

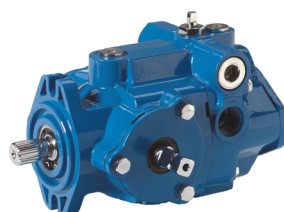
Eaton®

Medium Duty Piston Pump

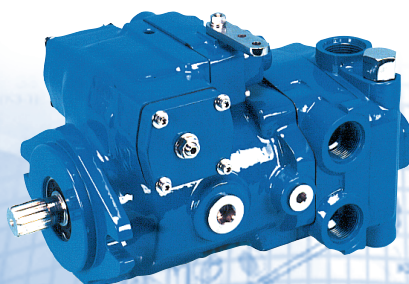
11-06-0611
EN 0201**EAT•N**

Variable Displacement Piston Pump

Manual Controlled

**Model 70160**20,3 cm³/r [1.24 in³/r]23,6 cm³/r [1.44 in³/r]**Model 70360**40,6 cm³/r [2.48 in³/r]49,2 cm³/r [3.00 in³/r]

Servo Controlled

**Model 72400**40,6 cm³/r [2.48 in³/r]49,2 cm³/r [3.00 in³/r]

We Manufacture

Solutions

Experienced system design engineers - Systems-based solutions to all your hydraulic needs.

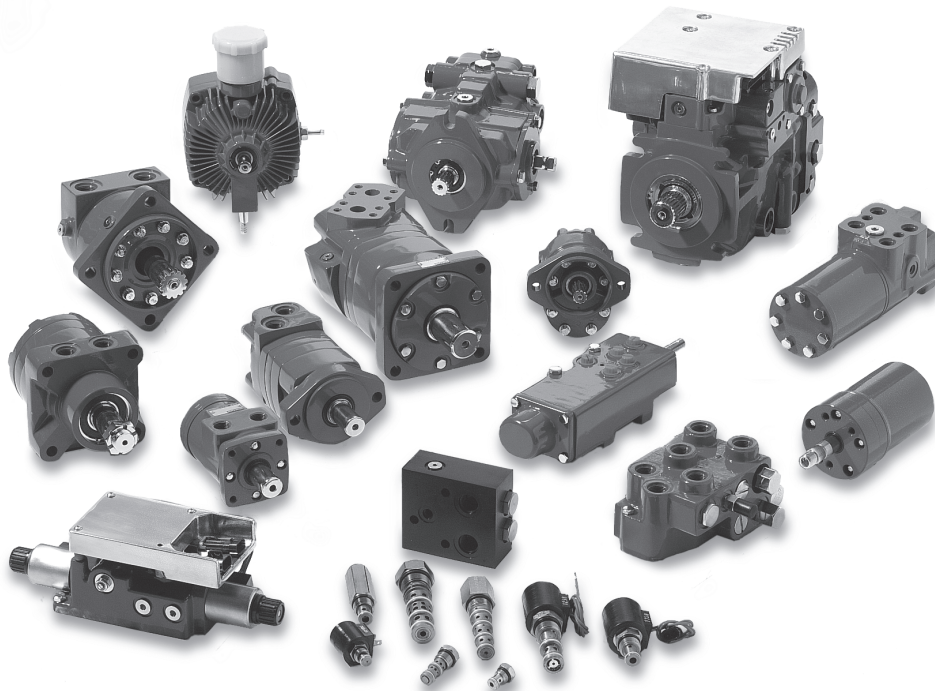
Global manufacturing capability - Manufacturing plants and joint ventures in the U.S., Europe, Japan and China.

Global sales support - Sales offices in the U.S., Scotland, Germany, Singapore, China and Korea.

World's largest distributor network - Over 100 distributors in 50 different countries.

Reliable, robust products - Field-proven leader in the hydraulics industry.

Exceptional product quality - All products manufactured in ISO 9001-certified sites.



Hydraulics Division



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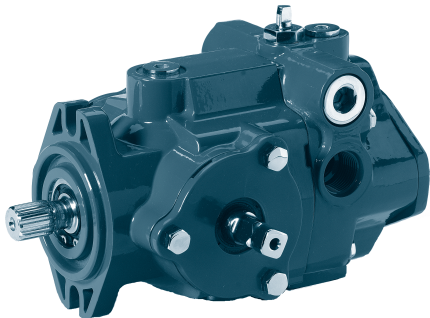
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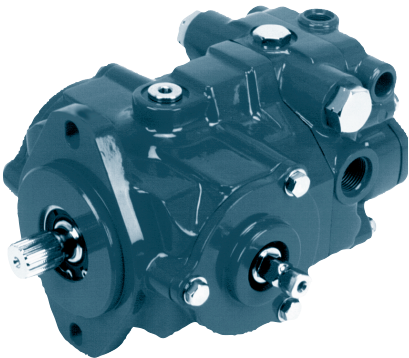
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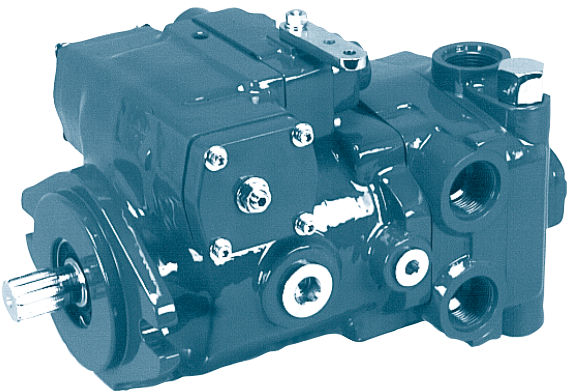
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Model 70160



Model 70360



Model 72400

Application Info.

Introduction

Variable displacement piston pumps are used in closed loop systems either as a single or tandem pump. Oil is circulated by the pump to the motor and then returned directly back to the pump. A charge supply is used to supplement the closed loop system with oil. The charge supply may be supplied by an internal charge pump (standard) or an external source.

Typical Applications

Harvester Equipment

- Combines
- Fruit or Vegetable Pickers
- Swathers

Forestry Equipment

- Log Skidders
- Bark Removers
- Limb Removers

Construction Equipment

- Trenchers
- Skid Loaders
- Utility Vehicles
- Sweepers

Turf Care Equipment

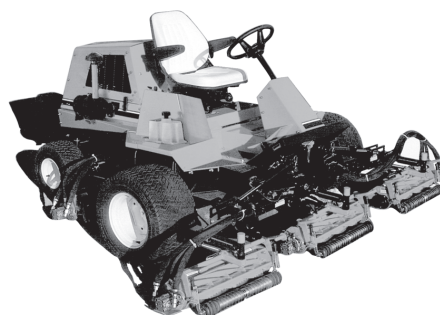
- Mowers
- Loaders

Industrial Equipment

- Lift Trucks
- Sissor lifts

Paving Equipment

- Rollers
- Packers



Section 1

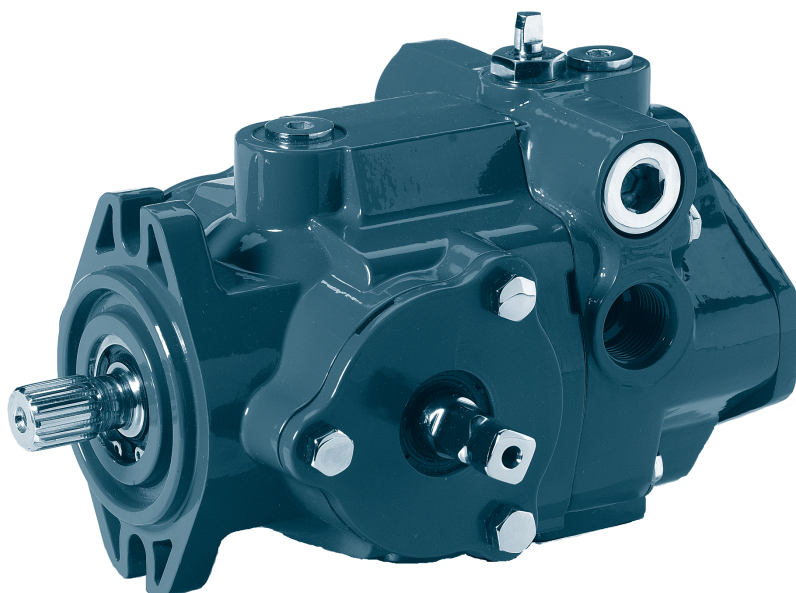
Model 70160

Manual Controlled

20,3 cm³/r [1.24 in³/r]

23,6 cm³/r [1.44 in³/r]

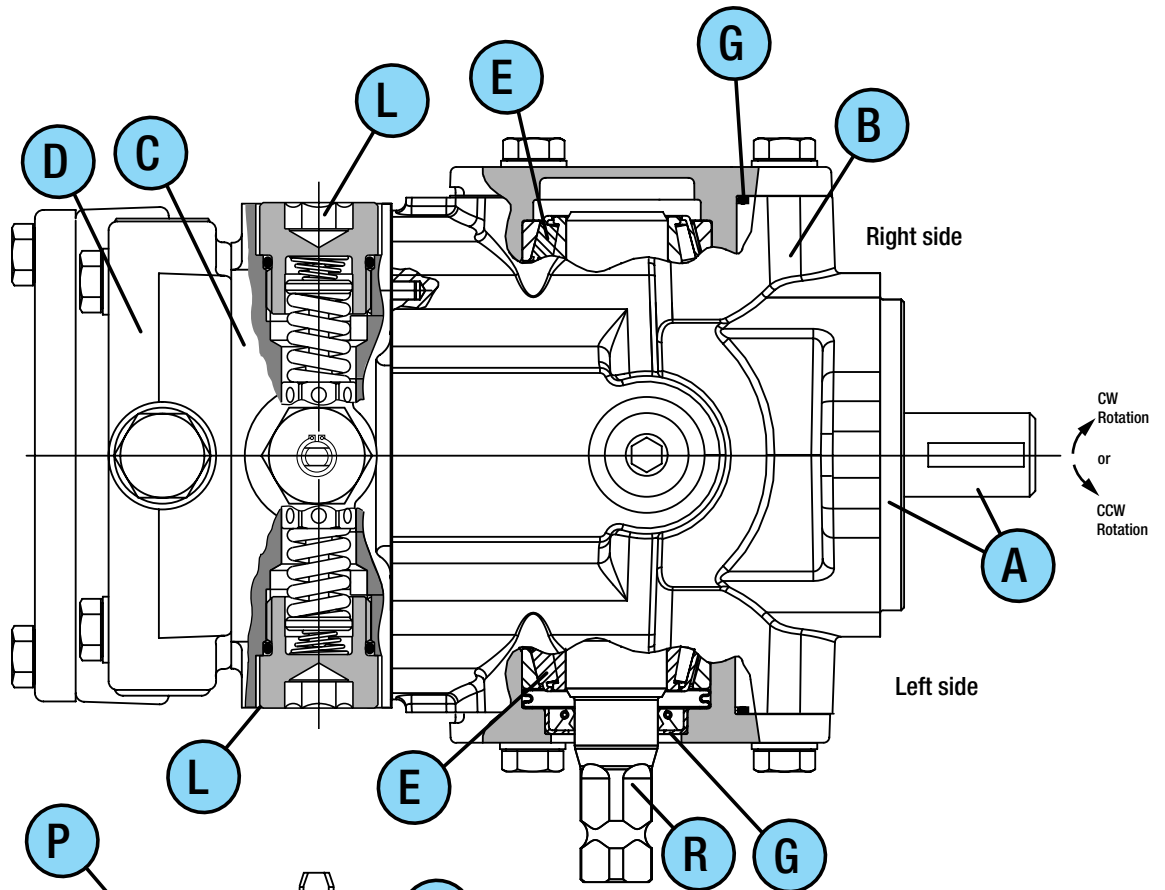
Displacement



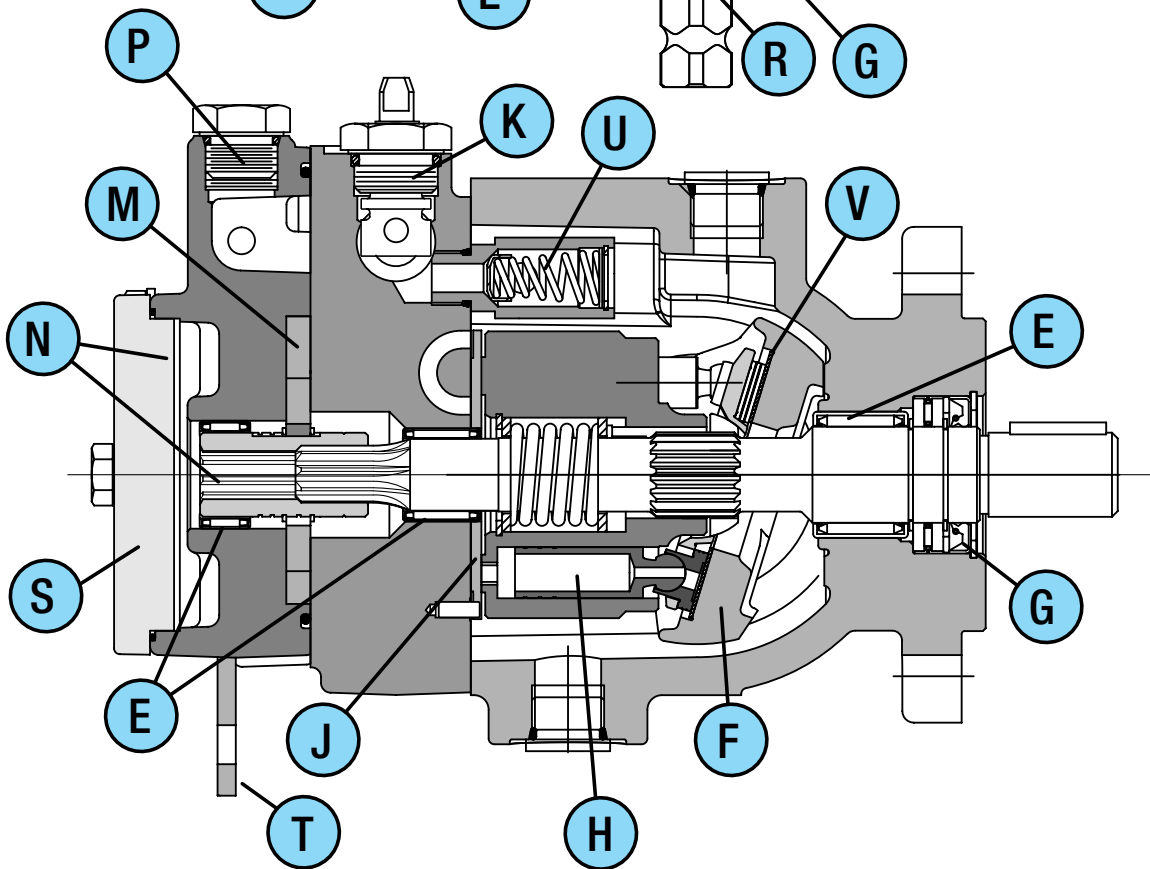
Model 70160 Features

Model 70160

Top View



Side View



Model 70160 Features

A Input Shaft and Mounting

- Shaft options
- SAE "A" mounting flange
- Tandem capability

B Housing

- Compact
- Lightweight, die cast aluminum

C Endcover

- Opposite side porting and same side porting available.

D Charge Pump Housing w/ Auxiliary Mount

E Bearings

F Swashplate

G Seals

H Rotating Group

- 20,3 cm³/r [1.24 in³/r] displacement
- 23,6 cm³/r [1.44 in³/r] displacement

J Valve Plate

K Bypass Valve

- Option for cross porting a closed loop hydraulic circuit — used to move a disabled machine a limited distance.

L Internal High Pressure Relief Valves

- Prevents excessive pressure

M Gerotor Charge Pump

- Two sizes available.
6,9 cm³/r [.42 in³/r]
13,8 cm³/r [.84 in³/r]

N Auxiliary Pump Drive

P Auxiliary Port

- For pressure check port or remote charge pressure port.

R Control Shaft

- Positioned on left or right side of pump.

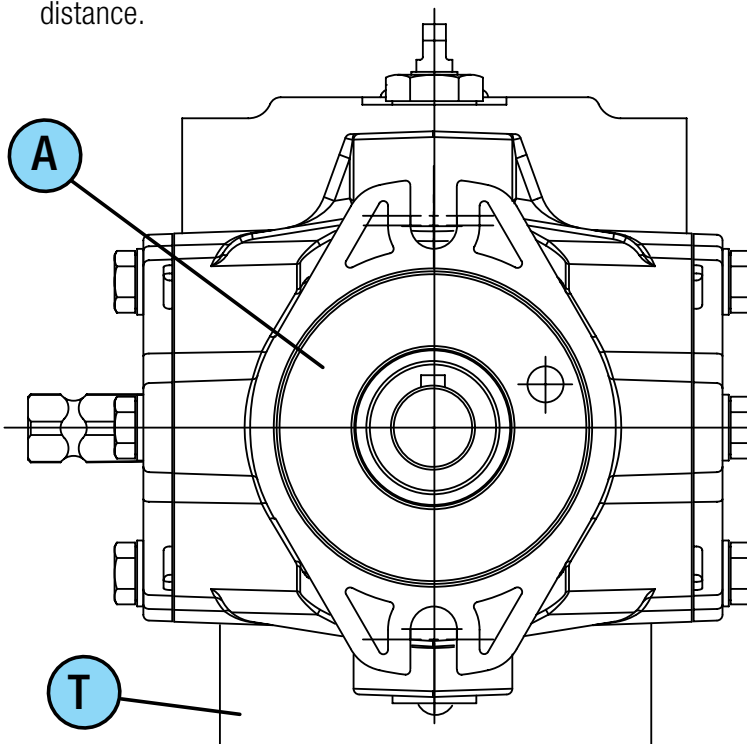
S "A" Pad Rear Cover Plate

T Mounting Bracket

- For support of rear unit of tandem pump. This bracket must be attached to the engine flywheel housing on the bulkhead used to mount the front unit of a tandem pump.

U Low Pressure Relief Valve

V Swashplate Insert

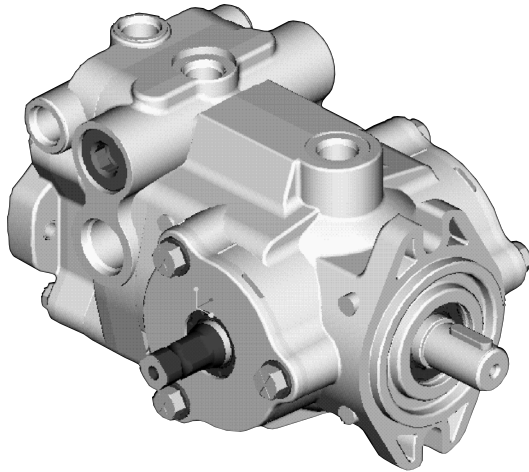


Front View

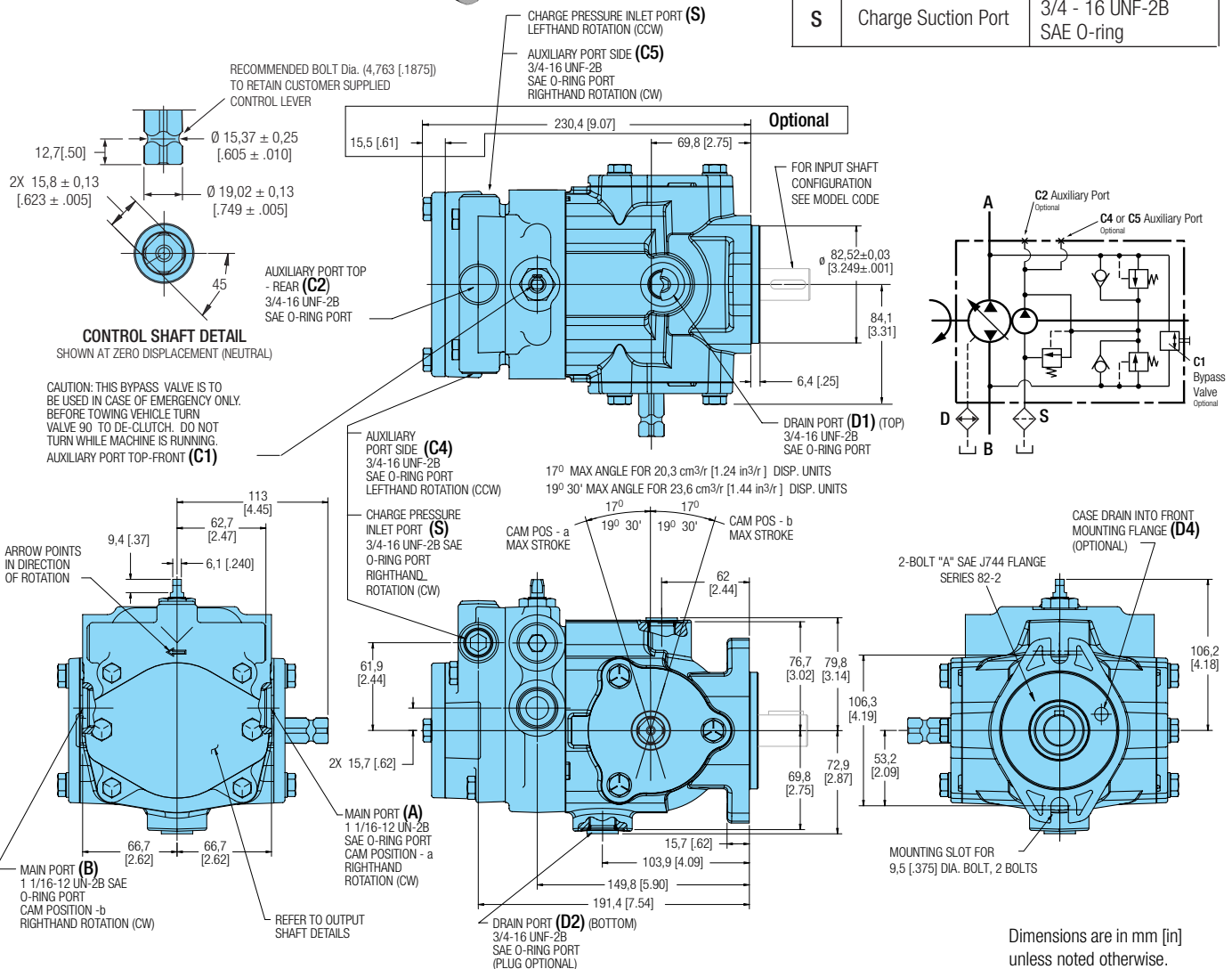
Model 70160

Assembly Installation Drawings

Opposite Side Porting, with internal Charge



Port ID	Type of Port	Size and Description
A	Main Port	1- 1/16 - 12 UN-2B SAE O-ring
B	Main Port	1- 1/16 - 12 UN-2B SAE O-ring
C1	Auxiliary Port Top - Front or Bypass Valve	3/4 - 16 UNF-2B SAE O-ring
C2	Auxiliary Port Top - Rear	3/4 - 16 UNF-2B SAE O-ring
C4	Auxiliary Port Side - Left Side	3/4 - 16 UNF-2B SAE O-ring
C5	Auxiliary Port Side - Right Side	3/4 - 16 UNF-2B SAE O-ring
D1	Drain Port - Top	3/4 - 16 UNF-2B SAE O-ring
D2	Drain Port - Bottom	3/4 - 16 UNF-2B SAE O-ring
D3	Thru Drain - Rear	9,27 [.365] Dia.
D4	Thru Drain - Front	9,27 [.365] Dia.
S	Charge Suction Port	3/4 - 16 UNF-2B SAE O-ring

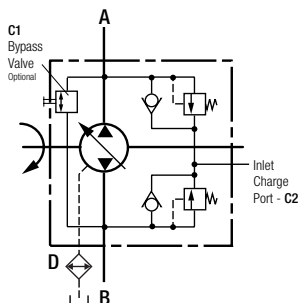
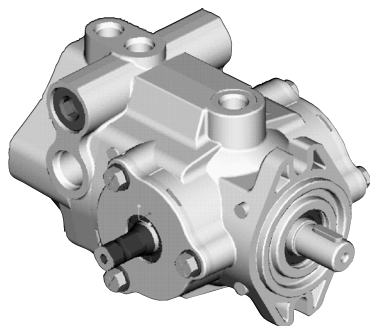


Model 70160

Assembly Installation Drawings

Opposite Side Porting

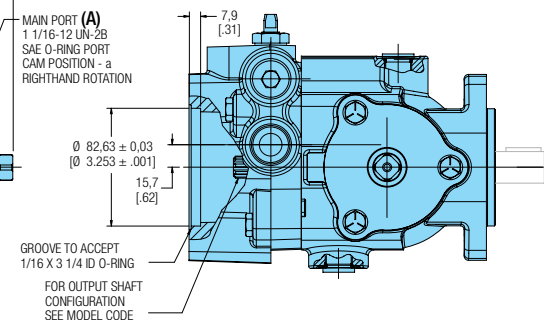
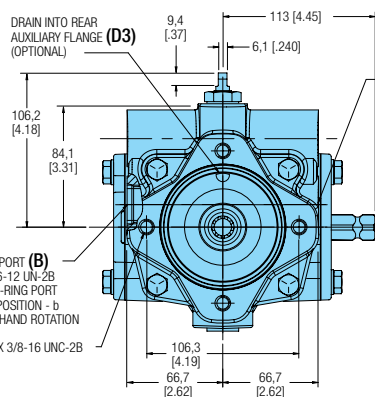
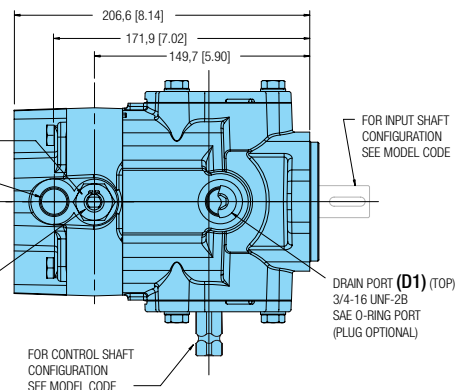
Note: External charge pump required.



CAUTION THIS BYPASS VALVE IS TO BE USED IN CASE OF EMERGENCY ONLY
EXCESS TOWING MAY DAMAGE HYDRAULIC SYSTEM. BEFORE TOWING VEHICLE TURN VALVE 90° TO DE-CLUTCH. DO NOT TURN WHILE MACHINE IS RUNNING.

