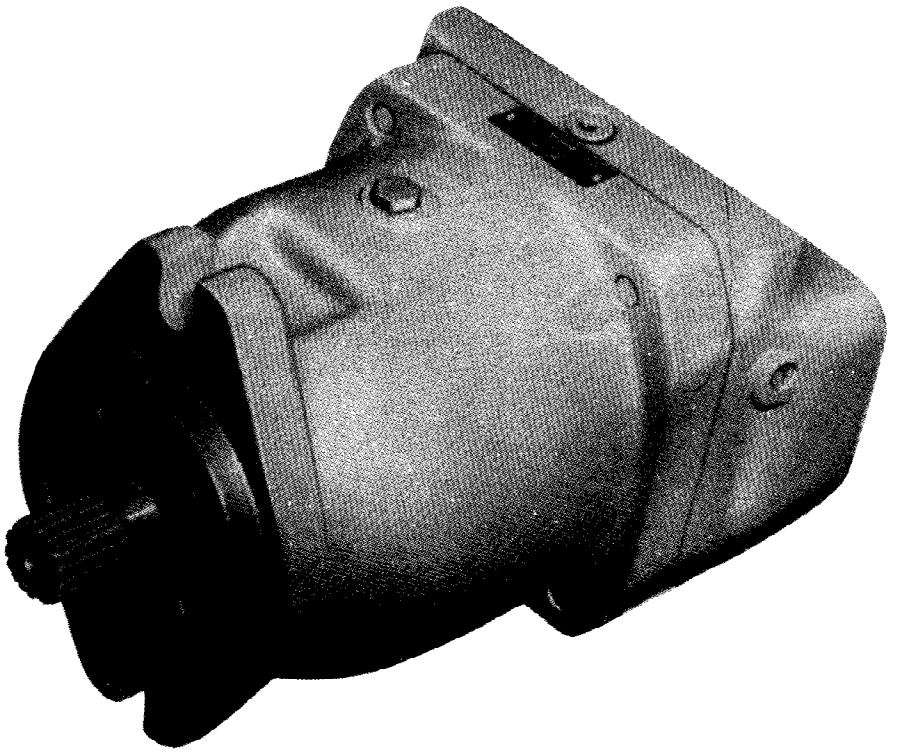
HÄGGLUNDS DENISON

Axial Piston Motor, Fixed Displacement

Series M6, M7 Design D

Installation and Overhaul Instructions



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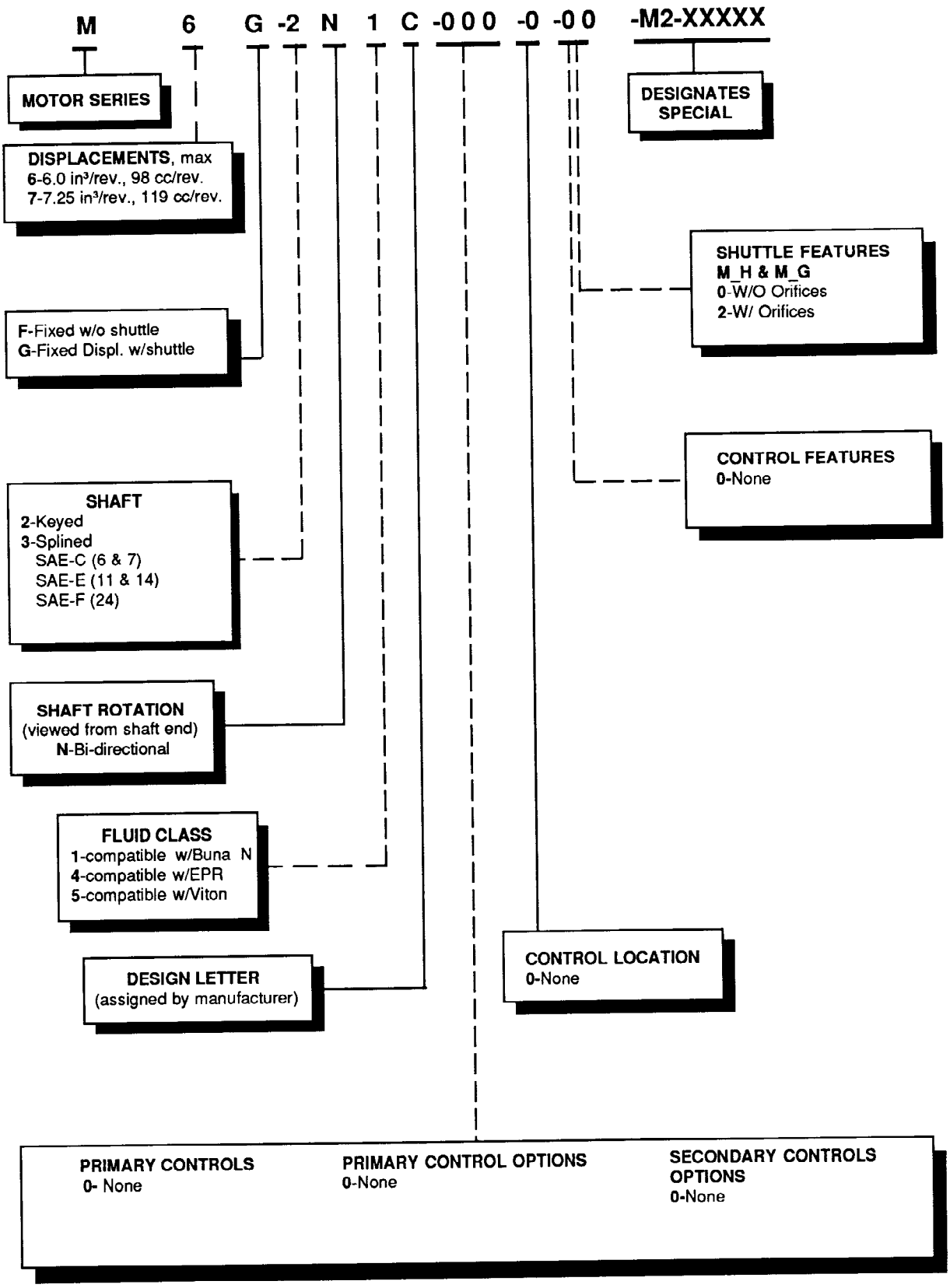

