive wear, galling, scratches, etc. If scratches exist across the spool land, replace the spool and inspect the body bore. Rotate the spool while moving in and out of the bore to check the binding. Binding cannot be tolerated. If binding is evident, use an India stone to break the sharp edges of the balancing grooves. Use 500 grit paper lightly on the outer surface of the spool. Clean in solvent and lubricate, then try the bind test again. If bonding persists, replace the spool and/or body.

6. Inspect the screws for damaged threads. Replace all damaged threads. Replace all damaged screws.

#### NOTE

The following step pertains to the CVP or CVPC compensator S/A.

7. Inspect the load sensing section of the CVP compensator as follows:

a. Inspect the load sensing section of the CVP compensator if wear is evident. Clean up burrs with an India stone.

b. If wear is evident, replace the part. Note: After assembly the compensator must be readjusted to the correct pressure. Refer to the test procedure Section VII for instructions on compensator adjustment.

c. Discard adjusting screw (14). Check seat (17) and spool (18) for wear. Refer to step B.5 for procedure when checking the pressure limiting spool.

d. Inspect body S/A (11) bores for scratches. Make sure the orifice plug (20) opening is clear.

## D. Assembly of Compensator

Replace the gaskets and O-Rings removed from the unit with those supplied in the seal kit. *DO NOT* use grease to hold the seals in place. Use a viscosity improver (STP or equivalent). Flood all parts with system fluid to provide initial lubrication and prevent seizure. Assembly of the parts will be in the reverse numerical sequence. Special procedures are included in the following steps.

#### NOTE

The following step refers to the CVP or CVPC compensator only.

1. Install parts (24) through (22) into body (11).

a. Install parts (20), (19), and spool (18). Make certain the spool does not bind or hang up in the body bore.

b. Assemble parts (17) through (15) together. Insert the assembled parts (seat first) into compensator body (11). Assemble with spool bores in vertical position to prevent seat from falling into cross port. Visually observe proper assembly through load sensing port. The seat must rest against compensator spool (18) at completion of assembly.

c. Thread adj. screw (14) into body (11) bore until top of adj. screw is .065 below body (11) surface.

d. Install O-Ring (13) over plug (12) and thread plug (12) into compensator body (11).

2. Install plug (24) into the "C" and "CV" compensator bodies. Plugs were installed into the "CVP" compensator body during the preceding step.

3. Install parts (10) through (3) into compensator body (11). Make certain the spool (10) does not bind within the bore. Refer to procedure established in step B.5 for further information. Lockwire and seal (4) will be installed during test procedure section VII.

4. Install gasket (2) in place in the face of compensator body (11). Cover the compensator body with clean Kraft paper and set aside for final assembly of the pump.

#### NOTE

Readjustment of the pressure limiter and load sensing compensators is required.

## E. Removal and Disassembly of Rotating Group

1. Remove the six screws (25) which hold pump housing (27) to valve block (26).

2. Pull valve block (26) away from housing (27) then discard gasket (30).

3. Remove wafer plate (28) and pins (29) from the valve block set aside for inspection.

4. Remove bearing (32) and bearing spacer (33 on PVE 19/21 models) from the end of drive shaft (48).

5. Slide the rotating group from the pump housing. (Hold the shoe plate with both hands during removal to prevent the group from separating.)

#### NOTE

The rotating group consists of a cylinder block S/A (34), nine piston and shoe subassemblies (43), a shoe plate (42), a spherical washer (41), three pins (39), and a pin retainer (40).



#### CAUTION

*The spring located within the cylinder block S/A is under a high tension and can cause bodily harm if the retaining ring is removed. See Figure 14 for disassembly instructions.*

6. Separate the rotating group components and set aside for inspection. Use care when handling these close tolerance parts to prevent burrs from forming.

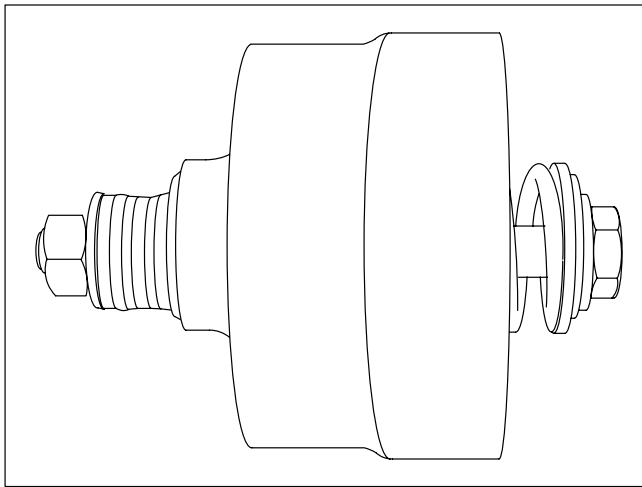


Figure 14. Cylinder block subassembly disassembly tool. (Tighten nut, remove snap ring, loosen nut to relieve spring tension).

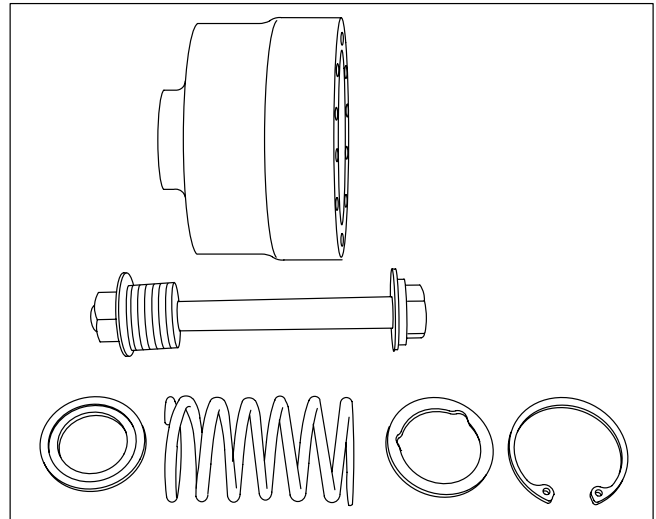


Figure 14a. Cylinder Block Subassembly parts.