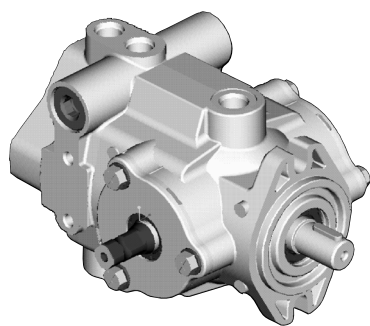
CHARGE PRESSURE INLET PORT (C2)
(AUXILIARY PORT REAR)

PORT TOP-REAR (C1)
(AUXILIARY PORT)
(BYPASS VALVE OPTIONAL)
(PLUG OPTIONAL)
(NO PORT OPTIONAL)



Same Side Porting

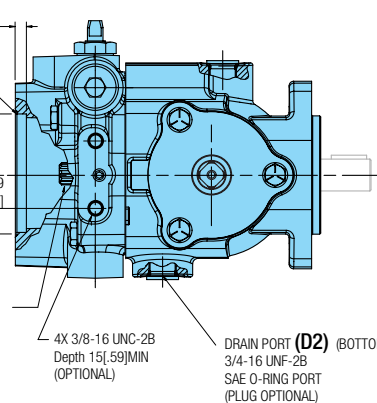
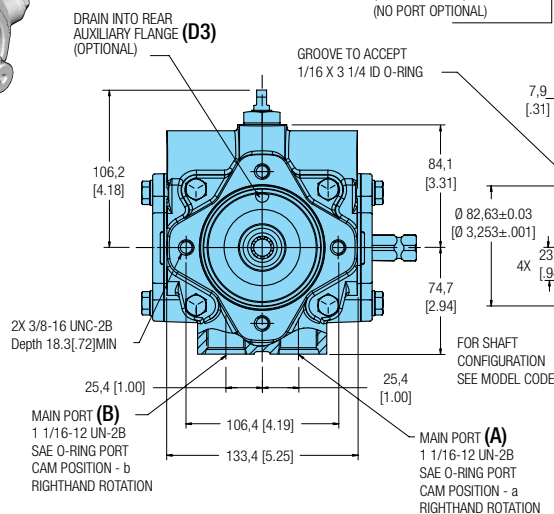
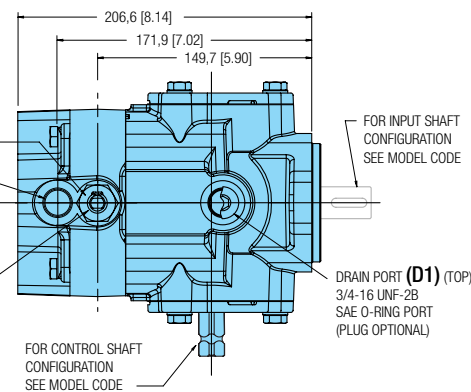
Note: External charge pump required.



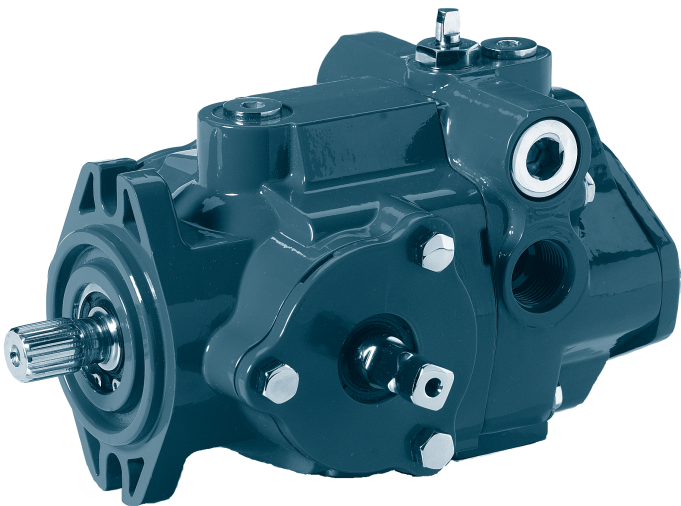
CAUTION THIS BYPASS VALVE IS TO BE USED IN CASE OF EMERGENCY ONLY
EXCESS TOWING MAY DAMAGE HYDRAULIC SYSTEM. BEFORE TOWING VEHICLE TURN VALVE 90° TO DE-CLUTCH. DO NOT TURN WHILE MACHINE IS RUNNING.

CHARGE PRESSURE INLET PORT (C2)
(AUXILIARY PORT - REAR)

PORT TOP REAR (C1)
(AUXILIARY PORT)
(BYPASS VALVE OPTIONAL)
(PLUG OPTIONAL)
(NO PORT OPTIONAL)



Model 70160 Specifications



Model 70160

Specifications - Piston Pump

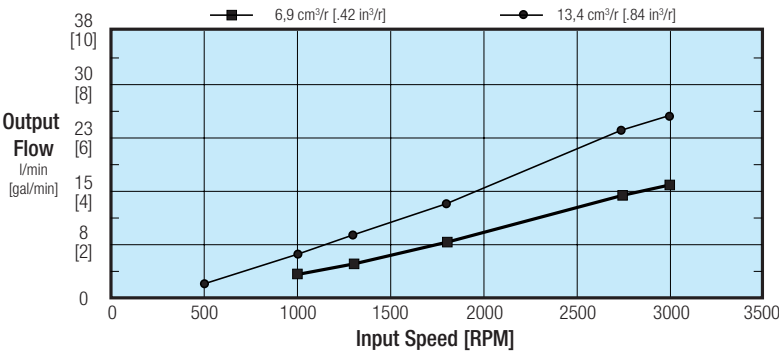
Maximum Displacement	20,3 cm³/r [1.24 in³/r]	23,6 cm³/r [1.44 in³/r]
Input Mounting Flange	SAE "A"	SAE "A"
Flow @ Rated Speed & PSI	64,3 l/min [17 gal/min]	75,7 l/min [20 gal/min]
Maximum Rated Speed	3600 RPM	3600 RPM
Continuous Rated Pressure	210 bar [3000 PSI]	210 bar [3000 PSI]
Maximum Intermittent Pressure	345 bar [5000 PSI]	345 bar [5000 PSI]
Continuous Allowable		
Case Pressure	2 bar [25 PSI]	2 bar [25 PSI]
Maximum Case Drain		
Temperature	107° C [225° F]	107° C [225° F]
Weight Per Single Pump	9,5 kg [21 lbs]	9,5 kg [21 lbs]

Specifications - Integral Gerotor Charge Pump

Displacement Options	
.....	6,9 cm³/r [.42 in³/r]
.....	13,8 cm³/r [.84 in³/r]
Operating Pressure Range (std.)	7 to 10 bar [100 to 150 PSI]
Maximum Charge Inlet Vacuum	0,80 bar Abs. [11.6 PSI Abs.]

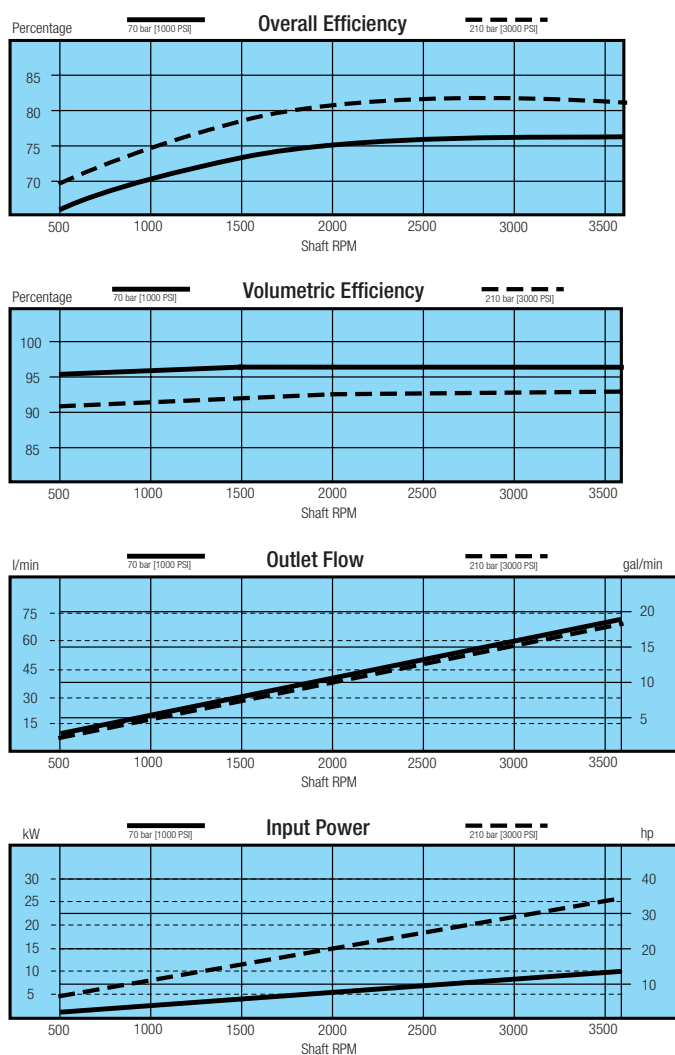
Charge Pump Performance - Flow vs Speed

The chart at right is representative of a 6,9 cm³/r [.42 in³/r] cm³/r and 13,4 [.84 in³/r] displacement charge pumps. The test was run at an oil temperature of 60°C [150°F] with viscosity 13 cSt [65 SUS].

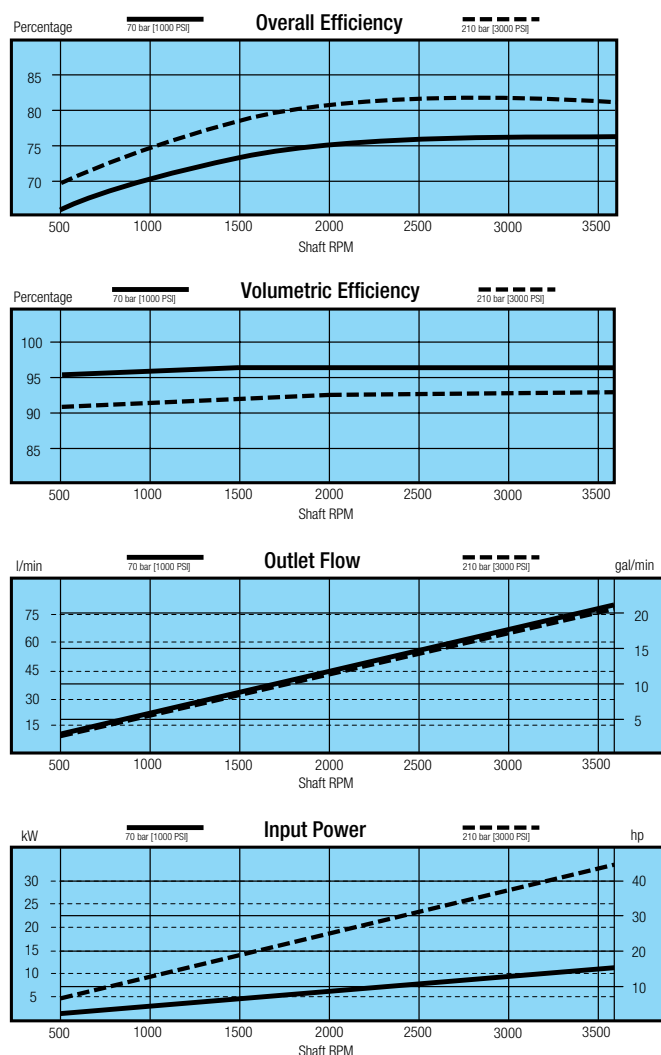


Model 70160 Performance Data

The charts below are representative of a **20,3 cm³/r [1.24 in³/r]** Variable Displacement Piston Pump. The tests were run at an oil temperature of 82°C [180°F] with viscosity 7 - 9 cSt [50 - 54 SUS] and the pump at maximum displacement.



The charts below are representative of a **23,6 cm³/r [1.44 in³/r]** Variable Displacement Piston Pump. The tests were run at an oil temperature of 82°C [180°F] with viscosity 7 - 9 cSt [50 - 54 SUS] and the pump at maximum displacement.



Model 70160 Code

The Model 70160 Variable Displacement Piston Pumps are specified by the following model code. Once a pump is built from the model code, a product number will be assigned to that configuration. Make sure all positions are selected within the 32 digit code for each pump.

Code Example:	ADB	12	R	1	A	B	D	1	1	T	T	1	A	0	A	A	A	3	1	1	A	0	0	0	0	A	0	C
Position-	1, 2, 3	4, 5	6	7	8	9	10	11	12	13	14	15	16	17	18	19, 20	21	22	23	24	25	26	27, 28	29, 30	31	32		
	ADB			1			D		1					0														C

Position 1, 2, 3 - Code Title

ADB = Series 160 Manually Variable Displacement Axial Piston Pump with SAE J744 Flange 82-2 (2 Bolt A)

Positions 4, 5 - Displacement

12 = 20,3 cm³/r [1.24 in³/r]

14 = 23,6 cm³/r [1.44 in³/r]

Position 6 - Input Shaft Rotation

R = Righthand Rotation (CW)

L = Lefthand Rotation (CCW)

Position 7 - Valve Plate

1 = Type 1

Position 8 - Input Shaft (see page 16 for details)

A = 13 Tooth 16/32 Pitch Spline, Shaft Extension 41,1 [1.62]

C = 35 Tooth 48/96 Pitch Spline, Shaft Extension 32,0 [1.26]

F = Straight Shaft Dia. 22,2 [.875], Keyway 6,35 [.25] x 25,9 [1.02], Shaft Extension 41,1 [1.62] (Key Included)

Position 9 - Control Shaft and Location

L = Left Side

R = Right Side

Position 10 - Control Shaft

D = with 15,7 [.62] square arm, with bolt groove; 113 [4.45] from unit centerline to control shaft end.

Position 11 - Main Ports (A and B) Location (see page 14 for port location)

1 = Opposite Sides

2 = Same Side (without internal charge pump)

Position 12 - Main Ports (A and B) Size

1 = 1 - 1/16 -12 UN-2B Port, SAE Straight Thread O-ring Ports

Positions 13, 14 - Relief Valve Setting for Main Ports

(Select a setting for port "A" in position 10 and port "B" in position 11.)

0 = No Relief, Check Valve Assembly Only

B = 138 bar [2000 PSI]

E = 173 bar [2500 PSI]

H = 207 bar [3000 PSI]

L = 241 bar [3500 PSI]

N = 276 bar [4000 PSI]

Q = 310 bar [4500 PSI]

T = 344 bar [5000 PSI]

Position 15 - Charge Displacement, Suction Port (S) (see page 17 for port location)

0 = No Charge

1 = 6,9 cm³/r [.42 in³/r]; 3/4 - 16 UNF-2B SAE o-ring port for suction inlet (right side CCW, Left side CW)

3 = 13,8 cm³/r [.84 in³/r]; 3/4 -16 UNF-2B SAE o-ring port for suction inlet (right side CCW, Left side CW)

Position 16 - Charge Relief Setting and Routing

0 = No (requires external relief set between 6,89 bar [100 lbf/in²] and 20,68 bar [300 lbf/in²])

A = 6,89-10,34 bar [100-150 PSI]; Relieved to case

B = 10,34-13,79 bar [150-200 PSI]; Relieved to case

C = 13,79-17,24 bar [200-250 PSI]; Relieved to case

D = 17,24-20,68 bar [250-300 PSI]; Relieved to case

E = 20,68-24,13 bar [300-350 PSI]; Relieved to case

F = 6,89-10,34 bar [100-150 PSI]; Recirculated

G = 10,34-13,79 bar [150-200 PSI]; Recirculated

H = 13,79-17,24 bar [200-250 PSI]; Recirculated

J = 17,24-20,68 bar [250-300 PSI]; Recirculated

K = 20,68-24,13 bar [300-350 PSI]; Recirculated

	Code	Single Unit	Tandem Unit Front	Tandem Unit Rear
<i>All left (CCW) or right (CW) directions given are viewed from the input shaft end of the pump.</i>				
12 = 20,3 cm ³ /r [1.24 in ³ /r]	12	Std.	Std.	Std.
14 = 23,6 cm ³ /r [1.44 in ³ /r]	14	Std.	Std.	Std.
R = Righthand Rotation (CW)	R	Std.	Std.	Std.
L = Lefthand Rotation (CCW)	L	Std.	Std.	Std.
1 = Type 1	1	Std.	Std.	Std.
A = 13 Tooth 16/32 Pitch Spline, Shaft Extension 41,1 [1.62]	A	Std.	Std.	NA
C = 35 Tooth 48/96 Pitch Spline, Shaft Extension 32,0 [1.26]	C	NA	NA	Std.
F = Straight Shaft Dia. 22,2 [.875], Keyway 6,35 [.25] x 25,9 [1.02], Shaft Extension 41,1 [1.62] (Key Included)	F	Opt.	NA	NA
L = Left Side	L	Std.	Std.	Std.
R = Right Side	R	Std.	Std.	Std.
D = with 15,7 [.62] square arm, with bolt groove; 113 [4.45] from unit centerline to control shaft end.	D	Std.	Std.	Std.
1 = Opposite Sides	1	Std.	Std.	Std.
2 = Same Side (without internal charge pump)	2	Opt.	Opt.	Opt.
1 = 1 - 1/16 -12 UN-2B Port, SAE Straight Thread O-ring Ports	1	Std.	Std.	Std.
0 = No Relief, Check Valve Assembly Only	0	Opt.	Opt.	Opt.
B = 138 bar [2000 PSI]	B	Opt.	Opt.	Opt.
E = 173 bar [2500 PSI]	E	Opt.	Opt.	Opt.
H = 207 bar [3000 PSI]	H	Opt.	Opt.	Opt.
L = 241 bar [3500 PSI]	L	Opt.	Opt.	Opt.
N = 276 bar [4000 PSI]	N	Opt.	Opt.	Opt.
Q = 310 bar [4500 PSI]	Q	Opt.	Opt.	Opt.
T = 344 bar [5000 PSI]	T	Std.	Std.	Std.
0 = No Charge	0	Opt.	Std.	Opt.
1 = 6,9 cm ³ /r [.42 in ³ /r]; 3/4 - 16 UNF-2B SAE o-ring port for suction inlet (right side CCW, Left side CW)	1	Std.	NA	NA
3 = 13,8 cm ³ /r [.84 in ³ /r]; 3/4 -16 UNF-2B SAE o-ring port for suction inlet (right side CCW, Left side CW)	3	Opt.	NA	Std.
0 = No (requires external relief set between 6,89 bar [100 lbf/in ²] and 20,68 bar [300 lbf/in ²])	0	Opt.	Std.	Opt.
A = 6,89-10,34 bar [100-150 PSI]; Relieved to case	A	Std.	NA	Std.
B = 10,34-13,79 bar [150-200 PSI]; Relieved to case	B	Opt.	NA	Opt.
C = 13,79-17,24 bar [200-250 PSI]; Relieved to case	C	Opt.	NA	Opt.
D = 17,24-20,68 bar [250-300 PSI]; Relieved to case	D	Opt.	NA	Opt.
E = 20,68-24,13 bar [300-350 PSI]; Relieved to case	E	Opt.	NA	Opt.
F = 6,89-10,34 bar [100-150 PSI]; Recirculated	F	Std.	NA	Std.
G = 10,34-13,79 bar [150-200 PSI]; Recirculated	G	Opt.	NA	Opt.
H = 13,79-17,24 bar [200-250 PSI]; Recirculated	H	Opt.	NA	Opt.
J = 17,24-20,68 bar [250-300 PSI]; Recirculated	J	Opt.	NA	Opt.
K = 20,68-24,13 bar [300-350 PSI]; Recirculated	K	Opt.	NA	Opt.

Dimensions are in mm [in] unless noted otherwise.

Model 70160 Code (continued)

Position 17 - Charge Special Feature

0 = No Special Feature 0 Std. Std. Std.

Position 18 - Auxiliary Rear Mount and Output Shaft (see page 15 for details)

A = With Integral Charge: Horizontal 2-Bolt "A" SAE J744 Flange 82-2;
Accepts 9 tooth internal 16/32 pitch spline with 31,7 [1.25] shaft extension A Std. NA Std.
B = No Integral Charge: Horizontal or Vertical 2-Bolt "A" SAE J744 Flange 82-2;
Accepts 11 tooth external 16/32 pitch spline with 31,7 [1.25] shaft extension (Coupler required) B Opt. NA Opt.
C = No Integral Charge: Horizontal or Vertical 2-Bolt "A" SAE J744 Flange 82-2;
Accepts 9 tooth external 16/32 pitch spline with 31,7 [1.25] shaft extension (Coupler required) C Opt. NA Opt.
D = No Integral Charge: Horizontal or Vertical 2-Bolt "A" SAE J744 Flange 82-2;
Accepts 35 tooth external 48/96 pitch spline with 32 [1.26] shaft extension (Coupler required) D Opt. Std. Opt.
E = No Integral Charge: Horizontal or Vertical 2-Bolt "A" SAE J744 Flange 82-2;
Accepts 9 tooth external 20/40 pitch spline with 31,7 [1.25] shaft extension (Coupler required) E Opt. NA Opt.

Position 19, 20 - Special Features Auxiliary Mounting

00 = No Special Features 00 Std. Std. Std.
AA = Supply Cover Plate for 2-Bolt "A" SAE J744 Flange 82-2 AA Opt. Opt. Opt.
AB = Supply Shaft Coupler 9 tooth 16/32 pitch AB Opt. Opt. Opt.
AC = Supply Shaft Coupler 9 tooth 20/40 pitch AC Opt. Opt. Opt.
AD = Supply Shaft Coupler 11 tooth 16/32 pitch AD Opt. Opt. Opt.
AE = Supply Shaft Coupler 35 tooth 48/96 pitch AE Opt. Opt. Opt.
AF = Bottom Mounting Bracket (632), Square Shaped AF Opt. Opt. Opt.
AG = Bottom Mounting Bracket (709), V Shaped AG Opt. Opt. Opt.
AH = Auxiliary Mounting Holes, 2 holes .375-16 UNC-2B thread, 15 [.59] min full thread, both sides AH Opt. Opt. Opt.
AJ = Auxiliary Mounting Holes, 2 holes .375-16 UNC-2B thread, 15 [.59] min full thread, both sides (9T coupler and Mounting Holes) AJ Opt.

Position 21 - Auxiliary Port Top-Front (C1) or Bypass Valve (see page 17 for port location)

0 = None 0 Std. Std. Std.
1 = 3/4 -16 UNF-2B SAE o-ring port 1 Opt. Opt. Opt.
2 = 3/4 -16 UNF-2B SAE o-ring port plugged 2 Opt. Opt. Opt.
3 = Bypass Valve Installed 3 Opt. Opt. Opt.

Position 22 - Auxiliary Port Top-Rear (C2) (see page 17 for port location)

1 = 3/4 -16 UNF-2B SAE o-ring port 1 Std. Std. Std.
2 = 3/4 -16 UNF-2B SAE o-ring port plugged 2 Opt. Opt. Opt.

Position 23 - Auxiliary Port Side (C4 or C5) (Integral Charge Only) (see page 17 for port location)

0 = None 0 Opt. NA Opt.
1 = 3/4 -16 UNF-2B SAE o-ring port (right side CW, left side CCW) 1 Opt. NA Opt.

Position 24 - Case Drain (D1 and D2) (see page 17 for port location)

A = 3/4 -16 UNF-2B SAE o-ring port D1-top (D2-bottom plugged) A Std. Opt. Std.
B = 3/4 -16 UNF-2B SAE o-ring port D2-bottom (D1-top plugged) B Opt. Opt. Opt.
C = 3/4 -16 UNF-2B SAE o-ring port (D1-top plugged and D2-bottom plugged) C Opt. Opt. Opt.
D = 3/4 -16 UNF-2B SAE o-ring port (D1-top and D2-bottom open) D Opt. Opt. Opt.

Position 25 - Thru Drain (D3 and D4) (see page 17 for port location)

0 = None 0 Opt. Opt. Opt.
A = .365 Dia. D3-rear A Opt. Std. Opt.
B = .376 Dia. D4-front B Opt. Opt. Std.
C = .365 Dia. D3-rear and .376 Dia. D4-front C Opt. Opt. Opt.

Position 26 - Additional Functions

0 = None 0 Std. Std. Std.

Position 27, 28 - Special Features

00 = None 00 Std. Std. Std.
0A = Fluorocarbon rubber drive shaft seal 0A Opt. Opt. Opt.

Position 29, 30 - Paint

0A = Primer, Red Oxide 0A Std. Std. Std.
0B = Black 0B Opt. Opt. Opt.
0C = Primer, Blue 0C Opt. Opt. Opt.

Position 31 - Identification

0 = Standard: Nameplate 0 Std. Std. Std.

Position 32 - Design Code

C = C C Std. Std. Std.

Model 70160

Input Shafts

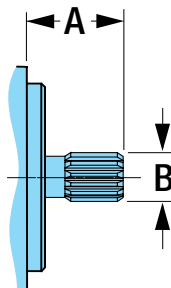
Code Position 8

Dimensions are in mm [in]
unless noted otherwise.

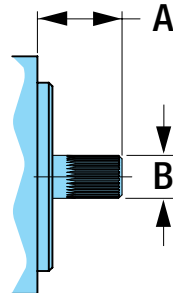
Code	Input Shafts		
	A	C	F
Type	13 Tooth	35 Tooth	Straight Keyed
A Dimension	41,1 [1.62]	32,0 [1.26]	41,1 [1.62]
B Dimension	21,810 [.8585]	19,0 [.75]	22,23 +0,00/-0,03 [.875 +.000/- .001] Dia.
Maximum Input Torque	209,3 N•m [1852 lbf•in]	Used for tandem connection only	209,3 N•m [1852 lbf•in]
Shaft Specifications	16/32 Pitch 30 Degree Involute Flat Root, Class 1 Side Fit Spline, SAE J498b	48/96 Pitch 45 Degree Involute Fillet Root, Class 1 Side Fit Spline, SAE J498b	

Torque Note:

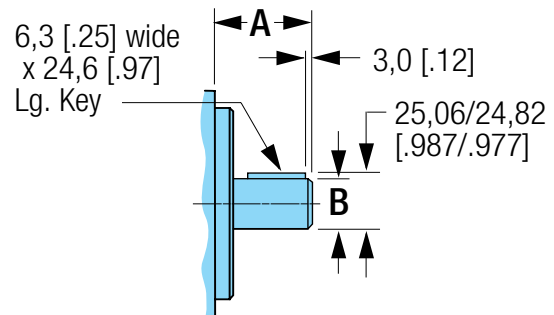
The combined torque required for multiple pumps must not exceed the torque rating of the input drive shaft of the front piston pump. Consult an Eaton representative and/or Eaton engineering on side load recommendations.



Input Shaft A
13 Tooth



Input Shaft C
35 Tooth



Input Shaft F
Straight Keyed

Model 70160

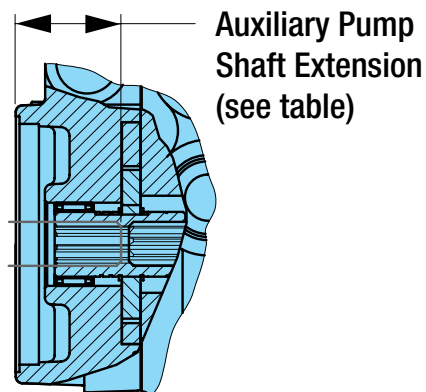
Auxiliary Rear Mounts & Output Shafts

Code Position 18

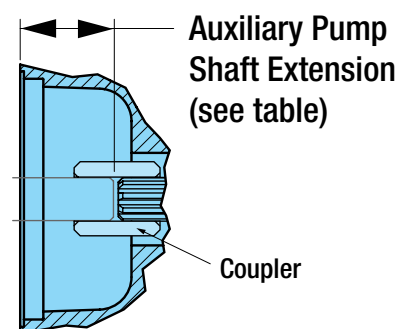
Dimensions are in mm [in]
unless noted otherwise.

