

P1-PD Series Medium Pressure Mobile Pumps Service Manual



ENGINEERING YOUR SUCCESS.

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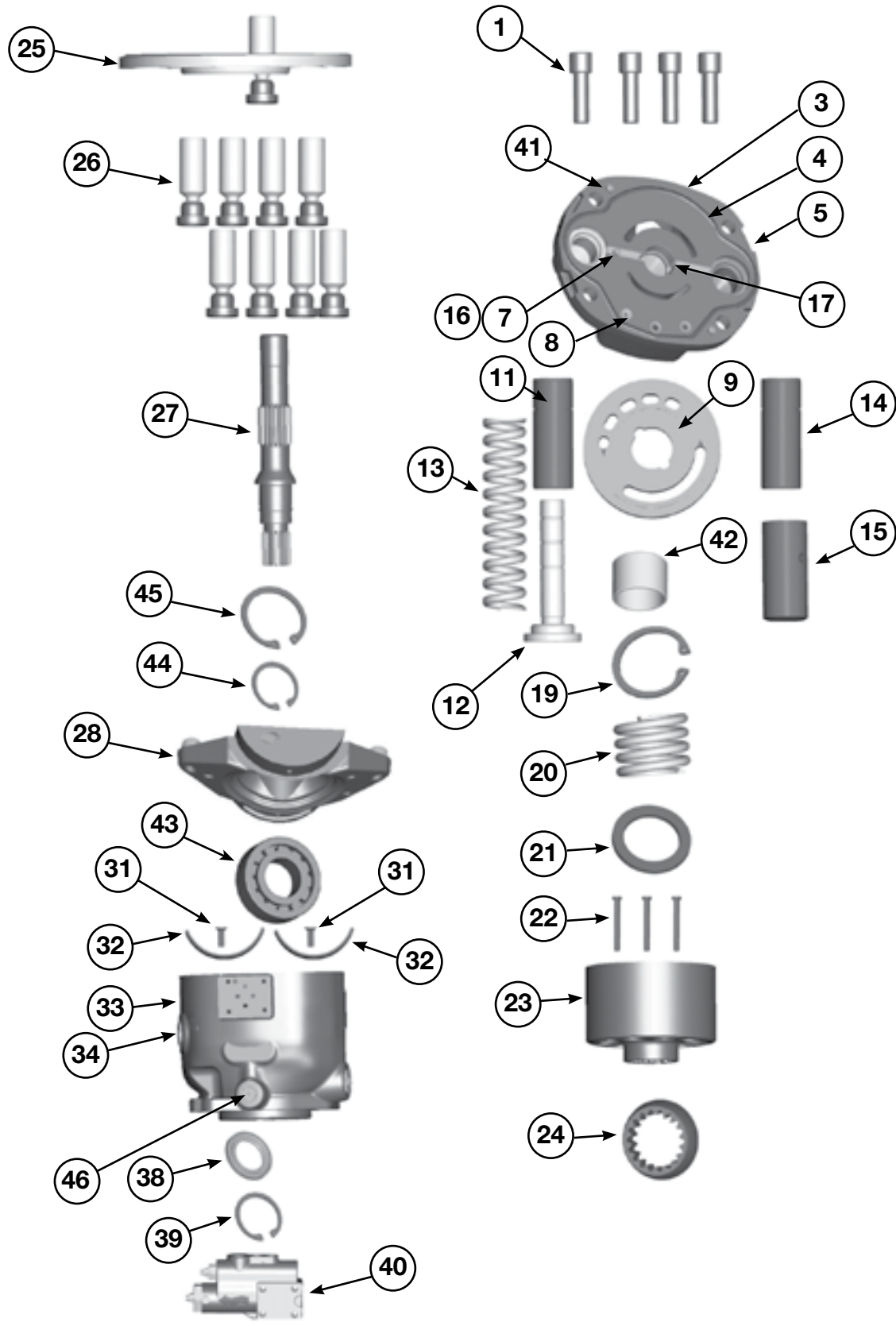
Model Coding Information	For model code designation meaning and general model code information please see P1/PD sales catalog HY28-2665-01/P1/EN.
Mounting	These pumps are designed to operate in any position with the shaft horizontal or pointing downward. For Shaft up mounting consult your nearest Parker representative. The pump shaft must be in alignment with the shaft of the source driver and should be checked with a dial indicator. The mating pilot bore and coupling must be concentric. This concentricity is particularly important if the shaft is rigidly connected to the driven load without a flexible coupling.
Shaft Information	<p>Splined: The shafts will accept a maximum misalignment of 0.005 in (0.15mm) total indicator reading. Angular misalignment at the external and internal spline axis must be less than $\pm 0,002$ mm per mm of shaft radius, ± 0.002 inches per inch of shaft radius. The coupling interface must be lubricated. PARKER recommends lithium molydisulfide or similar grease. The internal coupling should be hardened to Rc 27-34 and must conform to SAE-J498c, class 5 flat root side fit.</p> <p>Keyed: High strength heat treated keys must be used. Replacement keys must be hardened to 27-34 Rc. The key corners must be chamfered 0.032-0.040 in (0.81-1.0 mm) at 45° to clear radii that exist in the keyway.</p>
Side Load Capability	The P1/PD series is designed for inline-drive. Side loading on the shaft is not recommended. If this is unavoidable consult your nearest Parker representative.
Fluid Connections	<p>Connect inlet and outlet lines to the port block of the pump. The maximum case pressure is 2 bar (30 psi) continuous, 4 bar (60 psi) intermittent. The case pressure must never exceed inlet pressure by more than .5 bar (7 psi). When connecting case drain line make certain that drain plumbing passes above highest point of the pump before passing to the reservoir. The case leakage line must be of sufficient size to prevent back pressure in excess of 2 bar (30 psi) and returned to the reservoir below the surface of the oil as far from the supply inlet as possible. All fluid lines, whether pipe, tubing, or hose must be adequate size and strength to assure free flow through the pump. An undersize inlet line will prevent the pump from operating properly at full rated speed. An undersize outlet line will cause back pressure and cause heat generation and increased noise. Flexible hose lines are recommended. If rigid piping is used, the workmanship must be accurate to eliminate strain on the pump port block or to the fluid connections. Sharp bends in the lines must be eliminated wherever possible. All system piping must be cleaned and flushed before installing pump. Make sure the entire hydraulic system is free of dirt, lint, scale, or other foreign material.</p> <p>CAUTION: Do not use galvanized pipe. Galvanized coating can flake off with continued use.</p>
System Relief Valves	Although the P1/PD series pumps have very fast off-stroke compensator response, system relief valves are recommended in all cases for safety considerations.
Recommended Fluids	The fluid recommended for use in these pumps has a petroleum base and contains agents which provide oxidation inhibition and anti-rust, anti-foam and de-aerating properties as described in Parker standard HF-1. Where anti-wear additive fluids are specified, see Parker standard HF-0.
Viscosity Index	90 V. I. minimum. Higher values extend the range of operating temperature but may reduce the service life of the fluid. Viscosity cannot be lower than 7 cSt.
Temperature	Determined by the viscosity characteristics of the fluid used. Because high temperatures degrade seals, reduce the service life of the fluid and create hazards, fluid temperature should not exceed 230°F (110°C) at the case drain.
Maintenance	The pump is self-lubricating and preventative maintenance is limited to keeping system fluid clean by changing filters frequently. Keep all fittings and screws tight. Do not operate at pressures and speeds in excess of the recommended limit. If the pump does not operate properly, check the troubleshooting chart before attempting to overhaul the unit. Overhauling may be accomplished by referring to the disassembly, rework limits of wear parts, and assembly procedures as provided in this service manual.
Fluid Cleanliness	Fluid must be cleaned before and continuously during operation, by filters that maintain a cleanliness level of ISO 20/18/14. Better cleanliness levels will significantly extend the life of the components. As contaminant generation may vary with each application, each must be analyzed to determine proper filtration to maintain the required cleanliness level.

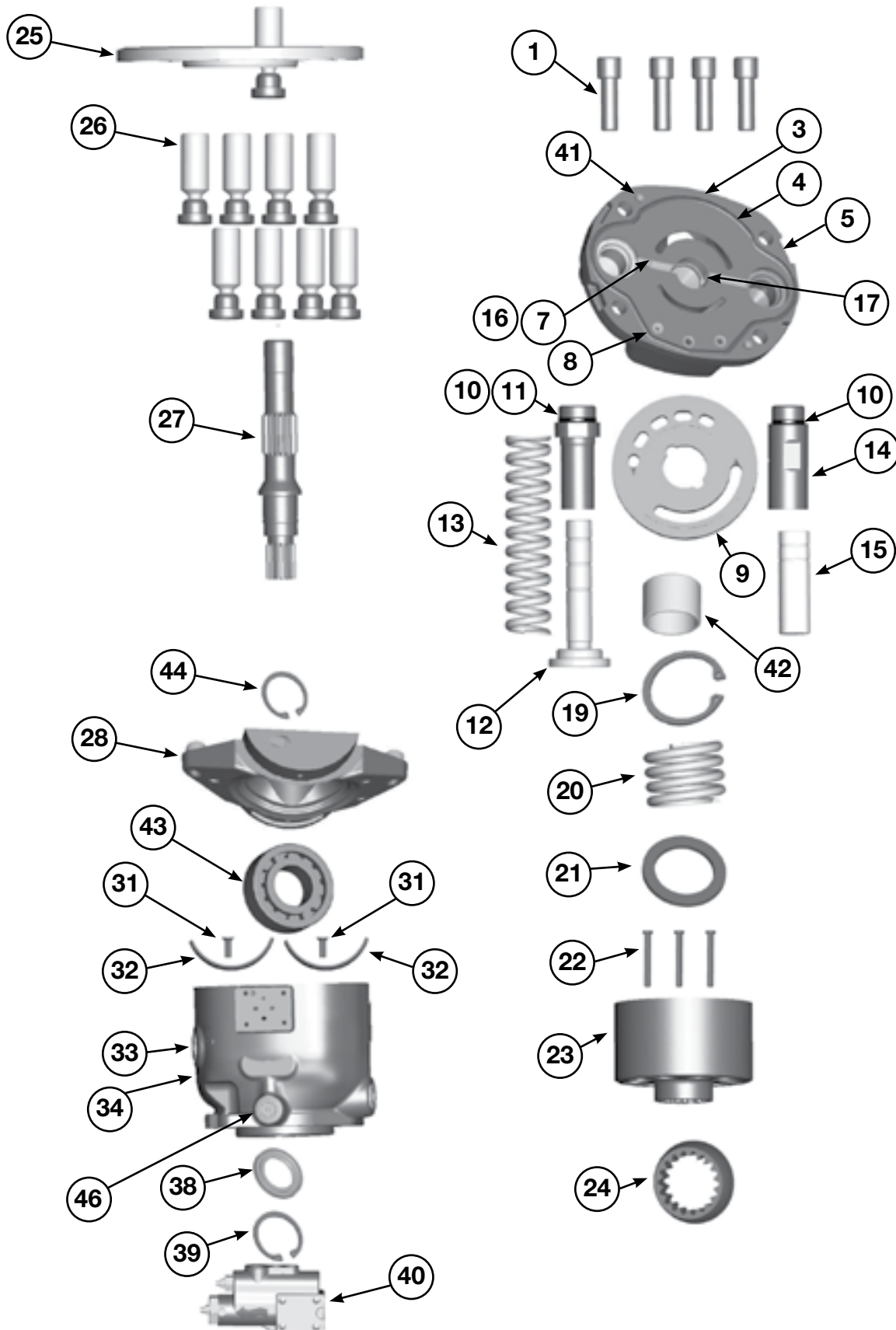
Model	P1/PD 018	P1/PD 028	P1/PD 045	P1/PD 060	P1/PD 075	P1/PD 100	P1/PD 140
Maximum Displacement, cm ³ /rev cu. in./rev	18 1.10	28 1.71	45 2.75	60 3.66	75 4.58	100 6.01	140 8.54
Outlet Pressure - Continuous	280 bar (4000 psi)						
Intermittent*	320 bar (4600 psi)						
Peak	350 bar (5000 psi)						
P1 Maximum Speed (1.3 bar abs inlet), rpm	3500	3400	3100	2800	2700	2500	2400
P1 (1.0 bar abs inlet), rpm	3300	3200	2800	2500	2400	2250	2100
P1 (0.8 bar abs inlet), rpm	2900	2900	2400	2200	2100	1900	1800
PD Maximum Speed (1.0 bar abs inlet), rpm	1800						
PD (0.8 bar abs inlet), rpm	1800						
Minimum Speed, rpm	600						
Inlet Pressure - Maximum	11 bar absolute (160 psi)						
Rated	1.0 bar absolute (14.5 psi)						
Minimum	0.8 bar absolute (11.6 psi)						
Case Pressure - Peak, bar	4.0 bar absolute (58 psi) and less than 0.5 bar (7.3 psi) above inlet pressure						
Rated, bar	2.0 bar absolute (29 psi) and less than 0.5 bar (7.3 psi) above inlet pressure						
Fluid Temperature Range, °C °F	-40 to +95 -40 to +203						
Fluid Viscosity - Rated, cSt	7 to 160						
Optimum Range, cSt	14-50 cSt.						
Max. Intermittent, cSt	5000 (for cold starting)						
Min. Intermittent, cSt	5						
Fluid Contamination - Rated, ISO	20/18/14						
Weight - End Port, kg (lb)	13.4 (29.5)	17.7 (39.0)	23 (50)	29 (64)	30 (66)	51 (112)	66 (145)
Side Port, kg (lb)	14.2 (31.3)	18.1 (40.0)	24 (52)	30 (67)	31 (68)	53 (117)	67 (147)
Thru-Drive, kg (lb)	15 (34)	22 (48)	27 (59)	34 (75)	35 (77)	55 (121)	82 (180)
Moment of Inertia kg·mm ²	760	1555	3208	4548	5041	12027	21400
Moment of Inertia Thru-Drive kg·mm ²	793	1618	3268	4687	5207	12402	22343

*Intermittent pressure is defined as less than 10% of operation time, not exceeding 6 successive seconds.

Typical Adjustment Ranges and Initial Settings (unless customer specified at time of order)

Function	Adjustment range	Adjustment value	Recommended or Initial Setting
Pressure compensator settings			
C, L, AM Controls	26-280 bar (380-4060 PSI)	55 bar/turn (800 PSI/turn)	Default factory setting = 1000 PSI
Load sense differential settings			
“L0”, “L2”	10-40 bar (150-580 PSI)	16 bar/turn (230 PSI/turn)	20 bar (290 PSI)
Maximum Volume stop			
018	100-40%	9% per turn (1.6 cc/turn)	100%
028	100-40%	8.2% per turn (2.3 cc/turn)	100%
045	100-20%	7.5% per turn (3.4 cc/turn)	100%
060	100-30%	6.8% per turn (4.1 cc/turn)	100%
075	100-35%	6.2% per turn (4.65 cc/turn)	100%
100	100-50%	5.5% per turn (5.5 cc/turn)	100%
140	100-50%	4.8% per turn (6.72 cc/turn)	100%
Minimum Volume stop			
018	0-68%	10% per turn (1.8 cc/turn)	0%
028	0-40%	9% per turn (2.6 cc/turn)	0%
045	0-40%	8.2% per turn (3.7 cc/turn)	0%
060	0-50%	4.6% per turn (2.76 cc/turn)	0%
075	0-45%	4.3% per turn (3.23 cc/turn)	0%
100	0-45%	3.9% per turn (3.9 cc/turn)	0%
140	0-25%	3.3% per turn (4.62 cc/turn)	0%