## F. Inspection Repair and Replacement

1. Check bearing (32) for scoring or brinelling of the rollers (PVE 19/21).
2. Check bearing spacer (33) for burrs (PVE 19/21).
3. Inspect cylinder block S/A face (34) for wear, scratches and/or erosion between cylinders. Check the spring, washers and retaining ring located within the cylinder block S/A.
4. Check each cylinder block bore for excessive wear. Use the piston and shoe subassemblies (43) for this purpose. The piston should be a very close fit and slide easily in and out of the bore. No bind can be tolerated. If binding is evident, clean the cylinder block and piston, lubricate with clean hydraulic fluid and try again. Even minor contamination of the fluid could cause the piston to freeze up in the cylinder bore.
5. Inspect each piston and shoe subassembly (43) for a maximum end play of 0.005 inch between the piston and shoe.
6. The face thickness dimension of each shoe must be within 0.001 inch of each other.
7. Inspect shoe plate (42) for excessive wear and cracking in the area of spherical washer (41). If heavy wear or cracks are found, replace the shoe plate and spherical washer at the same time.
8. Check spherical washer (41) for burrs, wear, and possible scratches due to pin breakage. Replace if wear is excessive.
9. Inspect pins (39) for equal length, excessive wear and possible bending. Replace all pins simultaneously if one is defective.
10. The pin retainer (40) may develop burrs. Remove all burrs with an India stone.

11. Inspect the face of the wafer plate (28) for excessive wear, scratches, and possible fracture. If the wafer plate is fractured, make sure the new plate rests flat against the valve block at assembly and that wafer plate pin (29) does not extend too far and hold the wafer plate away from the valve block.

### NOTE

Inspect the yoke face and shaft bearing as follows: If either are defective, perform step F.14 and remove the yoke from the housing. If the drive shaft is defective, follow procedure shown in step F.17 to remove the drive shaft from the front bearing. If the drive shaft, shaft bearing, housing or valve block are replaced, a shaft bearing preload adjustment must be performed. See Section VI.K.

12. Inspect pump drive shaft (48) for wear, chipped splines and burrs. Remove burrs with an India stone.
13. Inspect shaft bearing (61) for brinelling, pitting of the rollers, and roughness when turned in race (62) located in the housing. If the bearing is defective, both the bearing and the race must be replaced. If the bearing shows no evidence of wear, do not remove the bearing race from the housing or the bearing from the shaft. If the bearing requires removal, perform the following steps 14 through 18.
14. Inspect yoke (56) face for wear, roughness or scoring.
  - a. Remove the four screws (49) that hold pintle covers (50) on each side of the housing. Remove the pintle covers. Be careful not to damage the shims which lie directly under the covers.
  - b. Retain shims (51), if possible, and use a micrometer to measure the total shim thickness. If the bearings are not defective, the same shims or a new shim of the same thickness will be needed to preload the bearings at installation. Remove O-Rings (52) and bearing spacers (53) from each pintle.



**NOTE**

If shims (51) were destroyed during disassembly, a yoke bearing preload adjustment must be made at assembly.

c. Slide the yoke from side to side to loosen the yoke bearing races (54) within the housing. The races are a normal slip fit but may be tight. Use an open end wrench between the yoke and the pintle bearing to help slide out the races. Apply pressure to bearing (55) at the approximate center and allow the bearing rollers to gently press the race out of the housing.

15. Remove yoke (56) and drive shaft (48) from the housing together. Turn the yoke at an angle and slide the two parts out of the housing. See Figure 15.

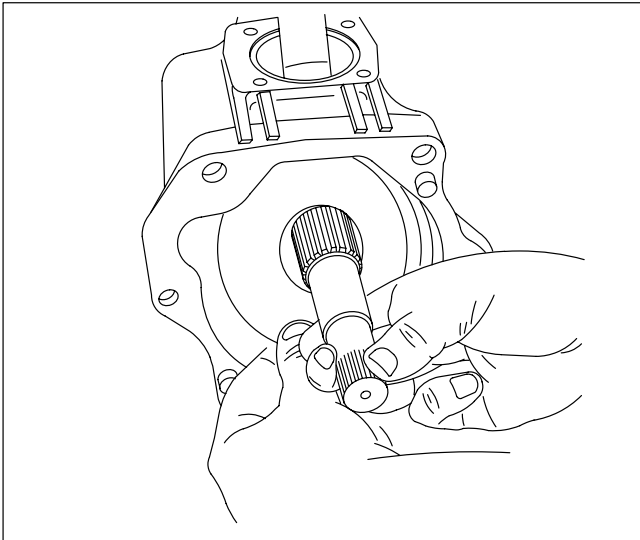


Figure 15. Removal of Yoke and Shaft from Housing.

16. After removal of yoke from the housing, remove seat (59) and yoke spring (60). Seat (58) and rollpin (57) will be attached to the yoke (56). Do not disassemble further unless seat (58) is damaged.

**NOTE**

Normally a wear pattern will exist on seat (58). If the seat is damaged or shows heavy wear, replace seat (58) and (59) and rollpin (57).

**NOTE**

If drive shaft (48) is defective, perform step F.17. If front bearing (61) was defective, perform steps F.17 and 18.

17. Remove bearing (61) from shaft (48) with the nine inch piece of 1 1/2" heavy wall tubing shown in Figure 9. Press off with an arbor press.

18. Remove bearing race (62) from housing (27) as shown in Figure 16. Use special tool shown in Figure 10.

**NOTE**

For units without shaft seal, omit shaft seal removal and installation procedure.

19. Remove retaining ring (44) then press shaft seal (45) from pump housing (27).

**NOTE**

If yoke (56) and front shaft bearing (61) were not defective, perform the following step.

20. Remove and replace shaft seal (42) located within housing (27) as follows: (Refer to figure 17.)

**NOTE**

For units without a shaft seal, this step will be used to remove a defective drive shaft only. In addition, references to shaft seal installation and removal must be omitted.

a. Install a nine inch piece of 1 1/2" heavy wall tubing over drive shaft (48) within the housing. The end of the tubing will rest against the inner race of tapered roller bearing (61) and extend out beyond the end of the pump housing. Place the complete unit with tubing into an arbor press with drive spline up. Press the drive shaft through the bearing and out of the unit. A 0.001 press exists between the shaft and bearing so considerable force is required to remove the bearing. See Figure 17 (PVE19/21).

b. Remove retaining ring (44) and pull shaft seal (45) from housing (27). Be careful not to damage the aluminum die cast housing in the seal area.

c. Press drive shaft (48) into shaft bearing (61) as follows: Use a short piece of 1 1/2" inch heavy wall tubing (approximately 6" long) over the drive spline of the shaft. The tubing must be long enough to go through the shaft seal end of the pump and make contact with the inner race of the front bearing. Press the shaft through the bearing with an arbor press until the bearing bottoms against the shoulder of the shaft (snap ring on the PVE12). See Figure 18.

d. Remove the short piece of tubing and turn shaft bearing (69) in its race with the end of the shaft. The bearing rollers must turn free and smooth.

e. Tape the spline end of drive shaft (48) with plastic tape to prevent cutting new shaft seal (45). Start taping the shaft close to the housing and work toward the end of the shaft. Install a new shaft seal in position over the shaft and press evenly into the housing. Use shaft seal driver shown in Figure 12. The seal must be positioned just below the retaining ring groove. Install retaining ring (44, 47 for PVE12) into the housing. Use internal Truarc pliers to install retaining ring.