M 6 G -2 N 1 C -0 0 0 -0 -0 0 -M2-XXXXX
MOTOR SERIES
DISPLACEMENTS, max
6-6.0 in³/rev., 98 cc/rev.
7-7.25 in³/rev., 119 cc/rev.
F-Fixed w/o shuttle
G-Fixed Displ. w/shuttle
SHAFT
2-Keyed
3-Splined
SAE-C (6 & 7)
SAE-E (11 & 14)
SAE-F (24)
SHAFT ROTATION
(viewed from shaft end)
N-Bi-directional
FLUID CLASS
1-compatible w/Buna N
4-compatible w/EPR
5-compatible w/Viton
DESIGN LETTER
(assigned by manufacturer)
DESIGNATES SPECIAL
SHUTTLE FEATURES
M_H & M_G
0-W/O Orifices
2-W/ Orifices
CONTROL FEATURES
0-None
CONTROL LOCATION
0-None
PRIMARY CONTROLS
0- None
PRIMARY CONTROL OPTIONS
0-None
SECONDARY CONTROLS OPTIONS
0-None

General

This manual contains installation, operation, maintenance and overhaul instructions for Hägglunds Denison Goldcup 6 and Goldcup 7 constant volume motors.

Description

The Goldcup Motor is a fixed displacement axial piston design which uses hydrostatically balanced piston shoes. This feature serves to lubricate as well as absorb much of the force generated by the shoes pressing against the cam, thereby increasing service life of the unit. Rotation of the unit is bi-directional.

TABLE 1 TYPICAL CHARACTERISTICS

Specification	Term	Goldcup 6	Goldcup 7
Displacement (theoretical) zero psi	in^3/rev. cm^3/rev	6.00 (98)	7.25 (119)
Pressure ports A & B max. continuous	psi bar	5000 (345)	5000 (345)
Intermittent (not to exceed 6 sec./min.)	psi bar	6000 (414)	6000 (414)
Mounting Standard, 2-bolt	SAE	C	C
Fluid Connections, Ports A&B SAE-4 Bolt Pad for 6000 psi split flange	in. mm	1-1/2 (38.1)	1-1/2 (38.1)
Speed, max. continuous at full displacement	rpm	3000	3000
Flow, theo. max at 100 rpm at 3000 rpm	gpm l/m gpm l/m	2.6 (9.8) 77.9 (295)	3.14 (11.87) 94.2 (356)
Torque, theo. max per 100 psi max at 5000 psi max at 6000 psi	in # Nm in # Nm in # Nm	95.5 (10.8) 4777 (539.8) 5729 (647)	115.4 (13) 5769 (652) 6923 (782)
Power theo. max at 5000 psi per 100 rpm at 3000 rpm	hp kW hp kW	7.57 (5.64) 227 (169)	9.15 (6.8) 274.3 (204.6)
Efficiency torque approx. stalled running	% theo. % theo.	81 93	81 93
Weight pkg. motor fixed displacement	lbs. kg	105 (47.6)	105 (47.6)

Mounting

This motor is designed to operate in any position. The mounting hub and two bolt mounting flanges are in full conformance with SAE standard. The motor shaft must be in alignment with the shaft of the driven load and should be checked with a dial indicator. The mounting pad or adaptor into which the fluid motor pilots must be concentric with motor shaft within 0.060" (.154 mm) TIR to prevent bearing failure. This concentricity is particularly important if the shaft is rigidly connected to the driven load without a flexible coupling.

Piping

Connect inlet and outlet lines to the port block of the motor . It is recommended that the case leakage line be connected to the top of the motor but it may be connected to the bottom. The case leakage line must be of sufficient size to prevent back pressure in excess of 75 PSI (5.17 BAR) and returned to the reservoir below the surface of the oil as far from the supply suction 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 motor from reaching full speed and torque. An undersize outlet line will create back pressure in the mo tor and cause improper operation. Flexible hose lines are recommended. If rigid piping is used, the workmanship must be accurate to eliminate strain on the motor port block or to the fluid connections. Sharp bends in the lines must be eliminated wherever possible. All system piping must be cleaned with solvent or equivalent before installing motor. Make sure the entire hydraulic system is free of dirt, lint, scale, and other foreign material.

Caution: Do not use galvanized pipe. Galvanized coating can flake off with continued use.

Service Information

These hydraulic products are designed to give long dependable service when properly applied and their systems properly maintained. These general instructions apply to typical systems. Specific instructions for particular equipment can be developed from them.

Start-Up Procedure for New Installation

1. Read and understand the instruction manual. Identify components and their functions.

2. Visually inspect components and their lines for possible damage.

3. Check reservior for cleanliness and drain and clean as required.

4. Check fluid level and fill as required with filtered fluid at least as clean as that recommended. Fill motor case as necessary.

5. Check alignment of drive.

6. Check oil cooler and activate it, if included in circuit. Check fluid temperature.

7. Reduce pressure settings of relief valve. Make sure accurate pressure readings can be made at appropriate places.

8. If solenoids in system, check for actuation.

9. Start pump drive. Make sure pump and motor fill properly.

10. Bleed system of air. Recheck fluid level.

11. Cycle unloaded machine at low pressure and observe actuation (at low speed if possible).

12. Increase pressure settings gradually in steps. Check for leaks in all lines, especially in pump and motor inlet lines.

13. Make correct pressure adjustments.

14. Gradually increase speed. Be alert for trouble as indicated by changes in sounds, system and air in fluid.

15. Equipment is operational.

Fluid

It is recommended that a hydraulic fluid be used as specified in Hägglunds Denison Bulletin 2002-G.

Maintenance

This motor is self lubricating and preventative maintenance is limited to keeping the system fluid clean by changing filters frequently. Fluid cleanliness level per NAS 1638, Class 8 above 15 micron or Class 9 under 15 micron must be maintained. This usually can be accomplished by effective use of 10 micron fliters. Do not allow dirt to accumulate on the motor especially around the shaft seal. Keep all fittings and screws tight. Do not operate at pressures and speeds in excess of the recommended limt. If the motor does not operate properly, check the Trouble shooting Chart before attempting to overhaul the unit. Overhauling is relatively simple and may be accomplished be referring to the Disassembly, Rework Limits of Wear Parts and Assembly procedures.