Code	Output Shafts				
	A	B	C	D	E
Type	9 Tooth	11 Tooth	9 Tooth	35 Tooth	9 Tooth
Shaft Outside Diameter	15,88 [.6250]	19,33 [.761]	15,88 [.6250]	19 [.75]	15,88 [.6250]
Shaft Diametrical Pitch	16/32 Pitch Int.	16/32 Pitch Ext.	16/32 Pitch Int.	48/96 Pitch Ext.	20/40 Pitch Ext.
Auxiliary Mount SAE "A" 2 Bolt	SAE J744	SAE J744	SAE J744	SAE J744	SAE J744
Auxiliary Pump Shaft Extension	31,7 [1.25]	31,7 [1.25]	31,7 [1.25]	32,0 [1.26]	31,7 [1.25]
Charge Pump	Yes	No	No	No	No
Maximum Torque	54 N•m [480 lbf•in]	119 N•m [1050 lbf•in]	76 N•m [672 lbf•in]	Used for tandem connection only	76 N•m [672 lbf•in]
Coupler Required; In code Position 19, 20 select...	No	Yes, Code "AD"	Yes, Code "AB"	Yes, Code "AE"	Yes, Code "AC"

**Auxiliary "A" Mount
with
Charge Pump**



**Auxiliary "A" Mount
without
Charge Pump**



		Type	Diameter	Length
Code Position 12 and 20	AB	9T	28,45 [1.12] Dia.	39,12 [1.540]
	AC	9T	28,45 [1.12] Dia.	34,29 [1.35]
	AD	11T	31,8 [1.25] Dia.	38,9 [1.531]
	AE	35T	28,45 [1.12] Dia.	37,9 [1.49]

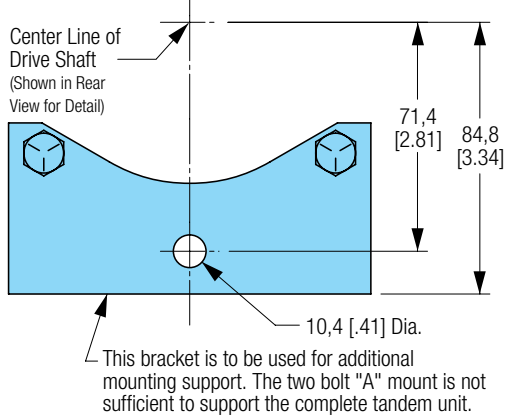
Model 70160

Bracket and Cover Plate

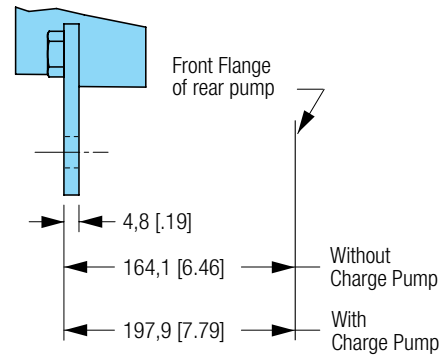
Model 70160

Code Position 19, 20 Bracket

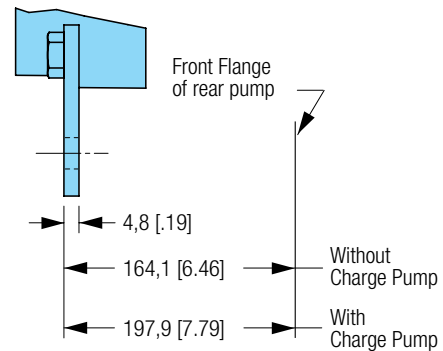
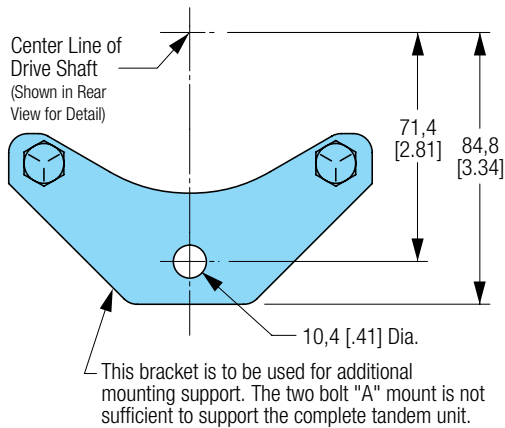
Code "AF" Bracket



For Units with Integral Charge Pump Only



Code "AG" Bracket



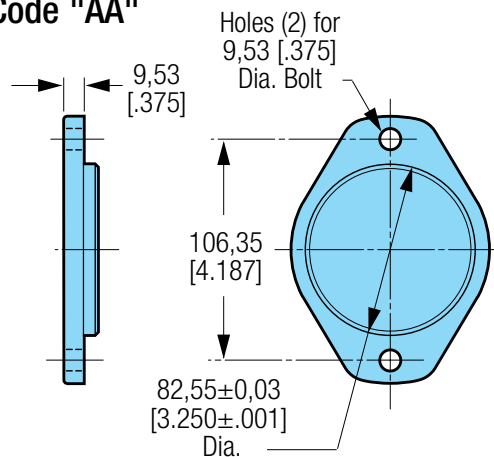
Cover Plate

Code Position 19, 20

Fits SAE "A" auxiliary mounting flange in place of auxiliary pump.

Cover Plate Kit #70142-915 includes cover plate, cap screws (2) and o-ring.

Code "AA"



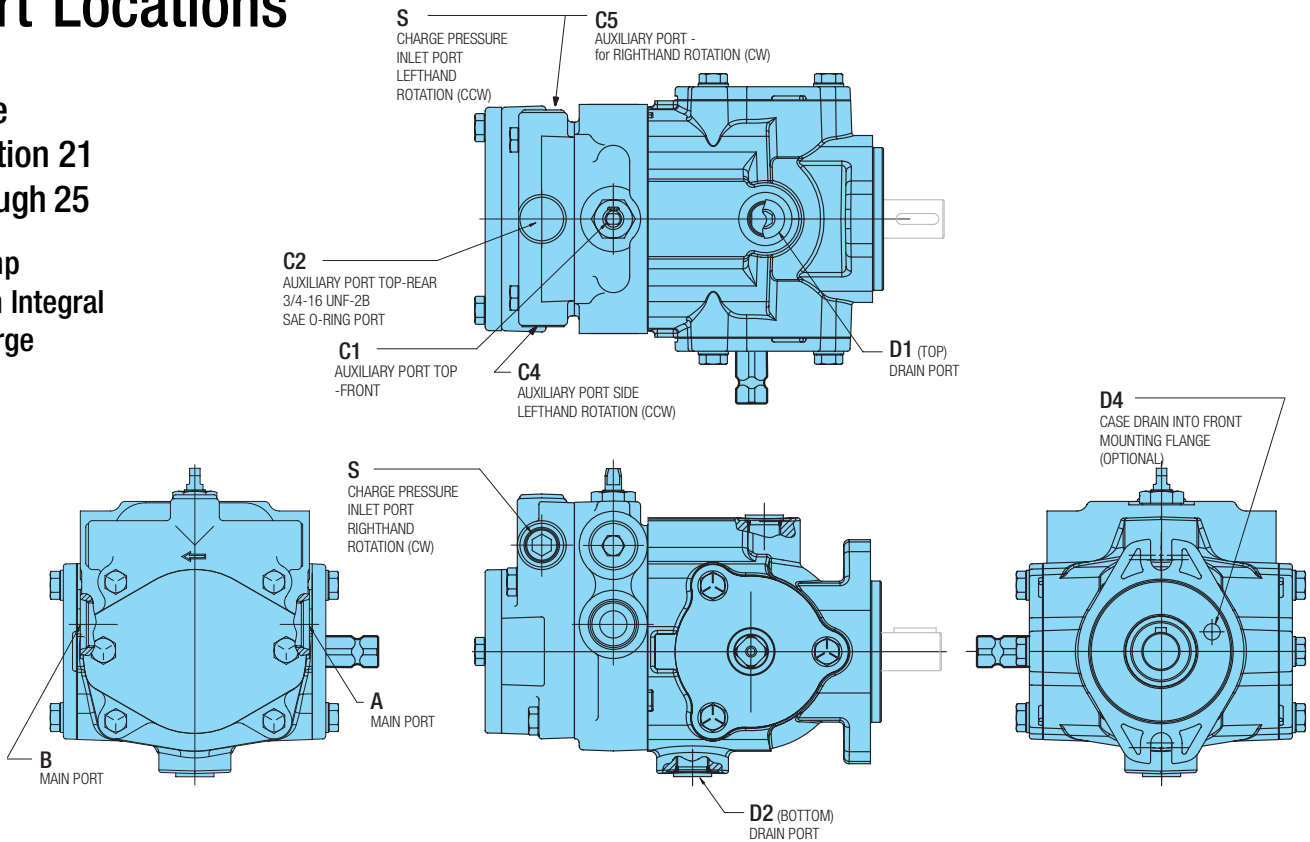
Dimensions are in mm [in] unless noted otherwise.

Model 70160

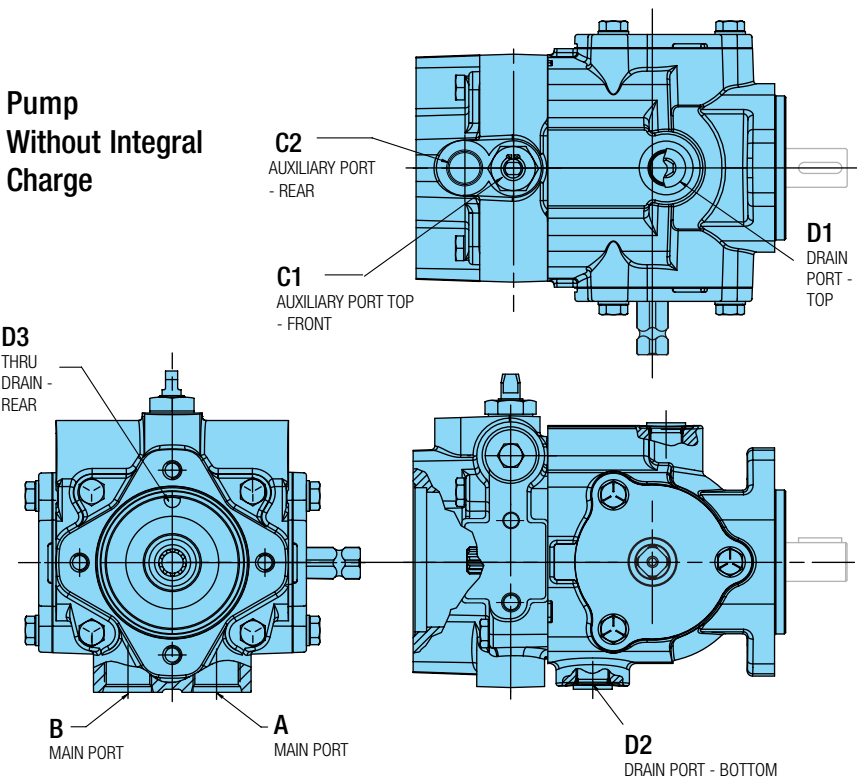
Port Locations

Code
Position 21
through 25

Pump
With Integral
Charge

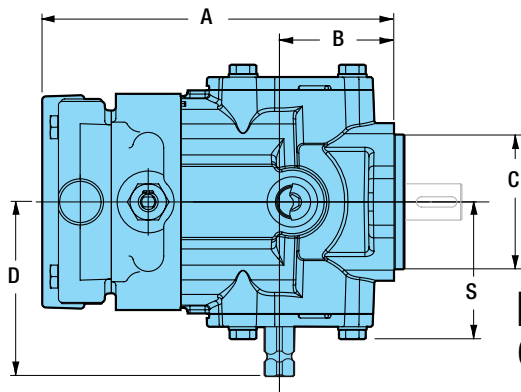


Pump
Without Integral
Charge

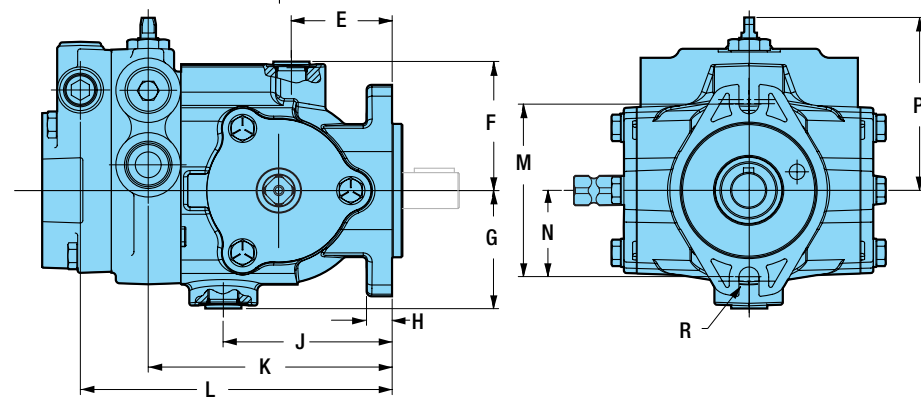


Port ID	Type of Port	Size and Description
A	Main Port	1- 1/16 - 12 UN-2B SAE O-ring
B	Main Port	1- 1/16 - 12 UN-2B SAE O-ring
C1	Auxiliary Port Top - Front or Bypass Valve	3/4 - 16 UNF-2B SAE O-ring
C2	Auxiliary Port Top - Rear	3/4 - 16 UNF-2B SAE O-ring
C4	Auxiliary Port Side - Left Side	3/4 - 16 UNF-2B SAE O-ring
C5	Auxiliary Port Side - Right Side	3/4 - 16 UNF-2B SAE O-ring
D1	Drain Port - Top	3/4 - 16 UNF-2B SAE O-ring
D2	Drain Port - Bottom	3/4 - 16 UNF-2B SAE O-ring
D3	Thru Drain - Rear	9,27 [.365] Dia.
D4	Thru Drain - Front	9,27 [.365] Dia.
S	Charge Suction Port	3/4 - 16 UNF-2B SAE O-ring

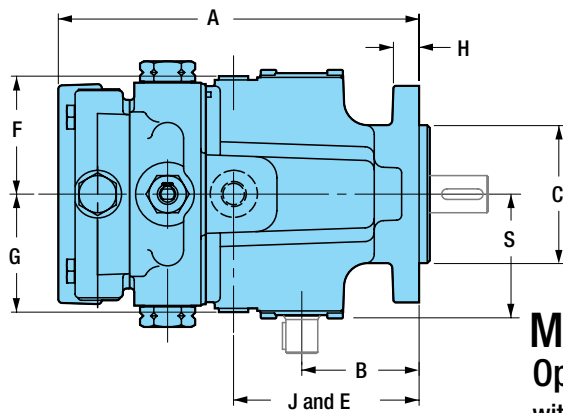
Model 70160 and 70142 Dimension Comparison



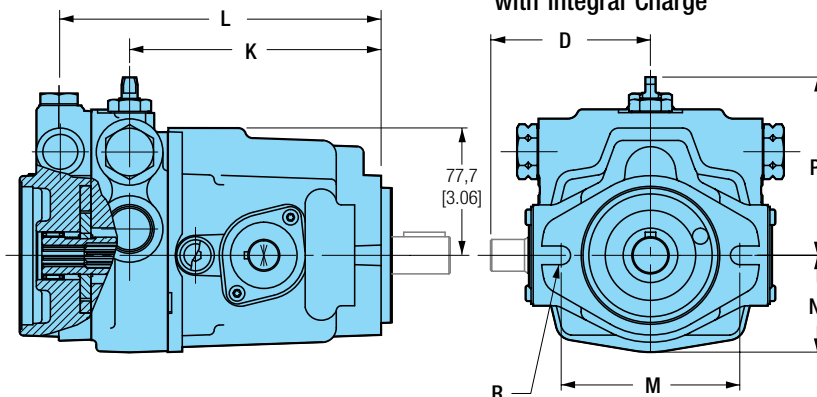
Model 70160
Opposite Side Porting, with integral Charge



	Model 70160	Model 70142
A	214,8 [8.46]	214,8 [8.46]
B	69,8 [2.75]	69,8 [2.75]
C	82,52 [3.249]	82,52 [3.249]
D	113,0 [4.45]	95,2 [3.75]
E	62,0 [2.44]	110,5 [4.35]
F	79,8 [3.14]	70,6 [2.75]
G	72,9 [2.87]	70,6 [2.75]
H	15,7 [.62]	15,2 [.60]
J	103,9 [4.09]	110,5 [4.35]
K	149,8 [5.90]	149,6 [5.89]
L	191,4 [7.54]	191,4 [7.54]
M	106,6 [4.19]	106,6 [4.19]
N	53,2 [2.09]	53,2 [2.09]
P	106,2 [4.18]	106,6 [4.20]
R	11,2 [.44] Ø Bolt Slot	9,5 [.375] Ø Bolt Slot
S	84,1 [3.31]	74,7 [2.94]



Model 70142
Opposite Side Porting,
with integral Charge



1.24 in³/r Displacement Frame Size

Key Improvements

- Redesigned Trunnion Bearing & Covers
 - Changed from needle to tapered roller bearings
 - Improved thrust load capabilities
 - Minimizes section seal leaks
 - Facilitates assembly and disassembly
- Swash Plate
 - Incorporates a thrust plate to improve serviceability
- Main Housing & Mounting Flange
 - Mounting flange rotated 90 degrees to facilitate larger trunnion bearings
 - Stiffer mounting flange to minimize requirement for additional mounting brackets
 - Larger case drain for higher flow capacity
 - Top & Bottom case drain locations minimize entrapped air and reduces risks of cavitation
- Input Control Shaft & Seals
 - Redesigned to ease customer assembly of control linkages
 - Square input shaft to reduce wear between linkage and input shaft
 - Annular groove in input shaft to facilitate retention of linkage to the input shaft
- Computer Generated Valve Plate Designs
 - Reduces noise and improved sound quality
 - Designs tailored to meet customer control and noise requirements
- Improved Rotating Group
 - Improved neutral centering characteristics

Section 2

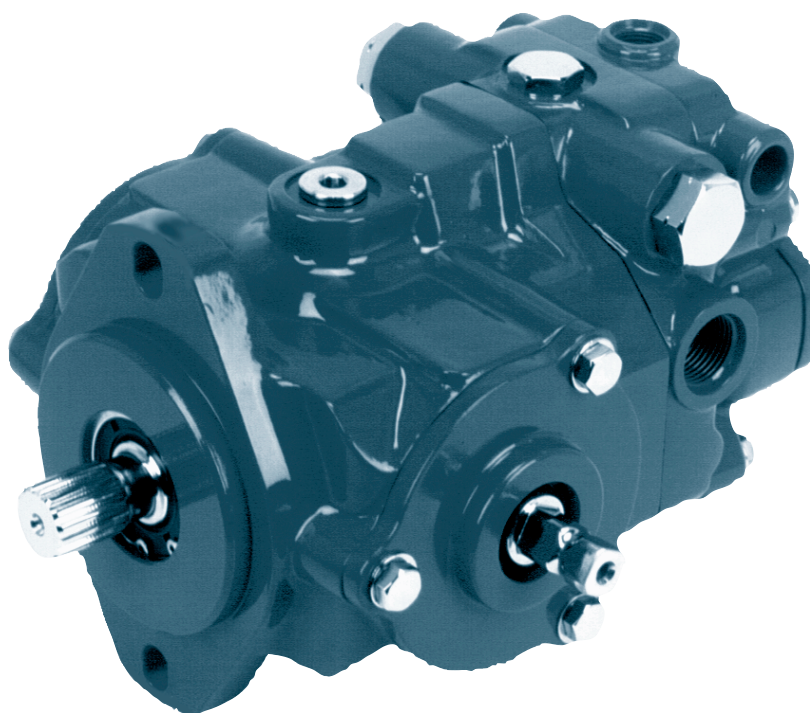
Model 70360

Manual Controlled

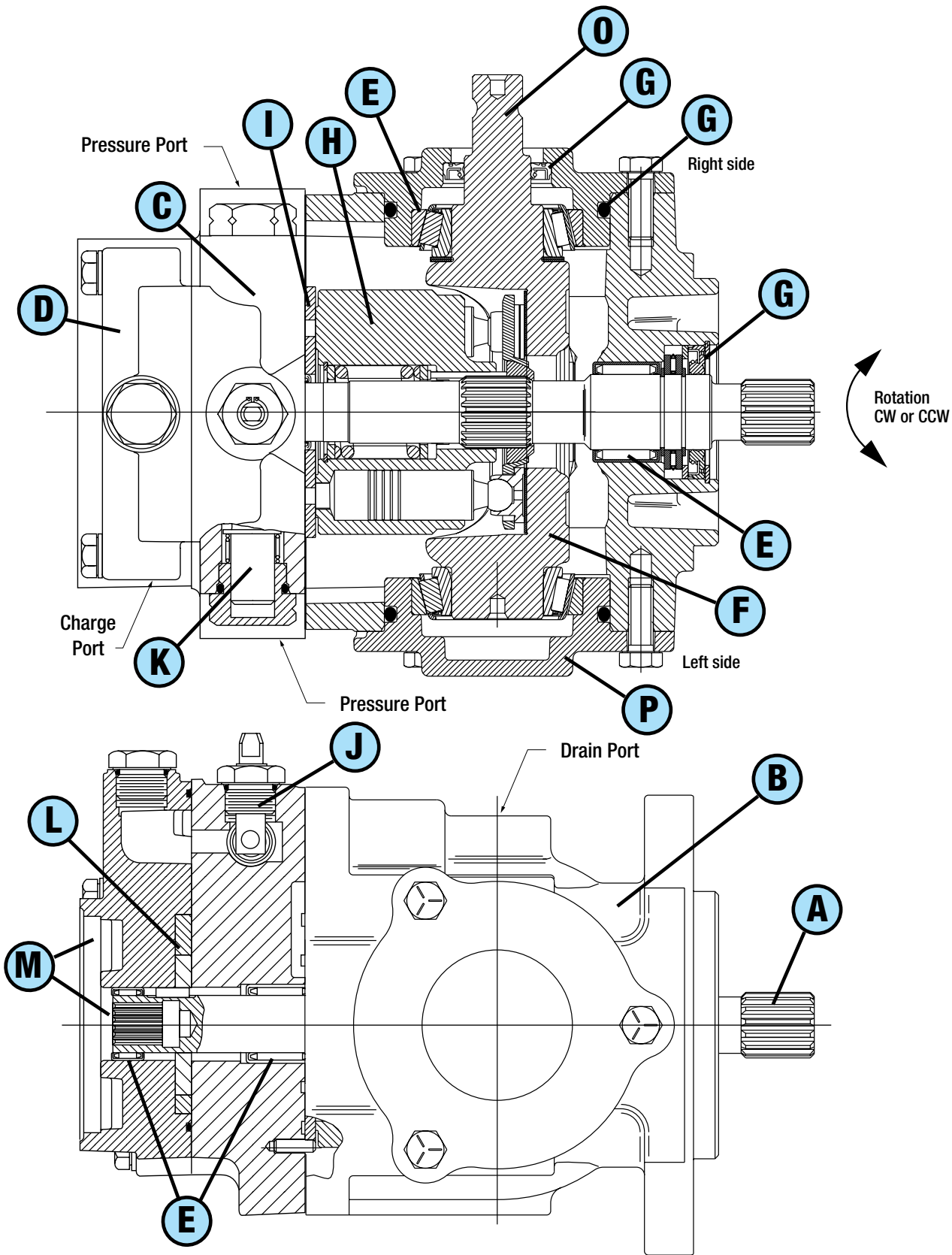
40,6 cm³/r [2.48 in³/r]

49,2 cm³/r [3.00 in³/r]

Displacement



Features



Model 70360

Features

Model 70360

A. Input Shaft and Mounting

- Auxiliary or tandem mount capability.
- Numerous shaft options.
- SAE "B" or "B-B" Mount (2 Bolt).

B. Housing

- Compact and lightweight package size.
- Durable, sturdy design.

C. Endcover

- Opposite side porting and same side porting w/ auxiliary mount

D. Charge Pump Housing

E. Bearings

F. Swashplate

G. Seals

H. Rotating Group

- 40,6 cm³/r [2.48 in³/r] Displacement
- 49,2 cm³/r [3.00 in³/r] Displacement

I. Valve Plate

J. Bypass Valve

- Cross ports the closed loop hydraulic circuit – used to move a disabled machine a limited distance.

K. Internal High Pressure Relief Valves

- Prevents excessive pressure

L. Gerotor Charge Pump

- Two sizes available
 - 6,9 cm³/r [.42 in³/r]
 - 13,8 cm³/r [.84 in³/r]

M. Auxiliary Pump Mounting Flange (Rear)

- SAE 'A' or 'B'

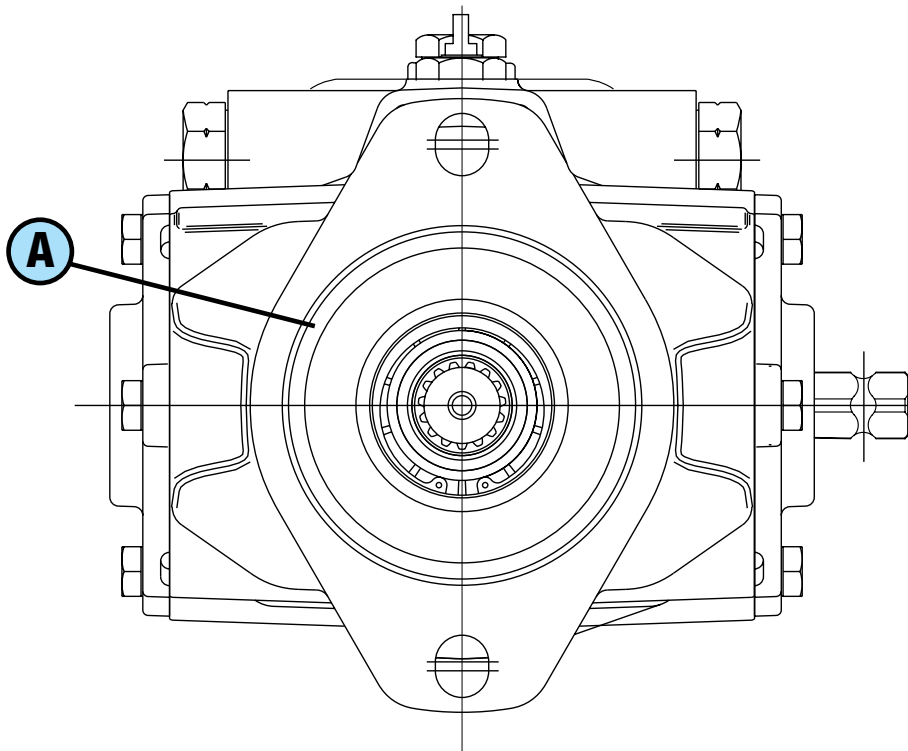
N. Auxiliary Port

- For Pressure check port or remote charge pressure port.

O. Control Shaft (Square Std.)

- Position on left or right side of pump.