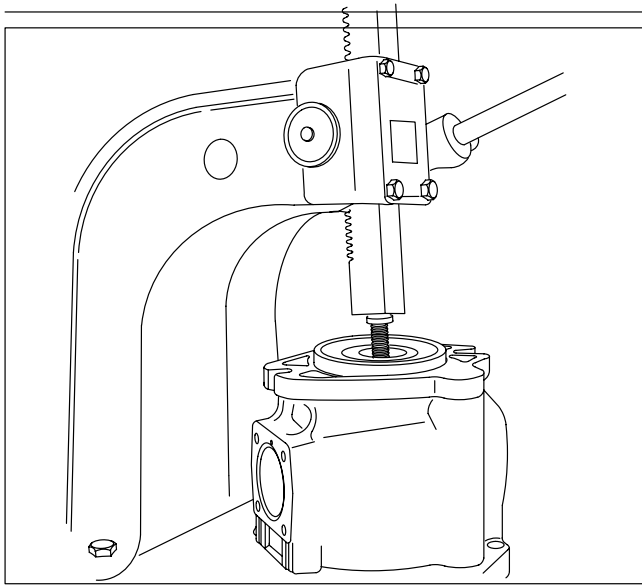


Figure 16. Removal of Front Bearing Race.

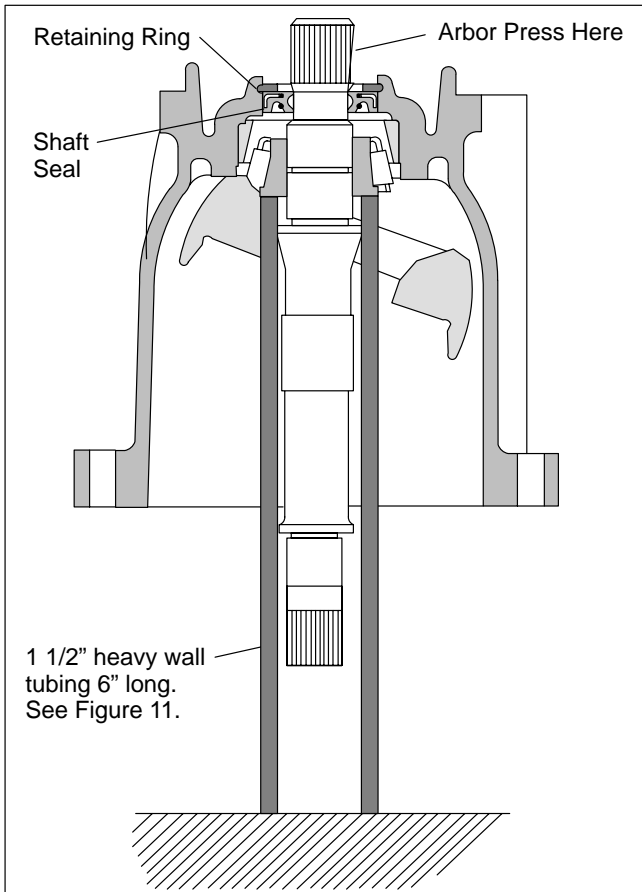


Figure 17. Front Bearing Removal.

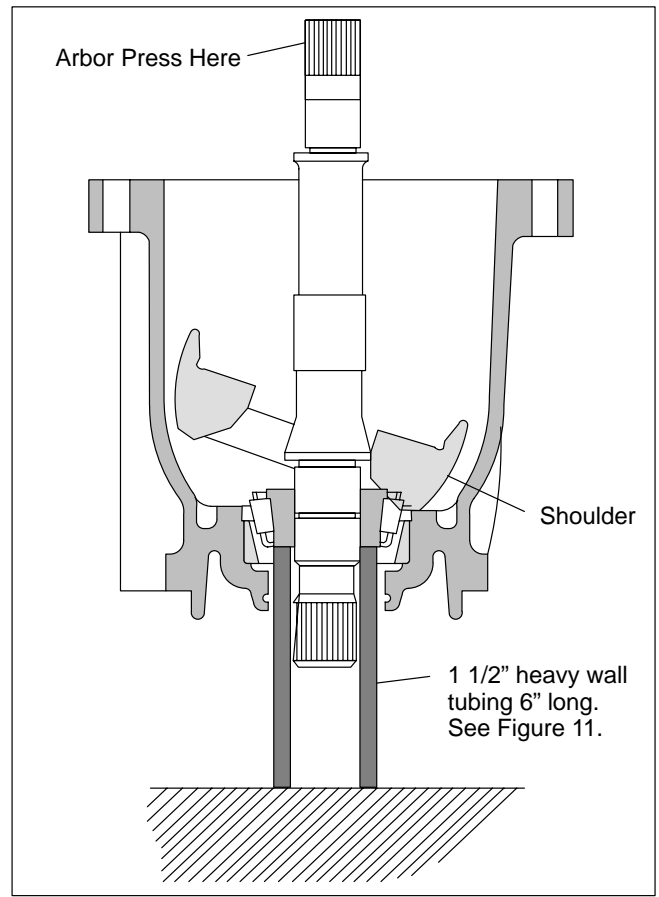


Figure 18. Front Bearing Installation.

## G. Assembly of Housing Parts

### NOTE

If a new shaft bearing (61), shaft (48), valve block (26), or housing (27) is required, a complete preload adjustment must be performed. If the same parts are returned to service, the preload adjustment can be omitted. The same procedure applies to yoke (56) and its associated bearings.