COMPARISON OF SOLID CONTAMINATION CLASSIFICATION SYSTEMS

NATIONAL AEROSPACE STANDARD (NAS) 1638

		CLASS													
		00	0	1	2	3	4	5	6	7	8	9	10	11	12
PARTICLE SIZE RANGE	5-15 µm	125	250	500	1,000	2,000	4,000	8,000	16,000	32,000	64,000	128,000	256,000	512,000	1,024,000
	15-25 µm	22	44	89	178	356	712	1,425	2,850	5,700	11,400	22,800	45,600	91,200	182,400
	25-50 µm	4	3	16	32	63	126	253	506	1,012	2,025	4,050	8,100	16,200	32,400
	50-100 µm	1	2	3	6	11	22	45	90	180	360	720	1,440	2,880	5,760
	>150µm	0	0	1	1	2	4	8	16	32	64	128	256	512	1,024
MAXIMUM PARTICLES	>5 µm	152	304	609	1.217	2,432	4,864	9,731	19,462	38,924	77,849	155,698	311,396	622,792	1,245,584
	>15 µm	27	54	109	217	432	864	1,731	3,462	6,924	13,849	27,698	55,396	110,792	221,584

ISO:DIS 4406; SAE J1165

		ISO SOLID CONTAMINANT CODE														
		8/5	9/6	10/7	11/8	12/9	13/10	14/11	15/12	16/13	17/14	18/15	19/16	20/17	21/18	22/19
MAXIMUM PARTICLES	>5 µm	250	500	1,000	2,000	4,000	8,000	16,000	32,000	64,000	130,000	250,000	500,000	1,000,000	2,000,000	4,000,000
	>15 µm	32	64	130	250	500	1,000	2,000	4,000	8,000	16,000	32,000	64,000	130,000	250,000	500,000

NOTES: ALL MEASUREMENTS ARE FOR A 100 ML SAMPLE SIZE.

Trouble Shooting

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 is the effect, not the cause of the problem. This general guide is offered to help in locating and eliminating the cause of the problems by studying their effects:

Effect of Trouble	Possible Cause	Fault Which Needs Remedy
Noisy motor	Air in fluid	Leak in suction line Leak at shaft seal 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 Suction line strainer acting as air trap
	Cavitation in motor rotating group	Fluid too cold Fluid too viscous Fluid too heavy Shaft speed too high Suction line too small Suction line collapsed Suction strainer too small Suction strainer too dirty Operating altitude too high Boost or replenishment pressure too low Replenishment flow too small for dynamic conditions
	Misaligned shaft	Faulty installation Distortion in mounting Axial interference Faulty coupling Excessive overhung loads
	Mechanical fault in motor	Piston and shoe looseness or failure Bearing failure
Erosion on barrel ports and port plate	Air in fluid	See above
	Cavitation	See above
High wear in motor	Excessive loads	Reduce pressure settings Reduce speeds
	Contaminant particles in fluid	Improper filter maintenance Fliters too course Introduction of dirty fluid into system Reservoir openings Reservior breather Improper line replacement

(Continued)

Effect of Trouble	Possible Cause	Fault Which Needs Remedy
High wear in motor	Improper fluid	Fluid too thin or thick for operating temperature range Breakdown of fluid with time/temperature/ shearing effects Incorrect additives in new fluid Destruction of additive effectiveness with chemical aging
	Improper repair	Incorrect parts Incorrect procedures, dimensions, finishes
	Unwanted water in fluid	Condensation Faulty breather/strainer Heat exchanger leakage Faulty cleanup, practice Water in make-up fluid
Pressure shocks	Cogging load	Mechanical considerations
	Worn relief valve	Needed repairs
	Slow response in check valves	Replace or relocate
	Excessive decompression energy rates	Improve decompression controls
	Excessive line capacitance (line volume, line stretch, accumulator effects)	Reduce line size or lengths. Eliminate hose Bleed air
	Barrel blow-off	Recheck holddown rotating group, drain pressure
Heating of fluid	Excessive motor leakage	Recheck case drain flow and repair as required Fluid too thin Improper shaft assembly, port timimg
	Reservior	Too little fluid Entrained air in fluid Improper baffles Insulating air blanket that prevents heat rejection Heat pickup from adjacent equipment

General

The instructions contained in this section cover a complete teardown of the motor. Disassemble only as far as necessary to replace or repair any worn parts. Drain all fluid from the motor and thoroughly clean the exterior surface. Prepare a clean, lint free surface on which to lay the internal parts for inspection and repair.

Barrel Holddown, Port Block and Shuttle Valve See fig. 4

1. Secure the motor in a vise or other suitable holding fixture with the shaft in horizontal position.

2. Remove screws (11) that secure the shuttle valve (10) to the port block.

3. Remove the shuttle valve assembly and seals (9). The shuttle valve is a complete assembly and should not be disassembled.

4. Remove plug ring (1) and O-ring (2).

5. Remove four screws (3) that secure the port block (4) to the housing (25).

6. Remove port block and gasket (5). Remove port plate (6) and port plate pins (8).

Caution: When removing the port plate can cling to the face plate because of oil film. Make sure it does not fall and become damaged.

Barrel

1. Remove the face plate (7) and two face plate pins (8).

2. Remove barrel assembly (17).

3. Remove the retaining ring (12), spring retainer (13), barrel stop (14), springs (15), and thrust washers (16) from the barrel.

Piston and Shoe Assembly

1. Remove the retaining ring (19) and thrust washer (20) from the cam center post.

2. Remove piston and shoe assembly (21).

Caution: Use extreme care when removing piston and shoe assembly. Shoe faces must not be scratched or marred.

3. Remove creep plate (22) from cam (23).

Drive Shaft and Seal

1. Remove four screws (33), gaskets (32), seal retainer (31), and O-ring (29).

2. Remove shaft seal (30) from shaft (27).

3. Remove screw (26) that secures cam to housing.

4. Remove shaft and bearing assembly and cam (23) by grasping shaft and pulling out of housing from end of unit opposite mounting flange.

5. Carefully remove shaft and bearing assembly from cam.

Caution: When removing shaft from cam, use extreme care not to damage seal surface of shaft. Any scratches or marks on this surface will cause leaks around shaft seal.