P. Cover Plate

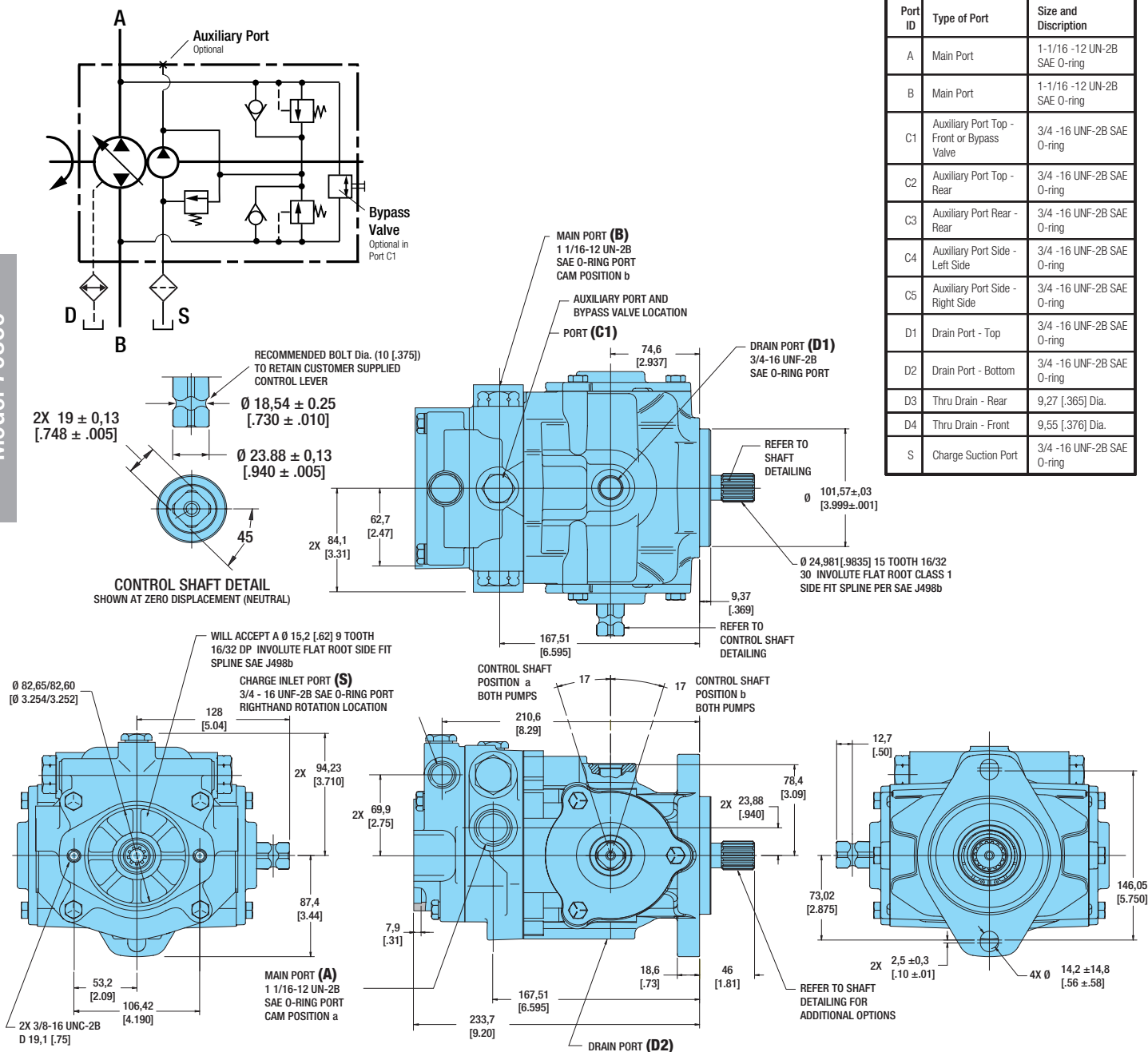


Model 70360

Typical Installation Drawings

Opposite Side Porting, with internal charge pump.
Used as a single pump or on rear of multiple units.

Note: The Charge Pump for a single pump is normally a 6,9 cm³/r [.42 in³/r] displacement and for a tandem unit is a 13,8 cm³/r [.84 in³/r] displacement.



Right-hand (CW) Rotation Shown

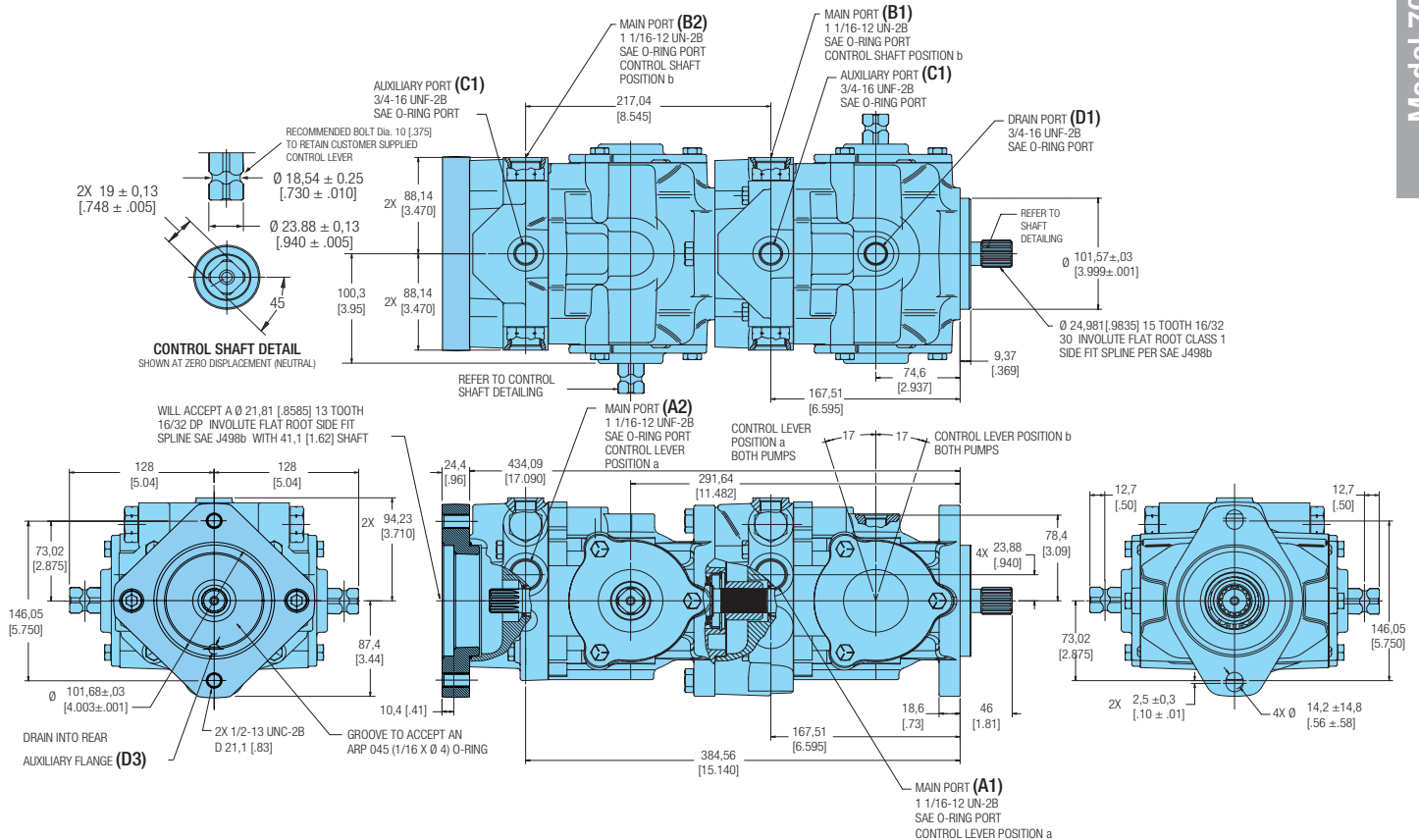
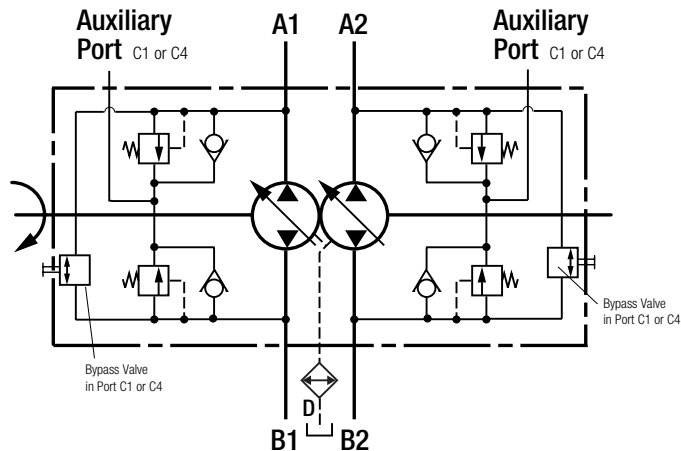
All left (CCW) or right (CW) directions given are viewed from the input shaft end of the pump.

Dimensions are in millimeters [inches], unless otherwise specified.

Model 70360

Tandem Assembly Installation Drawings

Opposite Side Porting, and Rear SAE "B" Auxiliary Mounting Flange.
(External Charge Pump Required)



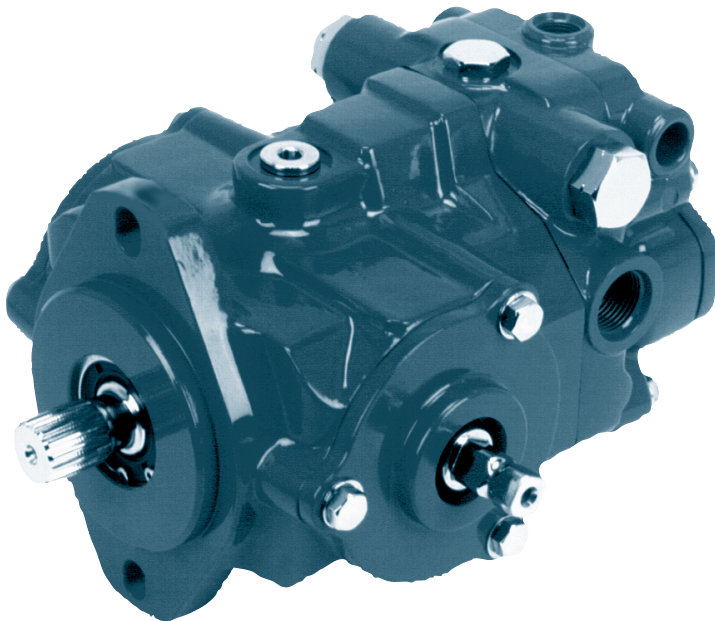
Right-hand (CW) Rotation Shown

All left (CCW) or right (CW) directions given are viewed from the input shaft end of the pump.

Dimensions are in millimeters [inches], unless otherwise specified.

Model 70360

Specifications



Model 70360

Model 70360

Specifications - Piston Pump

Maximum Displacement	40,6 cm ³ /r [2.48 in ³ /r]
Input Mounting Flange	SAE "B" or "BB"
Flow @ Rated Speed & PSI	140 l/min [37.0 gal/min]
Maximum Rated Speed	3600 RPM
Continuous Rated Pressure	210 bar [3000 PSI]
Maximum Intermittent Pressure	345 bar [5000 PSI]
Continuous Allowable	
Case Pressure	2 bar [25 PSI]
Maximum Case Drain	
Temperature	107° C [225° F]
Weight per single pump	14,1 to 15,9 kg [31 to 35 lbs]

49,2 cm ³ /r [3.00 in ³ /r]
SAE "B" or "BB"
169 l/min [44.8 gal/min]
3600 RPM
172 bar [2500 PSI]
286 bar [4150 PSI]
2 bar [25 PSI]
107° C [225° F]
14,1 to 15,9 kg [31 to 35 lbs]

Specifications - Internal Gerotor Charge Pump

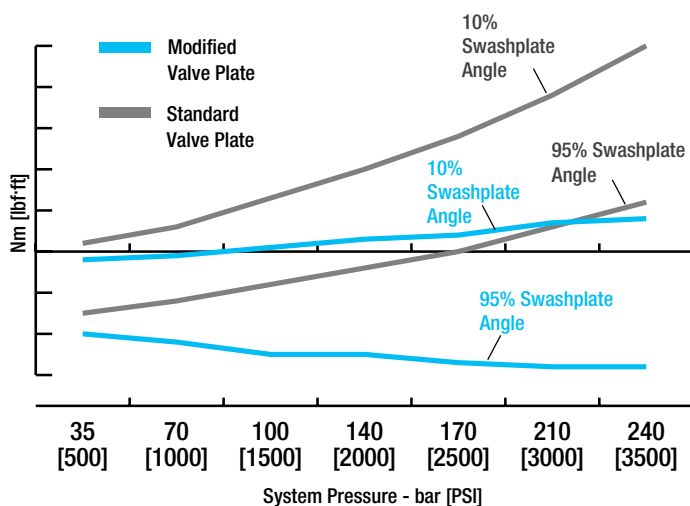
Displacement Options	
.....	6.9 cm ³ /r [.42 in ³ /r]
.....	13,8 cm ³ /r [.84 in ³ /r]
Operating Pressure Range (std.)	7 to 10 bar [100 to 150 PSI]
Maximum Charge Inlet Vacuum	0,80 bar Abs. [6 inHg]

Model 70360

Features & Benefits

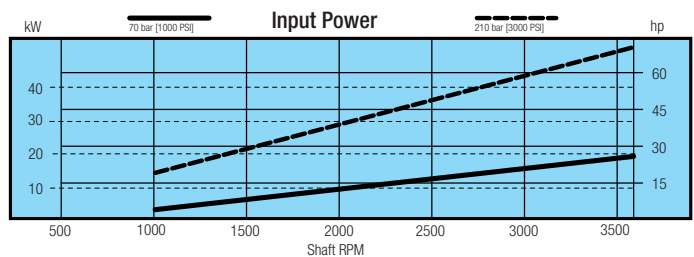
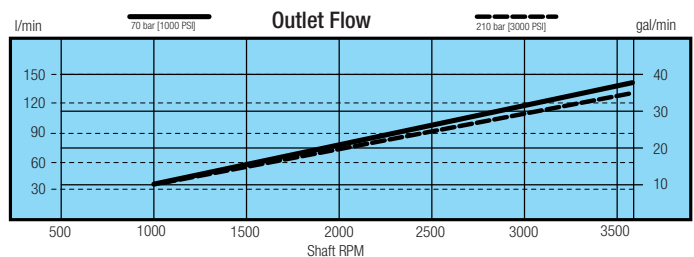
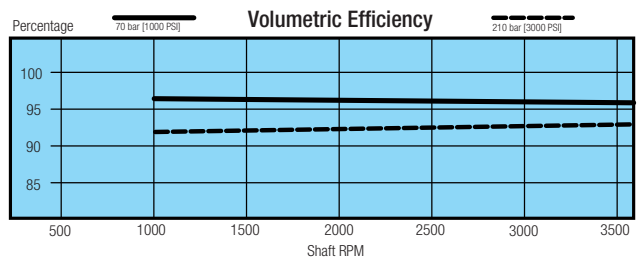
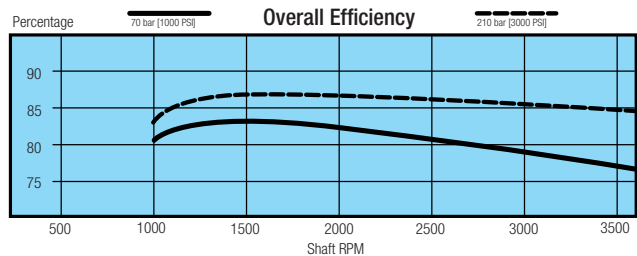
- Customized Valve Plate Designs & Porting
 - Reduces noise and swashplate moments.
- Tapered Trunnion Bearing Arrangement
 - Reduces noise and vibration.
 - Improves neutral return thrust load capabilities.
- Strengthened Mounting Flange
 - Reduces customer requirements for additional support brackets.
- Square Input Control Shaft
 - Eases the assembly of customer installed control lever and reduces wear on control shaft and control lever.
- Improved Swashplate Design
 - Reduces noise, and vibration.

Lower Swashplate Moments



Performance Data

The charts below are representative of a single 40,6 cm³/r [2.48 in³/r] Variable Displacement Piston Pump. The tests were run at an oil temperature of 82°C [180°F] with viscosity at 9 - 12 cSt [54-66 SUS] and the pump at maximum displacement.



Model 70360 Code

Position 14 - Auxiliary Port and Bypass Valve

No Bypass Valve Installed

	Code	Single Unit	Tandem Unit	
			Front	Rear
0 = No auxiliary port	0	Opt	NA	NA
A = 3/4 - 16 UNF - 2B SAE O-ring port, Top (C1)	A	Opt	Opt	Std
B = 3/4 - 16 UNF - 2B SAE O-ring port, Top w/ hex plug (C1)	B	Opt	NA	Opt
F = 3/4 - 16 UNF - 2B SAE O-ring port, Top w/ hex plug (C1); Rear (C3)	F	Opt	NA	Opt
G = 3/4 - 16 UNF - 2B SAE O-ring port, Top w/ hex plug (C1); Rear-Left 45° (C4)	G	Opt	Std	Opt
H = 3/4 - 16 UNF - 2B SAE O-ring port, Top w/ hex socket plug (C1); Rear (C3)	H	Opt	NA	Opt
J = 3/4 - 16 UNF - 2B SAE O-ring port, Top w/ hex socket plug (C1); Rear- Left 45° (C4)	J	Opt	Opt	Opt
K = 3/4 - 16 UNF - 2B SAE O-ring port, Top (C1); Rear - Left 45° w/ hex plug (C4)	K	Opt	Opt	Opt
L = 3/4 - 16 UNF - 2B SAE O-ring port, Top (C1); Rear w/ hex socket plug (C3)	L	Opt	NA	Opt
M = 3/4 - 16 UNF - 2B SAE O-ring port, Rear (C3)	M	Opt	NA	Opt
N = 3/4 - 16 UNF - 2B SAE O-ring port, Top (C1), Top - Rearward w/ hex socket plug (C2), Left side w/ hex socket plug (C6), Right side w/ hex socket plug (C7)	N	Opt	NA	Opt
P = 3/4 - 16 UNF - 2B SAE O-ring port, Top w/ hex plug (C1), Rear - Right 45° (C5)	P	Opt	Opt	Opt
V = 3/4 - 16 UNF - 2B SAE O-ring port, Top w/ hex plug (C1), Top - Rearward (C2)	V	Opt	NA	Opt
Bypass Valve installed in Top port (C1)				
C = 3/4 - 16 UNF - 2B SAE O-ring port, Top rearward (C2)	C	Opt	Opt	Opt
E = 3/4 - 16 UNF - 2B SAE O-ring port, Top (C1); Rear left 45° (C4)	E	Opt	Opt	Opt
R = 3/4 - 16 UNF - 2B SAE O-ring port, Rear (C3)	R	Opt	NA	Opt
S = 3/4 - 16 UNF - 2B SAE O-ring port, Top w/ hex plug (C2)	S	Opt	NA	Opt
T = 3/4 - 16 UNF - 2B SAE O-ring port, Top - Rearward (C2), Left side w/ hex socket plug (C6), Right side w/ hex socket plug (C7)	T	Opt	NA	Opt
Bypass Valve installed in rear port (C3)				
D = 3/4 - 16 UNF - 2B SAE O-ring port, Top (C1)	D	Opt	NA	Opt
U = 3/4 - 16 UNF - 2B SAE O-ring port, Top (C1)	U	Opt	NA	Opt

Position 15 - Charge Pump

0 = No charge pump	0	Opt	Std	Opt
1 = 6,9 cm ³ /r [.42 in ³ /r]; 3/4-16 UNF - 2B SAE O-ring port for suction inlet (S)	1	Std	NA	NA
2 = 13,8 cm ³ /r [.84 in ³ /r]; 3/4-16 UNF - 2B SAE O-ring port for suction inlet (S)	2	Opt	NA	Std

Position 16, 17 - Charge Pump Relief Setting and Routing

00 = None	00	Opt	Std	Opt
01 = No charge relief (Requires external relief set between 6,89 bar [100 PSI] 17,24 bar [250 PSI])	01	Opt	Opt	Opt
For Units with Charge Pump				
11 = 6,89-10,34 bar [100-150 PSI]; Recirculated	11	Std	NA	Std
12 = 10,34-13,79 bar [150-200 PSI]; Recirculated	12	Opt	NA	Opt
13 = 13,79-17,24 bar [200-250 PSI]; Recirculated	13	Opt	NA	Opt
14 = 17,24-20,68 bar [250-300 PSI]; Recirculated	14	Opt	NA	Opt
For Units without Charge Pump				
21 = 6,89-10,34 bar [100-150 PSI]; Relieved to case	21	Opt	NA	Opt
22 = 10,34-13,79 bar [150-200 PSI]; Relieved to case	22	Opt	NA	Opt
23 = 13,79-17,24 bar [200-250 PSI]; Relieved to case	23	Opt	NA	Opt

Position 18 - Drain Port Size and Location

0 = 3/4 - 16 UNF - 2B SAE o-ring port, Top (D1); Bottom plugged (D2); Thru drain in front mounting flange (D4)	0	NA	NA	Std
1 = 3/4-16 UNF-2B SAE o-ring port, Top (D1); Bottom, Plugged (D2)	1	Std	Std	Opt

Position 19 - Additional Functions

0 = None	0	Std	Std	Std
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Positions 20, 21 - Special Features

00 = None	00	Std	Std	Std
0A = Fluorocarbon Rubber Drive shaft seal and control shaft seal	0A	Opt	Opt	Opt
0C = Bottom Mounting Bracket with 13,7 [.54] diameter hole	0C	NA	NA	Std
0D = Coupling and o-ring included for rear mount	0D	Opt	Opt	Opt

Positions 22, 23 - Paint

0A = Primer	0A	Std	Std	Std
0B = Black	0B	Opt	Opt	Opt

Position 24 - Identification

0 = Standard (Nameplate)	0	Std	Std	Std
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Position 25 - Design Code

A = A	A	Std	Std	Std
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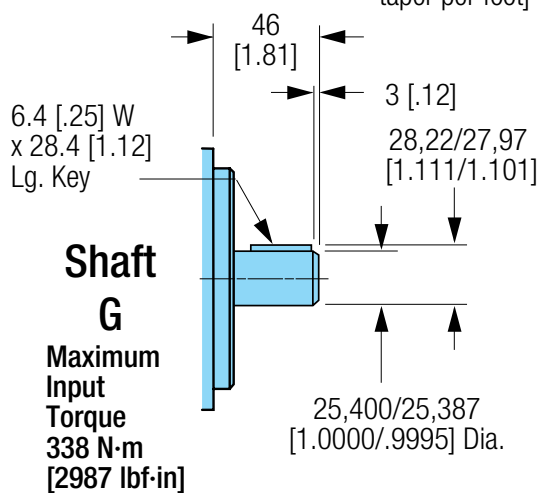
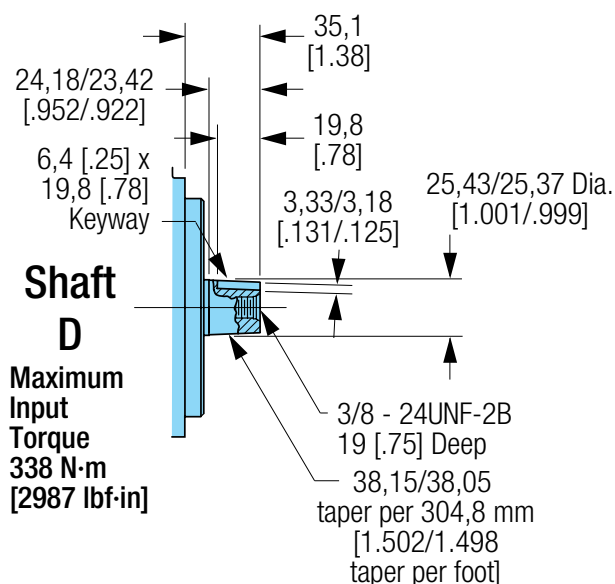
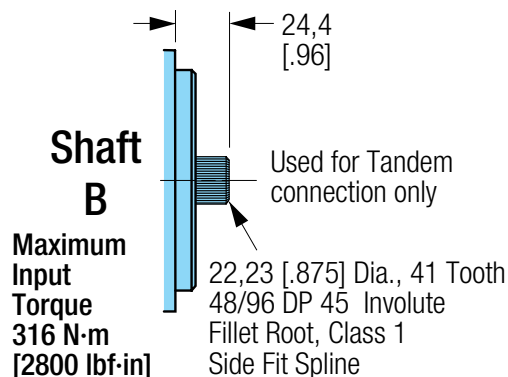
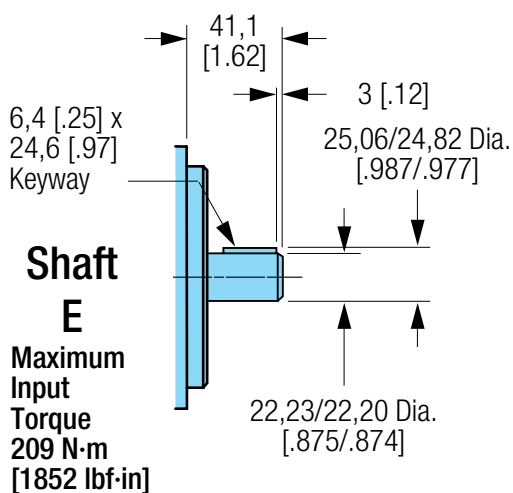
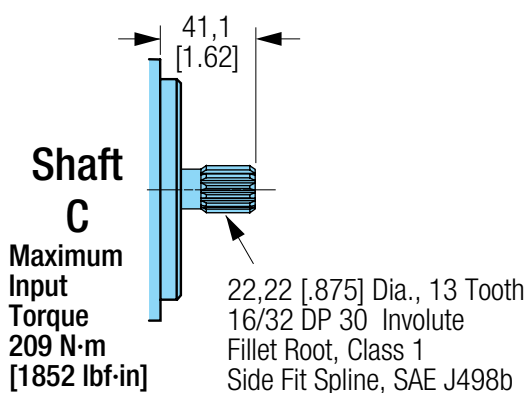
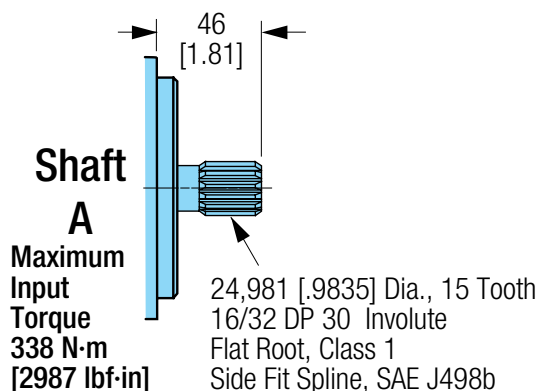
NA = Not Available
Std. = Standard
Opt. = Optional

70360

Input Shafts

Dimensions are in millimeters [inches],
unless otherwise specified.

Code Position 7



Torque Note:

The combined torque required to turn multiple pumps must not exceed the torque rating of the input drive shaft of the front piston pump.
Consult an Eaton representative and/or Eaton engineering on side load recommendations.