1. If the shaft bearing (61) requires replacement, install a new bearing race (62) into housing (27). Use tool shown in Figure 11 to press bearing race in place. Make sure the bearing race (62) is oriented properly to accept the roller bearing before pressing into the housing. The race must be bottomed against the shoulder of the housing at completion of press.
2. Place housing (27) on a flat surface with the shaft seal end down. Lay the front shaft bearing (61) into the race. Install yoke spring (60) and seat (59) into the housing.
3. Position the yoke pintle properly and install yoke into housing. Assemble the yoke bearings, races, and spacers as follows.

- a. Assemble pintle bearings (55) on each end of the yoke and insert bearing races (54).
- b. Install bearing spacer (53) at one pintle end.
- c. Install O-Ring (52) against spacer (53) into the groove, then install a 0.010 inch shim (51) under pintle cover (50). Install four pintle cover screws (49) and torque to 175–185 lbf. in.

**NOTE**

Early designs used a screw and washer arrangement. These should be torqued to 115–125 lbf. in.

- d. Set housing (27) on its side so the other pintle is up. Install bearing spacer (53) and rotate the yoke back and forth to seat bearings (55) within the bearing races. With spacer (53) fully in against the bearing race, measure the height of the spacer with respect to the housing pintle face in two places (180° apart). Use a depth micrometer to perform this measurement. See Figure 19. Average the readings to obtain a nominal value. A 0.007-0.009 inch preload is required of the pintle bearings. Calculate the necessary shims to provide this preload as follows: Assume the depth readings were 0.029 and 0.027 inch. Add the two figures together and divide by two to obtain the average. In this case the average calculated is 0.028 inch. Subtract the nominal preload of 0.008 inch from the calculated average to obtain the required shim thickness.

**NOTE**

If the calculated shim thickness is greater than 0.020, another shim must be added to the opposite side of the yoke to reduce the total shim thickness to less than 0.020. Shim thickness at either pintle must not exceed 0.020. This is necessary to provide proper O-Ring compression and prevent pintle seal leakage.

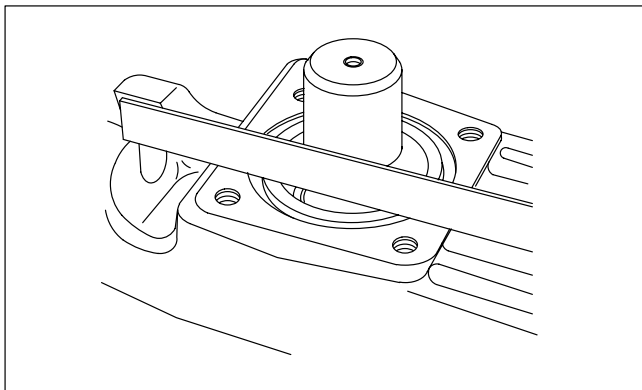


Figure 19. Pintle bearing spacer height with respect to pintle face.

- e. Install the correct shims (51) and cross torque pintle cover (50) screws to 175–185 lbf. in.

**NOTE**

The yoke (56) will be stiff but should be loose enough to be moved by hand (approximately 20 lb. in. torque). The tightness/drag indicates the bearings are preloaded. If the yoke cannot be moved by hand, the preload is too great. Repeat the preload adjustment until correct.

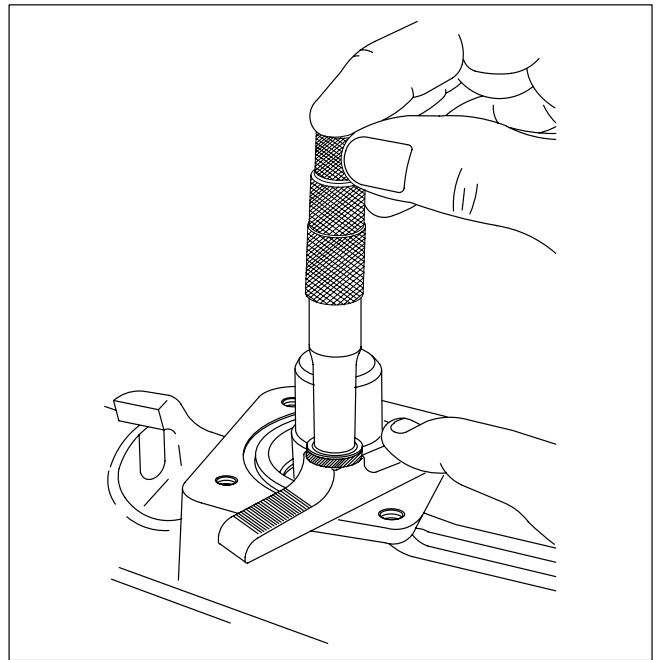


Figure 19a. Measuring height of pintle bearing spacer with respect to the pintle face.

4. Assemble the rotating group and install into housing as follows:

- a. Assemble the spring, two washers and retaining ring into the cylinder block. The washer with three notches is assembled next to retaining ring. See Figure 14 for instructions. Set the cylinder block S/A (34) face on a flat clean surface. Use Kraft paper between the block and surface to prevent scratching the cylinder block face.

- b. Install pin retainer (40) into cylinder block. Position the pin retainer approximately 1/4" below the surface, and orient the open end of the pin retainer to be away from the large spline openings.

- c. Slide the three pins (39) into cylinder block S/A (34) until they bottom against the spring washer within the block.

- d. Place spherical washer (41) on top of the three pins, then install shoe plate (42) with nine piston and shoe subassemblies (43) over spherical washer (41) and into cylinder block. Wobble shoe plate (42) to make sure that each piston is free within its bore in the cylinder block.

- e. Set housing (27) on its side and hold pump shaft (48) horizontal. Slide rotating group into the housing. Rotate the shaft to match the shaft splines to the cylinder block and spherical washer.

5. If alignment pins (31) were removed, install two alignment rollpins (31) into housing (27). Place gasket (30) over the rollpins, cover with Kraft paper and set aside for final assembly.

## H. Disassembly of Valve Block

1. Do not disassemble check valve parts (64) through (66), unless action of the valve indicates a problem. Check the valve action with a pencil or a screwdriver. Press the check valve in against the spring, it should return and hold firm against the seat. If the check valve is defective, remove and replace the complete assembly. Press new seat (64) flush with face of valve block. DO NOT scratch the face of valve block (26).