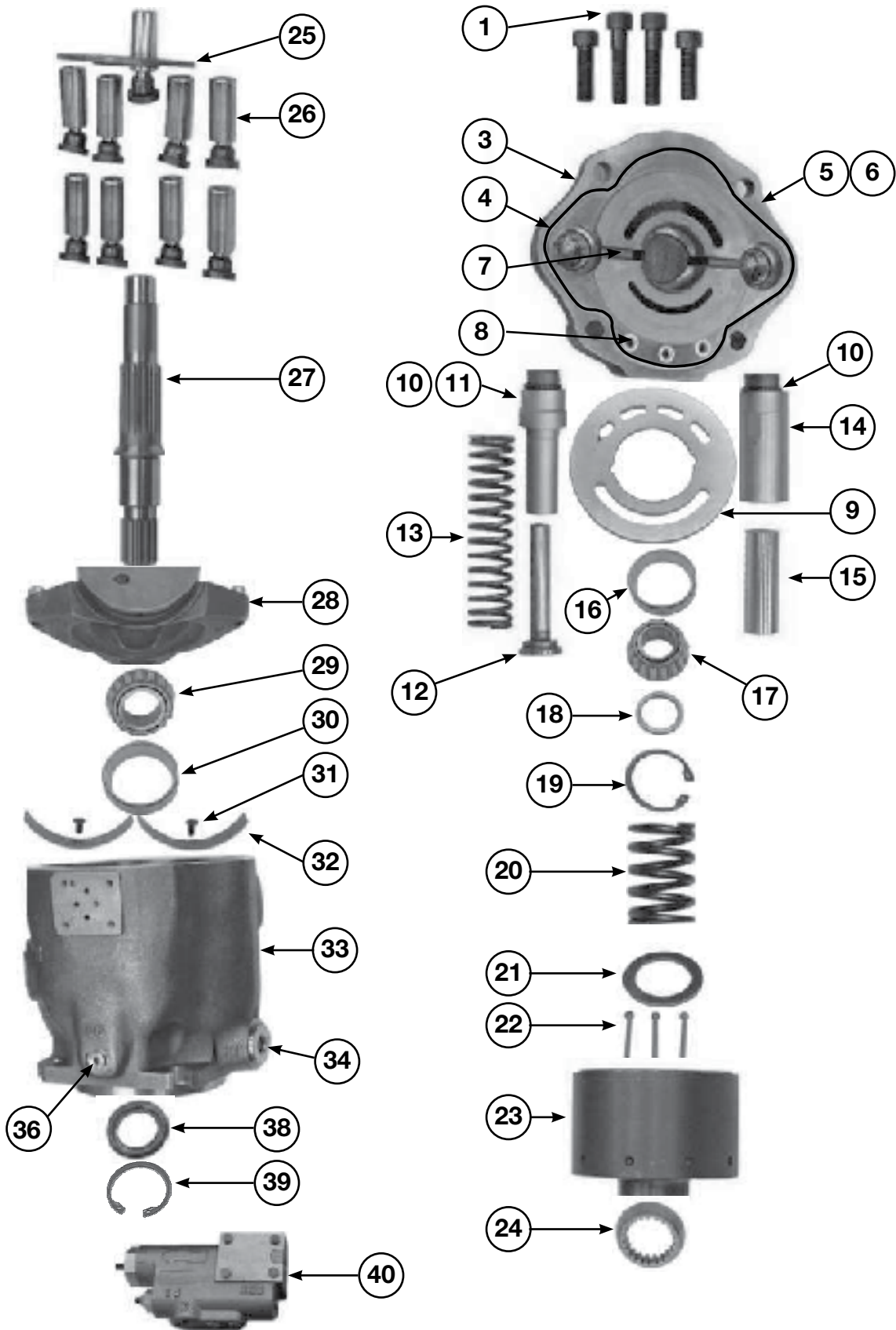




Item #	Qty.	018 Part #	028 Part #	045 Part #	Description
1	4	210X209	210X211	361-12229-0	Socket head cap screw
	4	**	210X209	**	Socket head cap screws (28cc thru drive version only)
3	1	Contact Factory for port block ordering information			Port block
4*	1	2050V-7	2160V-7	675-00162-0	Port block o-ring
5	2	108X2V	108X2V	108X2V	Boss plug & o-ring (not shown)
7	1	299X67	324-30014-0	324-30014-0	Port plate pin
8*	3	605-10077-0	605-10077-0	605-10077-0	Control pressure passage o-ring
9	1	03E-94415-0	03E-94969-0	03E-94339-0	Port plate, clockwise, industrial (PD)
		03E-94414-0	03E-94970-0	03E-94340-0	Port plate, counter clockwise, industrial (PD)
		03E-94413-0	03E-94969-0	03E-94341-0	Port plate, clockwise, mobile (P1)
		03E-94416-0	03E-94970-0	03E-94342-0	Port plate, counter clockwise, mobile (P1)
		03E-94963-0	03E-94376-0	03E-95374-0	Port plate, clockwise, industrial (PD), ripple chamber
		03E-94964-0	03E-94377-0	03E-95080-0	Port plate, counter clockwise, industrial (PD), ripple chamber
		03E-94965-0	03E-94378-0	03E-95374-0	Port plate, clockwise, mobile (P1), ripple chamber
10*	2	**	**	695-00912-0	Bias and control rod o-ring
11	1	03E-94427-0	03E-94390-0	03E-94355-0	Bias guide
		**	**	03E-95658-0	Bias guide (overcenter option)
12	1	03E-94428-0	03E-94391-0	03E-94354-0	Bias piston
13	1	03E-94430-0	03E-94393-0	03E-94356-0	Bias spring
		**	**	03E-95656-0	Bias spring (overcenter option)
14	1	03E-94427-0	03E-94390-0	03E-94353-0	Control guide
		**	**	03E-95657-0	Control guide (overcenter option)
15	1	03E-94426-0	03E-94389-0	03E-94352-0	Control piston
16	1	226X14	226X56	102X1	Ripple chamber set screw (plug for 45cc)
17	1	102X8V	102X8V	108X10V	Ripple chamber plug
19	1	256X521	256X525	356-65144-0	Retaining ring, internal
20	1	787635	03E-94387-0	03E-94350-0	Barrel hold down spring
21	2 (1:045)	786996	03E-94388-0	03E-94351-0	Barrel hold down washer
22	3	787000	03E-94386-0	03E-95903-0	Barrel hold down pin
23	1	03E-94717-0	03E-94375-0	03E-94338-0	Barrel
24	1	787002	03E-94385-0	03E-96852-0	Spherical washer
25	1	786994	03E-97011-0	03E-96988-0	Retainer plate
26	9	789641	S3E-18415-0	S2E-18413-0	Piston and shoe assembly
27	1	03E-94409-0	03E-94372-0	03E-94335-0	01 shaft option, no thru drive
		03E-94411-0	03E-94374-0	03E-94337-0	01 shaft option, with thru drive
		S2E-19657-0	S2E-19661-0	S2E-19665-0	02 shaft option , no thru drive
		S2E-19658-0	S2E-19662-0	S2E-19666-0	02 shaft option with thru drive
		S2E-19659-0	S2E-19663-0	S2E-19667-0	04 shaft option, no thru drive
		S2E-19660-0	S2E-19664-0	S2E-19668-0	04 shaft option with thru drive
		03E-94718-0	**	**	06 shaft option, no thru drive
		03E-96233-0	**	**	06 shaft option with thru drive
		03E-94804-0	03E-95166-0	03E-94990-0	08 shaft option, no thru drive
03E-94762-0	03E-95492-0	03E-95197-0	08 shaft option with thru drive		
28	1	S2E-19079-0	S2E-18414-0	S2E-18412-0	Cam
31	2	03E-94359-0	03E-94359-0	03E-94359-0	Bearing retainer screws
32	2	03E-94432-0	03E-94395-0	03E-94358-0	Cam bearing
33	1	**	**	**	Housing (not sold separately)
34*	2	108X6V	108X8V	108X10V	Case drain plug & o-ring - SAE ORB
		788153V	788161V	788161V	Case drain plug & o-ring - BSPP
		788516-06V	788516-10V	788516-10V	Case drain plug & o-ring - ISO
38*	1	787140	P2-060-3304	620-82125-5	Shaft seal
39	1	256X535	256X544	356-65158-0	Seal retainer
40	1	see separate compensator ordering information			Compensator
41	2	299X123	299X123	299X123	Cover dowel pin
42	1	216-10013-0	789814	230-82227-0	Port block bushing
43	1	230-82515-0	789815	230-82516-0	Cylindrical roller bearing
44	1	256X222	256X222	356-65159-0	External retaining ring (shaft)
45	1	256X544	256X544	**	Internal retaining ring (housing)
46*	1	108X4V	108X4V	108X4V	BG port plug & o-ring - SAE ORB
		789189V	789189V	789189V	BG port plug & o-ring - BSPP
		788516-04V	788516-04V	788516-04V	BG port plug & o-ring - ISO

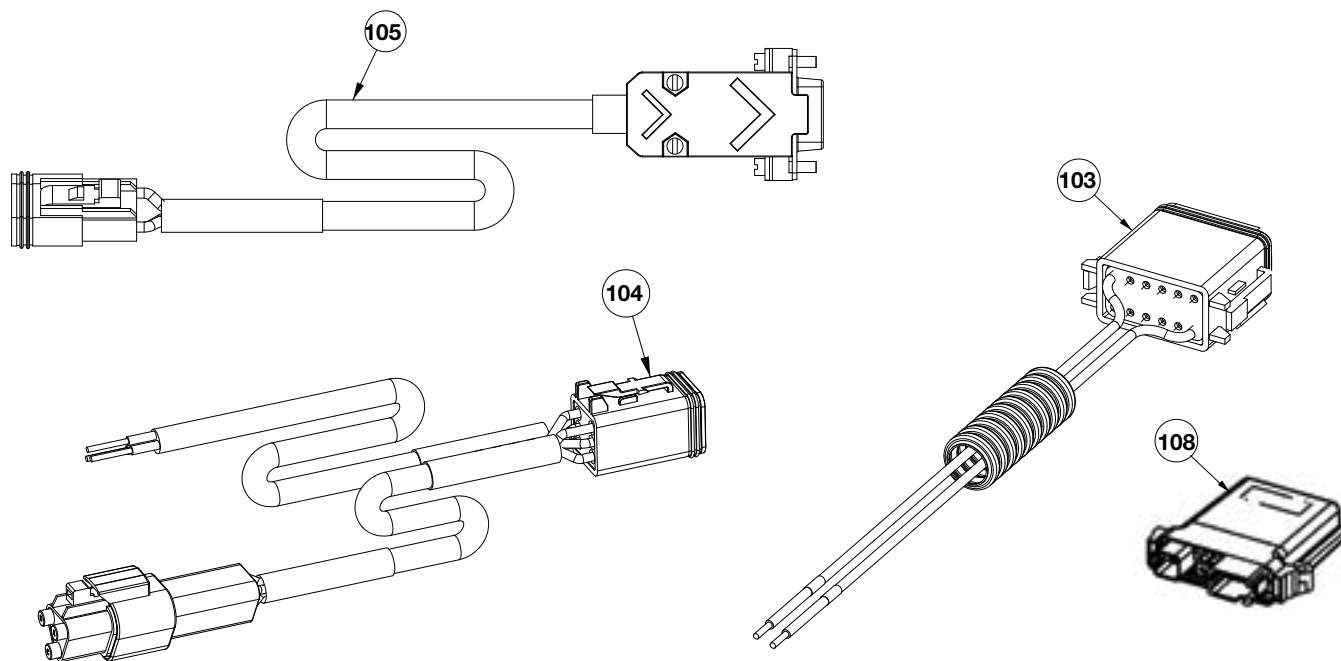
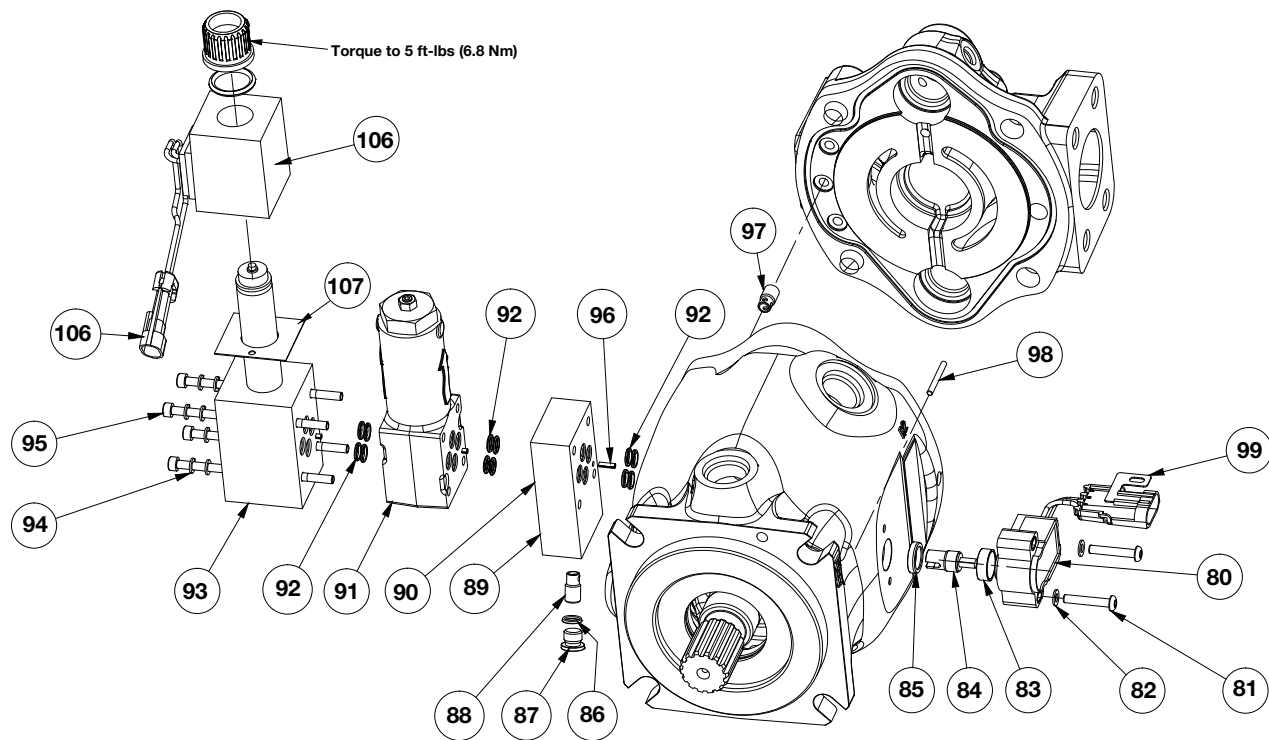
*Denotes seal or O-ring is included in the seal kit **Contact factory for 045 overcenter "X" port plate part number information





Item#	Qty.	060 Part #	075 Part #	100 Part #	140 Part #	Description
1	4 (2:075)	361-13250-0	361-13270-0	361-14290-0	361-15270-0	Socket head cap screw
	(2:075)	**	361-13250-0	**	**	
	4	361-13250-0	361-13250-0	361-14290-0	361-15267-0	Socket head cap screws (thru drive version only)
3	1	Contact factory for port block ordering information				Port block
4*	1	675-00164-0	675-00165-0	675-00169-0	675-00173-0	Port block O-ring
5*	2	108X2V	108X2V	108X2V	108X2V	Boss plug & o-ring (not shown)
6*	2	108X4V	108X4V	108X4V	108X4V	Boss plug & o-ring
7	1	324-30014-0	324-30014-0	324-30014-0	324-30014-0	Port plate pin
8*	3	605-10070-0	605-10070-0	605-10070-0	605-10070-0	O-ring
9	1	03E-94038-0	03E-93169-0	03E-95605-0	03E-93252-0	Port plate, clockwise, industrial (PD)
		03E-94039-0	03E-93170-0	03E-95606-0	03E-93253-0	Port plate, counter clockwise, industrial (PD)
		03E-94040-0	03E-93171-0	03E-95607-0	03E-93254-0	Port plate, clockwise, mobile (P1)
		03E-94041-0	03E-93172-0	03E-95608-0	03E-93255-0	Port plate, counter clockwise, mobile (P1)
10*	2	695-00912-0	695-00912-0	695-00914-0	695-00916-0	Bias and control rod o-ring
11	1	03E-94054-0	03E-93150-0	03E-93800-0	03E-93248-0	Bias guide
		03E-94832-0	03E-94498-0	03E-94827-0	03E-94743-0	Bias guide, overcenter option "X"
12	1	03E-94053-0	03E-93149-0	03E-93799-0	03E-94658-0	Bias piston
	1	03E-94835-0	03E-93149-0	03E-93799-0	03E-94658-0	Bias piston overcenter option "X"
13	1	03E-94055-0	03E-93151-0	03E-93801-0	03E-93963-0	Bias spring
		03E-94834-0	03E-94499-0	03E-94829-0	03E-94752-0	Bias spring overcenter option "X"
14	1	03E-94052-0	03E-93148-0	03E-93798-0	03E-97335-0	Control guide
	1	03E-94833-0	03E-94608-0	03E-94828-0	03E-93246-0	Control guide overcenter option "X"
15	1	03E-94051-0	03E-93147-0	03E-93797-0	03E-94751-0	Control piston
16*	1	108X4V	108X4V	108X4V	108X4V	Boss plug & o-ring
17	1	Included in Item 16		230-82518-0	Included in Item 16	Tapered roller bearing cone
18	1	S2E-18591-0K	S2E-18591-0K	S2E-18640-0K	S2E-18527-0K	Bearing shim kit (includes all standard shim sizes)
19	1	356-65152-0	356-65144-0	356-65146-0	356-65147-0	Retaining ring, internal
20	1	03E-94049-0	03E-93145-0	03E-93795-0	03E-93959-0	Barrel hold down spring
21	1	03E-94050-0	03E-93146-0	03E-93796-0	03E-93244-0	Barrel hold down washer
22	3	03E-95904-0	03E-95905-0	03E-95906-0	03E-95907-0	Barrel hold down pin
23	1	03E-94036-0	03E-93129-0	03E-95603-0	03E-93242-0	Barrel
24	1	03E-94047-0	03E-93142-0	03E-93794-0	03E-93241-0	Spherical washer
25	1	03E-97012-0	03E-93139-0	03E-93793-0	03E-93240-0	Retainer plate
26	9	S2E-18296-0	S2E-17003-0	S2E-17912-0	S2E-17323-0	Piston and shoe assembly
27	1	03E-94032-0	03E-93999-0	03E-93779-0	03E-93227-0	01 shaft option, no thru drive
		03E-94033-0	03E-94000-0	03E-93780-0	03E-93228-0	01 shaft option, with thru drive
		S2E-19669-0	S2E-19673-0	S2E-19677-0	S2E-19681-0	02 shaft option, no thru drive
		S2E-19670-0	S2E-19674-0	S2E-19678-0	S2E-19682-0	02 shaft option with thru drive
		S2E-19671-0	S2E-19675-0	S2E-19679-0	S2E-19683-0	04 shaft option, no thru drive
		S2E-19672-0	S2E-19676-0	S2E-19680-0	S2E-19684-0	04 shaft option with thru drive
		**	**	03E-94500-0	03E-95070-0	**
**	**	03E-94462-0	**	**	06 shaft option with thru drive	
28	1	S2E-18411-0	S2E-17443-0	S2E-17961-0	S2E-17957-0	Cam
29	1	230-82236-0	230-82236-0	230-82519-0	230-82241-0	Tapered roller bearing cone (and cup 140)
30	1	230-82235-0	230-82235-0	230-82245-0	**	Tapered roller bearing cup
31	2	03E-93763-0	03E-93763-0	03E-93763-0	03E-93763-0	Bearing retainer screws
32	2	03E-94057-0	03E-93950-0	03E-93952-0	03E-93953-0	Cam bearing
33	1	**	**	**	**	Housing (not sold separately)
34*	2	108X10V	108X12V	108X12V	108X16V	Case drain plug & o-ring - SAE ORB
		788175V	788175V	788175V	447-00038-5	Case drain plug & o-ring - BSPP
		788516-10V	788516-12V	788516-12V	788516-16V	Case drain plug & o-ring - ISO
36*	1	108X4V	108X4V	108X4V	108X4V	BG port plug & o-ring - SAE ORB
		789189V	789189V	789189V	789189V	BG port plug & o-ring - BSPP
		788516-04V	788516-04V	788516-04V	788516-04V	BG port plug & o-ring - ISO
38*	1	620-82118-5	620-82118-5	620-82121-5	620-82120-5	Shaft seal
39	1	356-65146-0	356-65146-0	356-65147-0	356-65148-0	Seal retainer
40	1	See separate compensator ordering information.				Compensator
*Denotes item is included in the seal kit						