Note: Do not remove the bearing (18) from the housing unless damaged or worn and needs replacement.

Rework Limits of Wear Parts

6 and 7.25 in³	Original Dimension		Max. Rework From Original Dimension		Min. Dimension After Rework	
Port plate face	.315/.305"	(8/7.7 mm)	.010"	(.254 mm)	.295"	(7.49 mm)
Cylinder barrel face	4.480"	(113.79 mm)	.010"	(.254 mm)	4.470"	(113.5 mm)
Shoe retainer face	.314/.312"	(7.97/7.93 mm)	.005"	(.127 mm)	.307"	(7.8 mm)
Piston shoe face (pocket)	.019/.014"	(.48/.36 mm)	.011/.006"	(.279/.152 mm)	.008"	(.2 mm)
Creep plate face	.293/.291"	(7.4/7.3 mm)	.010"	(.254 mm)	.281"	(7.13 mm)
Face plate			None		Replace	

Special Tools

The special tools T-2, T-3, and T-4 shown below are required in the assembly of this motor.

Barrel and Holddown Assembly
See fig. 1

1. Position the barrel (17)(fig.4) in a press with the large end down.

2. Place tool T-2 with the large end of the tapered hole up against the barrel face (ref. fig. 1).
Place retaining ring (12, fig. 4) into tool T-2. Install tool T-3 with small end against the ring.
Press on T-3 to compress the spring assembly (15) and allow the retaining ring (12) to seat in groove in barrel.

3. Remove tools T-1 and T-2 and check to make sure the ring is properly seated.

4. Tool T-4 is used to install the barrel bearing (18, fig. 4) if removed.

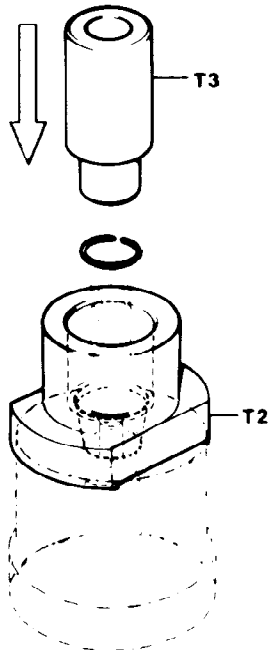
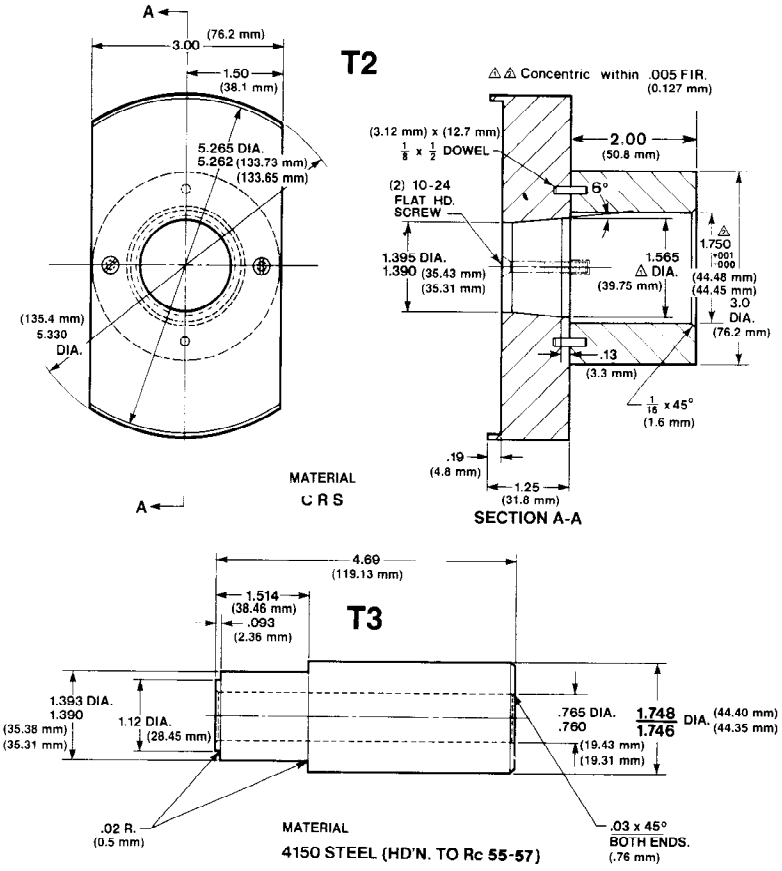
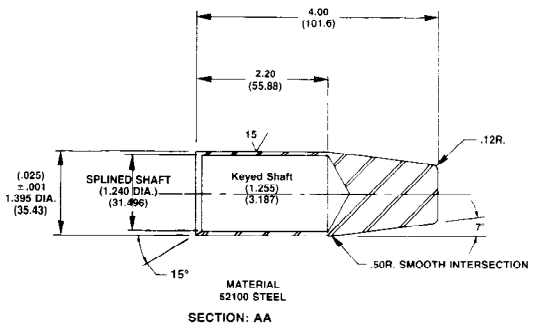


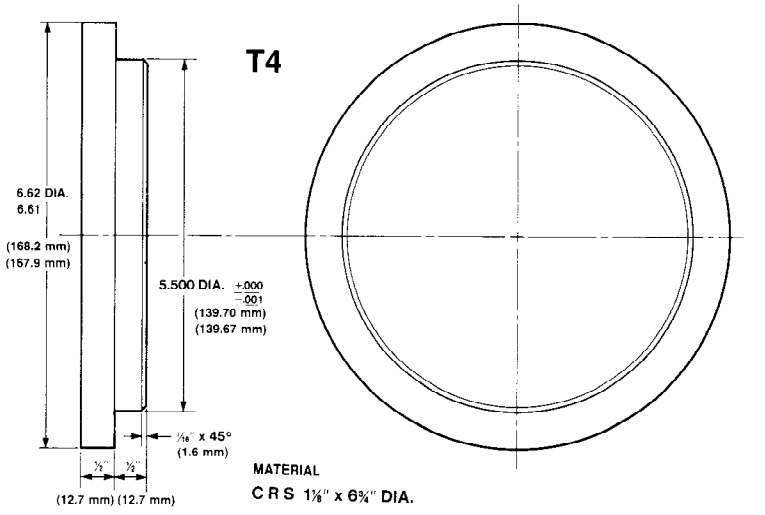
FIGURE 1
BARREL AND HOLDDOWN ASSEMBLY





NOTES:
1. NO TOOL MARKS OR SCRATCHES PERMISSIBLE ON O.D.
2. HDN 50-55 Rc

FIGURE 2
SHAFT SEAL ASSEMBLY



Cleaning and Inspection

1. All parts must be inspected and be free of material defects, dirt, scratches or any foreign material.

2. All parts must be cleaned with a suitable cleaning solvent and all holes and passages blown out with dry, clean, compressed air.