2. Remove parts (67) through (73) from valve block (26).

### NOTE

If bearing (32) was defective, perform the following step.

3. For PVE19/21, remove bearing race (63) from valve block (36). The PVE12 roller bearing is in the valve block. Refer to Figure 20 for removal information and use tool shown in Figure 10 for PVE\*\*G units. Use tool shown in Figure 10a and procedure shown in Figure 20a for PVE\*\* units with a blind hole in valve block (26). BE CAREFUL not to scratch face of the valve block during removal of the race.

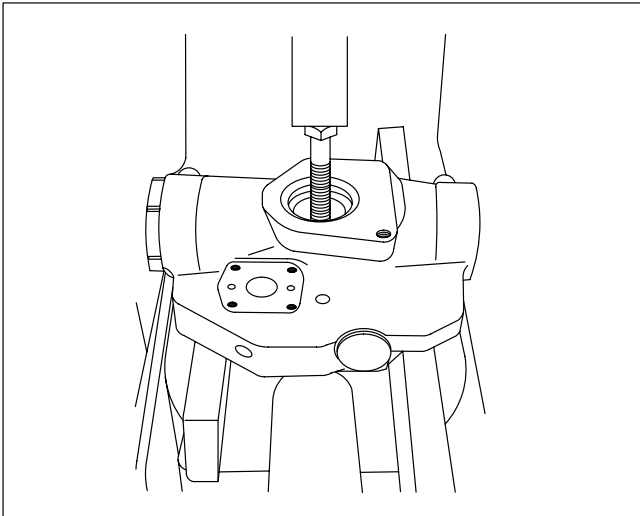


Figure 20. Removal of Bearing Race from Valve Block.

## I. Inspection, Repair, and Replacement

1. Clean all parts and place them on a clean sheet of Kraft paper for inspection. Follow general procedure noted in paragraph VI. GENERAL.

2. Inspect the threaded plugs for worn corners on the hex head, stripped threads and burrs in the O-Ring groove. Use an India stone to remove burrs. If threads are defective, replace the plug.

3. Inspect compensator piston rod (73) for nicks and burrs. Remove burrs and sharp edges with an India stone.

4. Inspect compensator piston (72) for wear at the area of yoke contact. The compensator piston and the piston rod are a close tolerance fit and must assemble together without evidence of wear or bind. Rotate the piston through 360° when checking for bind.

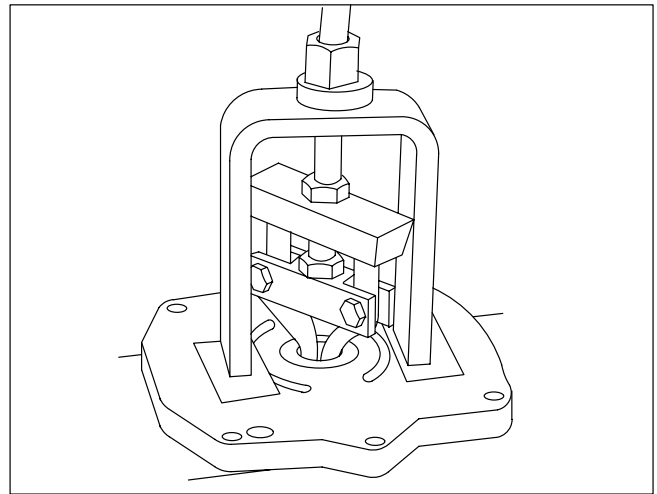


Figure 20a. Removal of Bearing Race from valve Block with Blind Hole.

5. Inspect valve block (26) for burrs, nicks, plugged body passages, flatness of the pump wafer plate area and porosity. Inspect check valve seat (64). Make sure the seat is tight with-in the valve block and does not protrude above the valve block face. Repair or replace the valve block if defective.

## J. Assembly of Valve Block

### NOTE

Refer to Figure 13 during the following assembly procedures.

1. If bearing (32) was defective and bearing race (63 for the PVE19/21) has been removed, a new bearing race must be installed into the valve block. Refer to Figure 21 and press a new bearing race in place with an arbor press. The bearing race must bottom against the shoulder of valve block at completion of press.

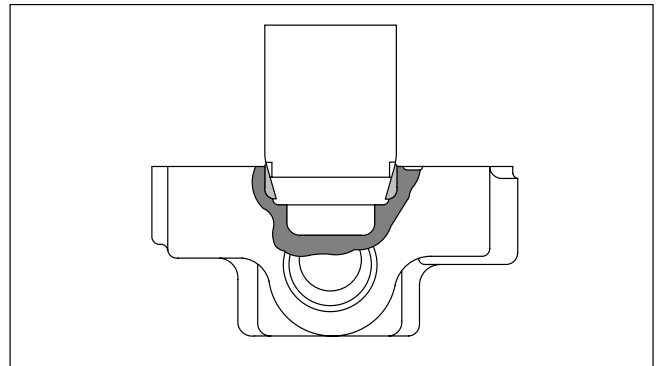


Figure 21. Installation of Bearing Race into Valve Block.

### NOTE

Check flatness of the valve block face in the area around each locating pin hole (31) and at bolt openings (25). Use an India stone to remove burrs or raised metal in these areas.

2. Install pipe plug (69) into valve block (26) and secure.
3. Assemble a new O—Ring (68) on hex plug (67) and thread plug into place.

## K. Shaft Bearing Preload Adjustment

(PVE 19/21 only)

### NOTE

If the shaft bearings, shaft, valve block or housing were not replaced, use the bearing spacer removed during the disassembly procedure to preload the shaft and perform step K.7. If preload adjustment is necessary, perform steps K.1 through K.7

1. Install the thickest bearing spacer (33) over shaft (48) with the chamfer facing into the housing (toward the shoulder on the shaft).

2. Slide new bearing (32) on the shaft and up against spacer (33). The small diameter of the tapered roller bearing must face out of the housing.

3. Install housing (27) to valve block (26) without gasket (30) and rotating group. Turn shaft (48) to seat the bearings then torque the six housing attaching screws (25) to 5 lbf. in. Check the opening between the valve block and housing to be as even as possible after tightening.