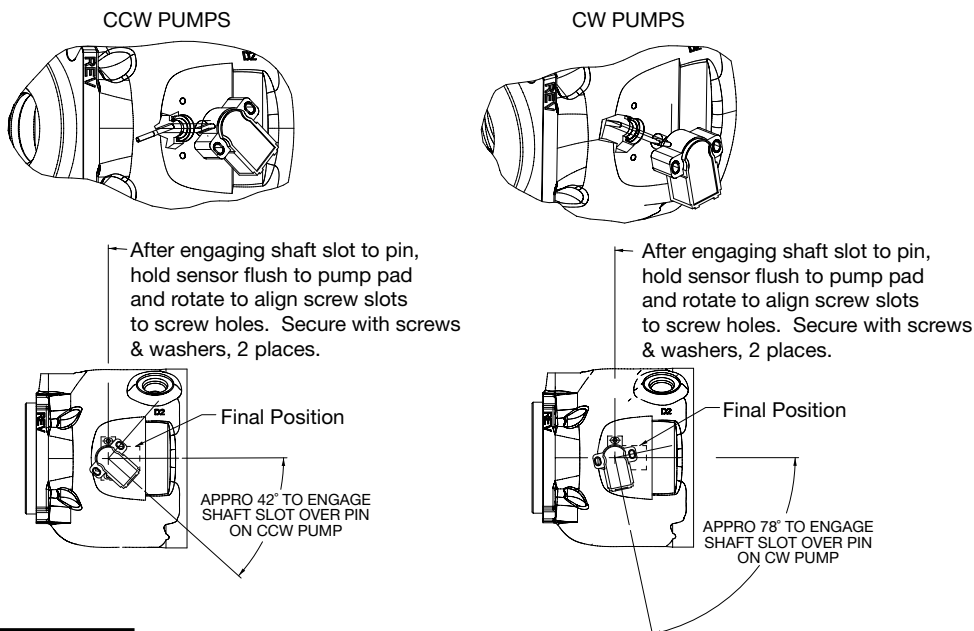


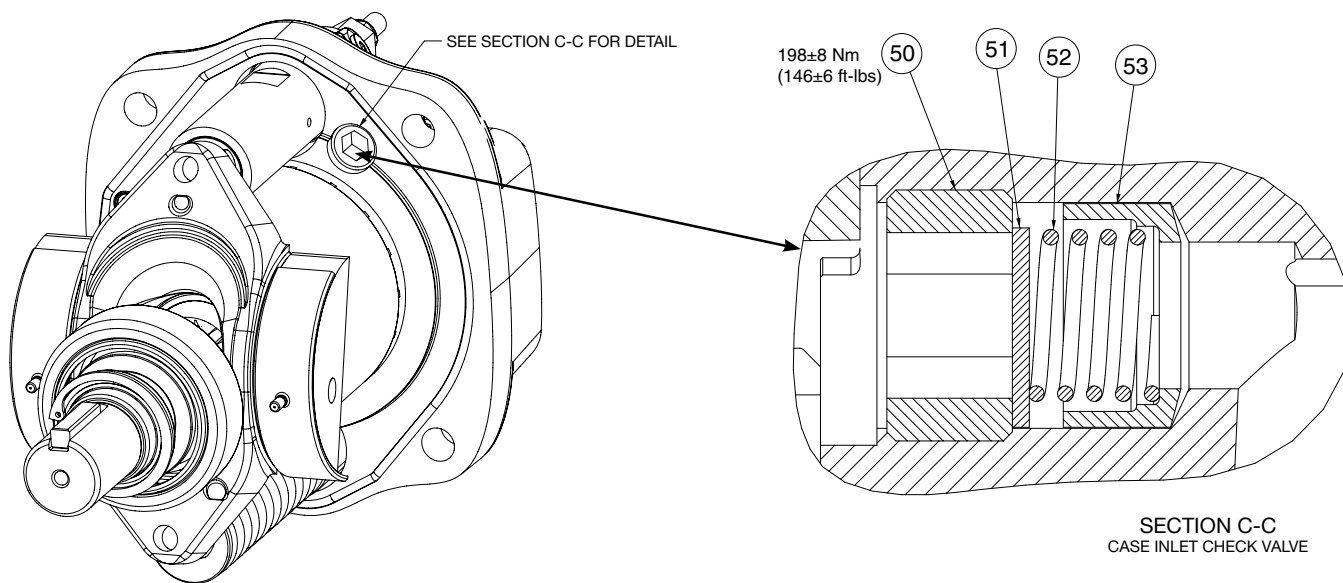


RDEC Parts List			
Item#	Qty.	Part #	Description
80	1	03E-95420-0	Rotary position sensor
81	2	210X73	Socket head cap screw
82	2	234X7	Washer
83	1	03E-95249-0	Position sensor spacer
84	1	03E-95201-0	Shaft position connector 18 and 45 thru 75
		03E-95545-0	Shaft position connector 28
		03E-95205-0	Shaft position connector 100 and 140
85	1	789764	Seal
86	1	675-00904-0	O-ring seal
87	1	108X4V	O-ring boss plug
88	1	S13-40266-0	Check valve
89	1	S2E-19182-5	External servo assembly*
90	1	03E-95347-0	External servo manifold
91	1	S2E-19174-5	Maximum pressure valve CCW
		S2E-19173-5	Maximum pressure valve CW
92	12	605-10069-0	O-ring seal
93	1	517-00178-5	Proportional valve 0 disp default CW
		517-00180-5	Proportional valve max disp default CW
		517-00179-5	Proportional valve 0 disp default CCW
		517-00181-5	Proportional valve max disp default CCW
94	8	350-10167-0	Lock washer
95	4	361-07360-8	M5X100 SHCS (Control options S, U, X, Z overcenter)
		361-07313-8	M5X75 SHCS (Control options S, U, X, Z)
		210X110	M5X60 SHCS (Control options P, T, W, Y overcenter)
		210X105	M5X35 SHCS (Control options P, T, W, Y)
96	1	325-36002-0	Roll pin
97	1	S13-40266-0	Check valve
98	1	03E-94859-0	Cam pin
99	1	S2E-19190-0K	Position sensor mating connector
100	1	S2E-19254-0	Electronic control unit (not shown)
101	1	S2E-19192-5K	Pressure sensor kit UNC threads (not shown)
		S2E-19523-5K	Pressure sensor kit BSPP threads (not shown)
		S2E-19191-0K	Pressure sensor mating connector (not shown)
103	1	S2E-19179-0	12 pin cable assembly
104	1	S2E-19259-0	CAN communication cable
105	1	S2E-19180-0	Control communication cable
106	1	1210694	Standard coil
107	1	121459	Gasket
108	1	S2E-19254-0	RDEC Electronic control module

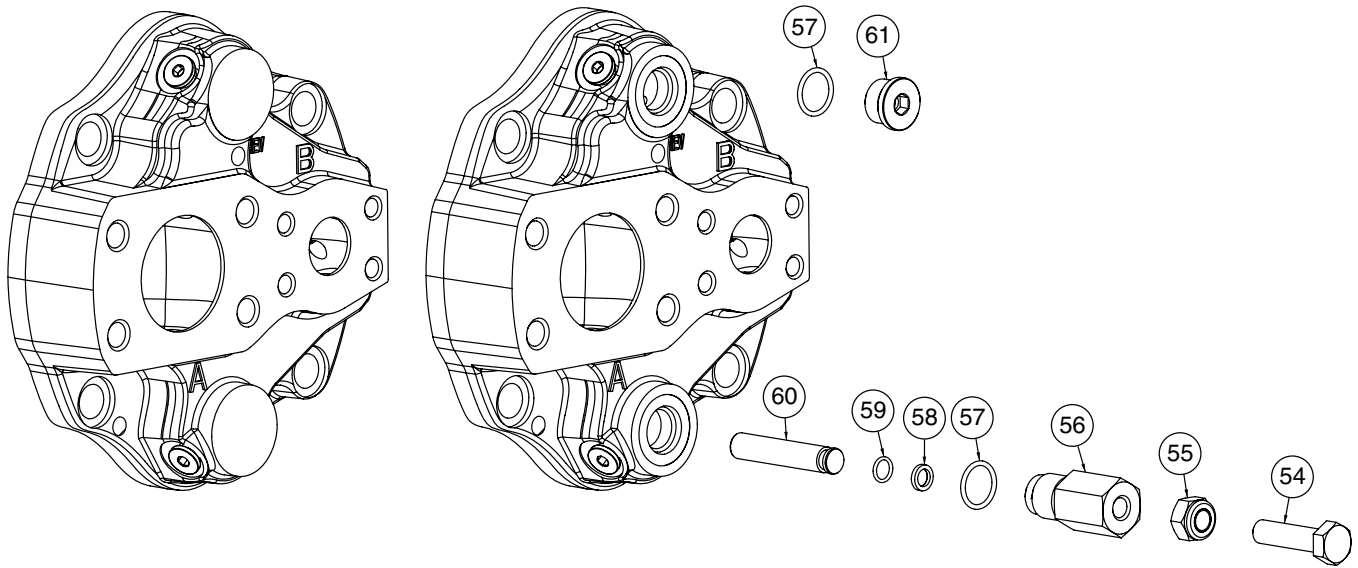
*Item 89 includes items 86, 87, 88, 90, 92 and 96

Displacement Sensor Installation



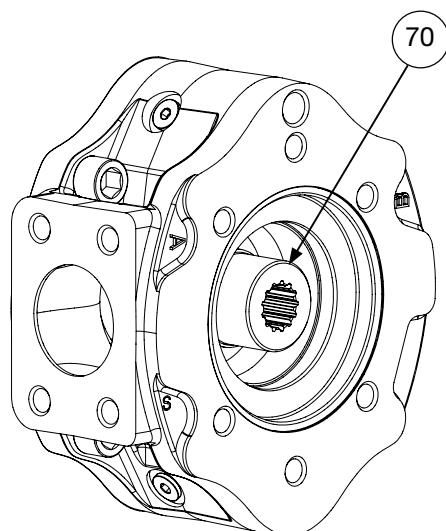


CASE TO INLET CHECK VALVE				
Item#	Qty.	018, 028, 045	060, 075, 100, 140	Description
50	1	314-10002-0	314-10000-0	Hollow set screw
51	1	03E-94720-0	03E-93931-0	Check valve poppet
52	1	03E-94721-0	03E-93987-0	Spring
53	1	03E-94722-0	03E-93988-0	Check valve stop



Volume Stop Kits									
Item #	Qty.	018	028	045	060	075	100	140	Description
54	1								Adjusting screw
55	1								Adjusting screw lock nut
56	1								Volume stop plug
57	1								Volume stop plug o-ring
58	1								Backup ring
59	1								Volume stop rod o-ring
60*	1								Volume stop rod
61	1								Plug (No volume stop)
Kit		S2E-19203-5K	S2E-19204-5K		S2E-19115-5K				Maximum volume stop kit
Kit		S2E-19608-5K	S2E-19609-5K		S2E-19115-5K				Minimum volume adjustment kit

*Min & max rods are the same for the 45 thru 140, but different for the 18 & 28.



Thru Drive Pad Coupling #70	Thru Drive Couplings							O-ring
	018	028	045	060	075	100	140	
SAE A, 9 Tooth	S2E-19538-0	S2E-19364-0	03E-94942-0	03E-93278-0	03E-93278-0	03E-94274-0	03E-93947-0	695-00237-0
SAE A, 11 Tooth	S2E-19726-0	S2E-19391-0	03E-94943-0	03E-94724-0	03E-94724-0	03E-94657-0	03E-95706-0	695-00237-0
SAE B, 13 Tooth	**	S2E-19365-0	03E-94945-0	03E-93277-0	03E-93277-0	03E-94273-0	03E-93946-0	695-00243-0
SAE BB, 15 Tooth	**	S2E-19409-0	03E-94361-0	03E-93279-0	03E-93279-0	03E-94272-0	03E-93945-0	695-00243-0
SAE C, 14 Tooth	**	**	**	03E-93276-0	03E-93276-0	03E-94271-0	03E-93944-0	695-00251-0
SAE CC, 17 Tooth	**	**	**	**	**	03E-94270-0	03E-93943-0	695-00251-0
SAE D&E, 13 Tooth	**	**	**	**	**	**	03E-93942-0	695-00259-0

A-mod Seal Kits	018	028	045	060	075	100	140
	S2E-18709-5K	S2E-19118-5K	S2E-19066-5K	S2E-18697-5K	S2E-18004-5K	S2E-18460-5K	S2E-18158-5K

Note: Seal kits contain all the seals required for any pump configuration.

Rotating Group Kits	018	028	045	060	075	100	140
CW Mobile P1	S2E-18710-0K	S2E-19119-0K	S2E-19067-0K	S2E-18698-0K	S2E-18032-0K	S2E-18485-0K	S2E-18489-0K
CW Mobile P1 with Ripple Chamber	S2E-19205-0K	S2E-19209-0K	S2E-19235-0K	**	**	**	**
CCW Mobile P1	S2E-18711-0K	S2E-19120-0K	S2E-19068-0K	S2E-18699-0K	S2E-18033-0K	S2E-18486-0K	S2E-18490-0K
CCW Mobile P1 w/ Ripple Chamber	S2E-19206-0K	S2E-19210-0K	S2E-19236-0K	**	**	**	**
CW Industrial PD	S2E-18712-0K	S2E-19121-0K	S2E-19069-0K	S2E-18700-0K	S2E-18483-0K	S2E-18487-0K	S2E-18491-0K
CW Industrial PD w/Ripple Chamber	S2E-19207-0K	S2E-19211-0K	S2E-19216-0K	**	**	**	**
CCW Industrial PD	S2E-18713-0K	S2E-19122-0K	S2E-19070-0K	S2E-18701-0K	S2E-18484-0K	S2E-18488-0K	S2E-18492-0K
CCW Industrial PD w/Ripple Chamber	S2E-19208-0K	S2E-19212-0K	S2E-19127-0K	**	**	**	**

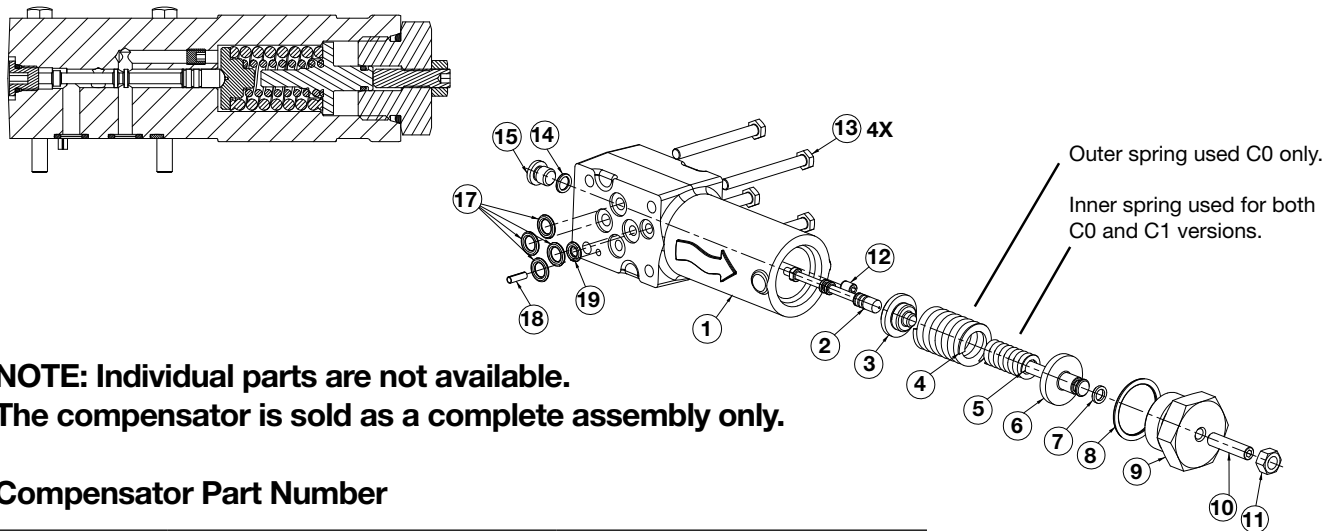
Rotating Group Kit includes barrel s/a, pistons, retainer, washer, pins, port plate

Torque Limiter Control Kits	045	060	075	100	140
Torque Limiter Kit for AMT Control	S2E-19102-5	S2E-19033-5	S2E-18720-5	S2E-18888-5	S2E-18963-5
Torque Limiter Kit for ALT Control	See Note		**	**	**
Torque Limiter Kit for LOT	**	**	S2E-18721-5	S2E-18759-5	S2E-18739-5

Torque Limiter Kits includes cartridge assembly, tubing and fittings.