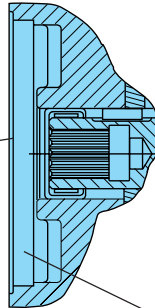
70360

Auxiliary Mounts & Output Shafts

Code Position 12 and 13

9 Tooth, 16/32 DP Int., 15,88 [.6250]
O.D., Accepts 31,8 [1.25] Shaft Ext.,
SAE "A" Mount J744

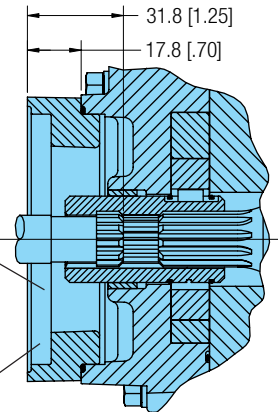
Torque limit on internal rear spline of piston pump with internal charge pump must not exceed 54 N•m [480 lbf•in]. Piston pump without internal charge pump must not exceed 76 N•m [672 lbf•in]



11 Tooth, 16/32 DP Int.; 19,33 [.761] O.D.; Accepts 31,8 [1.25]
Shaft Ext., "A" Auxiliary Mount SAE
J744

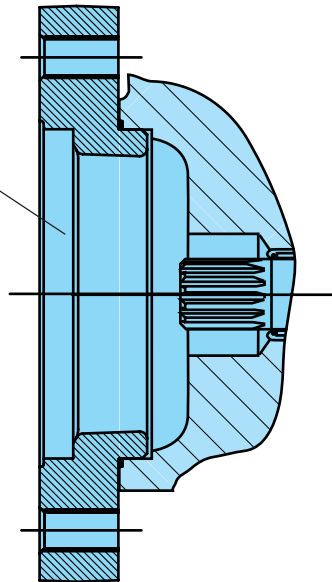
(Used on piston pump with internal charge pump)

Maximum Torque
119 N•m [1050 lbf•in]



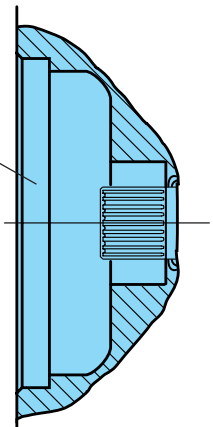
SAE "A" Auxiliary Mount with Charge Pump Shown

13 Tooth, 16/32 DP Ext.; 21,81 [.8585] O.D., Accepts 41,1 [1.62] Shaft Ext.; "B" Auxiliary Mount SAE J744
(Used on piston pump without internal charge pump)

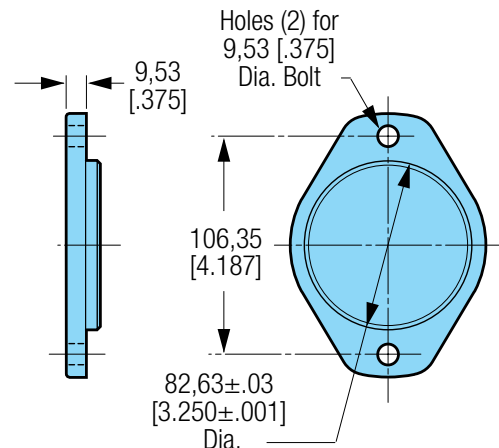


41 Tooth, 48/96 DP Ext., 22,23 [.8750] O.D., Accepts 24,9 [.98] Shaft Ext.; "B" Auxiliary Mount SAE J744
(Used for Tandem Connections)

Maximum Torque
316 N•m [2,800 lbf•in]



Cover Plate
Fits "A" SAE Auxiliary Mounting Flange. Cover Plate Kit #70142-915: Includes plate, cap screws (2), and o-ring



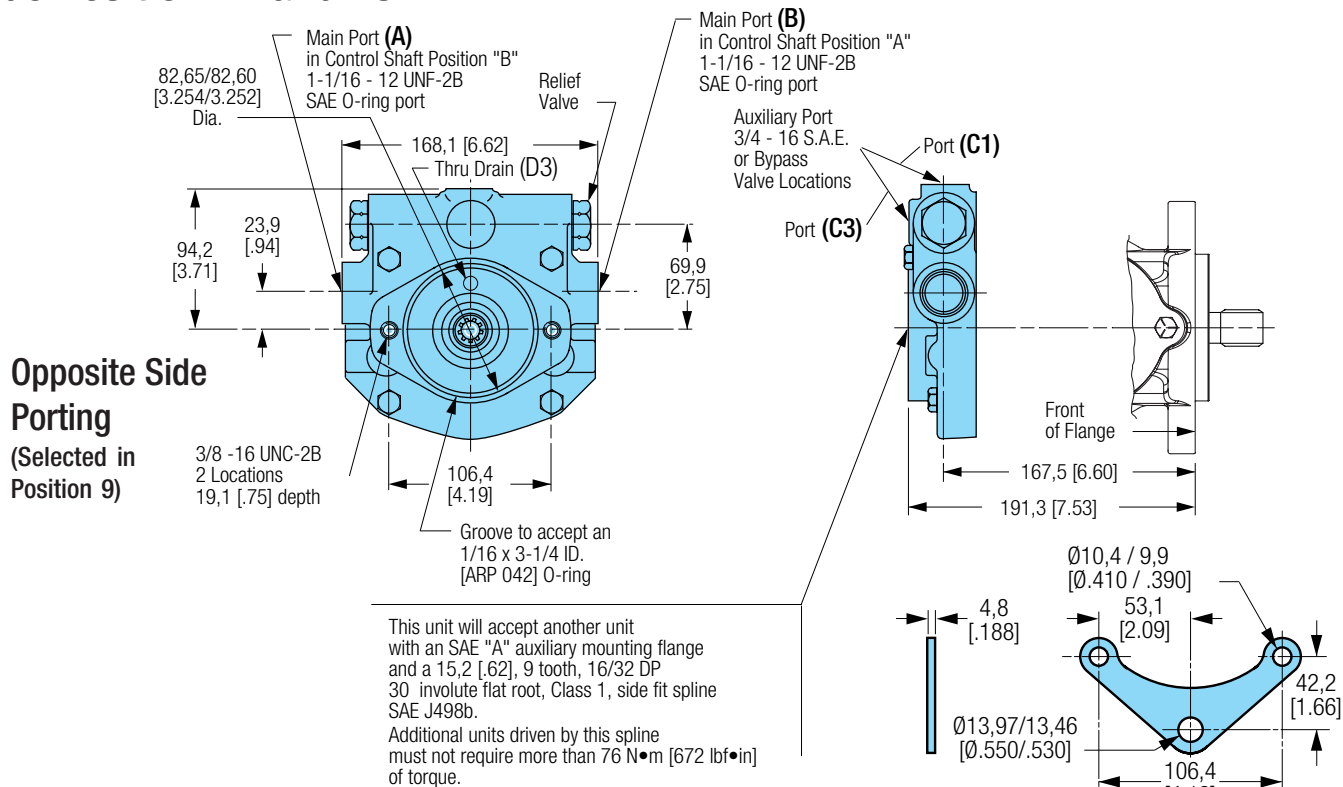
Model 70360

All left (CCW) or right (CW) directions given are viewed from the input shaft end of the pump.

70360 Port Locations

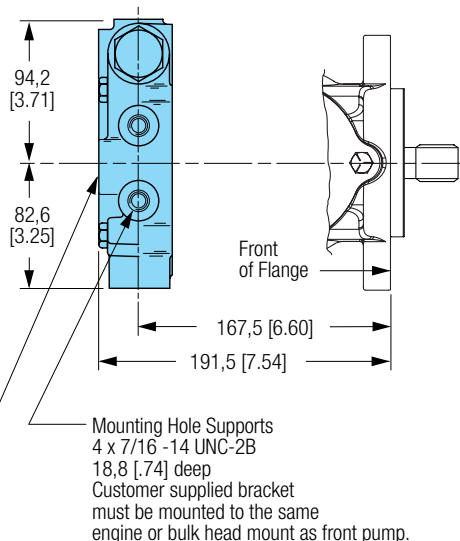
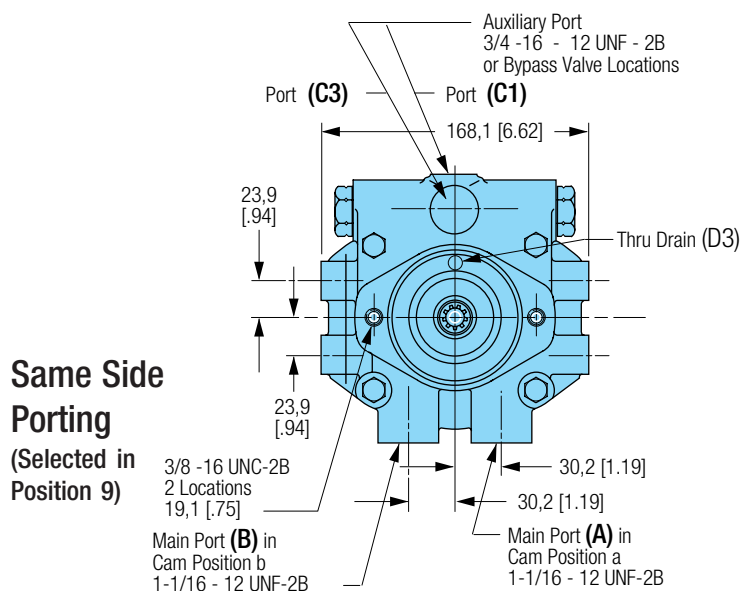
Code Position 12 and 13

All left (CCW) or right (CW) directions given are viewed from the input shaft end of the pump.



Mounting Bracket

Used to support tandem with opposite side porting.
Customer supplied bracket must be mounted to the same engine or bulk head mount as front pump.



70360 Port Locations

Code Position 12 and 13

Opposite Side Porting (Selected in Position 9)

Port ID	Type of Port	Size and Description
A	Main Port	1-1/16 - 12 UNF-2B SAE O-ring
B	Main Port	1-1/16 - 12 UNF-2B SAE O-ring
C1	Auxiliary Port Top - Front or Bypass Valve	3/4 - 16 UNF-2B SAE O-ring
C2	Auxiliary Port Top - Rear	3/4 - 16 UNF-2B SAE O-ring
C3	Auxiliary Port Rear - Rear	3/4 - 16 UNF-2B SAE O-ring
C4	Auxiliary Port Side - Left Side	3/4 - 16 UNF-2B SAE O-ring
C5	Auxiliary Port Side - Right Side	3/4 - 16 UNF-2B SAE O-ring
D1	Drain Port - Top	3/4 - 16 UNF-2B SAE O-ring
D2	Drain Port - Bottom	3/4 - 16 UNF-2B SAE O-ring
D3	Thru Drain - Rear	9,27 [.365] Dia.
D4	Thru Drain - Front	9,55 [.376] Dia.
S	Charge Suction Port	3/4 - 16 UNF-2B SAE O-ring

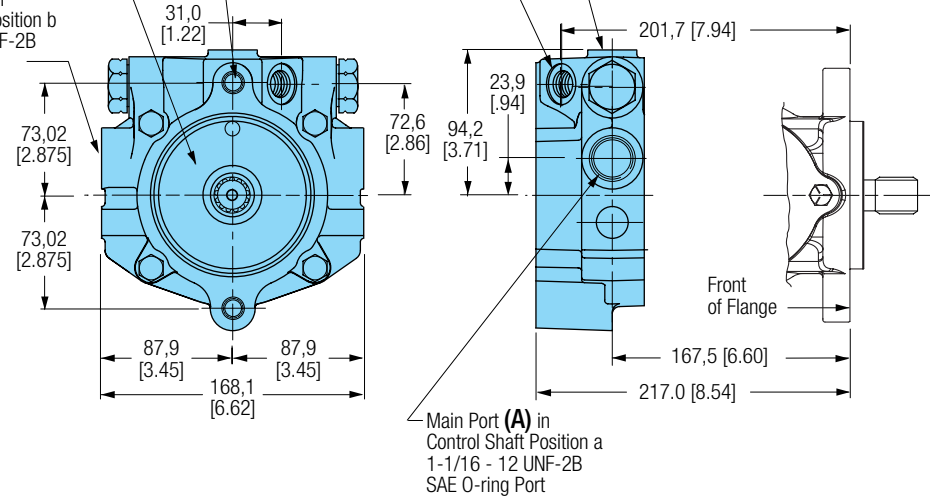
Will accept a \varnothing 22,23 [.875] 41 tooth 48/96 DP 45 involute fillet root, Class 1 side fit spline.
Accepts a SAE J498b with a 24,9 [.98] shaft extension

Main Port (B) in Control Shaft Position b
1-1/16 - 12 UNF-2B SAE O-ring Port

2X 1/2-13 UNC-2B
21,1 [.83] Deep

Auxiliary Port (C4)
3/4 - 16 - 12 UNF - 2B SAE O-ring Port

Auxiliary Port (C1)
3/4 - 16 - 12 UNF - 2B SAE O-ring Port or Bypass Valve Locations



Will accept a \varnothing 22,23 [.875] 41 tooth 48/96 DP 45 involute fillet root, Class 1 side fit spline.
Accepts a SAE J498b with a 24,9 [.98] shaft extension

Mounting Hole Supports
4 x 7/16 - 14 UNC-2B
18,8 [.74] deep
Customer supplied bracket must be mounted to the same engine or bulk head mount as front pump.

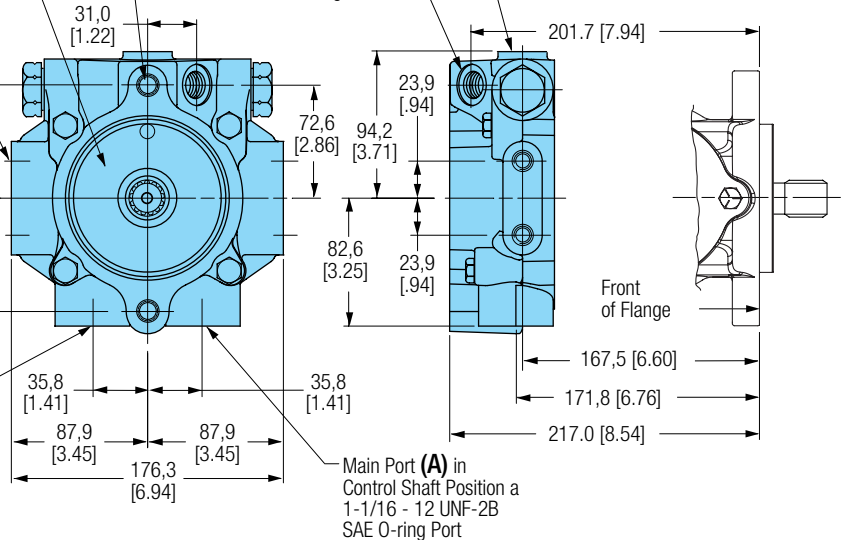
2X 1/2-13 UNC-2B
21,1 [.83] Deep

Auxiliary Port (C4)
3/4 - 16 - 12 UNF - 2B SAE O-ring Port

Auxiliary Port (C1)
3/4 - 16 - 12 UNF - 2B SAE O-ring Port or Optional Bypass Valve Locations

Same Side Porting (Selected in Position 9)

Main Port (B) in Control Shaft Position b
1-1/16 - 12 UNF-2B SAE O-ring Port



Section 3

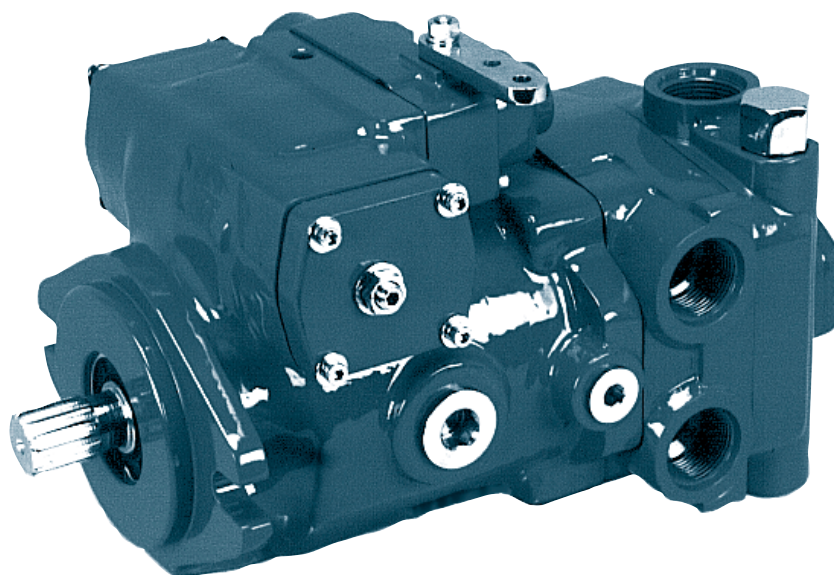
Model 72400

Servo Controlled

40,6 cm³/r [2.48 in³/r]

49,2 cm³/r [3.00 in³/r]

Displacement



Model 72400

Features

Model 72400

A. Housing

- Compact package size.
- Durable cast iron design.
- Multiple drain options.
- Quiet operation.

B. Endcover

C. Charge Pump Adapter

D. Manual Displacement Servo Control Valve

- Low operator effort.
- Modular design.

E. Input Shaft and Mounting

- SAE "B" or "B-B" Mount (2 Bolt)
- Numerous shaft options.

F. Seals

G. Bearings

H. Swashplate Cradle

I. Swashplate Bushing

J. Swashplate

K. Rotating Group

- 40,6 cm³/r [2.48 in³/r] Displacement
- 49,2 cm³/r [3.00 in³/r] Displacement

L. Valve plate

- Improved serviceability.

M. Servo Piston Assembly

N. Bypass Valve

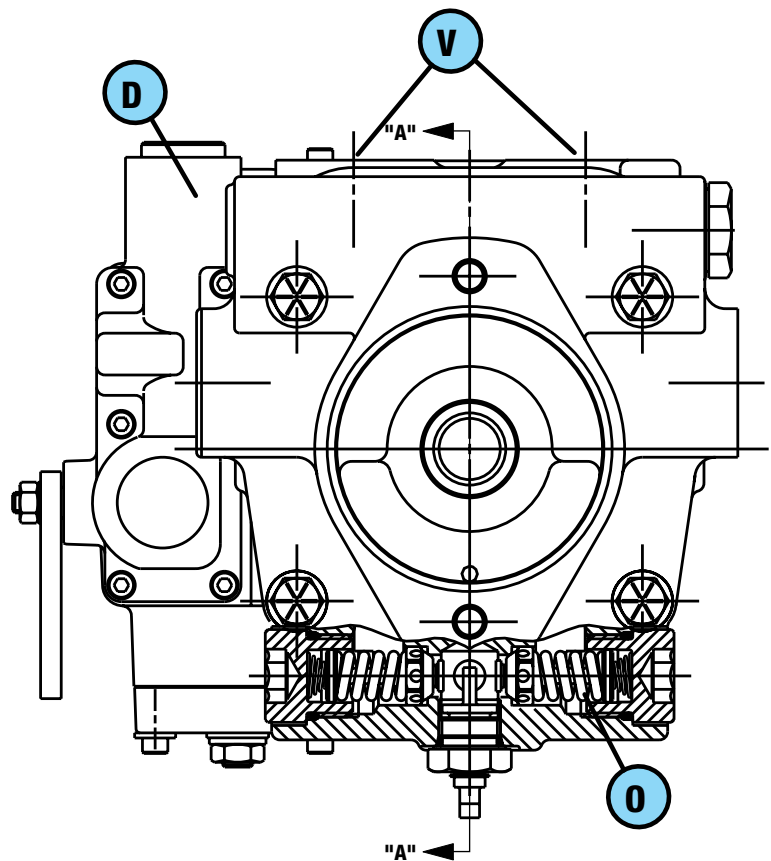
- Cross ports the closed loop hydraulic circuit - used to move a disabled machine a limited distance.

O. Internal High Pressure Relief Valves

- prevents excessive pressure.

P. Gerotor Charge Pump

- Two sizes available
 - 6,9 cm³/r [.42 in³/r]
 - 13,8 cm³/r [.84 in³/r]



Q. Auxiliary Pump Mounting Flange (Rear)

- SAE "A" or "B"

R. Case Drain Port

S. Auxiliary Port

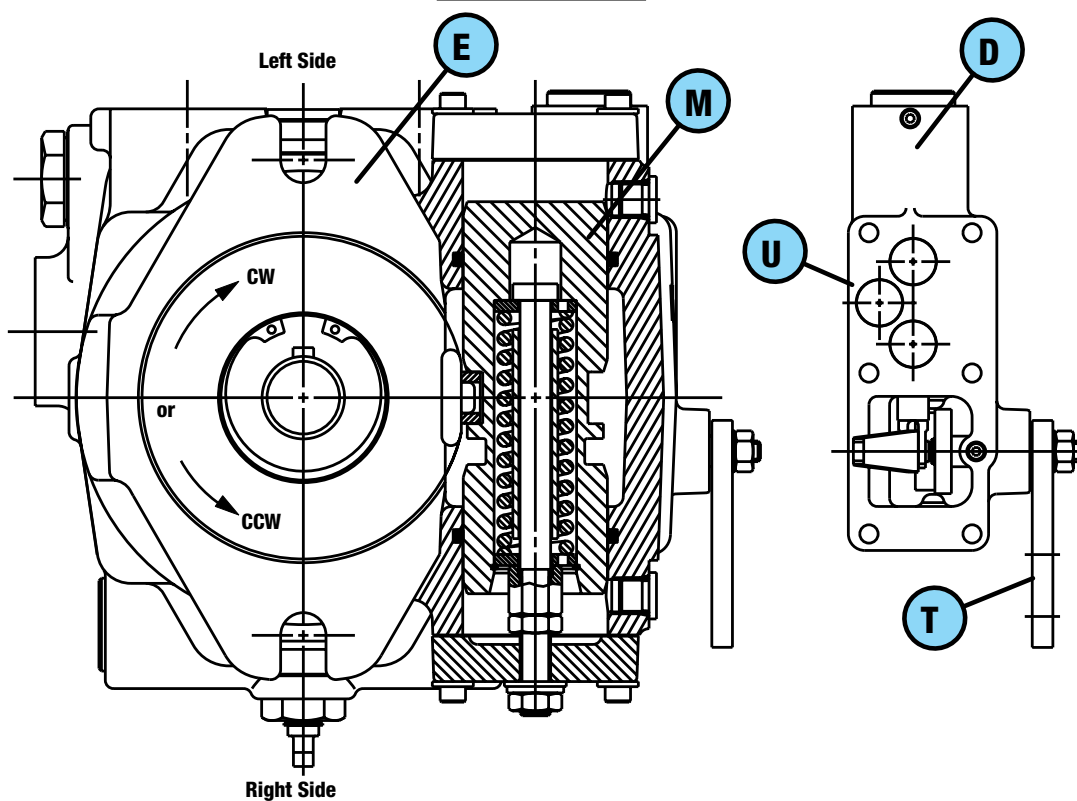
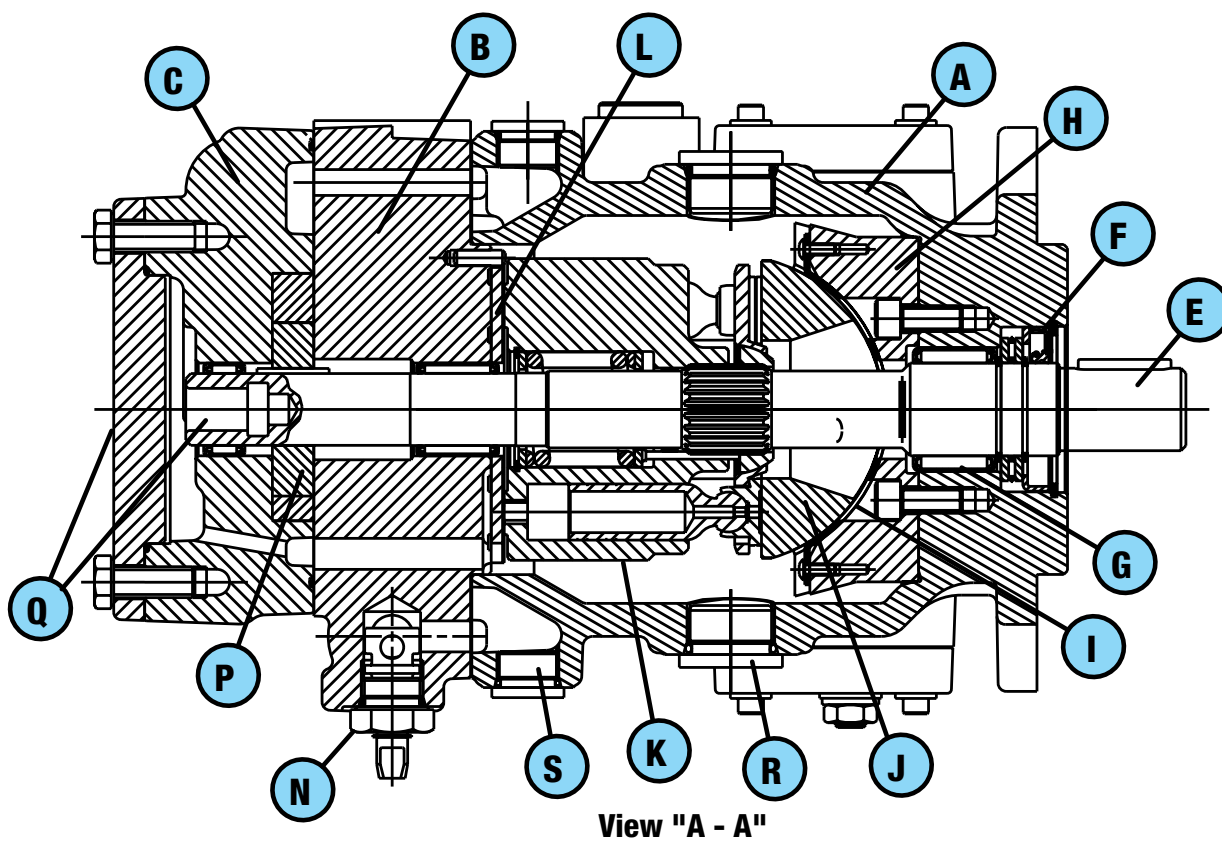
- For pressure check port or remote charge pressure port.

T. Control Lever

U. Control Orifices

- Controls rate of change of displacement.