4. Use a feeler gauge to measure the opening between valve block (26) and housing (27). Four measurements should be obtained equidistant around the unit. A tapered feller gauge is especially useful for this purpose. Average the four readings by adding them together and dividing by 4. Calculate thickness of the shaft bearing spacer as follows:

+ 0.150	Measured thickness of bearing spacer
– 0.027	Average gap (estimated)
+ 0.003 ±0.001	Preload setting
+ 0.020	Compressed thickness of gasket
<hr/>	
0.146±0.001	Required bearing spacer thickness to provide a 0.003±.001 bearing preload.

5. Remove six mounting screws (25) then remove housing (27) from the valve block.

6. Remove bearing (32) and bearing spacer (33).

7. Locate a bearing spacer with calculated dimensions and place next to the new bearing on the shaft. Chamfer must face shoulder on shaft. Use the original spacer and bearing if preload is not performed. Set aside for final assembly.

## L. Final Assembly of the PVE Series Pump

### NOTE

Lubricate all moving parts of the piston pump with system fluid to facilitate assembly and provide initial lubrication. Pour system fluid liberally over the rotating group and wafer plate as these parts are without lubrication until the pump primes.

1. Assemble wafer plate locating pin (29) into valve block (26). Refer to Figure 13.

2. Assemble wafer plate (28) over the bearing race (pins on the PVE12) and locating pin (29) with wear surface away from valve block (26). Determine from the model code which wafer plate is used. See Figure 22.



### CAUTION

*The wafer plate must be flat against the valve block face. Check to make sure it does not rock back and forth. If rocking of the wafer plate occurs, check locating pin (29), it may not be bottomed out in the valve block. Rocking of the wafer plate will induce high stress conditions across the wafer plate and cause fractures to appear.*

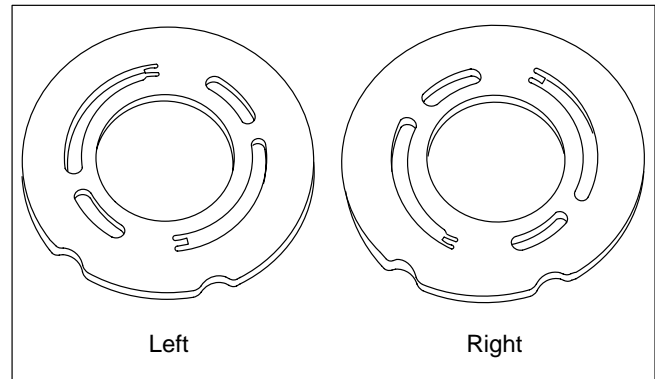


Figure 22. Wafer plates showing right and left hand.

3. Place valve block (26) on its side. See Figure 13 for position required.

4. Install compensator piston rod (73) into valve block (26) and attach spirolox retaining ring (71).

5. Install a new O-Ring (70) in the compensator piston rod O-Ring groove.

6. Install compensator piston (72) over compensator piston rod (73).

7. Assemble housing (27) and valve block (26) together as shown in Figure 13. Thread six screws (25) hand tight through the housing into the valve block. Cross torque the screws to bring the valve block and housing together against gasket (30). Final torque screws (25) to 31–35 N.m (23–26 lbf. ft.) for the PVE19/21 and 22–27 N.m. for the PVE12.

8. Check the shaft torque to verify correct bearing preload. If the torque exceeds eight (8) N.m (6 lbf. ft.), perform a shaft bearing preload adjustment, Section VI.K. and repeat steps VI.L.7 and 8.

9. Determine shaft rotation from the model code stamped on the mounting flange. Refer to Figure 7 and mount the compensator subassembly. Thread four screws (1) through the compensator into valve block (32). Cross torque screws to 7–8 N.m (60–70 lbf.in.).

# Section VII – Test Procedure

## A. Test Conditions

**FLUID MEDIUM:** SAE 10W meeting API service classification MS or equivalent.

**FLUID TEMPERATURE:** 120° F ±5° F at pump outlet.

Fluid entering the pump must be maintained below a maximum contamination limit of class four according to NAS1638.

## B. Preliminary Check

1. Rotate the drive shaft through one complete revolution. The shaft must rotate with less than 8 N.m (6 lbf. ft.) torque and be free without evidence of binding.
2. Direction of rotation by the model code stamped into the edge of the mounting flange. See Table 2 for definition of model code variables.

## C. Preliminary Set-Up

### NOTE

Install unit as shown in test circuit diagram with case drain up. Use the correct circuit diagram for the unit: Figure 23–PVE 19/21 (G)–\*–\*\*–C/CG–1\*. Figure 24–PVE 19/21 (G)–\*–\*\*–CV/CVP/CVPC units.

1. Maintain 0–10 Psig at pump inlet.
2. Fill pump housing with system fluid and connect case drain line.
3. During test, case pressure must not exceed 15 Psig.
4. Pressure differential between case and inlet must be 0–5 psid unless otherwise indicated. (Note: A special test for maximum differential pressure between case and inlet will be performed later.)

## D. Performance Test

1. Open globe valves V1 and V2.
2. Set load valve one (1) to minimum pressure. If the unit has an auxiliary gear pump, set load valve two (2) to minimum pressure.
3. Turn compensator plug (9), Figure 13, clockwise until seated.
4. Jog the unit under test until prime occurs. If the unit has an auxiliary gear pump, both pumps must prime before proceeding.
5. Operate the unit at 1200 RPM and 100 Psig until all air is expelled from the test circuit.
6. Piston pump case leakage must exceed 10cc/minute as read on flow rater Q2.

## E. Performance Test of Piston Pump with “C” Compensator Control

1. Adjust load valve one (1) and globe valve one (V1), Figure 23, for exactly 100 Psig as read at gauge P1. The unit must meet the following requirements at full stroke, and 1200 RPM. See Table 4. Record the flows obtained.

2. Close globe valve one (V1) and readjust load valve one (1) to system pressure shown in Table 5. Read Psig at gauge P1.

3. Check delivery loss and case leakage as follows. (See Table 5.)

4. Open globe valve one (V1) and load valve (1).

5. Back off compensator adjustment screw until approximately 0.060 inches of threads are exposed. Close load valve one (1) and globe valve one (V1). The pressure as read at gauge P1 must not exceed 250 Psig.

6. Adjust the compensator screw to retract the yoke to minimum stroke position at Table 6 pressures. Case drain leakage not to exceed two (2.0) USGPM. Pressure fluctuations must not exceed 50 Psig. Rapid globe valve (V1) movement from open to closed must not produce yoke hunting.