Note: AM control can be converted to an AL control with conversion kit S2E-19117-0.

European customers will receive a solid spool in this kit. US customer will receive a set screw to plug orifice in spool.



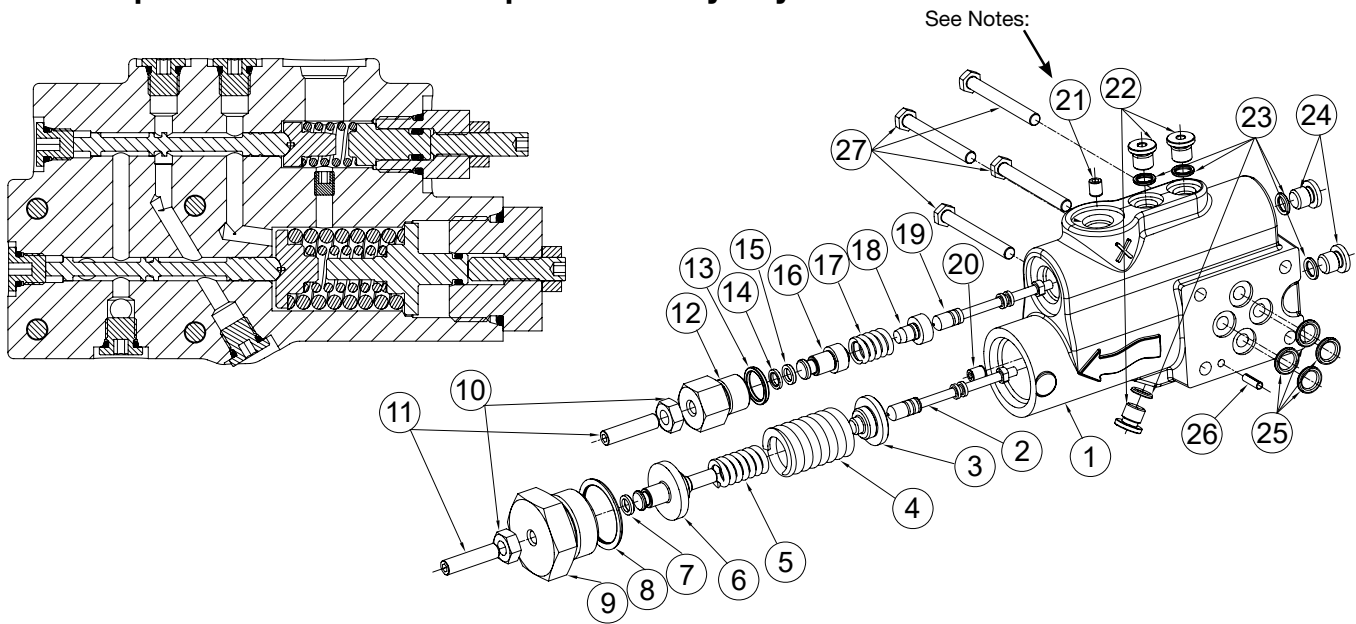
**NOTE: Individual parts are not available.
 The compensator is sold as a complete assembly only.**

Compensator Part Number

Rotation	C0 80 - 280 bar (1150 - 4000 psi)	C1 20 - 80 bar (300 - 1150 psi)
CW	S2E-19149-5T	S2E-18285-5T
CCW	S2E-19249-5T	S2E-18286-5T

Item No.	Qty.	Description	NOTES / Tightening Torque
1	1	Compensator body CW rotation	
		Compensator body CCW rotation	
2	1	Spool	
3	1	Spring seat	
4	1	Outer spring	C0 versions only
5	1	Inner spring	
6	1	Spring seat & piston	
7	1	Seal piston o-ring	
8	1	Spring cap o-ring	
9	1	Spring cap	115 ± 7 N·m (85 ± 5 ft-lbs)
10	1	Adjusting screw	
11	1	Adjusting screw lock nut	7.9 ± 0.8 N·m (70 ± 7 in-lbs)
12	1	Socket set screw	(Loctite 242) 3.4 ± 0.4 N·m (30 ± 3 in-lbs)
13	4	Hex mounting screw	5.0 ± 0.3 N·m (45 ± 3 in-lbs)
14	1	SAE #2 o-ring	
15	1	Hardened SAE #2 o-ring boss plug	4.0 ± 0.6 N·m (35 ± 5 in-lbs)
17	4	Teflon o-ring	
18	1	Roll pin	
19	1	Teflon o-ring	

**NOTE: Individual parts are not available.
 The compensator is sold as a complete assembly only.**



Compensator Part Number

Port	Rotation	L0	L1	L2
		80 - 280 bar (1150 - 4000 psi)	20 - 100 bar (300 - 1150 psi)	80 - 280 bar (1150 - 4000 psi)
SAE	CW	S2E-19051-5T	S2E-18245-5T	S2E-18584-5T
	CCW	S2E-19053-5T	S2E-18244-5T	S2E-18586-5T
ISO	CW	S2E-19467-5T	N/A	N/A
	CCW	S2E-19245-5T	N/A	N/A
BSPP	CW	S2E-17937-5T	N/A	N/A
	CCW	S2E-17936-5T	N/A	N/A

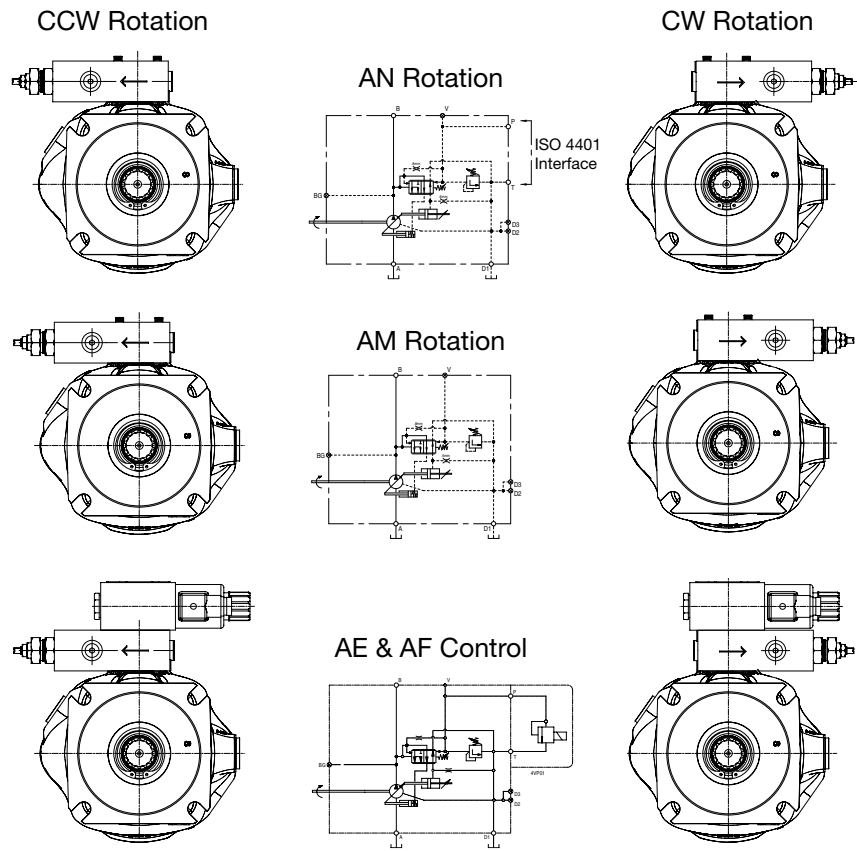
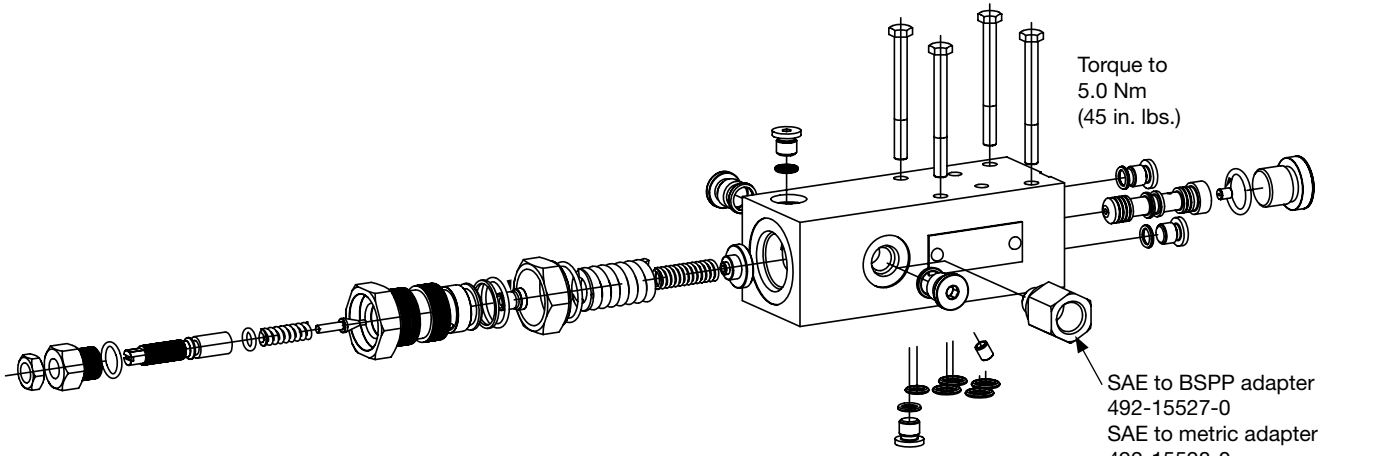
Item No.	Qty.	Description	NOTES / Tightening Torque
1	1	Compensator body	
2	1	Main compensator spool	
3	1	Main compensator spring seat	
4	1	Main compensator outer spring	Used on L0 and L2 versions only
5	1	Main compensator inner spring	
6	1	Main compensator spring seat & piston	
7	2	Compensator seal piston o-ring	
8	1	Main compensator spring cap o-ring	
9	1	Main compensator spring cap	115 ± 7 N·m (85 ± 5 ft-lbs)
10	2	Adjusting screw locknut	7.9 ± 0.8 N·m (70 ± 7 in-lbs)
11	2	Adjusting screw	
12	1	Load sense compensator spring cap	36.5 ± 1.5 N·m (27 ± 1 ft-lbs)
13	1	Load sense compensator spring cap o-ring	
14	1	Load sense compensator piston backup ring	
15	1	Load sense compensator piston o-ring	
16	1	Load sense compensator seal piston	
17	1	Load sense compensator spring	
18	1	Load sense compensator spring seat	
19	1	Load sense compensator spool	
20	1	Socket set screw	(Loctite 242) 3.4 ± 0.4 N·m (30 ± 3 in-lbs)
21	1	Socket set screw	L0 & L1 versions (Loctite 242) 3.4 ± 0.4 N·m (30 ± 3 in-lbs)
		Orifice	L2 version
22	3	SAE #2 o-ring boss plug	4.0 ± 0.6 N·m (35 ± 5 in-lbs)
23	5	SAE #2 o-ring	
24	2	Hardened SAE #2 o-ring boss plug	4.0 ± 0.6 N·m (35 ± 5 in-lbs)
25	4	Teflon o-ring	
26	1	Roll pin	
27	4	Hex mounting screw	5.0 ± 0.3 N·m (45 ± 3 in-lbs)

**NOTE: Individual parts are not available.
 The compensator is sold as a complete assembly only.**

Compensator Part Number

Rotation	AM*	AN*	AL*	AE*	AF*
CW	S2E-18745-5T	S2E-18743-5T	S2E-19107-5T	S2E-18747-5T	S2E-18749-5T
CCW	S2E-18746-5T	S2E-18744-5T	S2E-19106-5T	S2E-18748-5T	S2E-18750-5T

Note: To convert "AM*" to "AL*", use conversion kit S2E-19117-0



COMPENSATOR DISASSEMBLY

NOTES:

Access plugs on end of compensator spool bores are hardened plugs. Do not interchange with other plugs in the control.

For rotation change, the complete compensator assembly will need to be replaced.

Compensator Disassembly:

1. Measure and record the extension of the two pressure adjusting screws.
2. Carefully remove the main compensator spring cap. Remove the two springs. Remove the seal piston and spring seat. Remove the o-ring boss access plug on the opposite side of the compensator. Remove the compensator spool. NOTE: the compensator spool and inner spring are not interchangeable with the load sense compensator spool and spring.
3. For "L" series compensators: Carefully remove the load sense compensator spring cap with spring seat/seal piston. Remove the spring. Remove the spring seat. Remove the o-ring boss access plug on the opposite side of the compensator. Remove the load sense compensator spool. NOTE: the load sense compensator spool and spring are not interchangeable with the main compensator spool and inner spring of the main compensator.
4. Remove all SAE o-ring boss access plugs.

COMPENSATOR INSPECTION

NOTE: The compensator is supplied as an assembly. Individual parts are not available. If there is significant damage to any of the parts, the complete compensator will need to be replaced.

1. Inspect the main compensator spool and the load sense spool for scratches or other damage.
2. Inspect the springs for proper free extension length (see chart below).
3. Inspect the spool bores for damage. Apply a light oil film on the appropriate spool and check its fit in the bore. The spool should fit snugly in housing and not have any radial play.

COMPENSATOR SPRING FREE LENGTH			
Type	Item Number	Component	Tolerances
C*/L*	5	Main compensator spring - inner	Free height: 25.9 ± 0.5 mm (1.020 ± 0.020 in.)
C0/L0/L2	4	Main compensator spring - outer	Free height: 39 ± 0.7 mm (1.535 ± 0.028 in.)
L*	17	Load sense spring	Free height: 14 ± 0.4 mm (0.551 ± 0.016 in.)

Reference item numbers on page 18.

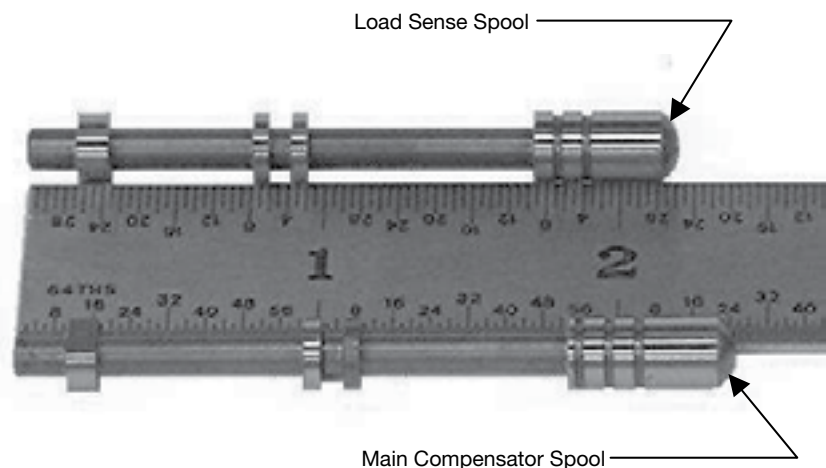


COMPENSATOR ASSEMBLY

NOTE: instructions are for load sense compensator. For other compensator types disregard steps related to extra spool assembly.

Carefully clean and dry all parts prior to assembly. Use caution to insure that spools and other parts are not damaged during cleaning process. Use clean oil to lubricate seals and spools for easier disassembly.

1. Remove and discard all o-rings. Install new o-rings on SAE boss plugs and seal pistons.
2. Apply a light film of oil to the o-ring on the main compensator seal piston. Install the main compensator seal piston in the main compensator spring cap.
3. Place inner compensator spring on seal piston. Install the outer compensator spring over the inner spring on the seal piston. Position the spring seal over the springs. Insert this assembly into the main compensator housing bore. Torque the main compensator spring cap to 169-183 Nm (125-135 ft.-lb.).
4. Apply a light film of oil on the main compensator spool (the longer of the 2 spools). Insert the spool into the spool bore opposite the main compensator spring assembly in the compensator body. The rounded end of the spool should be installed first so it will contact the spring seat. Install a new o-ring on the hardened SAE boss fitting and place it into the port. Torque fitting to 4 ± 0.5 Nm (37 ± 5 in-lb.).
5. Apply a light film of oil to the o-ring on the load sense seal piston. Install the load sense compensator seal piston seat in the load sense spring cap. Install the load sense spring over the seal piston. Position the spring seat over the spring. Install the assembly into the load sense bore of the compensator housing. Torque the load sense spring cap to 35-38 Nm (26-28 ft. lb.).
6. Apply a light film of oil to the load sense compensator spool (the shorter of 2 spools). Insert the spool into the spool bore opposite the load sense spring assembly. The spool should be installed with the rounded end in first so it will contact the load sense spring seat. Install a new o-ring on the hardened SAE boss fitting and place it into the port. Torque fitting to 4 ± 0.5 Nm (37 ± 5 in-lb.).
7. Install o-rings on remaining SAE boss fittings and install into housing. Torque SAE-2 fittings to 4 ± 0.5 Nm (37 ± 5 in-lb.).



PUMP DISASSEMBLY

Pump disassembly for inspection should be limited to the following cases:
a) Malfunction or oil leakage resulting from damage or wear and tear.
b) Troubleshooting procedures previously listed do not solve the problem.

For rotation change or shaft conversion, disassembly should be done only as far as necessary to complete conversion.

Disassembly and reassembly should be performed in a clean environment.

Caution: Spring assemblies in the pump are normally set under high compression and bodily injury may occur if caution is not taken during disassembly.

It is usually not necessary to replace spring (20) fitted in cylinder barrel. Do not replace the spring unless absolutely necessary.

After disassembly, the internal parts should be coated with a film of clean oil and protected from dirt and moisture.