V. Main System Ports



Installation Drawing - Model 72400 Servo Controlled Single Piston Pump

Lever Position vs. Pressurized Port

Righthand (CW) Rotation

Lever position "A" --- Port (A) is Pressurized

Lever position "B" --- Port (B) is Pressurized

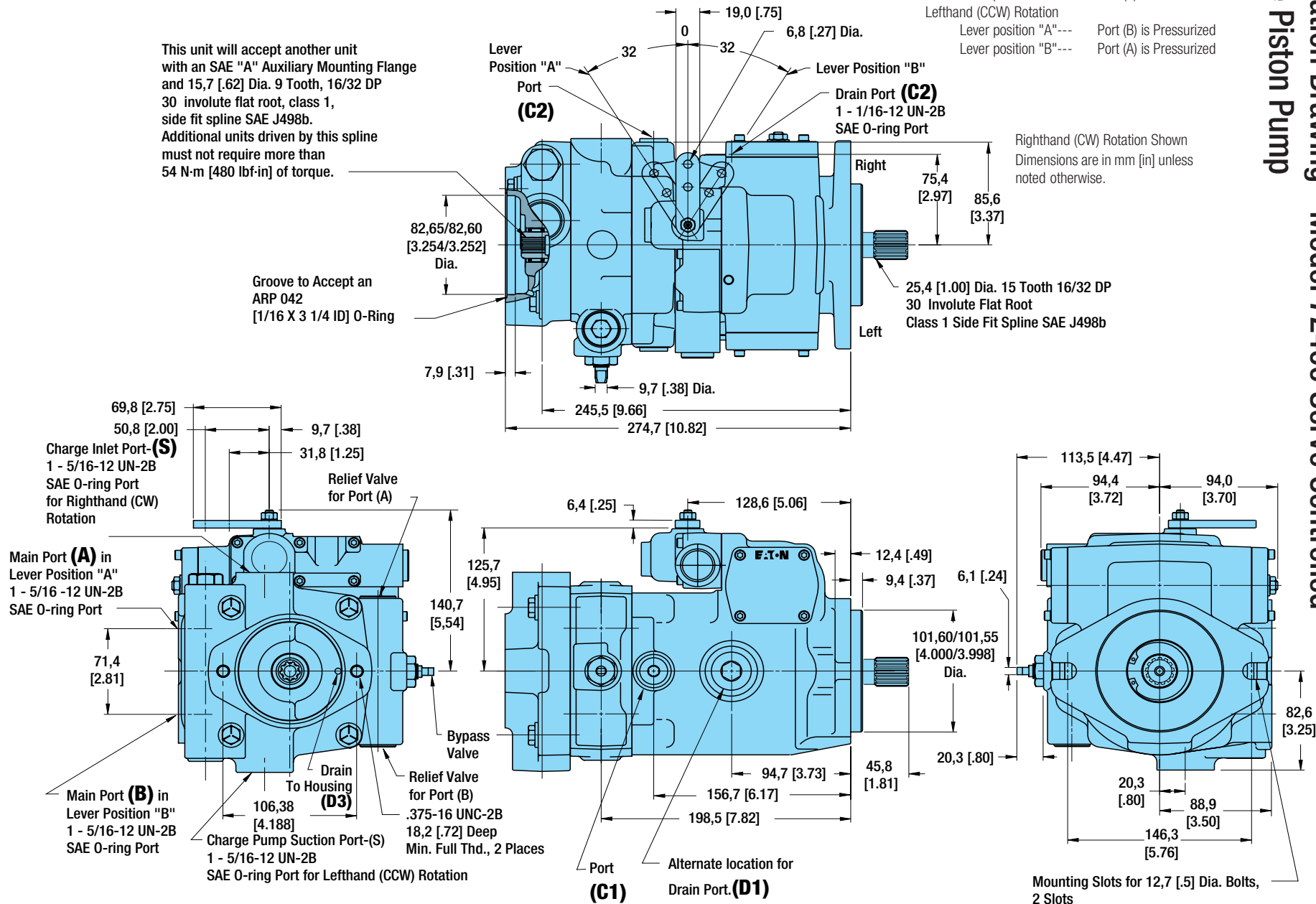
Lefthand (CCW) Rotation

Lever position "A" --- Port (B) is Pressurized

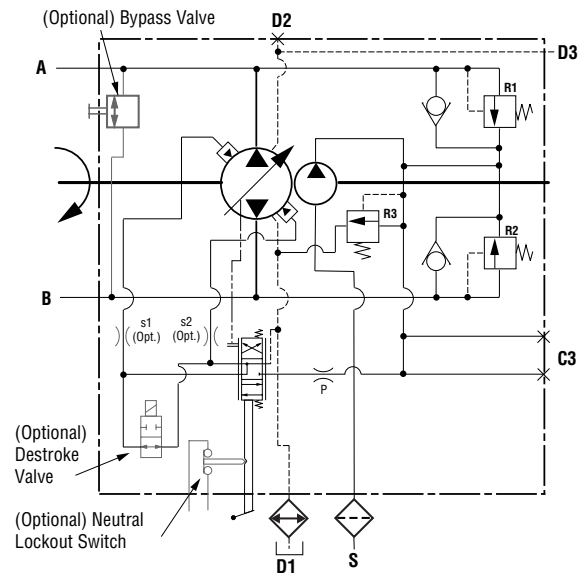
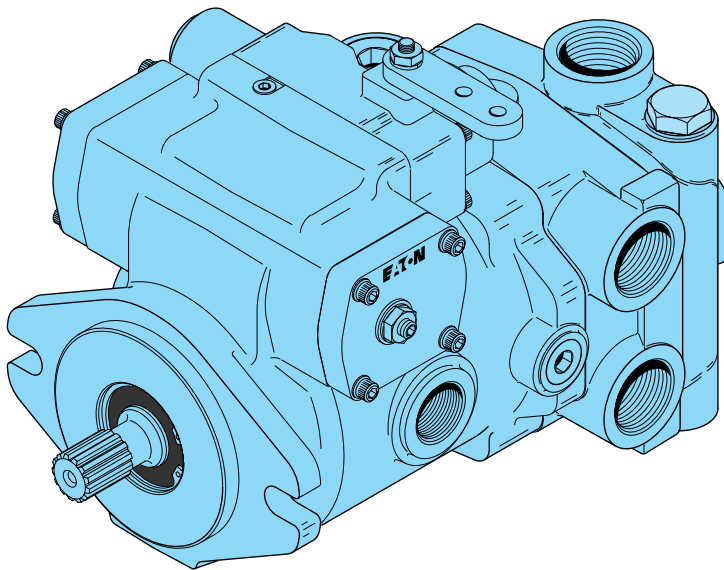
Lever position "B" --- Port (A) is Pressurized

This unit will accept another unit with an SAE "A" Auxiliary Mounting Flange and 15,7 [.62] Dia. 9 Tooth, 16/32 DP 30 involute flat root, class 1, side fit spline SAE J498b. Additional units driven by this spline must not require more than 54 N-m [480 lbf-in] of torque.

Groove to Accept an ARP 042 [1/16 X 3 1/4 ID] O-Ring



Model 72400 Servo Controlled Single Piston Pump



Description of Unit on Opposite Page:

Righthand (CW) Rotation
 Input Shaft: 15 tooth
 Output Shaft: 9 tooth
 Auxiliary Rear Mounting: SAE "A" Series 82-2
 Charge Pump: 6,9 cm³/r [.42 in³/r] disp. with Inlet Port 1 - 5/16-12 UN-2B, SAE O-ring Port
 Charge Pump Relief Setting: 17 to 21 bar [250 to 300 PSI], relieved to case.
 Auxiliary Port: 3/4-16 UNF-2B, SAE O-ring Port, plugged on both sides.
 Drain Port: 1 - 1/16-12 UN-2B, SAE O-ring Port, on right side and rear flange drained into housing
 Main Ports: 1 - 5/16-12 UN-2B, SAE O-ring Port, same side on right
 Relief Valves: Available in a range of settings to 379 bar [5500 PSI]
 Additional Functions: Bypass Valve
 Control Assembly: Manual with no additional features
 Supply Orifice: .71 mm [.028 in]
 Paint: Black

Additional options are available by using the Model Code and Details.

All left (CCW) or right (CW) directions given are viewed from the input shaft end of the pump.

Model 72400

Medium Duty Piston Pump

EATON

Assembly Dimensions - Model 72400 Servo Controlled Front Piston Pump of Tandem Pumps

Lever Position vs. Pressurized Port

Righthand (CW) Rotation

Lever position "A"--- Port (A) is Pressurized

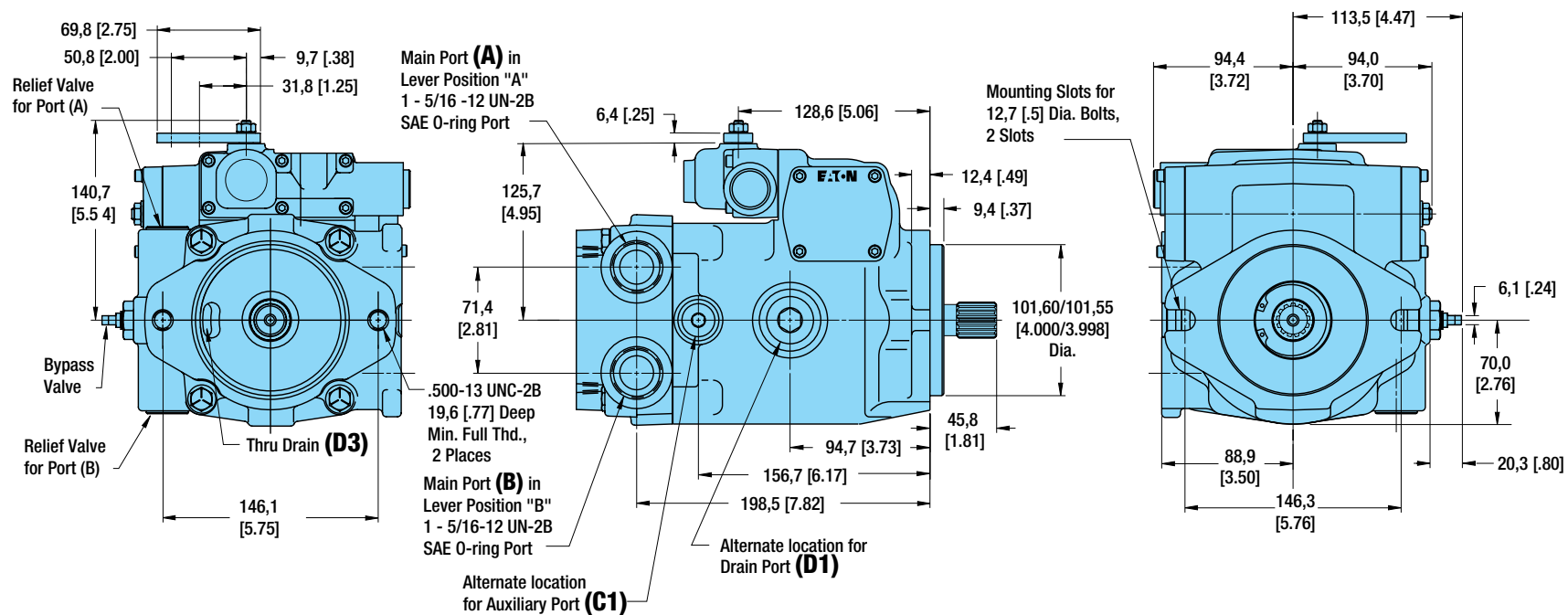
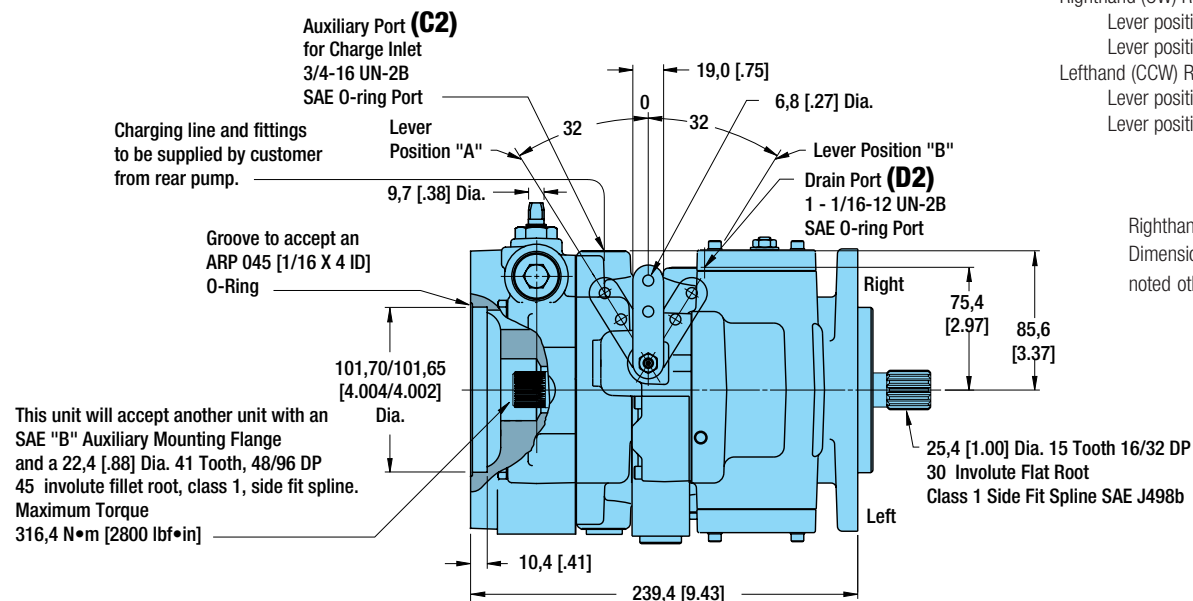
Lever position "B"--- Port (B) is Pressurized

Lefthand (CCW) Rotation

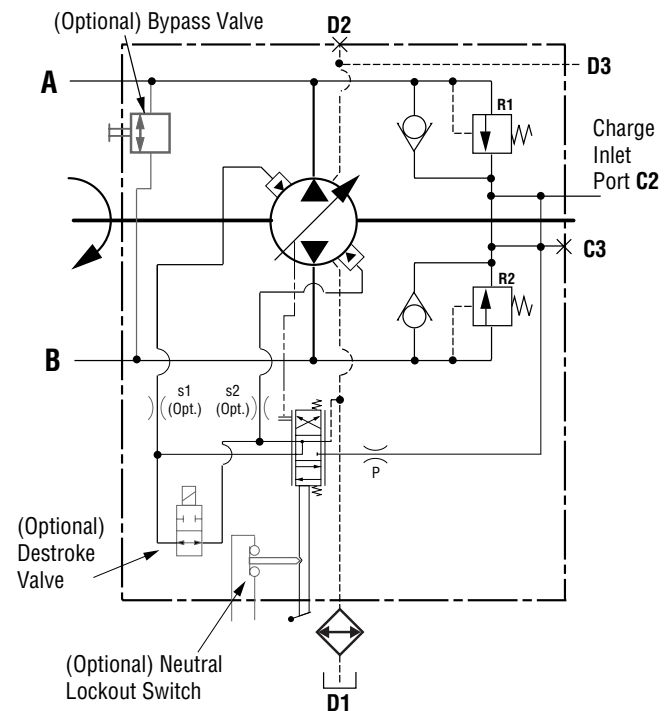
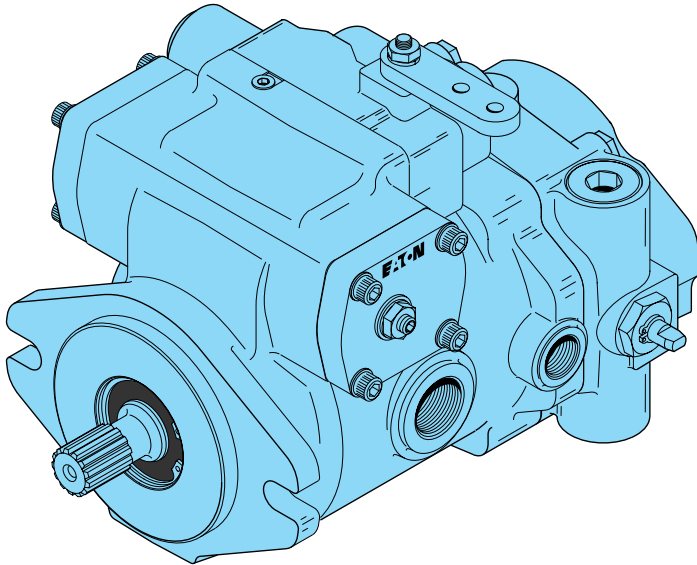
Lever position "A"--- Port (B) is Pressurized

Lever position "B"--- Port (A) is Pressurized

Righthand (CW) Rotation Shown
Dimensions are in mm [in] unless
noted otherwise.



Model 72400 Servo Controlled Front Piston Pump of Tandem Pumps



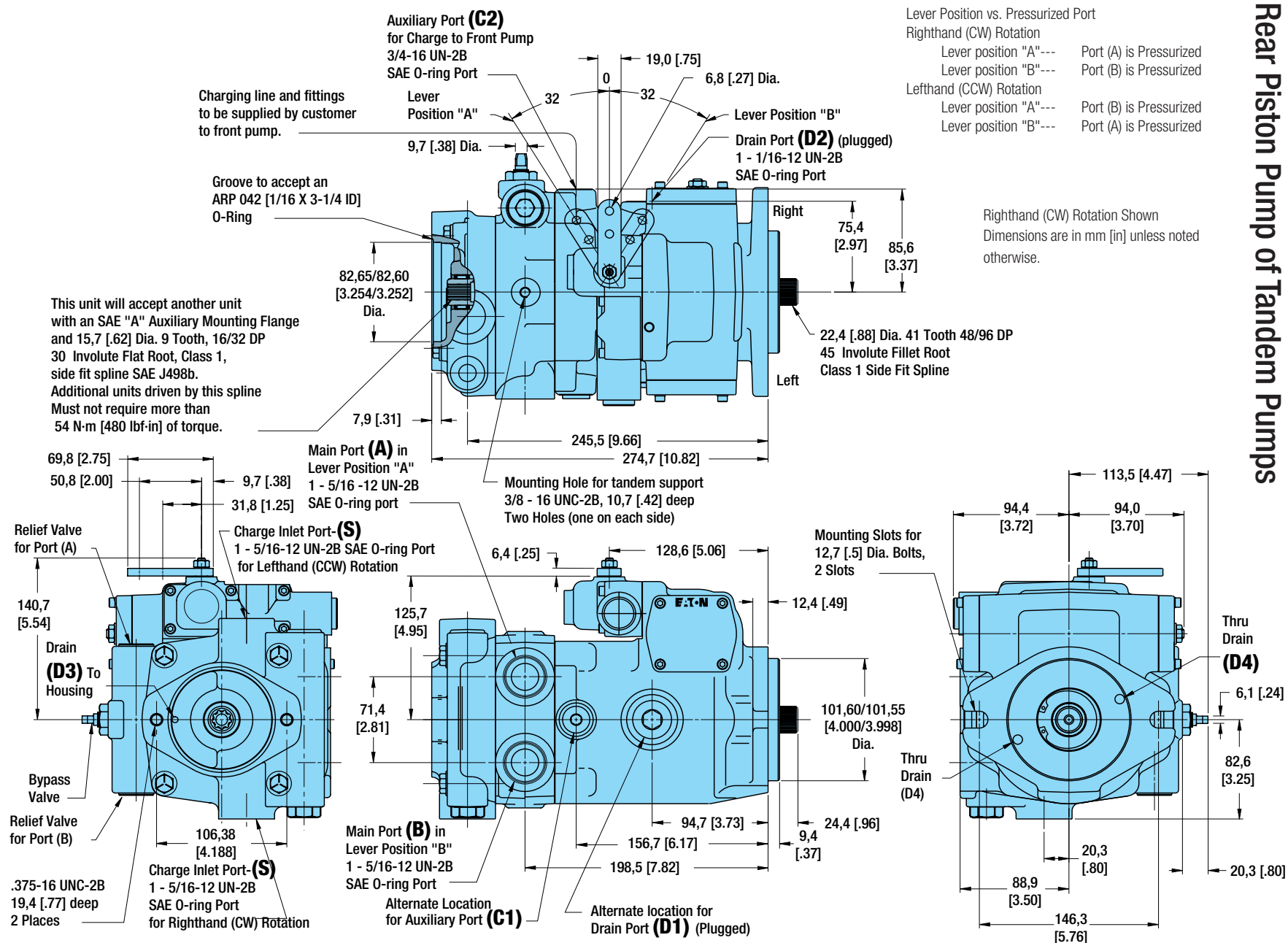
Description of Unit on Opposite Page:

Righthand (CW) Rotation
 Input Shaft: 15 tooth
 Output Shaft: 41 tooth
 Auxiliary Rear Mounting: SAE 2 bolt "B" Series 101-2
 Charge Pump: Not included
 Auxiliary Port: 3/4-16 UNF-2B SAE O-ring Port on right side
 Drain Port: 1 - 1/16-12 UN-2B SAE O-ring Port on right side and rear flange drained into housing
 Main Ports: 1 - 5/16-12 UN-2B SAE O-ring Port on same side (left side of pump)
 Relief Valves: Available in a range of settings to 379 bar [5500 PSI]
 Additional Functions: Bypass Valve
 Control Assembly: Manual with no additional features
 Supply Orifice: .71 mm [.028 in]
 Paint: Black

Additional options are available by using the Model Code and Details.

All left (CCW) or right (CW) directions given are viewed from the input shaft end of the pump.

Model 72400

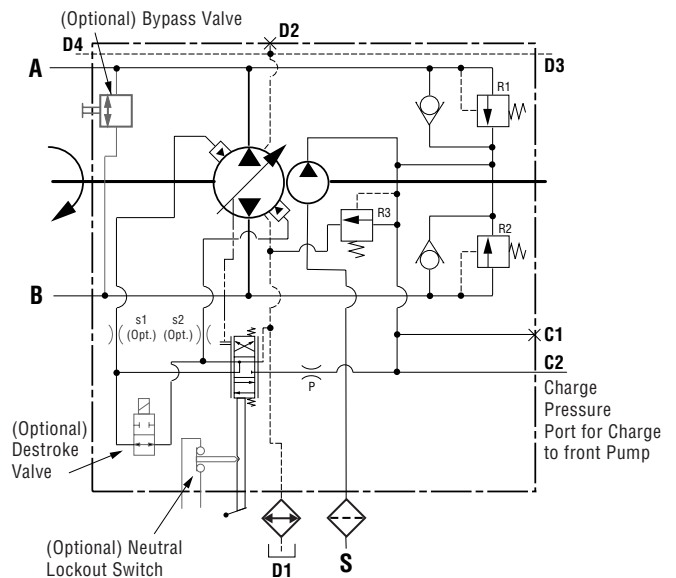
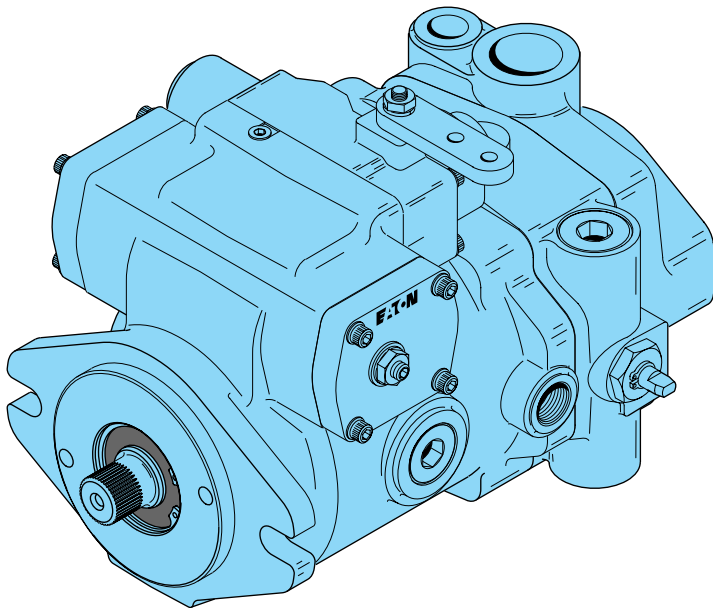


Medium Duty Piston Pump

Assembly Dimensions - Model 72400 Servo Controlled Rear Piston Pump of Tandem Pumps

EAT•N

Model 72400 Servo Controlled Rear Piston Pump of Tandem Pumps



Description of Unit on Opposite Page:

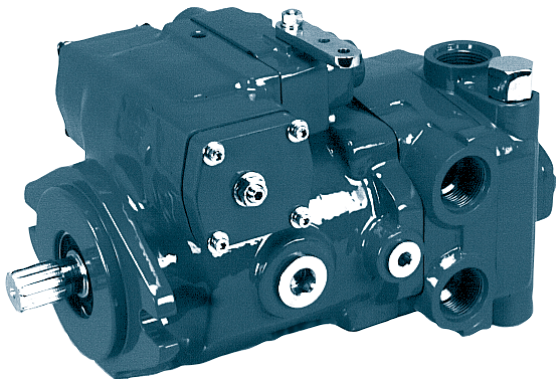
Righthand (CW) Rotation
 Input Shaft: 41 tooth
 Output Shaft: 9 tooth
 Auxiliary Rear Mounting: SAE "A" Series 82-2 w/mounting support hole
 Charge Pump: 13,8 cm³/r [.84 in³/r] disp. with Inlet Port, 1 - 5/16-12 UN-2B SAE O-ring Port
 Charge Pump Relief Setting: 17 to 21 bar [250 to 300 PSI], Relieved to Case.
 Auxiliary Port: 3/4-16 UNF-2B SAE O-ring Port on right side
 Drain Port: 1 - 1/16-12 UN-2B SAE O-ring Port on both sides, plugged, and drain hole thru housing to front pump.
 Main Ports: 1 - 5/16-12 UN-2B SAE O-ring Port same side on left
 Relief Valves: Available in a range of settings to 379 bar [5500 PSI]
 Additional Functions: Bypass Valve
 Control Assembly: Manual with no additional features
 Supply Orifice: .71 mm [.028 in]
 Paint: Black

Additional options are available by using the Model Code and Details.

All left (CCW) or right (CW) directions given are viewed from the input shaft end of the pump.