7. With the pump operating at cutoff, close the case drain port slowly (globe valve V2) while observing gauge P2. Pressure differential P2–P3 must be 6–12 Psid with globe valve V2 fully closed. If pressure starts to exceed 12 Psid while closing globe valve V2, the internal check valve is malfunctioning. DO NOT close globe valve V2 further; return to the open condition and repair the malfunction.

100 PSI System Pressure			
Model	PVE12	PVE19	PVE21
Delivery	7.5-8.4 USgpm	12.5-13.5 USgpm	13.75-14.85 USgpm
Max. Case Leakage	620cc/Min.	800cc/Min.	800cc/Min.

Table 4. Maximum flow and maximum case leakage at 100 Psig.

	3000 Psig System Pressure		2700 Psig System Pressure
	PVE12	PVE19	PVE21
Max. Delivery	1.15 USgpm	1.50 USgpm	1.50 USgpm
Loss Max. Case Leakage	1.12 USgpm	1.45 USgpm	1.45 USgpm

Table 5. Delivery loss and maximum allowable leakage at indicated Psig.

8. With load valve one (1) set to pressure noted in Table 6 and globe valve V1 fully closed, the pressure at P1 must return within 50 Psig of initial setting.

9. Drill and lockwire the compensator adjusting screw (9) Figure 13.

10. Check for signs of external leakage (none permissible) including shaft seal.

11. Remove power, remove unit from stand, drain case, then plug openings to prevent dirt from entering the unit. This completes test and adjustment of the piston pump and “C” compensator S/A.

Model Number	Lockwire	Pressure Setting
PVE12/19*–*–**–C10	Yes	3000 Psig
PVE21*–*–**–C10	Yes	2700 Psig

Table 6. Final compensator pressure setting.

## F. Performance Test of PVE 12/19/21 Piston Pump with "CG" Compensator Control

1. Operate pump at 1200 RPM. Set remote control valve to minimum pressure setting.

2. Refer to Figure 23 and adjust load valve (1) and globe valve (1) to 100 PSI system pressure at P1. Observe maximum pump flow and maximum case leakage requirement noted in Table 4.

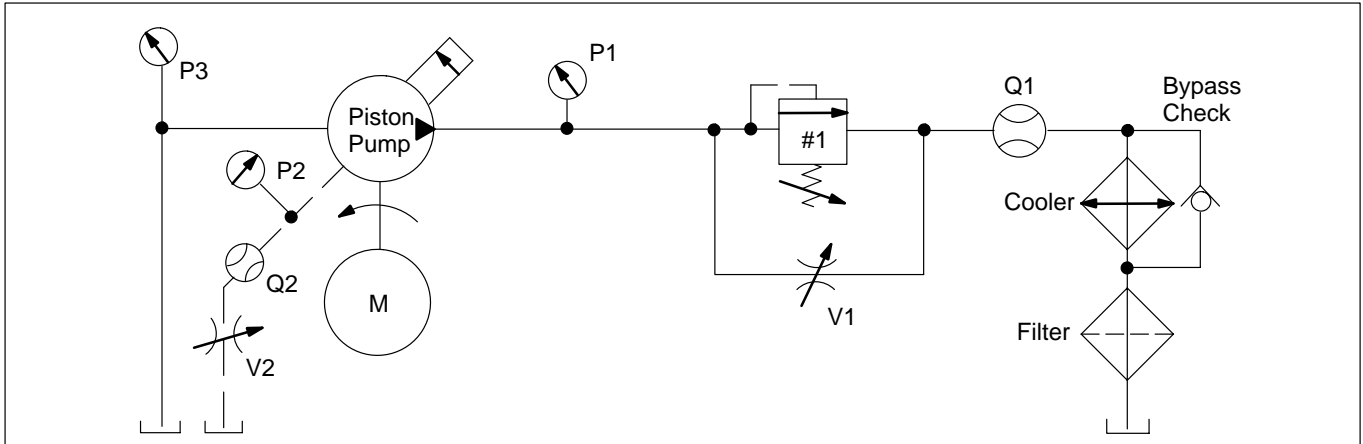


Figure 23. Circuit Diagram for "C" and "CG" Control.

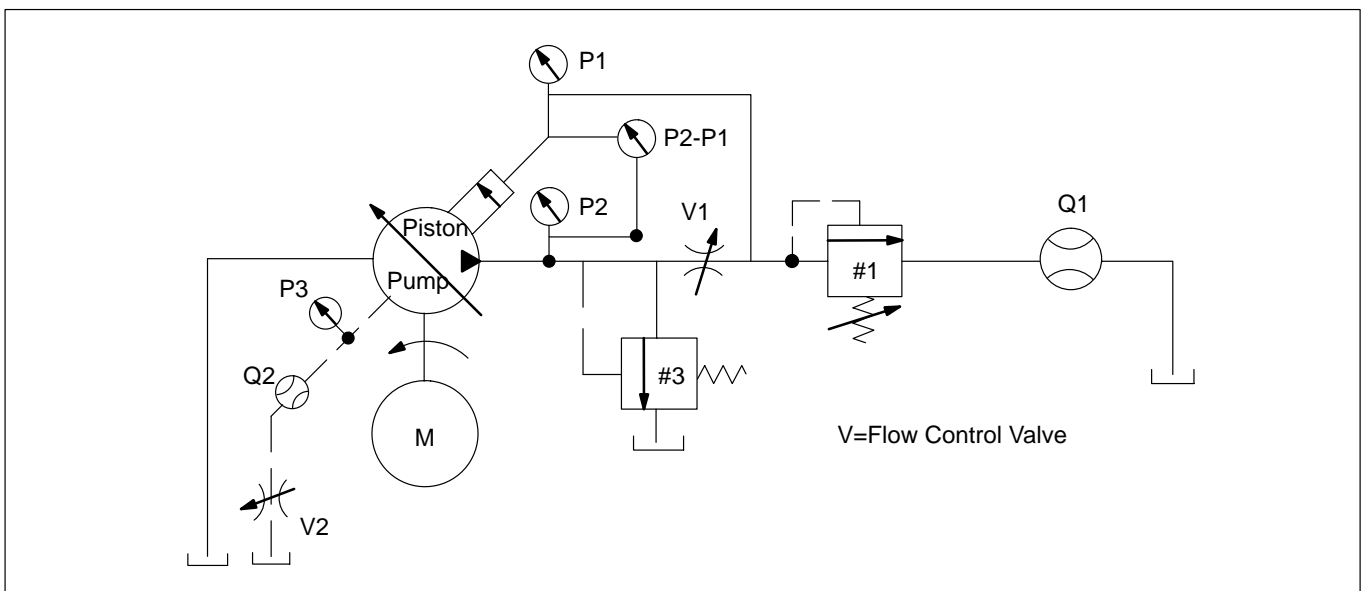


Figure 24. Circuit Diagram for "CV", "CVP", and "CVPC".