It is recommended that the length of the protruding portion of the compensator adjusting screws, on the control 40 be measured and noted as this information will prove useful during assembly.

Care must be taken to avoid dropping, damaging or contaminating the machined parts and the control valve.

For complete overhaul, all o-rings and seals should be discarded and replaced.

1. Identify the pump from information on the data tag. Figure 1.



Figure 1

PUMP DISASSEMBLY
Continued

2. Drain fluid from housing. Fluid drained from pump should be disposed of properly.
3. Mount pump in fixture to prevent movement while removing main housing bolts.
4. Remove bolts holding the compensator assembly on the pump housing. Additional fluid may drain out of the passages when the compensator is removed. Set compensator aside for later disassembly and inspection.
5. Remove the bolts attaching the port block to the main housing.
6. Carefully remove the port block. Use caution to avoid dropping the port plate. Note the location of the bias spring - piston assembly and the control piston assembly. The control piston, bias piston and bias spring may remain in pump when port block is removed. Remove and discard the three white Teflon seals on the port block. These seals should be replaced each time the pump is disassembled.
7. Remove the control piston and the bias piston - spring assembly.
NOTE: For rotation change only, do not disassemble further, proceed to step 14.
8. Position the pump horizontally and remove the rotating group. Avoid separating the pistons from the barrel if possible. This will assist in identifying damage between an individual piston and bore during component inspection.
- 8a. If completing a seal change or complete overhaul on a **045** pump turn housing over and remove the snap and shaft seal from the housing before moving on to step 9.
9. Remove cam from housing. See Figure 2.

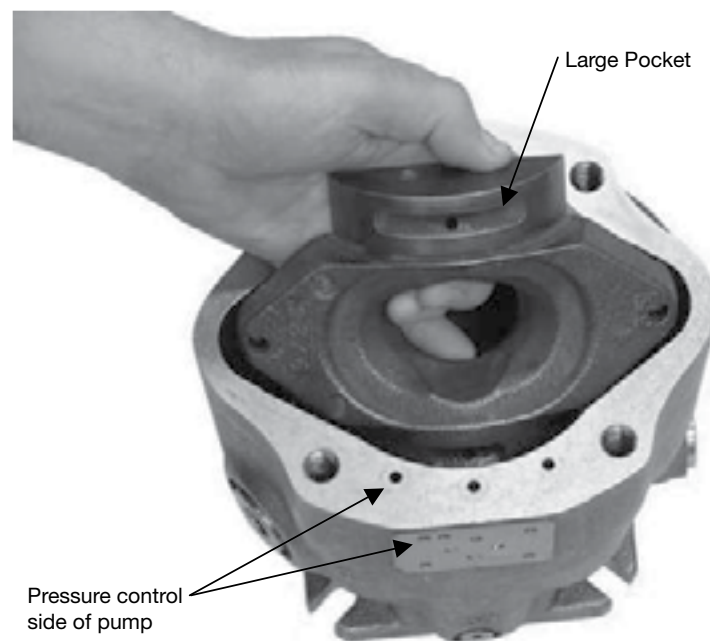


Figure 2

PUMP DISASSEMBLY
Continued

10. Remove cam bushing screws and cam bushings from pump.
11. Remove snap ring in housing and shaft bearing assembly.
12. If completing a seal change or a complete overhaul turn the housing over and remove the snap ring and shaft seal from the housing.
 - 12a. If you are working on an **045** pump please omit this step as this has already been completed in step 8a.
 - 12b. Always use a new shaft seal. Do not reuse old shaft seal.
13. If there is excessive wear on the port block bushing; remove the bushing from the port block.
14. If complete overhaul or rotation change, remove control piston and bias piston guides. The Control piston and bias piston guides are installed with Anaerobic thread lock. Place the port block in an oven at 163°C (325°F).

NOTE: to prevent annealing of heat treated surfaces DO NOT USE A TORCH TO HEAT PISTON GUIDES. (45 Size only)

COMPENSATOR DISASSEMBLY **NOTES:** Access plugs on end of compensator spool bores are hardened plugs. Do not interchange with other plugs in the control. For rotation change, the complete compensator assembly will need to be replaced.

1. Measure and record the extension of the two pressure adjusting screws.
2. Carefully remove the main compensator spring cap. Remove the two springs. Remove the seal piston and spring seat. Remove the o-ring boss access plug on the opposite side of the compensator. Remove the compensator spool. NOTE: the compensator spool and inner spring are not interchangeable with the load sense compensator spool and spring.
3. Load sense compensator: Carefully remove the load sense compensator spring cap with spring seat/seal piston. Remove the spring. Remove the spring seat. Remove the o-ring boss access plug on the opposite side of the compensator. Remove the load sense compensator spool. NOTE: the load sense compensator spool and spring are not interchangeable with the main compensator spool and inner spring of the main compensator.
4. Remove all SAE o-ring boss access plugs.

Proceed to inspection section of this manual.

PUMP INSPECTION PROCEDURES

Carefully clean and dry all parts prior to inspection. Refer to chart 1 for dimensional information regarding allowable tolerances.

1. Examine piston diameters for scratches or gouges. If any piston is severely damaged, note which piston bore it came out of. Extra attention should be given to that bore in step 2. Check end play of piston shoe assembly. Check the bottom surface of the shoes for damage. The shoe surface should be square and flat. Measure the depth of the pocket of the shoe. Shoes may be lapped as a set if the pocket depth is within allowable limits. Confirm pocket depth after lapping to insure it is still within limits.
2. Examine the bores in cylinder for scratches. Check diameter of bores in 4 different locations, including near the bottom of the barrel where the piston does not travel. If the dimensions vary by more than 0.0102 mm (0.0004 in.) or any dimension exceeds the allowable limit, the barrel needs to be replaced. Examine the barrel face for scratches and gouges. The barrel can be reworked if dimensions are within specifications listed in chart 1.
3. The port plate can be lapped lightly if the face is only lightly scratched, otherwise it should be replaced.
4. Examine the retainer plate in the area of contact with the piston shoes. Any marks beyond light polishing indicate that replacement is necessary. Check the surface of the spherical area of the retainer plate and the spherical guide ball. Inspect the back surface of the spherical guide ball where the load pins make contact. If indentations are present, replace the guide ball.
5. Examine cam on top and bottom surface. If scratches or gouges appear to penetrate the surface treatment, the cam must be replaced.
6. The cam bearings cannot be reworked and should be replaced if worn through the Teflon surface.
7. Both the bias piston and the compensator piston should move freely in their respective bores. The pistons and bores should be free of scratches or gouges.
8. The seal area of the drive shaft should be smooth and not have marks due to seal wear. Keyed shafts should be inspected for signs of brinelling and damage to the key area. Splined shafts may have a contact wear pattern but should not show excessive wear on the spline area.

NOTE: Spinning on shaft for P1/PD-018, 028 and 045 the cylindrical bearing should not have any signs of roller spalling, brinelling or discoloration. The bearing should be free to rotate without bind or rough feel

COMPENSATOR INSPECTION

NOTE: The compensator is supplied as an assembly. Individual parts are not available. If there is significant damage to any of the parts, the complete compensator will need to be replaced.

1. Inspect the main compensator spool and the load sense spool for scratches or other damage.
2. Inspect the springs for proper free extension length (see chart on page 17).
3. Inspect the spool bores for damage. Apply a light oil film on the appropriate spool and check its fit in the bore. The spool should fit snugly in housing and not have any radial play.

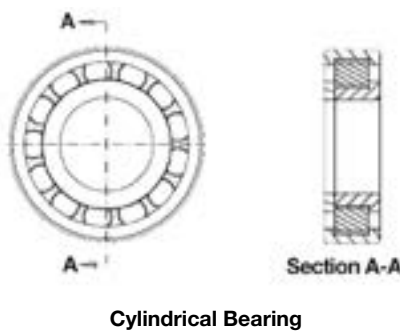
PUMP ASSEMBLY PROCEDURES

For major overhauls, all plugs should be removed, and the seals replaced. Prior to assembly, all parts should be thoroughly cleaned. Assembly should be performed in a clean work environment.

Do not use bearing grease during installation. Grease does not dissolve in hydraulic oil and may plug orifices or filters in the system. Clean petroleum jelly is preferred to lubricate o-rings and seals, and to adhere parts for assembly.

NOTE: For fluids other than petroleum based hydraulic oil, insure that petroleum jelly is compatible with the fluid. If not compatible, another product should be used instead.

Inspect all bearing surfaces and seal areas to insure that they are free from nicks, dings, scratches, and rust.



Cylindrical Bearing

1. Turn housing over. Using installation tool T1, press the shaft seal in the seal bore. Install the snap ring into the groove in the seal housing bore. **NOTE:** Install shaft and bearing on 45 unit before installing shaft seal. T1 tool not used on 45 unit, use T3 tool to insert shaft seal over input shaft.
2. Install cylindrical bearing on pump shaft (slip fit). Install external retaining ring to hold bearing in place on the shaft. Insert shaft assembly into the pump housing with the bearing sliding into the bearing diameter in the housing. Install internal retaining ring into the housing. (See drawing).
3. If barrel hold down spring was removed during disassembly process, install three pins to slots in barrel spline (45 size only). Petroleum jelly can be used to hold pins in place while installing remaining parts. (Figure 4) Place barrel on fixture with pin side down. Install backup washer and hold down spring and second back up washer. Compress spring in press and install snap ring. **Caution:** Make sure snap ring is properly seated in groove prior to removing barrel from press.



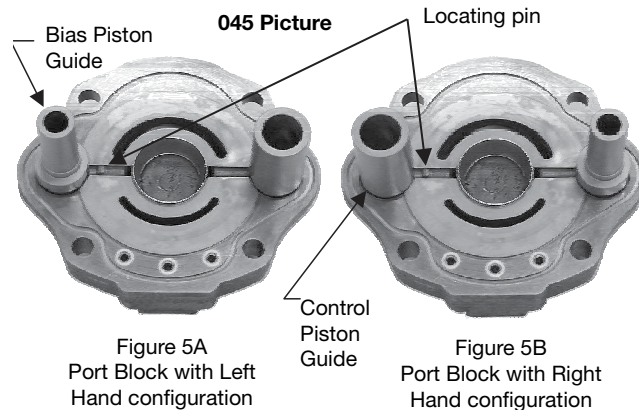
Figure 4

4. Apply a light film of oil into the piston bores. Lightly lubricate the spherical surface of the guide ball. Install the nine pistons into the bores in the hold down plate. Install the spherical guide ball into the hold down plate. While holding the guide ball against the hold down plate, install the pistons into the barrel

**PUMP ASSEMBLY
 PROCEDURES**
 continued

Chart 2	
Pump	Control and bias guide torque
018	Press Fit
028	Press Fit
045	142 Nm (105 ft lbs)

5. Install the locating pin on the port block face.
6. For 045: Apply Loctite Primer Grade T to guide threads and allow to dry. Install unlubricated o-rings on the control guide and bias guide. Apply Loctite 271 to guide threads. For left hand rotation the bias guide is installed nearest to the dowel pin (Figure 5A). For right hand rotation the control guide is installed nearest to the dowel pin (Figure 5B). Torque the control and bias guides as specified in Chart 2. For 018, 028: The guides are identical and press fit into the holes. (Not shown in picture below).



7. Apply light oil film to control piston and install it in the control guide bore.
8. Apply light oil film to the bias piston. Install the bias spring and the bias piston in the bias piston guide bore.
9. Apply a light layer of petroleum jelly to the back surface of the port plate. Install the port plate on the port block, lining up the slot on the port plate with the locating pin. (Refer to Figure 6).

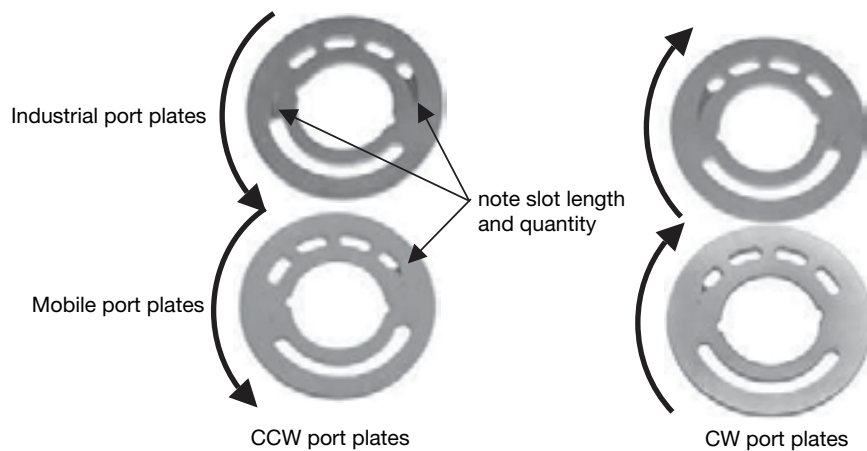


Figure 6

10. Install the large o-ring in the groove on the port block. Install the three teflon o-rings on the pressure communication ports of the port block.

PUMP ASSEMBLY PROCEDURES
 continued

Chart 3	
Pump	Housing bolt torque
018	51 Nm (38 ft lbs)
028	70 Nm (52 ft lbs)
045	85 Nm (63 ft lbs)

11. Install the cam bearings in the cradle area of the housing. The chamfer on the back of the bearing must face the outer wall of the housing. Use Loctite Primer Grade "T" or other suitable primer on screws and mating threads in housing. Apply Loctite #242 (use sparingly) to screw threads and install orifice screws to hold bearings in place. Torque screws to 3.4 ± 0.25 Nm (33 ± 3 in-lb).
12. Place thin film of clean oil on cam bearing surfaces. Install cam in housing. For 045, the cam must be tilted to permit entry into the housing. (Figure 2).
NOTE: The large pocket on the bottom surface of the cam must be on the same side as the three pressure communication holes on the main housing. Pump rotation does not affect the assembly of the cam.
13. Install the drive shaft into the pump housing. Position pump horizontally. Install the rotating group over the pump shaft. Rotate the barrel to insure that it is seated against the cam. Insure that the pump shaft is seated properly in the front bearing.
14. Confirm that compensator rotation, port plate rotation, control and bias piston location indicate same direction of rotation.
15. Carefully install the assembled port block on the pump housing. Press the port block to compress the bias spring and install housing bolts. Tighten the bolts in a cross pattern to insure the port block does not get cocked on the housing. When port block is seated on the housing, torque bolts in a cross pattern as specified in chart 3.
16. Install o-ring seals and assembled compensator on side of pump housing. Pump rotation is indicated by arrow on compensator housing. Torque bolts to 5 ± 0.25 Nm (45 ± 3 in-lb). (See Figure 7).

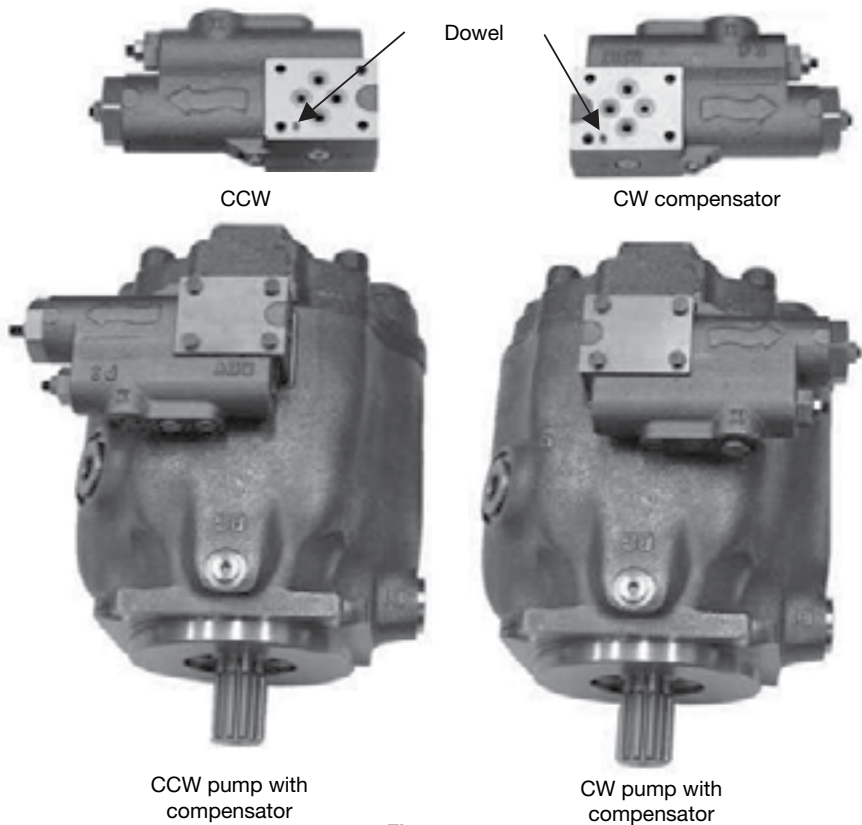
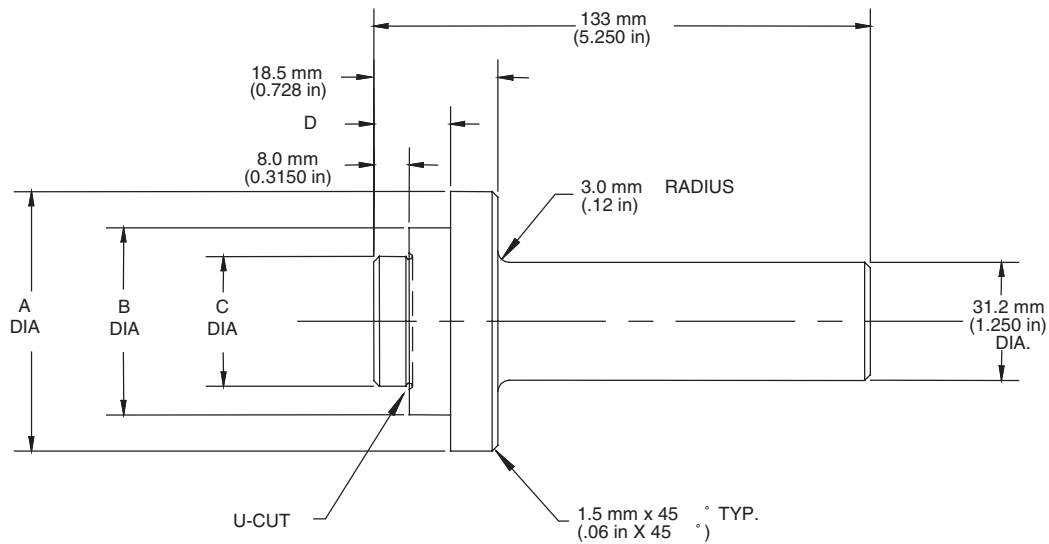