3. After cleaning and inspection, all parts must be covered with with a light film of oil and protected from dirt and moisture. Excessive handling of internal parts should be avoided prior to assembly.

4. During assembly, lapped and ground surfaces must be lubricated with clean oil and protected from nicks or surface damage.

Piston and Shoe Assembly

1. Place cam (23) flat side down on a clean surface.

2. Install creep plate (22), counterbored side first, over center post on cam until seated against face of cam.

3. Apply a light film of oil to face of creep plate and to the face of the piston shoes (21). Hold the piston and shoe assembly so that the assembly will not fall from the retainer and lower over the center post of the cam. Gently seat face of shoes against face of creep plate.

4. Install thrust washer (20) over cam centerpost and seat against retainer plate. The flat I.D. of thrust washer and the flat on the center post of cam must match. The grooved side of the thrust washer must face the piston and shoe retainer.

5. Secure the piston and shoe assembly by installing the thickest of the five retaining rings (19) that will fit in the groove on the cam center post. Check clearance between shoe faces and creep plate with a feeler gauge. Grasp one piston and lift tightly against the shoe retainer to obtain clearance. Gap should be between .002"(.051mm) and .004"(.102mm). Assembly must be free to rotate by hand with approximate force of 5 ft. lbs.(6.8 Nm)

Port Block and Cylinder Barrel

1. Install two dowel pins (8) in dowel holes in face of port block (4).

2. Apply a liberal amount of grease to the port plate.

3. Place port plate so that the dowel holes line up with the assembled pins in port block, and seat against the port block face. Make sure port plate is firmly seated on port block.

4. Assemble the spring retainer (13), twelve springs (15), and thrust washers (16) as shown in enlarged view. Install this assembly in bore of barrel and secure with retaining ring (12) in groove of barrel.

Note: See fig. 1 for instructions to install the retaining ring (12).

5. Install three face plate pins (8) in the holes provided in the barrel face. Shoulder of pin must be below barrel face.

6. Apply grease to the face of the barrel and install the face plate (7) over the pins. Make sure the face plate is properly seated over the pins with steel side against the barrel, bronze side up.

7. Rest cylinder barrel (17) onto port plate.

Rotating Group

1. Place assembled port block and cylinder barrel on a clean surface with the barrel facing up.

2. Apply a thin film of clear oil to the bores in the barrel and to the pistons of the cam assembly.

3. Hold cam so that the pistons are hanging down. Carefully engage the pistons in the barrel bores and lower.

Housing and Port Block

1. Install gasket (5) on port block and align holes.

2. Position the cam (23) on the assembled rotating group so the thick part of cam is at bottom of the port block.

3. Position housing assembly (25) above and directly over cam and cylinder barrel. Carefully lower housing, align barrel bearing (18) with barrel, dowel pins in housing to holes in port block, and pilot in housing cavity with cam until housing is seated against port block and gasket.

4. Install screw (26) and tighten. Install screws (3) and torque to 150 ft. lbs.(203.4 Nm)

5. Install O-ring (2) to plug (1) and thread into hole in end of port block. Place O-ring (34) on plug (35) and install in side of housing.

Shaft, Seal and Retainer

1. Insert barrel stop (14) into the spring assembly (15) through the shaft seal end of motor.

2. Insert the small end of drive shaft (27) and bearing through the bore of housing, bore of cam, and into the barrel spline until shaft rests against the springs (15) in the barrel.

3. Install O-ring (29) into counterbore of housing.

4. Install shaft seal (30) onto shaft. Use shaft seal assembly tool. (See figure 2)

Note Take careful precaution not to scratch seal surface of shaft. Scratches will cause leakage around the seal.

5. Slide seal retainer (31) over shaft and against the seal. Place seals (32) on screws (33). Install screws into shaft seal and alternately torque down to 50 ft.lbs.(68 Nm)

Shuttle Valve Assembly Internal Drain

1. Place valve assembly (10, fig. 4) in a horizontal position with the O-ring groove up.

2. Press seat (11) in the .500"(12.7 mm) diameter bore until it is flush with the body surface.

3. Install spring centering washer (4) over each end of spool.

5. Install springs (3) over ends of spool and into sockets of centering washers.

6. Lubricate O-rings (2) and install over plugs (1). Install the plugs over springs and into body.

7. Install spool (10) in bore against seat (11).

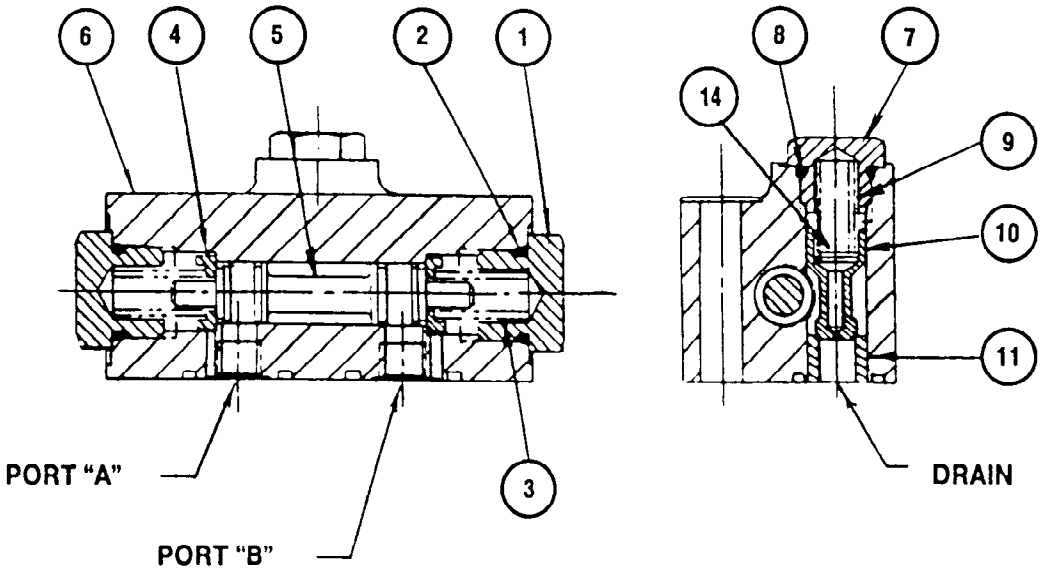
8. Install spring (9) in spool (10).