Model 72400

Features, Benefits & Specifications



Features

- Modular design
- Durable cast iron housing
- Multiple drain options
- SAE "B" or "B-B" Mount (2 Bolt) Flange
- Numerous shaft options
- Auxiliary or tandem mount capability
- Charge pump
- Control options

Benefits

- Compact package size
- Quiet operation
- Low operator effort
- Improved serviceability

Model 72400

Specifications - Piston Pump

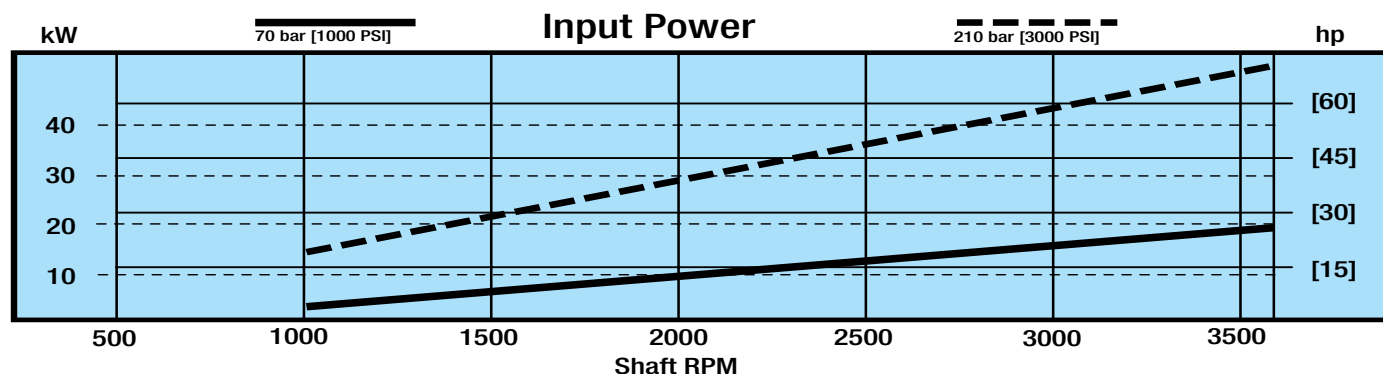
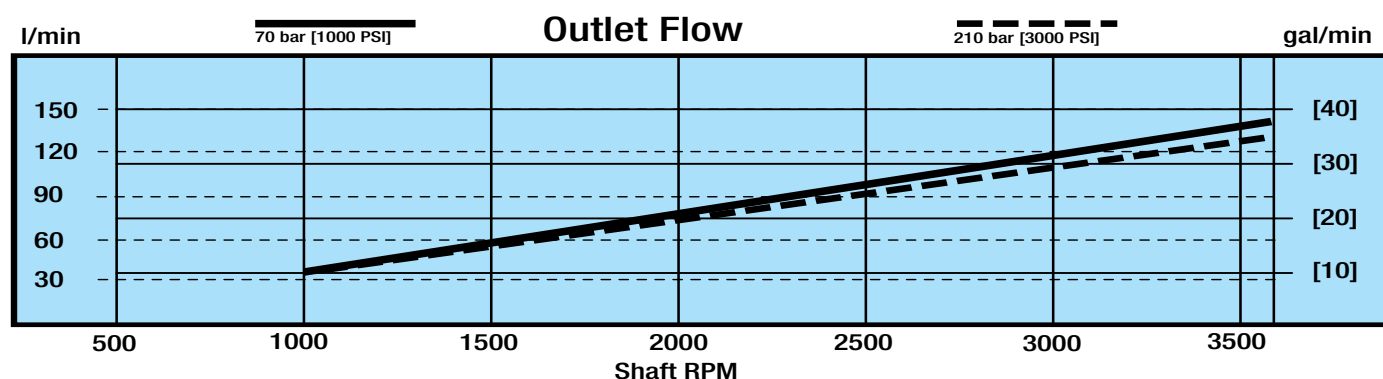
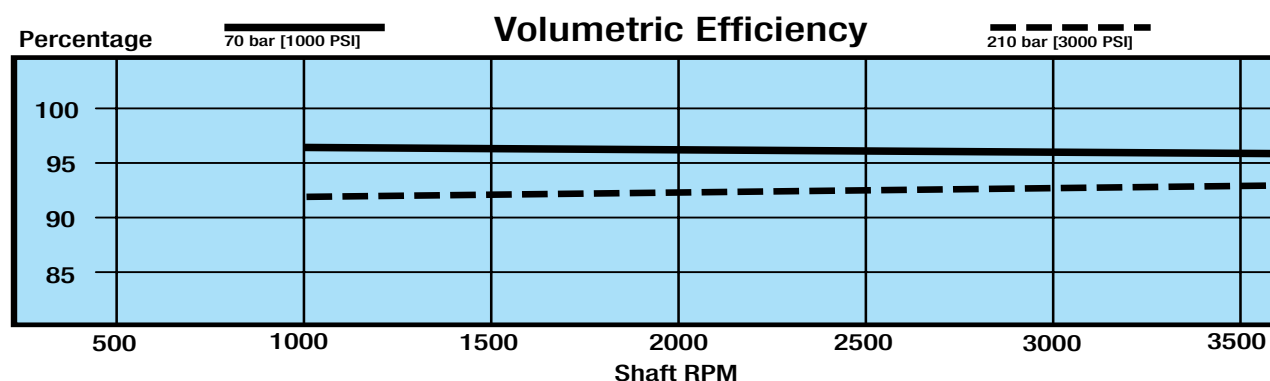
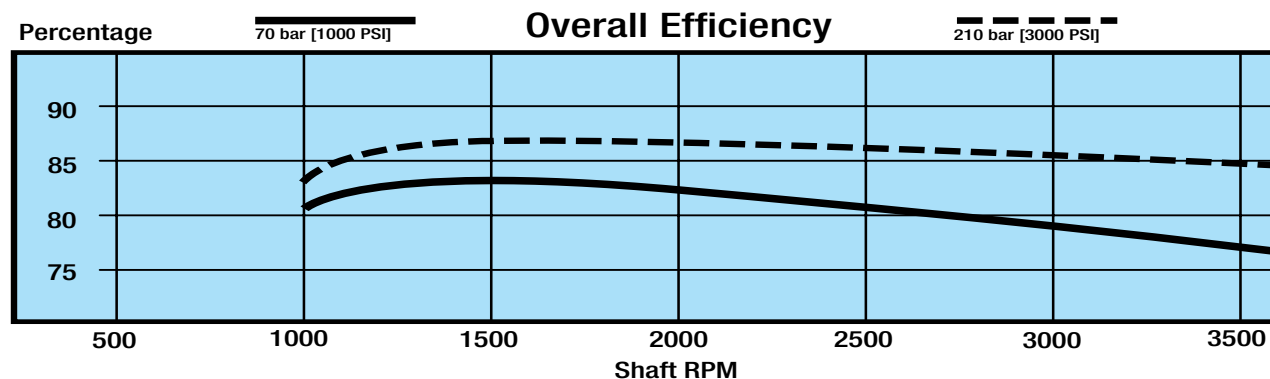
Maximum Displacement	40,6 cm ³ /r [2.48 in ³ /r]
Input Mounting Flange	SAE "B" or "BB"
Flow @ Rated Speed & PSI	140 l/min [37.0 gal/min]
Maximum Rated Speed	3600 RPM
Continuous Rated Pressure	210 bar [3000 PSI]
Maximum Intermittent Pressure	379 bar [5500 PSI]
Continuous Allowable Case Pressure	2 bar [25 PSI]
Maximum Case Drain Temperature	107° C [225° F]
Weight per single pump (aprox.)	27 to 28 kg [59 to 62 lbs]

49,2 cm ³ /r [3.00 in ³ /r]
SAE "B" or "BB"
170 l/min [44.8 gal/min]
3600 RPM
210 bar [3000 PSI]
345 bar [5000 PSI]
2 bar [25 PSI]
107° C [225° F]
27 to 28 kg [59 to 62 lbs]

Specifications - Internal Gerotor Charge Pump	
Displacement Options	
.....	6,9 cm ³ /r [.42 in ³ /r]
.....	13,8 cm ³ /r [.84 in ³ /r]
Operating Pressure Range (std.)	17 to 21 bar [250 to 300 PSI]
Maximum Charge Inlet Vacuum	0,80 bar Abs. [6 inHg]

Model 72400 Performance Data

The charts below are representative of a single 40,6 cm³/r [2.48 in³/r] Variable Displacement Piston Pump. The tests were run at an oil temperature of 82°C [180°F] with viscosity at 9 - 12 cSt [54 - 66 SUS] and the pump at maximum displacement.



Model Code for the 72400 Piston Pumps

Ordering Instructions

The Model 72400 Servo Controlled piston pumps are selected by using the following Model Code System tailoring the pump configuration to the requirement. Once a pump is built from the model code, a product number will be assigned to that configuration and the pump identified.

Make sure all positions are selected within the 27-digit code for each pump ordered.

Code Example:	A	A	D	R	A	A	A	1	3	E	E	1	T	T	A	M	0	0	A	0	0	0	A	0	0	0	0
Position:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
																					0	0	A			0	D

Positions 1, 2, 3 - Code Title

AAD = 40,6 cm³/r [2.48 in³/r] Servo Controlled Variable Displacement Pump
 AAE = 40,6 cm³/r [2.48 in³/r] Servo Controlled Variable Displacement Pump (Tandem Front Pump)
 AAF = 40,6 cm³/r [2.48 in³/r] Servo Controlled Variable Displacement Pump (Tandem Rear Pump)
 ACG = 49,2 cm³/r [3.00 in³/r] Servo Controlled Variable Displacement Pump
 ACH = 49,2 cm³/r [3.00 in³/r] Servo Controlled Variable Displacement Pump (Tandem Front Pump)
 ACJ = 49,2 cm³/r [3.00 in³/r] Servo Controlled Variable Displacement Pump (Tandem Rear Pump)

Position 4 - Input Shaft Rotation

R = Righthand Rotation (CW)
 L = Lefthand Rotation (CCW)

Position 5 - Input Shaft

A = 15 Tooth, 16/32 External Spline, 46 [1.81] Shaft Extension A
 B = 41 Tooth, 48/96 External Spline, 24,4 [.96] Shaft Extension B
 C = 13 Tooth, 16/32 External Spline, 41,1 [1.62] Shaft Extension C
 D = Taper 1.502:12, 6,4 [.25] x 19,8 [.78] keyway, 3/8 - 24 UNF Int. Thread, 35,1[1.38] Shaft Extension D
 G = 25.4 [1.00] Dia. Str., 6,4 [.25] x 28,4 [1.12] keyway, 46 [1.81] Shaft Extension (Key Included) G

Position 6 - Output Shaft

A = 9 Tooth, 16/32 Internal Spline, Accepts 31,8 [1.25] Shaft Extension (for SAE "A" mount only) A
 B = 41 Tooth, 48/96 External Spline, Accepts 24,4 [.96] Shaft Extension (for SAE "B" mount only) B
 F = 11 Tooth, 16/32 Internal Spline, Accepts 31,8 [1.25] Shaft Extension (for SAE "A" mount only) F
 J = 11 Tooth, 16/32 External Spline, Accepts 31,8 [1.25] Shaft Extension (for SAE "B" mount only)
 (To be used with 36,8 [1.45] spacer) J

Position 7 - Auxiliary Rear Mounting

A = "A" SAE Flange Series 82-2 A
 B = 2 Bolt "B" SAE Flange Series 101-2 B
 C = "A" SAE Flange Series 82-2 w/ Cover Plate C
 D = "A" SAE Flange Series 82-2 w/ Cover Plate and Mounting Support Holes D
 E = "A" SAE Flange Series 82-2 w/ Mounting Support Holes E
 F = 2 Bolt "B" SAE Flange Series 101-2 w/ Mounting Support Holes F

Position 8 - Charge Pump

0 = No charge pump 0
 1 = 6,9 cm³/r [.42 in³/r] disp. w/1-5/16 - 12 UN-2B SAE O-ring straight thread inlet port (S) 1
 2 = 13,8 cm³/r [.84 in³/r] disp. w/1-5/16 - 12 UN-2B SAE O-ring straight thread inlet port (S) 2

Position 9 - Charge Pump Relief Setting and Routing

0 = No charge pump 0
 3 = 17- 21 bar [250-300 PSI] (Relieved to Case) 3
 4 = 17- 21 bar [250-300 PSI], 1- 5/16 - 12 UN-2B SAE O-ring straight thread Outlet port (C3),
 3/4 - 16 UNF-2B SAE O-ring straight thread Return Port (C4),
 (Remote filter and/or heat exchanger, relieved to case) 4

Position 10 - Auxiliary Port, Size and Location (left C1 and right C2)

D = On both sides w/left side plugged (housing), 3/4 - 16 UNF-2B SAE O-ring straight thread port D
 E = On both sides and both plugged (housing), 3/4 - 16 UNF-2B SAE O-ring straight thread port E

Position 11 - Drain Port Size and Location (left D1 and right D2)

D = On both sides w/ right side plugged & rear flange drained into housing,
 1-1/16 - 12 UN-2B SAE O-ring straight thread port D
 E = On both Sides w/ left side plugged & rear flange drained into housing,
 1-1/16 - 12 UN-2B SAE O-ring straight thread port E
 M = On both sides w/ left side plugged & thru drain into mount (front),
 1-1/16 - 12 UN-2B SAE O-ring straight thread port M
 S = On both sides w/ both sides plugged & thru drain into mount (front),
 1-1/16 - 12 UN-2B SAE O-ring straight thread port S

Position 12 - Main Ports, Size and Location (port A and B)

1 = 1- 5/16 - 12 UN-2B O-ring straight thread port, Same Side (Right Side) 1
 2 = 1- 5/16 - 12 UN-2B O-ring straight thread port, Same Side (Left Side) 2

Positions 13, 14 - Relief Valve Setting for Main Ports

(Select a Setting for port "A" in position 13 and port "B" in Position 14)

0 = Check Valve Only 0
 B = 140 bar [2000 PSI] B
 E = 175 bar [2500 PSI] E
 H = 210 bar [3000 PSI] H
 L = 240 bar [3500 PSI] L

Code	Single Unit	Tandem Unit	
		Front	Rear
A	Std.	Std.	NA
B	NA	NA	Std.
C	Opt.	NA	NA
D	Opt.	Opt.	NA
G	Opt.	NA	NA
A	Std.	NA	Std.
B	NA	Std.	NA
F	Opt.	NA	Opt.
J	Opt.	NA	Opt.
A	Std.	NA	Opt.
B	Opt.	Std.	Opt.
C	Opt.	NA	Opt.
D	Opt.	NA	Opt.
E	Opt.	NA	Std.
F	Opt.	Opt.	Opt.
0	Opt.	Std.	Opt.
1	Std.	NA	NA
2	Opt.	NA	Std.
0	Opt.	Std.	Opt.
3	Std.	NA	Std.
4	Opt.	NA	Opt.
D	Opt.	Std.	Std.
E	Std.	NA	NA
D	Opt.	Opt.	NA
E	Std.	Std.	NA
M	NA	NA	Opt.
S	NA	NA	Std.
1	Std.	Opt.	Opt.
2	Opt.	Std.	Std.
0	Opt.	Opt.	Opt.
B	Opt.	Opt.	Opt.
E	Opt.	Opt.	Opt.
H	Opt.	Opt.	Opt.
L	Opt.	Opt.	Opt.

Model Code for the 72400 Piston Pumps

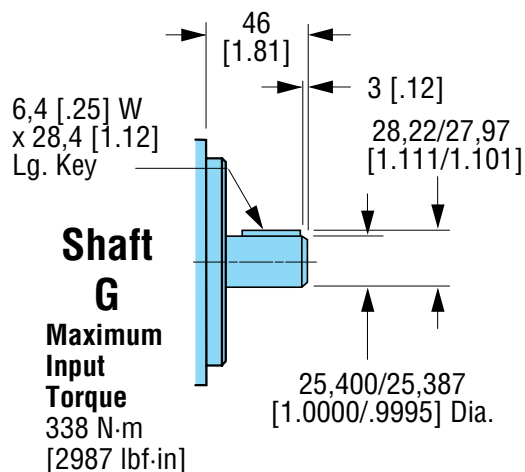
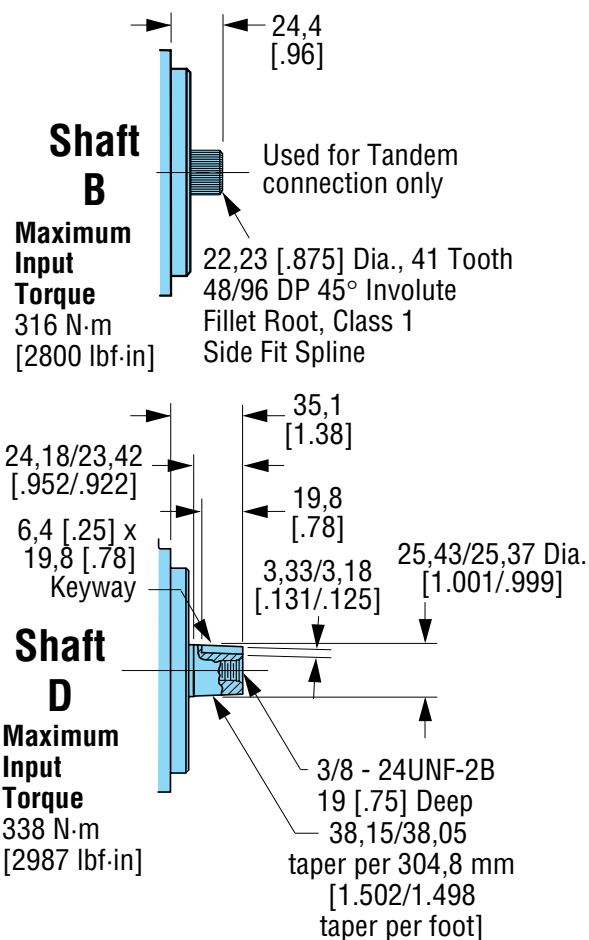
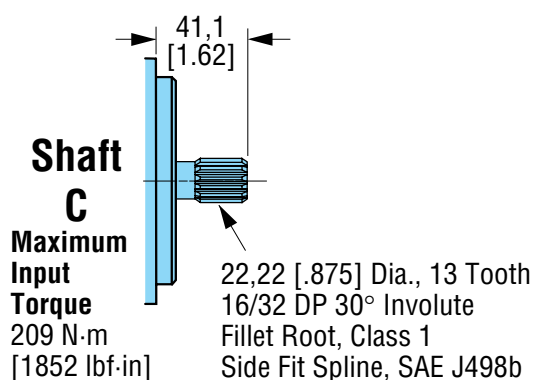
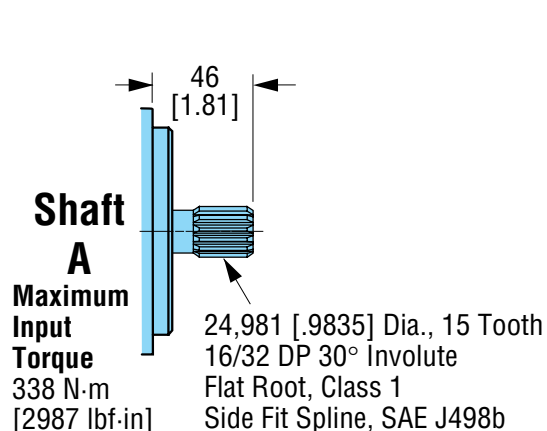
	Code	Single Unit	Tandem Unit	
		Unit	Front	Rear
N = 275 bar [4000 PSI]	N	Opt.	Opt.	Opt.
Q = 310 bar [4500 PSI]	Q	Opt.	Opt.	Opt.
T = 345 bar [5000 PSI]	T	Std.	Std.	Std.
Y = 379 bar [5500 PSI]	Y	Opt.	Opt.	Opt.
Position 15 - Additional Functions				
0 = No Additional Functions	0	Std.	Std.	Std.
A = Bypass Valve	A	Opt.	Opt.	Opt.
Positions 16, 17 - Control Assembly				
Manual Control				
M0 = No Additional Features	M0	Std.	Std.	Std.
MA = Neutral Lockout Switch (Includes Wide Band Neutral)	MA	Opt.	Opt.	Opt.
MB = Neutral Detent (Includes Wide Band Neutral)	MB	Opt.	Opt.	Opt.
MC = Wide Band Neutral	MC	Opt.	Opt.	Opt.
Port Plate				
P0 = No Additional Features	P0	Opt.	Opt.	Opt.
Hydraulic Remote Control				
HA = 5-15 bar [72-217 PSI] Pilot Pressure range, 2X Port .4375-20 UNF-2B SAE O-ring Port	HA	Opt.	Opt.	Opt.
Electrohydraulic Control				
EC = Electronic Proportional Control 12 Vdc without Electronic Driver	EC	Opt.	Opt.	Opt.
ED = Electronic Proportional Control 24 Vdc without Electronic Driver	ED	Opt.	Opt.	Opt.
EE = Electronic Proportional Control 12/24 Vdc and Electronic Driver	EE	Opt.	Opt.	Opt.
with 1 to 6 Vdc Potentiometric Command Input		Opt.	Opt.	Opt.
EG = Electronic Proportional Control 12/24 Vdc and Electronic Driver with 4 to 20 mA Command Input	EG	Opt.	Opt.	Opt.
EL = Electronic Proportional Control 12 Vdc and Electronic Driver with ± 100 mA Command Input	EL	Opt.	Opt.	Opt.
Solenoid Operated				
SA = 3 pos (FNR) 12 Vdc solenoids with Weather Pack Connectors (locations at port s1 and s2)	SA	Opt.	Opt.	Opt.
SB = 2 pos 12 Vdc solenoid with Weather Pack Connectors (location at port s1)	SB	Opt.	Opt.	Opt.
SC = 2 pos 12 Vdc solenoid with Weather Pack Connectors (location at port s2)	SC	Opt.	Opt.	Opt.
Position 18 - Destroke Valve				
0 = Not required	0	Std.	Std.	Std.
1 = with 12 VDC Coil and Weather Pack Connector	1	Opt.	Opt.	Opt.
2 = with 24 VDC Coil and Weather Pack Connector	2	Opt.	Opt.	Opt.
3 = with 12 VDC Coil and DIN 43650 Connector	3	Opt.	Opt.	Opt.
4 = with 24 VDC Coil and DIN 43650 Connector	4	Opt.	Opt.	Opt.
Position 19 - Supply Orifice (location p)				
0 = No Supply Orifice (NA for pumps w/ destroke)	0	Opt.	Opt.	Opt.
A = 0,71 mm [.028 in]	A	Opt.	Opt.	Opt.
B = 0,81 mm [.032 in]	B	Opt.	Opt.	Opt.
C = 0,91 mm [.036 in]	C	Std.	Std.	Std.
D = 1,02 mm [.040 in]	D	Opt.	Opt.	Opt.
E = 1,12 mm [.044 in]	E	Opt.	Opt.	Opt.
F = 1,32 mm [.052 in] (Maximum orifice size if position 18 selection is 1 thru 4)	F	Opt.	Opt.	Opt.
G = 1,45 mm [.057 in] (NA for pumps w/ destroke)	G	Opt.	Opt.	Opt.
H = 1,65 mm [.065 in] (NA for pumps w/ destroke)	H	Opt.	Opt.	Opt.
J = 1,85 mm [.073 in] (NA for pumps w/ destroke)	J	Opt.	Opt.	Opt.
Position 20 - Control Orifice (location s1 & s2)				
0 = No Control Orifice	0	Std.	Std.	Std.
A = 0,71 mm [.028 in]	A	Opt.	Opt.	Opt.
B = 0,81 mm [.032 in]	B	Opt.	Opt.	Opt.
C = 0,91 mm [.036 in]	C	Opt.	Opt.	Opt.
D = 1,02 mm [.040 in]	D	Opt.	Opt.	Opt.
E = 1,12 mm [.044 in]	E	Opt.	Opt.	Opt.
F = 1,32 mm [.052 in]	F	Opt.	Opt.	Opt.
G = 1,45 mm [.057 in]	G	Opt.	Opt.	Opt.
Position 21 - Special Control Option				
Manual Control (only)				
0 = No Special Control Options (Standard Control Lever Position)	0	Std.	Std.	Std.
Positions 22, 23 - Paint				
0A = Primer	0A	Std.	Std.	Std.
0B = Black	0B	Opt.	Opt.	Opt.
Positions 24, 25 - Special Features				
00 = No Special Features	00	Std.	Std.	Std.
BB = Adjustable Displacement Limiter, Both Sides	BB	Opt.	Opt.	Opt.
Position 26 - Identification				
0 = Standard	0	Std.	Std.	Std.
Position 27 - Design Code				
D = Eaton - assigned design code				

72400

Input Shafts

Code Position 5

Dimensions are in millimeters [inches], unless otherwise specified.



Torque Note:
 The combined torque required to turn multiple pumps must not exceed the torque rating of the input drive shaft of the front piston pump.
 Consult an Eaton representative and/or Eaton engineering on side load recommendations.

Ordering Note:
 Input and output shafts (code position 5 & 6) must be selected in relationship to pump code (position 1, 2, & 3).

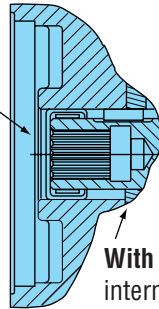
72400

Output Shafts - Code Position 6

9 Tooth, 16/32 DP Int., 15,875
[.6250] O.D., Accepts 31,8 [1.25]
Shaft Extension, "A" Mount SAE J498b

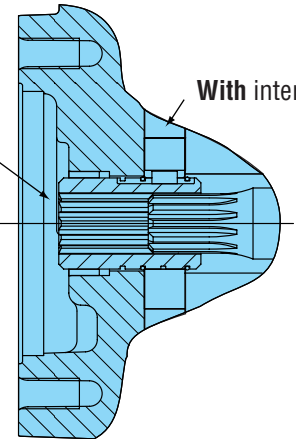
Position 6
Shaft A

Torque limit on internal rear spline of piston pump with internal charge pump must not exceed 54 N·m [480 lbf·in]. Piston pump without internal charge pump must not exceed 76 N·m [672 lbf·in].



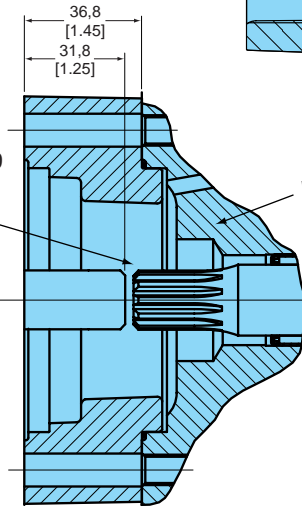
11 Tooth, 16/32 DP Int., 19,33
[.761] O.D., Accepts 31,8 [1.25]
Shaft Extension, "A" Mount SAE J498b

Position 6
Shaft F
Maximum Torque
119 N·m [1050 lbf·in]



11 Tooth, 16/32 DP Ext., 19,05
[.750] O.D., Accepts 31,8 [1.25]
Shaft Extension, "A" Mount SAE J498b
(Used with spacer)

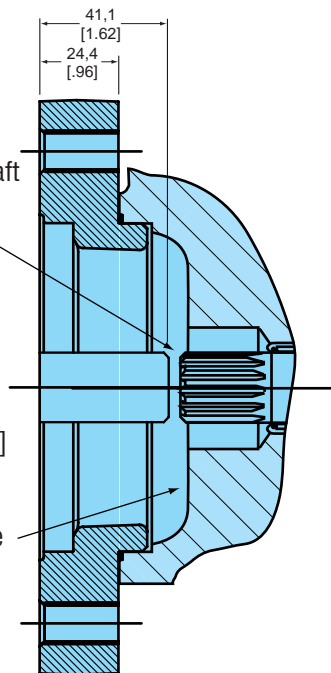
Position 6
Shaft J
Maximum Torque
119 N·m [1050 lbf·in]



13 Tooth, 16/32 DP External, 21,81
[.8585] O.D., Accepts 41,1 [1.62] Shaft
Extension "B" Auxiliary Mount,
SAE J744

Position 6
Shaft L
Maximum Torque
209 N·m [1852 lbf·in]

Without internal charge

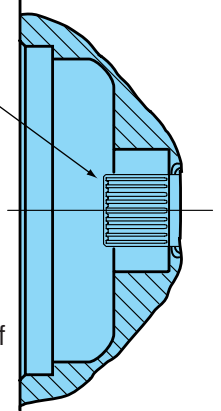


41 Tooth, 48/96 DP Extension, 22,225
[.8750] O.D., Accepts 24,4 [.96] Shaft
Extension "B" Auxiliary Mount,
SAE J498b

Position 6
Shaft B
Maximum Torque
316 N·m [2,800 lbf·in]

41 Tooth for tandem connections on rear of front pump.

Tandem Servo Piston Pump
SAE "B" Mounting Kit #72400-902:
Includes 41T coupling, o-ring, cap screws (2),
and washer.