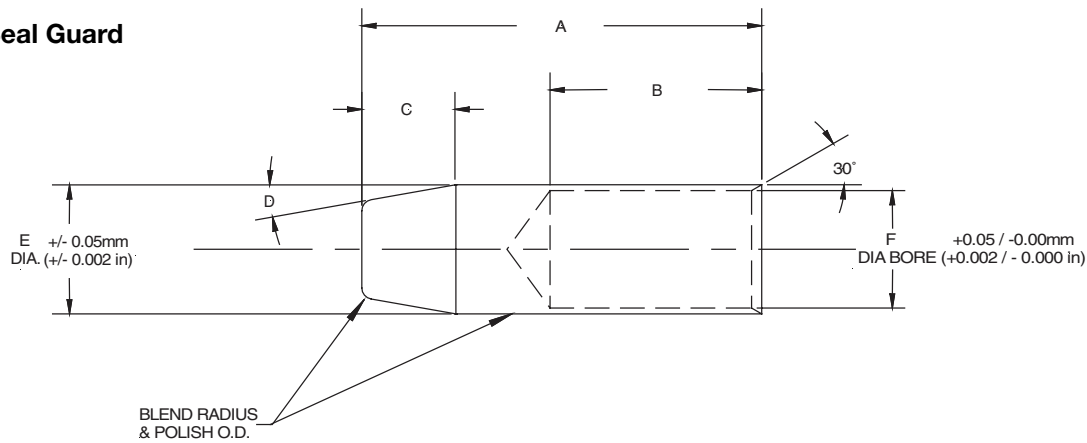
Figure 7

T1 Seal Installation Tool



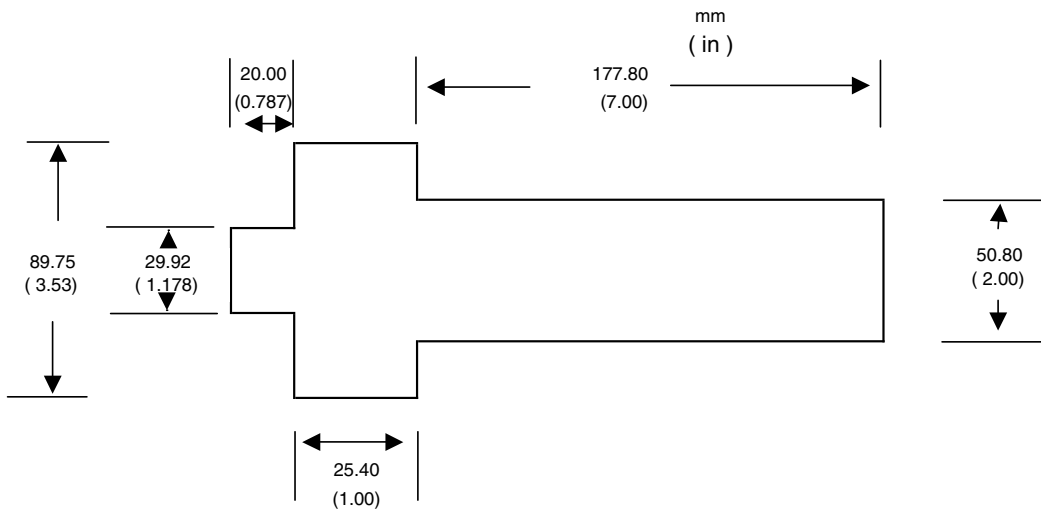
T1 Seal installation tool	A	B	C	D
(018)	2.250	1.62	1.180	0.406
(028)	2.250	2.00	1.378	0.447

T3 Seal Guard

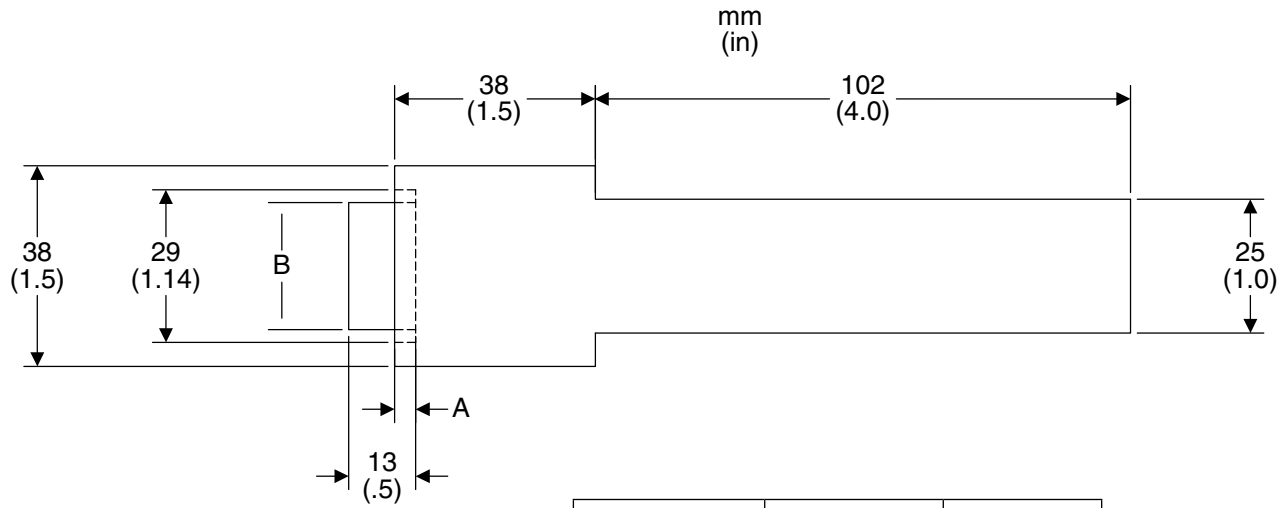


Pump Model	A	B	C	D	E	F
018 "01", "02", "04" Shafts	76.20 mm 3.00 in.	50.80 mm 2.00 in.	19.05 mm 0.75 in.	15°	28.82 mm 1.135 in.	20.45 mm 0.805 in.
018 "06" Shaft	76.20 mm 3.00 in.	50.80 mm 2.00 in.	19.05 mm 0.75 in.	15°	28.82 mm 1.135 in.	16.76 mm 0.66 in.
028 / 045 "01", "02", "04" Shafts	76.20 mm 3.00 in.	50.80 mm 2.00 in.	19.05 mm 0.75 in.	15°	38.10 mm 1.50 in.	26.00 mm 1.024 in.
018 / 028 / 045 "08" Shaft	76.20 mm 3.00 in.	50.80 mm 2.00 in.	19.05 mm 0.75 in.	15°	28.82 mm 1.135 in.	22.50 mm 0.885 in.

T2 Front Bearing P1/PD045 Installation Tool



T5 Rear Bushing Installation Tool



Pump Size	A	B
018	3.71 mm 0.146 in.	19.9 mm 0.772 in.
028	4.00 mm 0.157 in.	21.6 mm 0.85 in.
045	4.00 mm 0.157 in.	24.1 mm 0.95 in.

PUMP DISASSEMBLY NOTES

- A. Pump disassembly for inspection should be limited to the following cases:
 - a) Malfunction or oil leakage resulting from damage or wear and tear.
 - b) Troubleshooting procedures previously listed do not solve the problem
- Caution: Spring assemblies in the pump are normally set under high compression and bodily injury may occur if caution is not taken during disassembly.**
- B. For rotation change or shaft conversion, disassembly should be done only as far as necessary to complete conversion.
 - C. Disassembly and reassembly should be performed in a clean environment.
 - D. It is usually not necessary to replace spring (20) fitted in cylinder barrel. Do not replace the spring unless absolutely necessary.
 - E. After disassembly, the internal parts should be coated with a film of clean oil and protected from dirt and moisture.
 - F. It is recommended that the length of the protruding portion of the compensator adjusting screws, be measured and noted, as this information will prove useful during assembly.
 - G. Care must be taken to avoid dropping, damaging or contaminating the machined parts and the control valve.
 - H. For complete overhaul, all o-rings and seals should be discarded and replaced.

PUMP DISASSEMBLY PROCEDURE

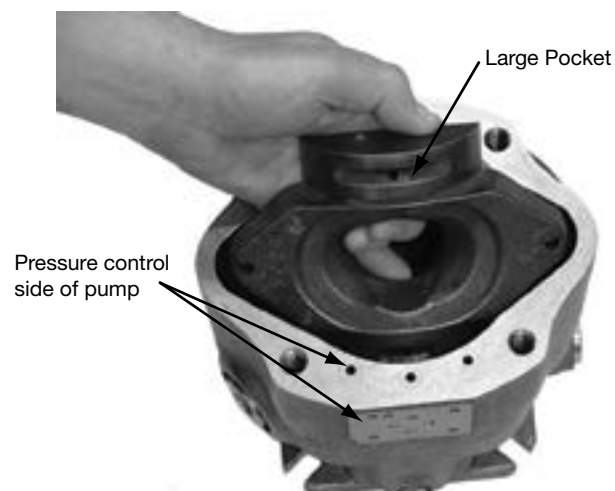
1. Identify the pump from information on the data tag. Figure 1.
2. Drain fluid from housing. Fluid drained from pump should be disposed of properly.
3. Mount pump in fixture to prevent movement while removing main housing bolts.
4. Remove bolts holding the compensator assembly on the pump housing. Additional fluid may drain out of the passages when the compensator is removed. Set compensator aside for later disassembly and inspection.
5. Remove the bolts attaching the port block to the main housing.



Figure 1 Pump Data Tag

**PUMP DISASSEMBLY
PROCEDURE**
(continued)

6. Carefully remove the port block. Use caution to avoid dropping the port plate. Note the location of the bias spring - piston assembly and the control piston assembly. The control piston, bias piston and bias spring may remain in pump when port block is removed. Remove and discard the three white Teflon seals on the port block. These seals should be replaced each time the pump is disassembled.
7. Remove the control piston and the bias piston - spring assembly.
NOTE: For rotation change only do not disassemble further, proceed to step 16.
8. Remove the tapered roller bearing cone and shim from the end of the shaft.
9. Position the pump horizontally and remove the rotating group. Avoid separating the pistons from the barrel if possible. This will assist in identifying damage between an individual piston and bore during component inspection.
10. Remove the drive shaft.
NOTE: For shaft change only, no further disassembly is required. Proceed to assembly procedure step 5.
11. Remove the cam by rotating it 90 degrees and carefully extracting it from the pump housing. Note the large pocket under the cam fits on the pressure control side of the pump housing (same side as the three seals on the housing flange). Figure 2.
12. Remove the front tapered roller bearing cone.
13. If there is excessive wear or damage, remove the tapered roller bearing cup from the bottom of the housing.
14. If completing a seal change or complete overhaul, turn the housing over and remove the snap ring and shaft seal from the housing. Note: do not reuse the shaft seal.
15. If there is excessive wear on the port block bearing cup, cone, or both; remove the tapered roller bearing cup from the port block.
16. If complete overhaul or rotation change, remove control piston and bias piston guides. The control piston and bias piston guides are installed with anaerobic thread lock. Place the port block with piston guides in oven at 163°C (325°F).
NOTE: To prevent annealing of heat treated surfaces. DO NOT USE A TORCH TO HEAT PISTON GUIDES.



PUMP INSPECTION PROCEDURE

Carefully clean and dry all parts prior to inspection.

Refer to chart 1 for dimensional information regarding allowable tolerances.

1. Examine piston diameters for scratches or gouges. If any piston is severely damaged, note which piston bore it came out of. Extra attention should be given to that bore in step 2. Check end play of piston shoe assembly. Check the bottom surface of the shoes for damage. The shoe surface should be square and flat. Measure the thickness of the shoe. Shoes may be lapped as a set if the thickness is within allowable limits. Confirm shoe thickness after lapping to insure it is still within limits.
2. Examine bores in cylinder for scratches. Check diameter of bores in 4 different locations, including near the bottom of the barrel where the piston does not travel. If the dimensions vary by more than 0.0102 mm (0.0004 in.) or any dimension exceeds the allowable limit, the barrel needs to be replaced. Examine the barrel face for scratches and gouges. The barrel can be reworked if dimensions are with specifications listed in chart 1.
3. The port plate can be lapped lightly if the face is only lightly scratched, otherwise it should be replaced.
4. Examine the retainer plate in the area of contact with the piston shoes. Any marks beyond light polishing indicate that replacement is necessary. Check the surface of the spherical area of the retainer plate and the spherical guide ball. Inspect the back surface of the spherical guide ball where the load pins make contact. If indentations are present replace the guide ball.
5. Examine cam on top and bottom surface. If scratches or gouges appear to penetrate the surface treatment, the cam must be replaced.
6. The cam bearings cannot be reworked and should be replaced if worn through the Teflon surface.
7. Both the bias piston and the compensator piston should move freely in their respective bores. The pistons and bores should be free of scratches or gouges.
8. The seal area of the drive shaft should be smooth and not have marks due to seal wear. The bearing surfaces should not have any indication of the bearing cone spinning on the shaft. Keyed shafts should be inspected for signs of brinelling and damage to the key area. Splined shafts may have a contact wear pattern but should not show excessive wear on the spline area.

PUMP ASSEMBLY PROCEDURE

For major overhauls, all plugs should be removed, and the seals replaced. Prior to assembly, all parts should be thoroughly cleaned. Assembly should be performed in a clean work environment.

Do not use bearing grease during installation. Grease does not dissolve in hydraulic oil and may plug orifices or filters in the system. Clean petroleum jelly is preferred to lubricate o-rings and seals, and to adhere parts for assembly.

NOTE: For fluids other than petroleum based hydraulic oil, insure that petroleum jelly is compatible with the fluid. If not compatible, another product should be used instead.

Inspect all bearing surfaces and seal areas to insure that they are free from nicks, dings, scratches, and rust.

1. Using installation tool T2, press the front bearing cup into the bottom of the housing. Make sure the cup is seated firmly against the bottom of the housing.
2. Turn housing over. Using installation tool T1, press the shaft seal in the seal bore. Install the snap ring into the groove in the seal housing bore.
3. Using installation tool T5, press the rear bearing cup into the port block. Insure that the cup is seated firmly against the bottom of the housing.
4. Install the front bearing cone and shaft into the housing.
5. Install the rear bearing cone on the shaft.
6. Install the port block onto the housing using housing bolts and tighten to 27 ± 1.3 Nm (20 ± 1 ft. lb.).
7. Position the pump so shaft end is up.
8. Lay a parallel bar on the pump pilot.
9. Press down on the shaft and rotate it 3-5 times then measure the height of the shaft end to the parallel bar using dial calipers or a dial indicator.
10. Grasp the shaft and pull it up and rotate it 3-5 times. Measure the height of the shaft end to the parallel bar. Note: if the shaft slips or fails, the steps must be repeated to get an accurate measurement. Figure 3.
11. Subtract the larger from the smaller to get the differential gap.
12. Repeat the procedure three times. Once recorded, take the average of the three measurements.
13. With the average, use chart 2 to determine the correct shim to install in the pump.
14. Rebuilt the pump with the shaft bearings, and selected shim. Check end play, then disassemble port block and continue with pump assembly.