9. Lubricate O-rings (8) and install on groove of plug (7) on internally drained shuttle.

10. Install plug (7) over spring (9) and tighten.

11. Install seal (9, fig. 4) in counterbore in center of shuttle valve assembly. Hold in place with a coating of grease. Install the two seals in remaining counterbores.

12. Install the shuttle valve assembly on port block pad and secure with screws (11, fig. 4) torque screws to 20 ft. lbs.(27.2 Nm)



S13-48273
Assembly, Shuttle Valve

Item	Qty.	Part No.	Description
1	2	488-35002	Plug
2	2	691-00908	O-ring
3	2	033-70515	Spring
4	2	033-70495	Washer, Spring Centered
5	1	033-70529	Spool
6	1	033-53117	Body
7	1	033-72129	Plug
8	1	691-00906	O-ring
9	1	033-71923	Spring, Relief Valve
10	1	033-71925	Spring, Relief Valve
11	1	033-53154	Seat
12		Not Shown	
13		Not Shown	
14	2	345-20004	Shim Washer

FIGURE 3

ITEM	DESCRIPTION	PART NO.	QTY.
1	Plug, Hex Soc.	488-35014	2
2	O-ring	691-00912	2
3	Screw, Hex Hd. Cap	306-40181	4
4	Port Block w/ Shuttle	033-59992	1
	Port Block w/o Shuttle	033-59991	1
5	Gasket	033-70577	1
6	Port Plate, Motor, Bi-Directional 6.0 CIPR	033-71531	1
	Port Plate, Motor, Bi-Directional 7.25 CIPR	033-53775	
7	Face Plate, 7.25 CIPR	033-72532	1
	Face Plate, 6.0 CIPR	033-71530	
8	Face Plate Pin, Port Plate Pin	035-49825	5
9	O-ring	671-10016	3
10	Shuttle Valve w/ Two Orifices	S13-48776	1
	Shuttle valve, w/o Orifices	S13-48273	1
11	Screw Hex Hd.	306-40106	3
12	Retaining Ring	033-70494	1
13	Spring Retainer	033-53945	1
14	Barrel Stop	033-59973	1
15	Disc Spring	032-59743	12
16	Thrust Washer	032-59363	12
17	Cylinder Barrel 6.0 CIPR	S13-43657	1
	Cylinder Barrel 7.25 CIPR	S13-47511	1
18	Barrel Bearing	033-70580	1
19	Retaining Ring (Yellow) .083"(2.11 mm)	033-70584	Use Only One
	Retaining Ring (Green) .081"(2.03 mm)	033-70488	1
	Retaining Ring (Red) .079"(2.01 mm)	033-70490	1
	Retaining Ring (White) .086"(2.18 mm)	033-72175	1
	Retaining Ring (Blue) .084"(2.13 mm)	033-72176	1
	Retaining Ring (Black) .077"(1.96 mm)	033-54826	1
20	Thrust Washer	033-72249	1
21	Piston, Shoes and Retainer 6.0 CIPR	S13-43655	1
	Piston, Shoes and Retainer 7.25 CIPR	S13-42308	1
22	Creep Plate	033-71261	1
23	Cam (Std. 6.0/7.25 CIPR)	033-59987	1
	Cam (used w/6.0 Rot.Grp.= 4.0CIPR,	033-57902	
	used w/7.25 Rot.Grp.= 4.83CIPR)		
	Cam (used w/6.0 Rot. Grp.= 4.71CIPR,	033-57363	
	used w/7.25 Rot. Grp.= 5.5 CIPR)		
24	Dowel Pin	033-59985	2
25	Housing	033-59990	1
26	Screw, Soc. Hd. Cap	358-10120	1
27	Shaft, Splined	033-57233	1
	Shaft, Keyed	033-59989	1
	Shaft, Spline w/ Bearing	S23-03759	1
	Shaft, Spline w/ Cone	S23-03758	1
28	Bearing Assembly	S23-03262	1
29	O-ring	671-00242	1
30	Shaft Seal	620-82066	1
31	Seal Retainer	033-59986	1
32	O-ring	691-00905	4
33	Screw, Hex Hd. Cap	306-40225	4
34	O-ring	691-00908	1
35	Plug, Hex Soc.	488-35018	1
36	Key	035-71348	1
37	Seal Kit w/o Shuttle	S23-03237	1