3. Close load valve (1) and globe valve (1) to obtain minimum pump pressure setting. Minimum pump pressure should be approximately 250 PSI at P1.

### NOTE

The "CG" compensator is preset at the factory at 250–350 PSI. When a hydraulic line is attached between the "CG" compensator and remote control valve, back pressure may exist within the hydraulic line. As a result, the back pressure may keep the minimum pump pressure above 350 PSI.

4. Adjust load valve (1) and remote valve to get maximum system pressure shown in Table 5. Check pump delivery loss and case leakage requirements from Table 5.

5. Re-adjust remote valve settings.

6. Closed load valve (1). Increase the remote control valve setting until the pump yoke retreats to minimum stroke position. Observe pressure at P1. Case leakage should not exceed 2 GPM. Open and close load valve (1). The pressure at P1 should return within 50 PSI of initial setting.

7. Check the pump for external leakage. No external leakage is permissible.

## G. Performance Test of PVE 12/19/21 Piston Pump with “CV”, “CVP”, “CVPC” and “CVPD” Compensator Control

### NOTE

Refer to Figure 24 for location of circuit components.

1. Open load valve one (1) and turn compensator adjustment plug clockwise until seated.
2. Operate at 1200 RPM and 100 Psig outlet pressure until all air is removed from the test circuit.
3. The case leakage as read at flow rater Q2 must exceed 10cc/minute. Make sure globe valve V2 is open.
4. Adjust globe valve V1 closed. Then adjust relief valve three (3) to a pressure higher than the compensator setting noted in Table 8.
5. Open globe valve V1 and set load valve one (1) for 100 Psig as read at gauge P2.
6. The unit must meet the following requirements at 1200 RPM and full stroke. See Table 7. Record the flow readings.

100 Psig System Pressure		
Model Code	Delivery USgpm	Max. Case Leakage
PVE12*-**-CV-10	11.5	1020cc/min
PVE12*-**-CVP/CVP-11/CVPD	11.5	1020cc/min
PVE19*-**-CV-10	12.5-13.5	800cc/min
PVE19*-**-CVP/CVP-12/CVPD	12.45-13.45	1020cc/min
PVE21*-**-CV-10	13.75-14.85	800cc/min
PVE21*-**-CVP/CVPC-12/CVPD	13.7-14.8	1020cc/min

Table 7. Maximum delivery and maximum case leakage.

7. Adjust load valve one (1) for pressures noted in Table 8. Check the delivery loss by comparing flow at the highest system pressure setting to the flow at 100 Psig. (Note: CVP and CVPC compensators may require an adjustment to obtain a full stroke at system pressure.) Make sure relief valve three (3) is not bypassing fluid to tank. The unit must meet the following requirements at full stroke and 1200 RPM.

System Pressure	Psig	Delivery Loss	Max. Case Leakage
Model Code			
PVE12*-**-CVP/CVPC/CVPD	3000	1.15 USgpm	1.12 USgpm
PVE19*-**-CV-10	3000	1.5 USgpm	1.45 USgpm
PVE19*-**-CVP/CVPC-12	3000	1.65 USgpm	1.70 USgpm
PVE21*-**-CV-10	2700	1.5 USgpm	1.45 USgpm
PVE21*-**-CVP/CVPC-12	2700	1.65 USgpm	1.70 USgpm

Table 8. Delivery loss and maximum case leakage.

8. Units with a CV, CVP, or CVPC compensator S/A shall perform the compensator control and integral case to inlet test. Refer to steps F1 through F6. Set compensator pressure pressure as shown in Table 6.

## H. Load Sensing Control Test

1. At 1200 RPM, load the pump outlet port pressure to  $2000 \pm 50$  Psig with load valve one (1). Shim the load sensing compensator spool to obtain a differential pressure P1–P2 per Table 9 with globe valve V1 adjusted for  $6.5 \pm .25$  USGPM outlet flow and gauge P1 at 2000 Psig.
2. Vary the outlet flow from 0.5 USGPM to maximum with globe valve one (1). Pump outlet pressure must be stable.
3. Set globe valve one (1) fully open. Differential pressure P2–P1 will be at minimum. Slowly close globe valve V1 while observing the differential pressure gauge P2–P1 and flow rater Q1. A point will be reached (compensator cracking pressure) where flow will start to diminish; pressure gauge P2–P1 should read the value noted in Table 9.
4. Cycle the pump from minimum to maximum flow with globe valve one (1), pump outlet must be stable. At minimum pump flow, the standby pressure P2 after P1 has decayed to zero (0) must correspond to Table 9. Lockwire the compensator adjustment plug.
5. Check for external leakage (none permissible).
6. Disconnect and drain the unit under test. Plug all openings to prevent contamination.



Model	Compensator Pressure Setting Psig	Lockwire	Standby Pressure P2	P @ USgpm (P2-P1)	P @ Compensator Cracking Pressure (P2-P1)
PVE12*-*-**C**VP11	3000	Yes	250 psi Max.	160 psi ± 20 psi 4 USgpm	160 +20 -30 psi
PVE12*-*-**C**VPC24	3000	Yes	500 psi Max.	350 psi ± 25 psi 4 USgpm	350 +20 -30 psi
PVE12*-*-**C**VPD41	3000	Yes	900 psi Max.	600 psi ± 50 psi 4 USgpm	600 +20 -30 psi
PVE19*-*-**CV-10 PVE21*-*-**CV-10 PVE19*-*-**CVP-12 PVE21*-*-**CVP-12	Not Applicable Not Applicable 3000 2700	Yes	250 psi Max.	160 psi ± 20 psi 6.5 USgpm	160 +20 -30 psi
PVE19*-*-**CVPC-12 PVE21*-*-**CVPC-12	3000 2700	Yes	550 psi Max.	350 psi ± 25 psi 6.5 USgpm	360 +20 -30 psi

Table 9. Load sensing compensator adjustment range.

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