PUMP ASSEMBLY PROCEDURE
 continued

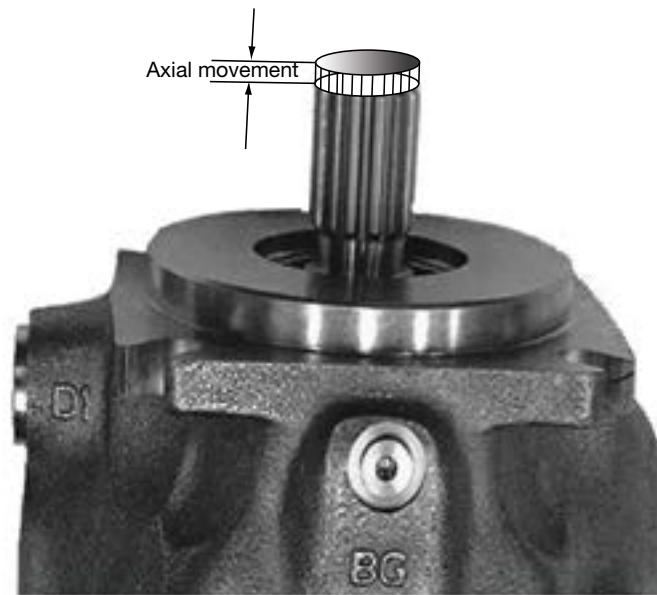


Figure 3

Chart 2: Shim Thickness Selection					
Measured Differential		Shim Thickness	Displacement		
Minimum	Maximum		060/075	100	140
3.07 mm (.121 in)	3.12 mm (.123 in)	3.04 mm (.1196 in)	03E-95262-0	03E-95268-0	03E-95265-0
3.15 mm (.124 in)	3.22 mm (.126 in)	3.12 mm (.1228 in)	03E-95263-0	03E-95269-0	03E-95266-0
3.23 mm (.127 in)	3.29 mm (.129 in)	3.20 mm (.1259 in)	03E-95264-0	03E-95270-0	03E-95267-0
3.30 mm (.130 in)	3.36 mm (.132 in)	3.28 mm (.1291 in)	03E-93180-0	03E-94148-0	03E-93260-0
3.37 mm (.133 in)	3.44 mm (.135 in)	3.36 mm (.1323 in)	03E-93566-0	03E-94149-0	03E-93970-0
3.45 mm (.136 in)	3.51 mm (.138 in)	3.44 mm (.1354 in)	03E-93567-0	03AE-94150-0	03E-93971-0
3.52 mm (.139 in)	3.62 mm (.142 in)	3.52 mm (.1386 in)	03E-93568-0	03E-94151-0	03E-93972-0
3.63 mm (.143 in)	3.70 mm (.145 in)	3.60 mm (.1417 in)	03E-93569-0	03E-94152-0	03E-93973-0
3.71 mm (.146 in)	3.77 mm (.148 in)	3.68 mm (.1449 in)	03E-93570-0	03E-94153-0	03E-93974-0
3.78 mm (.149 in)	3.85 mm (.151 in)	3.76 mm (.1480 in)	03E-93571-0	03E-94154-0	03E-93975-0
3.86 mm (.152 in)	3.92 mm (.154 in)	3.84 mm (.1512 in)	03E-93572-0	03E-94155-0	03E-93976-0
3.93 mm (.155 in)	4.00 mm (.157 in)	3.92 mm (.1539 in)	03E-93573-0	03E-94156-0	03E-93977-0
4.01 mm (.158 in)	4.10 mm (.161 in)	4.00 mm (.1575 in)	03E-93574-0	03E-94157-0	03E-93978-0
4.11 mm (.162 in)	4.18 mm (.164 in)	4.08 mm (.1606 in)	03E-93575-0	03E-94158-0	03E-93979-0
4.19 mm (.165 in)	4.25 mm (.167 in)	4.16 mm (.1638 in)	03E-93576-0	03E-93864-0	03E-93980-0
Shim Kits:			S2E-18591-0K	S2E-18640-0K	S2E-18527-0K

**PUMP ASSEMBLY
 PROCEDURE**
 continued

Chart 3	
Pump	Control and bias guide torque
060	142 ± 6.5 Nm (105 ± 5 ft-lbs)
075	142 ± 6.5 Nm (105 ± 5 ft-lbs)
100	184 ± 8 Nm (136 ± 6 ft-lbs)
140	203 ± 8 Nm (170 ± 6 ft-lbs)

15. If barrel hold down spring was removed during disassembly process, install three pins to slots in barrel spline. Petroleum jelly can be used to hold pins in place while installing remaining parts. Place barrel on fixture with pin side down. Install backup washer and hold down spring. Compress spring in press and install snap ring.
Caution: Make sure snap ring is properly seated in the groove prior to removing the barrel from the press.

16. Apply a light film of oil into the piston bores. Lightly lubricate the spherical surface of the guide ball. Install the nine pistons into the bores in the hold down plate. Install the spherical guide ball into the hold down plate. While holding the guide ball against the hold down plate, install the pistons into the barrel.

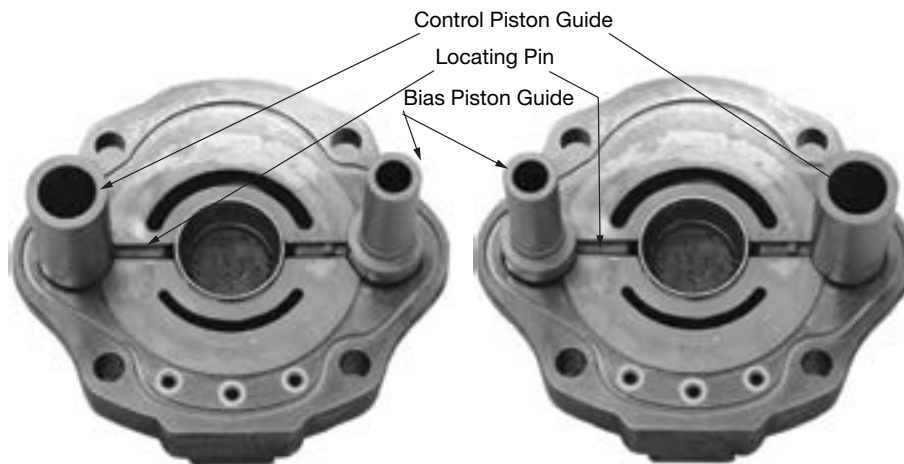


Figure 4A
 Port block with
 Right hand configuration

Figure 4B
 Port block with
 Left hand configuration

17. Install the locating pin on the port block face.

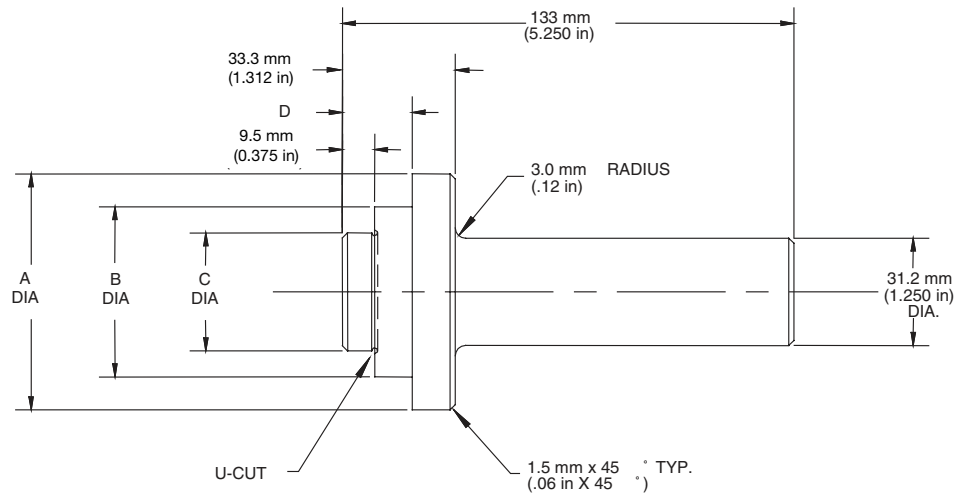
18. Apply Loctite Primer 7469 to the guide threads and allow to dry. Install unlubricated o-rings on the control guide and bias guide. Apply Loctite 272 to the guide threads. For right hand rotation the control guide is installed nearest to the dowl pin (Figure 4A). For left hand rotation the bias guide is installed nearest to the dowl pin (Figure 4B). Torque the control and bias guides as specified in Chart 3.

**PUMP ASSEMBLY
 PROCEDURE**
 continued

Pump	Housing Bolt Torque
060	135.6 ± 5 Nm (100 ± 4 ft-lbs)
075	135.6 ± 5 Nm (100 ± 4 ft-lbs)
100	229 ± 7 Nm (170 ± 5 ft-lbs)
140	278 ± 7 Nm (205 ± 5 ft-lbs)

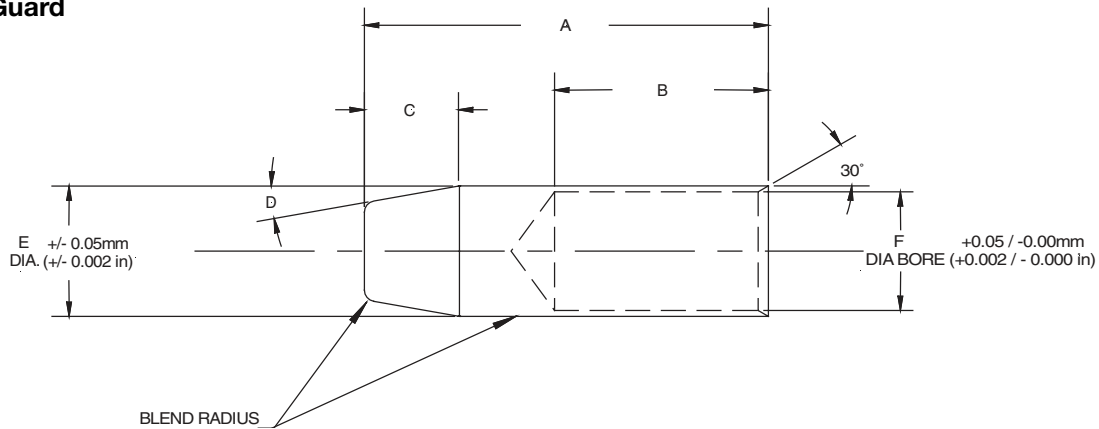
19. Apply light oil film to control piston and install it in the control guide bore.
NOTE: The 140 size has a lubrication hole in the piston. Confirm that the hole is facing the port block. The control piston has nonsymmetrical lubrication grooves. The end with the closest grooves must be installed towards the port block.
20. Apply light oil film to the bias piston. Install the bias spring and the bias piston in the bias piston guide bore.
21. Apply a light layer of petroleum jelly to the back surface of the port plate. Install the port plate on the port block, lining up the slot on the port plate with the locating pin.
22. Install the large o-ring in the groove on the pump port block. Install the three white Teflon o-rings in the pressure communication ports on the pump housing.
23. Install the cam bearings in the cradle area of the housing. The chamfer on the back of the bearing must face the outer wall of the housing. Use Loctite Primer Grade "T" or other suitable primer on screws and mating threads in housing. Apply Loctite #242 (use sparingly) to screw threads and install orifice screws to hold bearings in place. Torque screws to 3.4 ± 0.25 Nm (33 ± 3 in-lb).
24. Place thin film of clean oil on cam bearing surfaces. Install cam in housing. The cam must be tilted to permit entry into the housing. (Figure 2). **NOTE:** The large pocket on the bottom surface of the cam must be on the same side as the three pressure communication holes on the main housing. Pump rotation does not affect the assembly of the cam.
25. Install the drive shaft into the pump housing. Position pump horizontally. Install the rotating group over the pump shaft. Rotate the barrel to insure that it is eated against the cam. Insure that the pump shaft is seated properly in the front bearing.
26. Install bearing spacer as determined from the chart (see step 11). Install the rear bearing on the drive shaft.
27. Confirm that compensator rotation, port plate rotation, control and bias piston location indicate same direction of rotation.
28. Carefully install the assembled port block on the pump housing. Press the port block to compress the bias spring and install housing bolts. Tighten the bolts in a cross pattern to insure the port block does not get cocked on the housing. When port block is seated on the housing, torque bolts in a cross pattern as specified in Chart 4.
29. Install o-ring seals and assembled compensator on side of pump housing. Pump rotation is indicated by arrow on compensator housing. Torque bolts to 5 ± 0.25 Nm (45 ± 3 in-lb).

T1 Seal Installation Tool



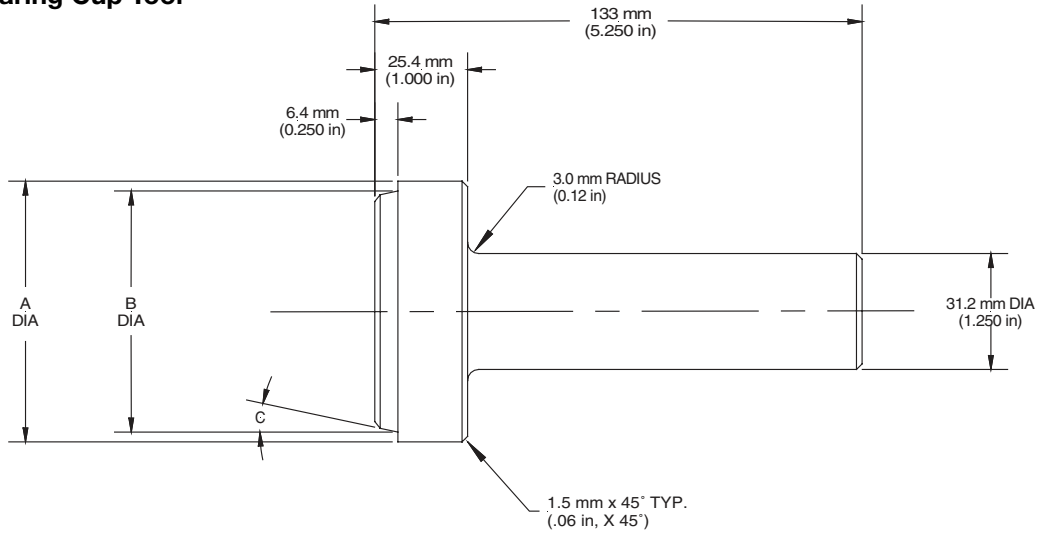
Pump Model	Part Number	A	B	C	D
060 & 075	213-0-004194	69.9 mm (2.750 in.)	50.3 mm (1.980 in.)	34.9 mm (1.375 in.)	20.3 mm (0.800 in.)
100	213-0-004208	63.5 mm (2.50 in.)	56.6 mm (2.230 in.)	43.3 mm (1.703 in.)	14.0 mm (0.550 in.)
140	213-0-004199	85.7 mm (3.375 in.)	70.6 mm (2.780 in.)	53.4 mm (2.10 in.)	19.1 mm (0.750 in.)

T3 Seal Guard



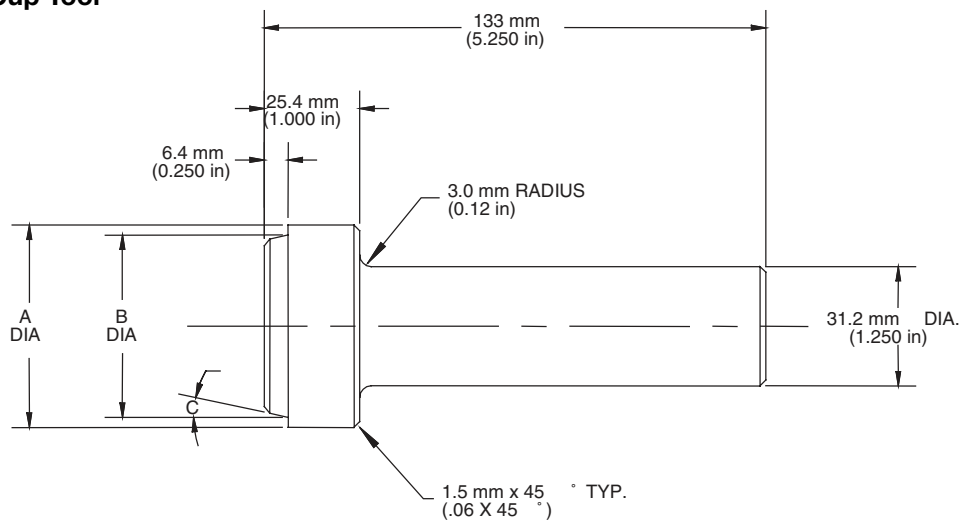
Pump Model	Part Number	A	B	C	D	E	F
060 & 075	213-0-004195	108 mm (4.25 in.)	57.1 mm (2.25 in.)	25.4 mm (1.00 in.)	10°	34.90 mm (1.373 in.)	31.75 mm (1.250 in.)
100 SAE	213-0-004206	108 mm (4.25 in.)	70.6 mm (2.78 in.)	25.4 mm (1.00 in.)	10°	43.26 mm (1.703 in.)	38.1 mm (1.500 in.)
100 ISO	213-0-004207	114 mm (4.50 in.)	76.2 mm (3.00 in.)	22.4 mm (0.88 in.)	15°	43.26 mm (1.703 in.)	40.06 mm (1.577 in.)
140 SAE	213-0-004200	108 mm (4.25 in.)	70.6 mm (2.78 in.)	25.4 mm (1.00 in.)	10°	53.04 mm (2.088 in.)	44.48 mm (1.751 in.)
140 ISO	213-0-004201	114 mm (4.50 in.)	76.2 mm (3.00 in.)	22.4 mm (0.88 in.)	15°	53.04 mm (2.088 in.)	50.04 mm (1.970 in.)