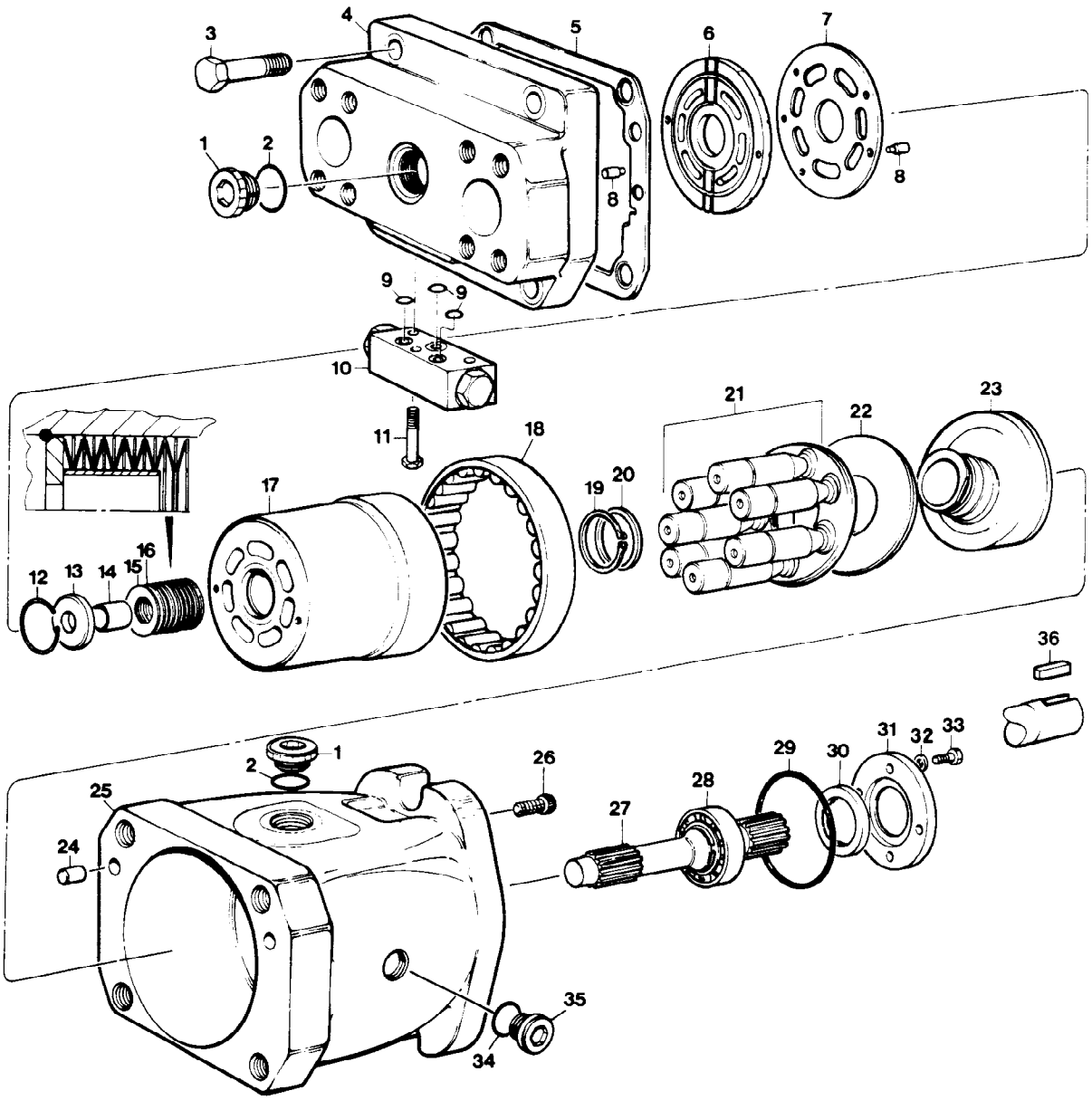

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FIGURE 4

Specification	Symbol for Unit	SI Unit	American Unit
Displacement	V_i	cm^3/rev	in^3/rev
Pressure	p	bar	psi
Pressure Drop	Δp_d	bar	psi
Charge Pressure	p_c	bar	psi
Speed (rotation)	n	rev/min	rev/min
Power	P	kW	hp
Torque (output)	M_v	Nm (da)	lbf•ft (in/lbs)
Torque (Specific)	m_v	Nm/bar	lbf•ft/1000 psi
Force	F	N	lbf
Flow	Q	l/min	GPM
Total Volumetric Loss	Q_l	l/min	GPM
Moment of Inertia	I	$kg.m_2$	$lb.in^2$
Temperature	T	°C	°F
Viscosity (kinematic)	ν	*c*St	SSU
Dimensions		mm	inch
Weight		kg	lbs

Definition & Unit	Example
DISPLACEMENT cm^3/rev	
1 in^3/rev = 16.387 cm^3/rev	40 cm^3/rev = 2.44 in^3/rev
FLOW l/min	
1 gpm = 3.78 l/min	148 l/min = 39.15 GPM
POWER kW	
1 hp = 0.7457 kW	25 kW = 33.52 hp
TORQUE Nm	
1 ft-lb = 1.3567 Nm	63 Nm = 46.46 ft-lbs
PRESSURE bar	
1 psi = 0.069 bar	100 bar = 1450 psi
WEIGHT kg	
1 lb = 0.455 kg	29 kg = 63.7 lbs
FORCE N	
1 lb = 1.55 N	600 N = 131.87 lbs
VOLUME cm^3	
1 in^3 = 16.387 cm^3	1000 cm^3 = 61 in^3
AREA cm^2	
1 in^2 = 6.45 cm^2	50 cm^2 = 7.75 in^2
DISTANCE mm	
1 in = 25.4 mm	101.6 mm = 4 in
TEMPERATURE °C	
Deg. F = $\frac{9 \times \text{Deg. C}}{5} + 32$	50°C = 122 ° F
VISCOSITY mm^2/sec (equivalent to *c*St)	
60 SSU = 10 mm^2/sec	25 mm^2/sec = 130 SSU

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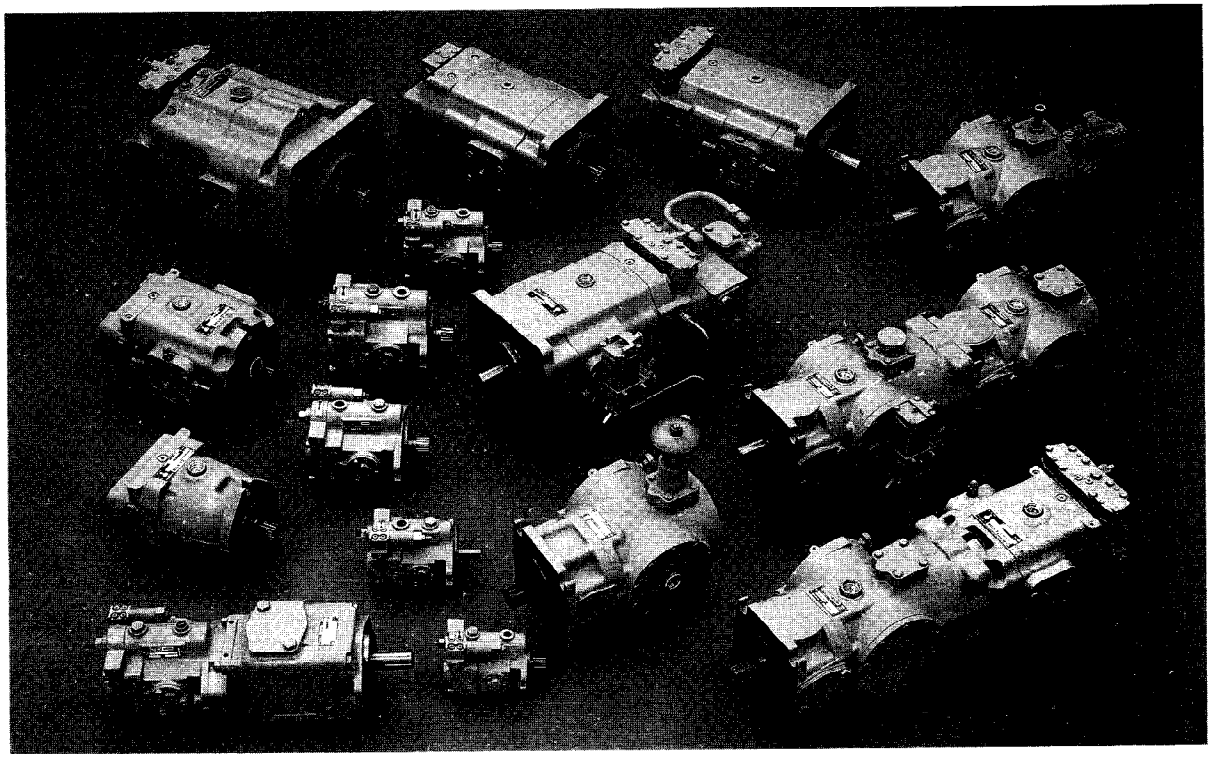

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Haidbachstrasse 69
A-4061 Pasching
Austria
Tel. 43 722 94887
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Telex 21672 DENIS

(AUS)
HAGGLUNDS-DENISON
PTY. LIMITED
41-43 St. Hillers Road
P.O. Box 192
Auburn, N.S.W. 2144
Australia
Tel. 61 2 646 5200
Fax 61 2 643 1305
Telex AA126773 HAGGS

(CDN)
HAGGLUNDS-DENISON
Canada Inc.
6675-1 Millcreek Dr.
Mississauga, ON L5N 5M4
(416) 858-2250
Fax 416/858-5980

(CH)
HAGGLUNDS-DENISON GmbH
Zweigniederlassung Zürich
Grindlenstrabe 3
CH-8954 Geroldswill.
Switzerland
Tel. 41 1 7480535
Fax 41 1 7480542
Telex 823475

(D)
HAGGLUNDS DENISON
Gerresheimer Straße 93
D-4010 Hilden, Germany
Tel. 49 2103 3090
Telex 8581506
Fax 49 2103 309211

(DK)
HAGGLUNDS-DENISON A/S
Industrikrogen 2
DK-2635 Ishoj, Denmark
Tel. 45 43711500
Fax 45 43711516
Telex 35392

(F)
HAGGLUNDS-DENISON
14 Route du Bois Blanc
18104 Vierzon
France
Tel. 33 48 753391
Telex 760624
Fax 33 48 750230

(GB)
HAGGLUNDS-DENISON
LIMITED
Kenmore Road
Wakefield 41 Industrial Estate
Wakefield, West Yorkshire
WF2 OXE England
Tel. 44 924 826021
Fax 44 924 826146
Telex 557252

(HK)
ASEA HAGGLUNDS (HK) LTD.
Rm 510-515 Trade Sq.
681 Cheung Sha Wan Rd.
Kowloon, Hong Kong
P.O. Box 72597
Kowloon HK Central
Tel. 852 3 7253373
Fax 852 3 7253443
Telex 54085 ASEA HX
Telegram ASEA KMN HK

(I)
HAGGLUNDS-DENISON S.p.A.
Filiale Italiana
Via Melegnano 10
Villagio Cavour
20019 - Settimo
Milanese, Italy
Tel. 39 232 85341
Fax 39 232 85267
Telex 330226

(IND)
HAGGLUNDS-DENISON
INDIA LTD.
Balanagar, Hyderabad 500 037
India
Tel. 91 542 262794
Telex 425-6295

(J)
HAGGLUNDS JAPAN, INC.
Hagglunds Denison Division
15-19, Hirato 1-Chome
Totsuka Ku, Yokohama, 244
Japan
Tel. 81 45 824-6911
Fax 81 45 824-6969
Telex 3823854 HAGJPN J

(MAL)
HAGGLUNDS-DENISON Sdn
Bhd
No 28 & 28A Jalan Dedap 20
Taman Johor Jaya
Johor
Malaysia

(N)
HAGGLUNDS DENI
P.O. Box 175
Industriveien 33
N-1301 Sandvika
Norway
Tel: (02) 54 59 90
Fax: (02) 54 71 50
Tlx: 76992

(NL)
HAGGLUNDS-DENISON B. V.
Kamerlingh. Onnesweg 22
NL-3316 GL Dordrecht.
Holland
Tel. 31 781 79900
Fax 31 781 75755
Telex 28957

(NZ)
HAGGLUNDS DENISON
PTY. LTD.
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Takapuna
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(S)
HAGGLUNDS-DENISON
SVENSKA AB
Sporregatan 13
S-21377 - Malmo, Sweden
Tel. 46 40 210440
Fax 46 40 214726
Telex 32535

(SF)
HAGGLUNDS-DENISON OY
Sienitie 6
SF 00760 Helsinki, Finland
Tel. 358 0 387211
Fax 358 0 386466
Telex 126041 HDGN SF

(SGP)
HAGGLUNDS SOUTH EAST
ASIA PTE. LTD.
Hagglunds Denison Division
No. 11 Lorong Tukang Dua
Jurong,
Singapore 2261
Singapore
Tel. 65 261 6366
Fax 65 265 0176
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(USA)
HAGGLUNDS-DENSION
425 S. Sandusky St.
Delaware, OH 43015 U.S.A.
Tel. (614) 368-7500
Telex 4332015
Fax 614/368-7200
For Nearest Distributor
Call Toll Free 1-800-982-0030

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