T2 Front Bearing Cup Tool



Pump Model	Part Number	A	B	C
060 & 075	213-0-004192	71.4 mm (2.812 in.)	66.0 mm (2.60 in.)	12°
100	213-0-004204	92.1 mm (3.623 in.)	86.1 mm (3.390 in.)	15°
140	213-0-004197	93.7 mm (3.687 in.)	89.3 mm (3.515 in.)	15°

T5 Rear Bearing Cup Tool



Pump Model	Part Number	A	B	C
060 & 075	213-0-004193	53.8 mm (2.120 in.)	48.7 mm (1.918 in.)	12°
100	213-0-004205	65.1 mm (2.562 in.)	59.3 mm (2.335 in.)	15°
140	213-0-004198	71.1 mm (2.80 in.)	65.1 mm (2.562 in.)	15°

**Chart 1
Rework Limits**

Item Number	Component	018	028	045	Tolerances
13	Bias Spring	03E-94430-0 78.3 mm	03E-94393-0 87.5 mm	03E-94356-0 116.4 mm	Free Height +/- 0.2 mm
20	Barrel Spring	787635 41.4 mm	03E-94387-0 39.5 mm	03E-94350-0 48.3 mm	Free Height +/- 0.2 mm
26	Piston and shoe assembly. Sold in sets only.	789519 Max End Play 0.10 mm Min Shoe Flange Thickness 2.97 mm	S2E-18415-0 Max End Play 0.07 mm Min Shoe Flange Thickness 3.98 mm	S2E-184130-0 Max End Play 0.10 mm Min Shoe Flange Thickness 4.98 mm	Measure OD in 3 places, top, middle and bottom. Measurement should not vary by more than 0.01 mm End Play between piston and shoe should not exceed value shown
9	Port Plate	2.97 mm	3.98 mm	4.98 mm	Minimum allowable thickness after lapping 0.8 mm minimum allowable surface finish

Item Number	Component	060	075	100	140	Tolerances
13	Bias Spring	03E-94055-0	03E-93151-0 141.5 mm (5.57 in.)	03E-93801-0 174.6 mm (6.87 in.)	03E-93963-0 212.3 mm (8.36 in.)	Free Height: ± 0.51 mm (± 0.020 in.)
20	Barrel hold down spring	03E-94049-0	03E-93145-0 63.7 mm (2.50 in.)	03E-93795-0 72.2 mm (2.84 in.)	03E-93959-0 68.6 mm (2.70 in.)	Free Height: ± 0.51 mm (± 0.020 in.)
9	Port Plate	4.98 mm	5.98 mm	6.48 mm	6.48 mm	Minimum allowable thickness after lapping 0.8 mm minimum allowable surface finish
26	Piston and shoe assembly. Sold in sets only.	03E-94036-0 Maximum end play 0.10 mm (0.004 in.) Minimum shoe flange thickness 5.91 mm (0.233 in.)	S2E-17003-0 Maximum end play 0.10 mm (0.004 in.) Minimum shoe flange thickness 5.91 mm (0.233 in.)	S2E-17912-0 Maximum end play 0.13 mm (0.005 in.) Minimum shoe flange thickness 6.41 mm (0.252 in.)	S2E-17912-0 Maximum end play 0.13 mm (0.005 in.) Minimum shoe flange thickness 6.41 mm (0.252 in.)	Measure piston outside diameter in 3 places at the top, middle and bottom. The measurements should not vary by more than 0.0102 mm (0.0004 in.) End play between piston and shoe should not exceed values shown. Total material allowed to be removed from shoe face when lapping is 0.076 mm (0.003 in.)

STARTUP PROCEDURE FOR NEW INSTALLATIONS

- Read and understand the instruction manual.
- Identify components and their function.
- Visually inspect components and lines for possible damage.
- Insure that all necessary ports are properly connected.
- Check reservoir for cleanliness. Drain and clean as required.
- Check fluid level and fill as required with filtered fluid to a minimum ISO cleanliness level of 20/18/14.
- Fill pump case with clean oil prior to starting.
- If pump is mounted vertically with the shaft up, bleed the air out the D1 drain port located near the mounting flange.
- Check alignment of drive.
- Check oil cooler and activate it, if included in circuit. Check fluid temperature.
- Reduce pressure settings of compensator and relief valve. Make sure accurate pressure readings can be made at appropriate places.
- If solenoids in system, check for actuation.
- Jog the pump drive. Check for proper shaft rotation. Make sure pump fills properly.
- Start the pump drive.
- Bleed system of air. Recheck fluid level.
- Cycle unloaded machine at low pressure and observe actuation (at low speed, if possible).
- Increase pressure settings gradually in steps. Check for leaks in all lines especially in pump and motor inlet lines.
- Make correct pressure adjustments.
- Gradually increase speed. Be alert for trouble as indicated by changes in sounds, system shocks, and air in fluid.
- Equipment is operational.

PUMP TEST PROCEDURE

Test criteria based on hydraulic oil ISO 32 per Parker HF-0 specifications.
 Oil temperature: 50°C ± 2°C (120°F ± 10°F). **NOTE:** insure that the hydraulic system does not overheat during this test procedure.
 Operating speed: 0 - 2300 rpm ± 30 rpm.
 Case pressure: Maximum 14.5 psi (1 bar)

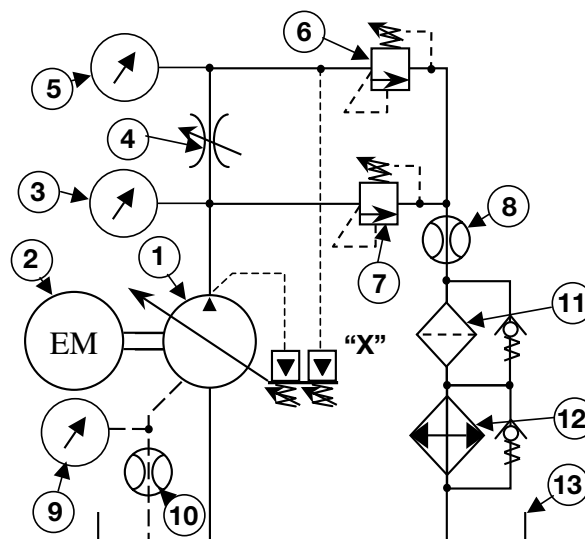
1. Mount pump on test fixture. Insure that shaft alignment is within specified tolerances.
2. Fill case with clean oil. Connect upper drain port to reservoir with no restrictions. Insure other drain ports are properly plugged.
3. Connect inlet and pressure lines. Insure that lines are filled with oil. Refer to circuit below. For units with “L” compensators, connect a suitable pilot line from port “X” to the pump discharge pressure line, down stream of the non-compensating flow valve.
4. Confirm direction of rotation for pump and drive are correct.
5. Reduce the main compensator setting to minimum. For units “L” compensators, advance the load sense compensator adjustment until it bottoms out, and lock into position.
6. Set maximum volume stop (if included) to full displacement. If minimum volume stop is included, back adjustment all of the way out.
7. If possible, gradually increase pump speed to 1800 ± 30 rpm with no load.
8. Screw in compensator adjusting screw until it bottoms out, with no pressure on system load-relief valve.
9. Break-in pump at times and pressures listed below. Adjust the load-relief valve to the pressure listed for the times indicated. After break-in, reduce compensator setting to 280 bar (4060 psi), and adjust system load relief to cause pump to compensate three times to verify that pump compensates on and off stroke properly.

Time	60 seconds	60 seconds	60 seconds
Pressure	62-69 Bar 900-1000 psi	200-207 Bar 2900-3000 psi	269-276 Bar 3900-4000 psi

TEST CIRCUIT

1. Test pump
2. Test stand prime mover
3. Pump pressure gauge
4. Non-compensating flow control
5. Load pressure gauge
6. Load relief valve
7. Safety bypass relief valve
8. Main flow meter
9. Case drain pressure gauge
10. Case drain flow meter
11. Filter assembly with bypass
12. Cooler assembly with bypass
13. Reservoir

NOTE: Items 4 and 5 are required for load sense pump test.



Circuit 1

TEST PROCEDURE PUMP WITH PRESSURE COMPENSATOR			
Step Reference	Condition	Required Value	Measured Value
1	Set the pump speed to 1800 RPM	1800 rpm	
2	Increase pump pressure compensator adjustment to maximum	n/a	
3	Record input oil temperature	43-54°C (110-130°F)	
4	Set output load pressure to minimum. Record output flow.	see performance chart	
5	Set output load pressure to 280 ± 2 bar (4060 ± 30 psi). Record output flow	see performance chart	
6	Record case leakage	see performance chart	
7	Set output pressure to 290 ± 2 bar (4200 ± 30 psi)	n/a	
8	Set pressure compensator to 280 ± 2 bar (4060 ± 30 psi)	n/a	
9	Record case leakage	see performance chart	
10	Record input torque	see performance chart	
11	Reduce output pressure to 273 ± 2 bar (3960 ± 30 psi). Record output flow.	see performance chart	
12	Verify no external leaks.	No leakage permitted	

PERFORMANCE SPECIFICATIONS PUMP WITH PRESSURE COMPENSATOR								
Step Ref.	Condition	018	028	045	060	075	100	140
1	Rated Speed	1800	1800	1800	1800	1800	1800	1800
4	Output flow at minimum pressure	31 lpm	47 lpm	77 lpm	105 lpm	129 lpm	172 lpm	239 lpm
5	Output flow at rated pressure of 280 bar	28 lpm	45 lpm	73 lpm	100 lpm	123 lpm	166 lpm	233 lpm
6	Case leakage at rated pressure of 280 bar	3.0 lpm	3.8 lpm	5.3 lpm	8.3 lpm	7.5 lpm	8.3 lpm	14 lpm
9*	Case leakage when compensated at 280 bar	5.7 lpm	7.6 lpm	11 lpm	13 lpm	15.1 lpm	20 lpm	23 lpm
10	Input torque when compensated at 280 bar	40 Nm	40 Nm	48 Nm	38.9 Nm	58 Nm	68 Nm	91 Nm
11	Output flow when pressure reduced to 273 bar with compensator set at 280 bar	28 lpm	45 lpm	73 lpm	100 lpm	123 lpm	166 lpm	233 lpm

TEST PROCEDURE PUMP WITH LOAD SENSE COMPENSATOR			
Step Reference	Condition	Required Value	Measured Value
1	Set the pump speed to 1800 RPM	1800 rpm	
2	Record input oil temperature	43-54°C (110-130°F)	
3A	Set output load pressure to 50 ± 2 bar (725 ± 30 psi)	n/a	n/a
3B	Adjust throttle valve and adjust differential setting until pressure at pump outlet is 20 ± 2 bar (290 ± 30 psi) higher than the load pressure gage	n/a	n/a
4	Adjust throttle valve to required flow rate. Adjust output load pressure valve if necessary to maintain 50 ± 2 bar (725 ± 30 psi)	see performance chart	
6	Lock the load sense adjustment screw. Confirm differential pressure at 20 ± 2 bar (290 ± 30 psi).	n/a	n/a
7	Verify no external leaks	No leakage permitted	

PERFORMANCE SPECIFICATIONS PUMP WITH LOAD SENSE COMPENSATOR								
Step Ref.	Condition	018	028	045	060	075	100	140
1	Rated Speed (RPM)	1800	1800	1800	1800	1800	1800	1800
4	Load sense output flow setting 70 +/- bar (1000 +/- 50 psi)	15-17 lpm	24-26 lpm	39-42 lpm	71-73 lpm	99-101 lpm	95-97 lpm	95-97 lpm
5	Allowable flow variation from 50 to 260 ± 2 bar (725 to 3770 ± 30 psi)	11-21 lpm	20-30 lpm	35-46 lpm	67-77 lpm	95-105 lpm	91-101 lpm	91-101 lpm

Component problems and circuit problems are often interrelated. An improper circuit may operate with apparent success but will cause failure of a particular component within it. The component failure can be the effect, not the cause of the problem. This general guide is offered to help in locating and eliminating the cause of problems by studying their effects.

Effect of Trouble	Possible Cause	Fault Which Needs Remedy
Noisy pump	Air in fluid	Leak in inlet line
		Low fluid level
		Turbulent fluid
		Return lines above fluid level
		Gas leak from accumulator
		Excessive pressure drop in the inlet line from a pressurized reservoir
		Inlet line strainer acting as air trap
	Cavitation in rotating group	Fluid too cold
		Fluid too viscous
		Fluid too heavy
		Shaft speed too high
		Inlet line too small
		Inlet strainer too small
		Inlet strainer too dirty
		Operating altitude too high
	Misaligned shaft	Inlet pressure too low
		Faulty installation
		Distortion in mounting
		Axial interference
		Faulty coupling
Mechanical fault in pump	Excessive overhung loads	
	Piston and shoe looseness or failure	
	Bearing failure	
	Incorrect port plate rotation	
Erosion on barrel ports and port plate	Eroded or worn parts in the displacement control	
	Air fluid	See noisy pump above
	Cavitation	See noisy pump above
Pressure shocks		Mechanical considerations
	Clogging load	Needed repairs
	Worn relief valve	Replace
	Worn compensator	Replace or relocate
	Slow response in check valves	Improve decompression control
	Excessive decompression energy rates	Rotating group worn, excessive case pressure
Compensator instability	Barrel blow-off	Change line size or lengths
	Line capacitance (line volume, line stretch, accumulator effects)	Add or remove hose
		Add orifice in load sense line
		Increase load sense differential pressure
		Relocate check valve further from outlet port
Outlet port check valve		

Effect of Trouble	Possible Cause	Fault Which Needs Remedy
High wear in pump	Excessive loads	Reduce pressure settings
		Reduce speeds
	Contaminant particles in fluid	Improper filter maintenance
		Filters too coarse
		Introduction of dirty fluid to system
		Reservoir openings
		Improper reservoir breather
	Improper fluid	Improper line replacement
		Fluid too thin or thick for operating temperature range
		Breakdown of fluid with time/temperature/heating effects
		Incorrect additives in new fluid
	Improper repair	Destruction of additive effectiveness with chemical aging
		Incorrect parts
	Unwanted water in fluid	Incorrect procedures, dimensions, finishes
		Condensation
		Faulty breather/strainer
Heat exchanger leakage		
Faulty clean-up practice		
Heating of fluid	Excessive pump leakage	Water in makeup fluid
		Recheck case drain flow and repair as required
		Fluid too thin
	Relief valve	Improper assembly, port timing
		Set too low (compared to load or to compensator)
	Compensator	Instability caused by back pressure, worn parts
		Set too high (compared to relief)
	Pump too large for fluid needs	Worn parts
		Select smaller pump displacement
	Heat exchanger	Water turned off or too little flow
		Water too hot
		Fan clogged or restricted
		Efficiency reduced by mud or scale deposits
		Intermittent hydraulic fluid flow
	Reservoir	Too little fluid
		Improper baffles
Insulating air blanket that prevents heat rejection		
Heat pickup from adjacent equipment		

**CONVERSION FACTORS
 DEFINITION & UNIT**

displacement	$\text{in}^3/\text{rev} \times 16.387 = \text{cm}^3/\text{rev}$	$\text{cm}^3/\text{rev} \times 0.06102 = \text{in}^3/\text{rev}$
flow	$\text{gpm} \times 3.78 = \text{L}/\text{min}$	$\text{L}/\text{min} \times 0.2642 = \text{gpm}$
power	$\text{hp} \times 0.7457 = \text{kW}$	$\text{kW} \times 1.341 = \text{hp}$
torque	$\text{lb-ft} \times 1.3567 = \text{Nm}$	$\text{Nm} \times 0.7376 = \text{lb-ft}$
pressure	$\text{lbs}/\text{in}^2 \text{ (psi)} \times 0.06895 = \text{bar}$ $\text{lbs}/\text{in}^2 \text{ (psi)} \times 6.895 = \text{kPa}$	$\text{bar} \times 14.50 = \text{lbs}/\text{in}^2 \text{ (psi)}$ $\text{kPa} \times 0.1450 = \text{lbs}/\text{in}^2 \text{ (psi)}$
weight	$\text{lb} \times 0.4536 = \text{kg}$	$\text{kg} \times 2.205 = \text{lbs}$
force	$\text{lb} \times 4.448 = \text{N}$	$\text{N} \times 0.2248 = \text{lbs}$
volume	$\text{in}^3 \times 16.387 = \text{cm}^3$	$\text{cm}^3 \times 0.06102 = \text{in}^3$
area	$\text{in}^2 \times 6.452 = \text{cm}^2$	$\text{cm}^2 \times 0.1550 = \text{in}^2$
length	$\text{in} \times 25.4 = \text{mm}$	$\text{mm} \times 0.03937 = \text{in}$
temperature	$\frac{\text{degree F}-32}{1.8} = \text{°C}$	$1.8 \times \text{C}+32 = \text{°F}$
viscosity	$\text{cSt} \times 1.0 = \text{mm}^2/\text{sec}$ $\text{SSU} = \text{cSt} \times 4.25 + 14$	$\text{mm}^2/\text{sec} \times 1.0 = \text{cSt}$ $20 \text{ cSt} = 99 \text{ SSU}$

FLUID POWER FORMULAS

Pump input torque	lbs. in.	$\frac{\text{pressure (psi)} \times \text{displacement (in}^3/\text{rev)}}{2\pi \times \text{mech. eff.}}$
Pump input power	hp	$\frac{\text{rpm} \times (\text{in}^3/\text{rev}) \times (\text{psi})}{395934 \times \text{overall eff.}}$
Pump output flow	U.S. gpm	$\frac{\text{rpm} \times (\text{in}^3/\text{rev}) \times \text{volumetric eff.}}{231}$
Fluid motor speed	rpm	$\frac{231 \times \text{flow rate (U.S. gpm)} \times \text{volumetric eff.}}{\text{displacement (in}^3/\text{rev)}}$
Fluid motor torque	lbs. in.	$\frac{\text{pressure (psi)} \times \text{displacement (in}^3/\text{rev)} \times \text{mech. eff.}}{2\pi}$
Fluid motor power	hp	$\frac{\text{rpm} \times (\text{in}^3/\text{rev}) \times (\text{psi}) \times \text{overall eff.}}{395934}$

(metric)

Pump input torque	Nm	$\frac{\text{pressure (bar)} \times \text{displacement (cm}^3/\text{rev)}}{2\pi \times \text{mech. eff.}}$
Pump input power	kW	$\frac{\text{rpm} \times (\text{cm}^3/\text{rev}) \times (\text{bar})}{600000 \times \text{overall eff.}}$
Pump output flow	Lpm	$\frac{\text{rpm} \times (\text{cm}^3/\text{rev}) \times \text{volumetric eff.}}{1000}$
Fluid motor speed	rpm(min ⁻¹) (tr/mn)	$\frac{1000 \times \text{flow rate (Lpm)} \times \text{volumetric eff.}}{\text{displacement (cm}^3/\text{rev)}}$
Fluid motor torque	Nm	$\frac{\text{pressure(bar)} \times \text{displacement (cm}^3/\text{rev)} \times \text{mech. eff.}}{20\pi}$
Fluid motor power	kW	$\frac{\text{rpm} \times (\text{cm}^3/\text{rev}) \times \text{bar} \times \text{overall eff.}}{600000}$