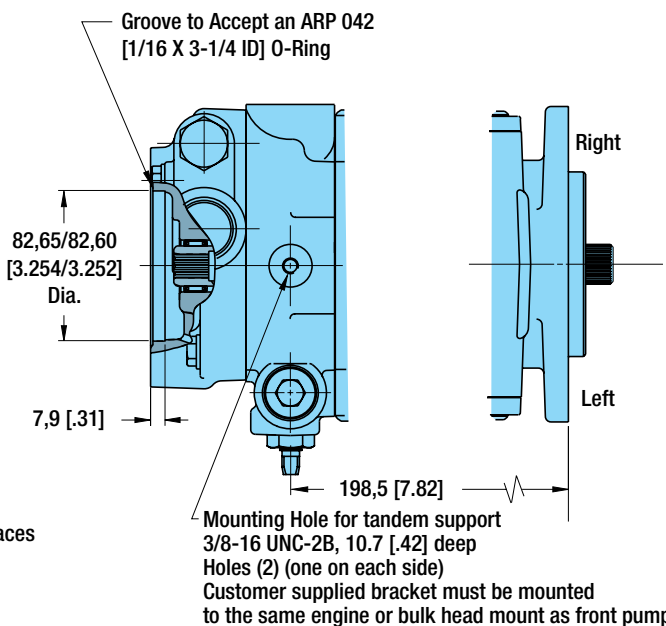
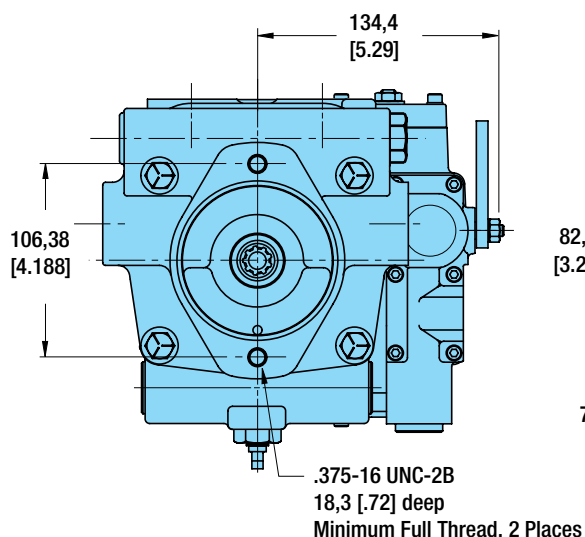
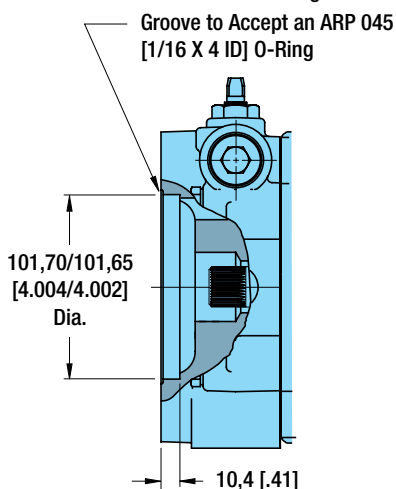
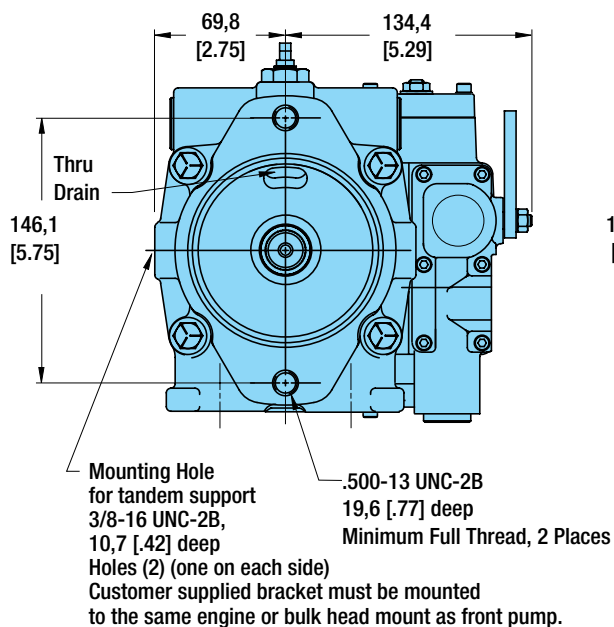


72400

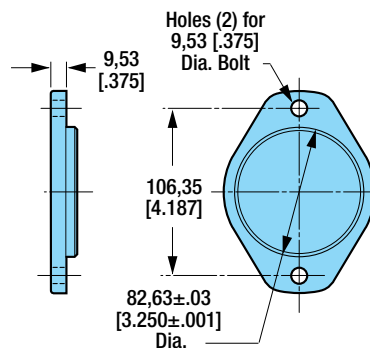
Auxiliary Rear Mounting

Code Position 7

Dimensions are in millimeters [inches], unless otherwise specified.

2 Bolt "A" Auxiliary Mounting Flange
(Rear of Single or Tandem Rear Pump)2 Bolt "B" Auxiliary Mounting Flange
(Rear of Front Pump)

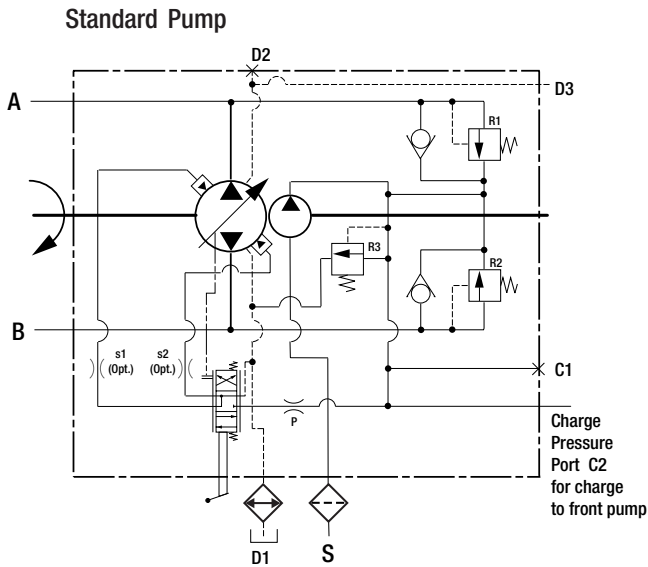
Cover Plate

Fits "A" SAE Auxiliary Mounting Flange.
Cover Plate Kit #70142-915: Includes plate,
cap screws (2), and o-ring.

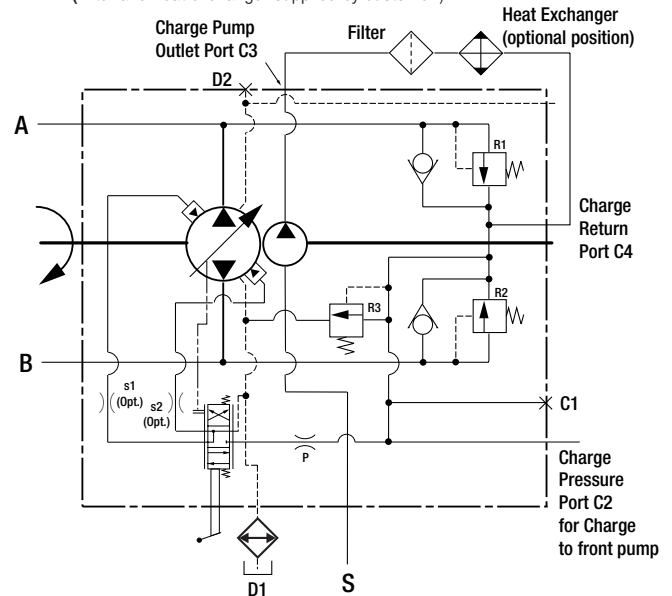
72400

Charge Pump Routing and Location

Code Position 9



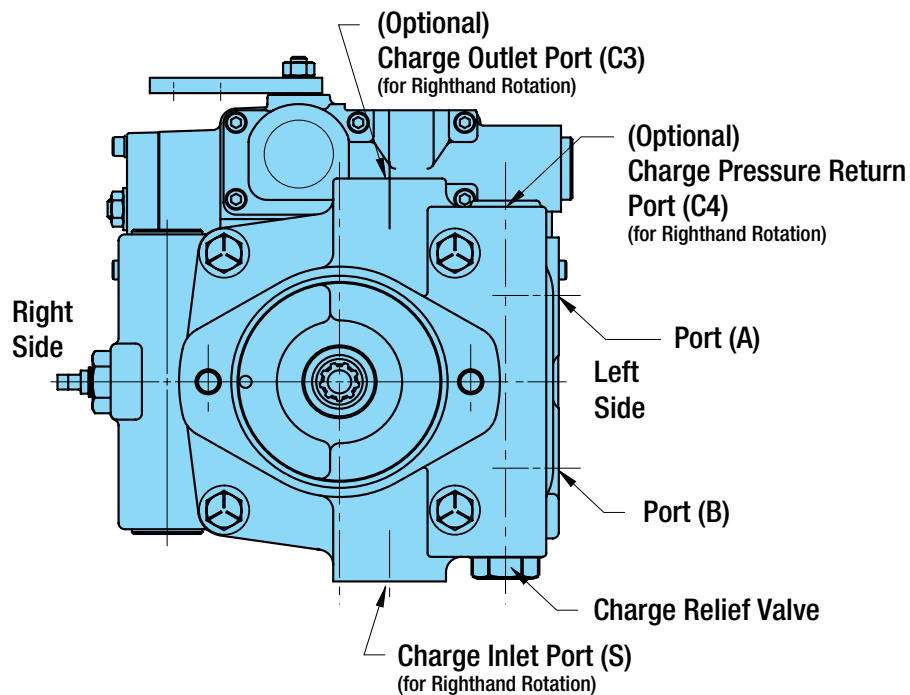
Charge Pump with Remote Filter/ Heat Exchanger Ports
(Filter and heat exchanger supplied by customer.)



Charge Outlet Port Location

The charge outlet and return port is located in the charge pump housing, opposite of the suction port and charge relief valve.

For further detail on port relationship to rotation and position, refer to installation drawings.



All left (CCW) or right (CW) directions given are viewed looking at the input shaft end of the pump.

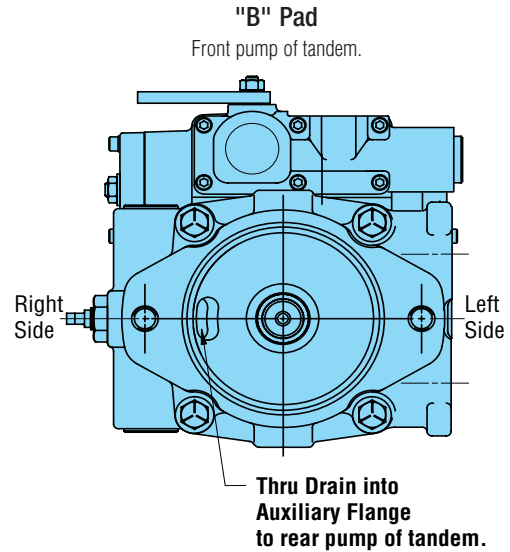
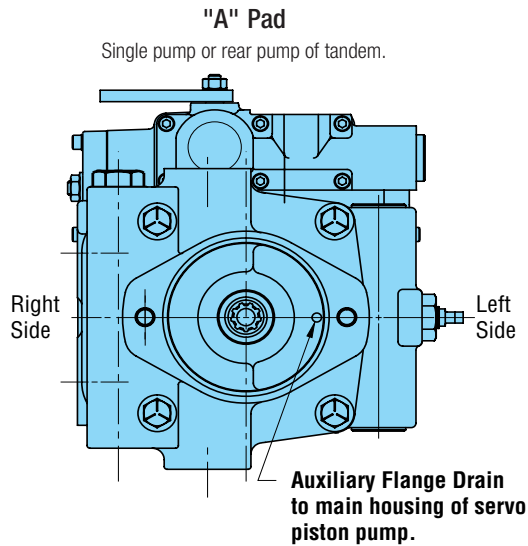
72400

Auxiliary and Drain Port Locations

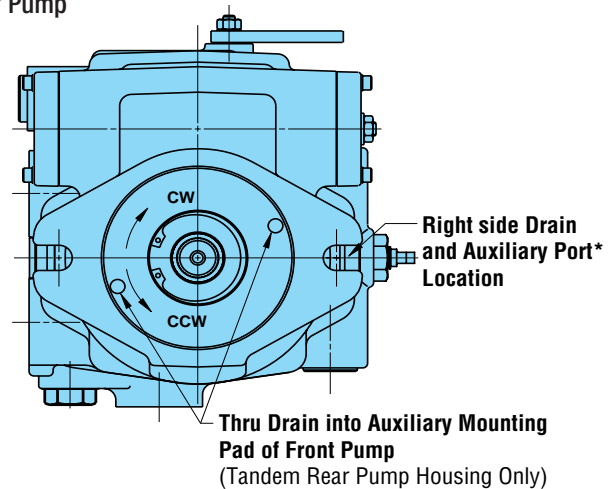
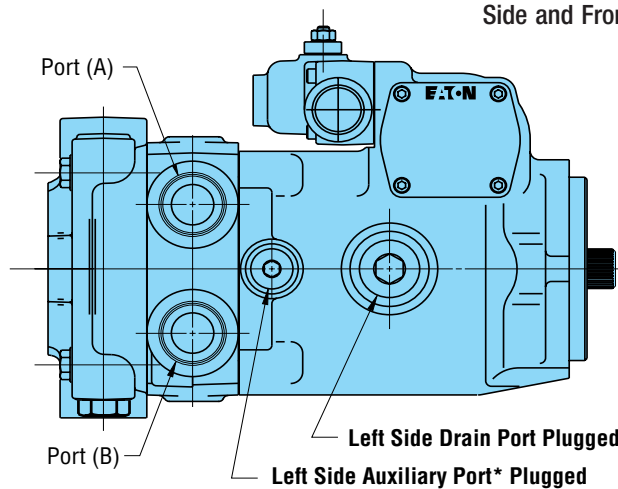
Code Position 10 and 11

(For dimensions, refer to Installation drawings.)

Drain Locations in Rear of Pumps



Side and Front of Pump



***NOTE:** Auxiliary port required in rear and front pump of tandem to provide charge flow and pressure to front pump.

All left (CCW) or right (CW) directions given are viewed looking at the input shaft end of the pump.

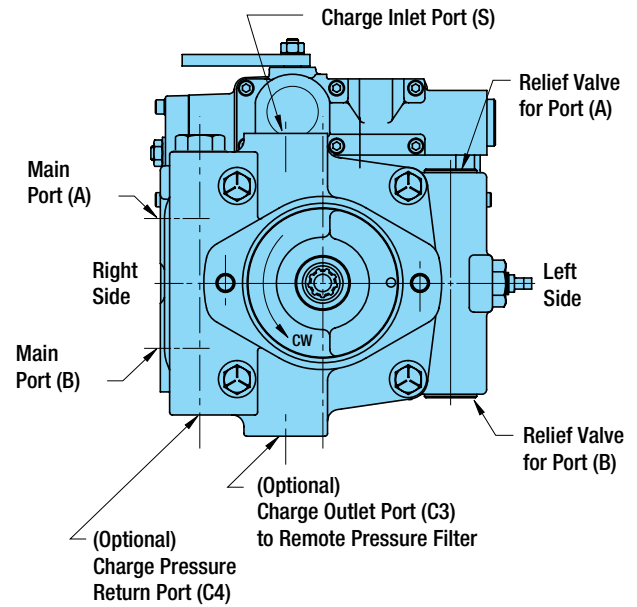
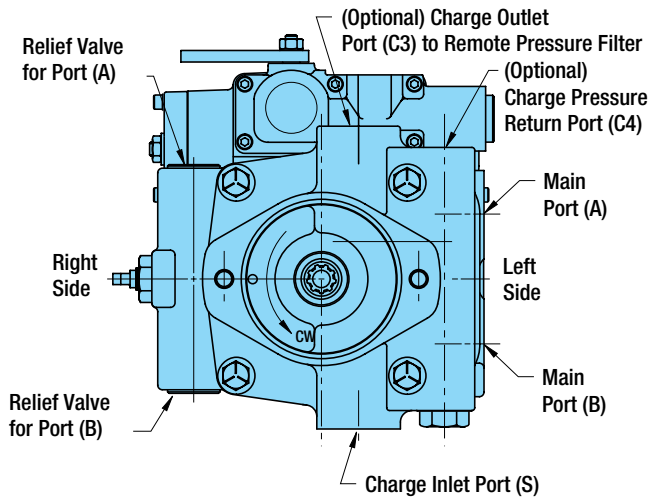
72400

Main Ports and Relief Valve Location

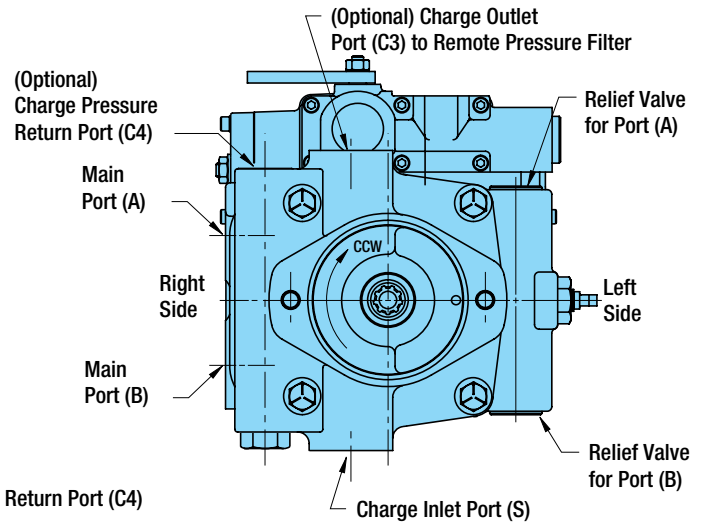
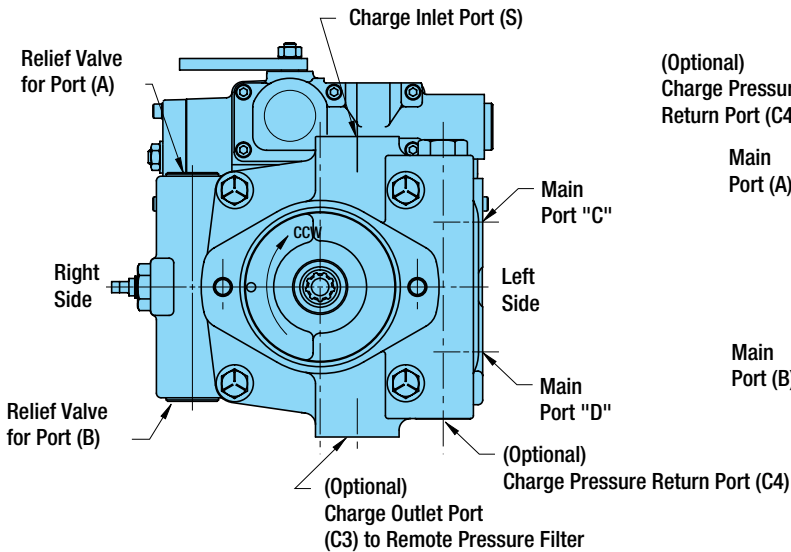
Code Position 12, 13, and 14

(For dimensions, refer to installation drawings.)
Charge pump position must stay in relationship to backplate as pictured below.

*Righthand Rotation (CW)



*Lefthand Rotation (CCW)



*All left (CCW) or right (CW) directions given are viewed looking at the input shaft end of the pump.

72400

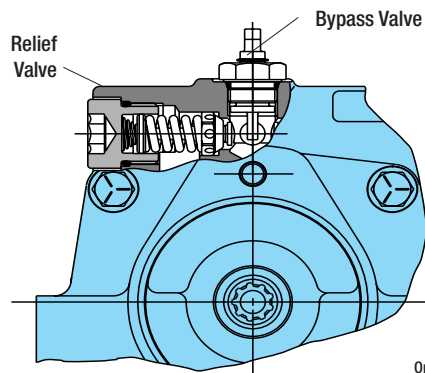
Additional Functions

Code Position 15

(For dimensions, refer to installation drawings.)

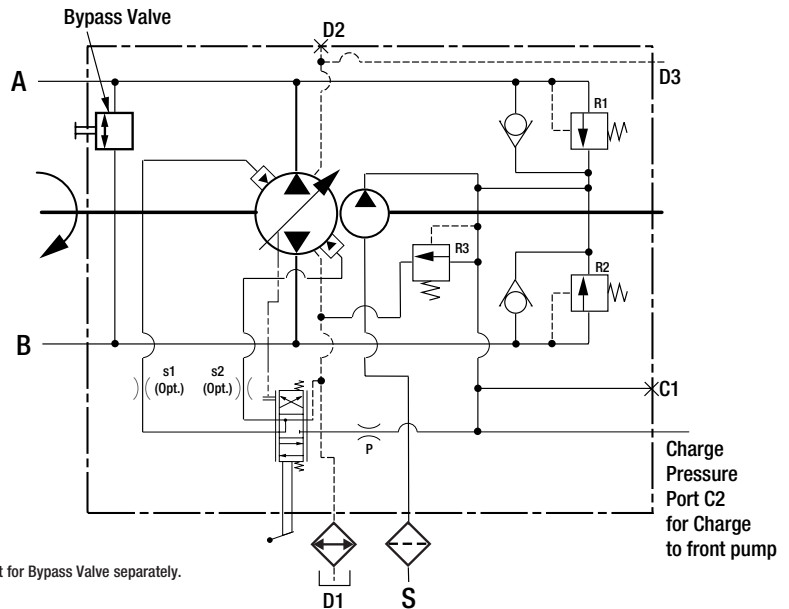
Bypass Valve

Opens the closed loop hydraulic circuit, allowing limited movement of a machine.



Order #72400-900 kit for Bypass Valve separately.

Dimensions are in millimeters [inches], unless otherwise specified.



Port Plate Control

Code Position 16,17, and,18

The port plate is commonly used as a slave control that receives commands from other controls in the same system.

Minimum required control-pressure is 17 bar [250 PSI]

Righthand (CW) Input Rotation

Pressure to Control Port 1
Pressure to Control Port 2

Output Flow

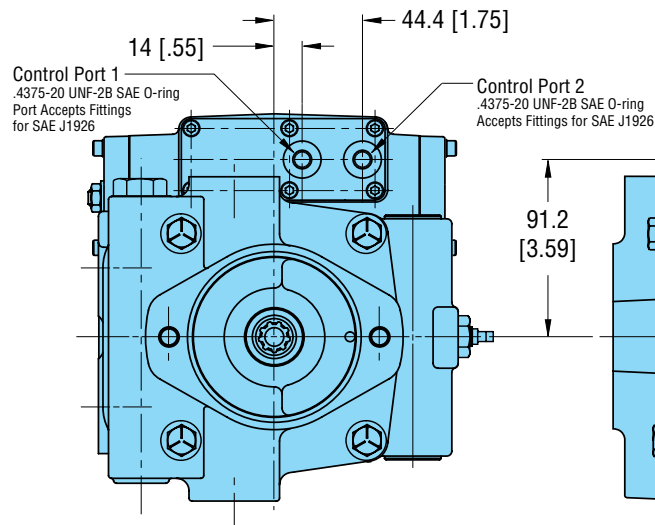
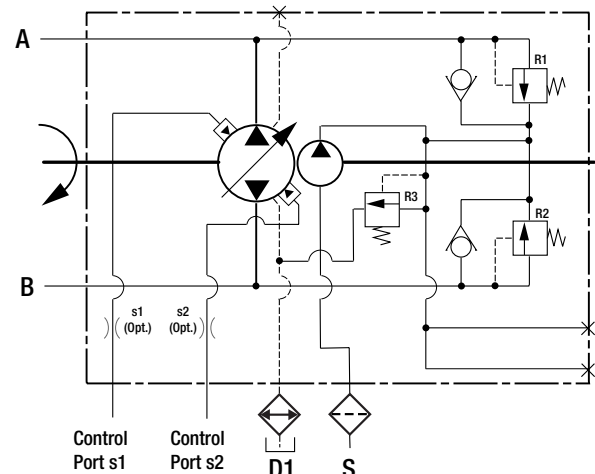
Port (B)
Port (A)

Lefthand (CCW) Input Rotation

Pressure to Control Port 1
Pressure to Control Port 2

Output Flow

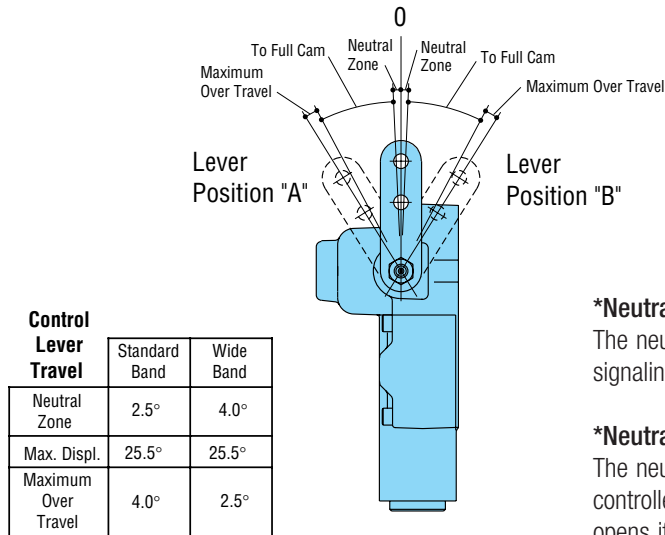
Port (A)
Port (B)



72400

Manual Control

Code Position 16,17, and,18



Dimensions are in millimeters [inches], unless otherwise specified.

*Neutral Detent Feature

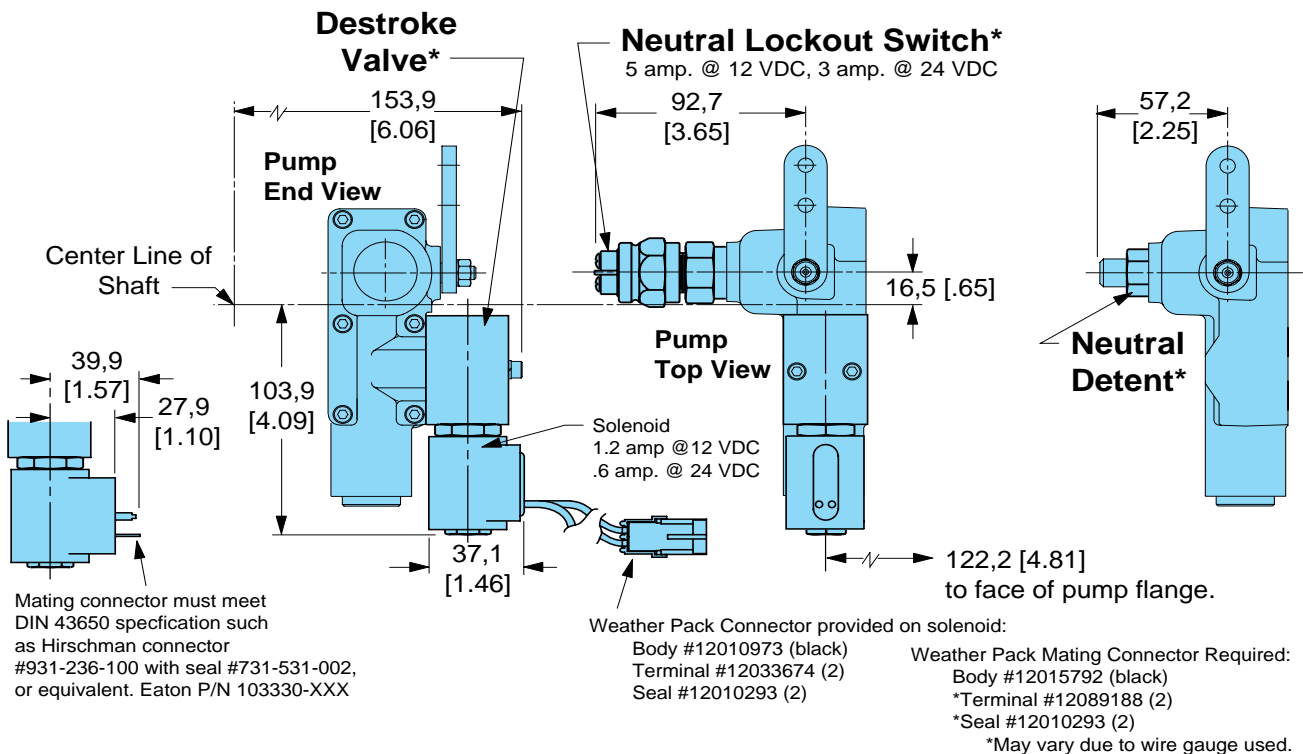
The neutral detent provides a positive, centered feeling to the handle, signaling the operator when the pump is in neutral position.

*Neutral Lockout Feature

The neutral lockout switch consists of an electrical switch installed on the controller. This switch closes at the neutral position of the input lever and opens if lever is rotated either direction. The electronic "lockout" prevents the operator from starting any auxiliary functions unless the pump is in neutral position.

*Destroke Valve Feature

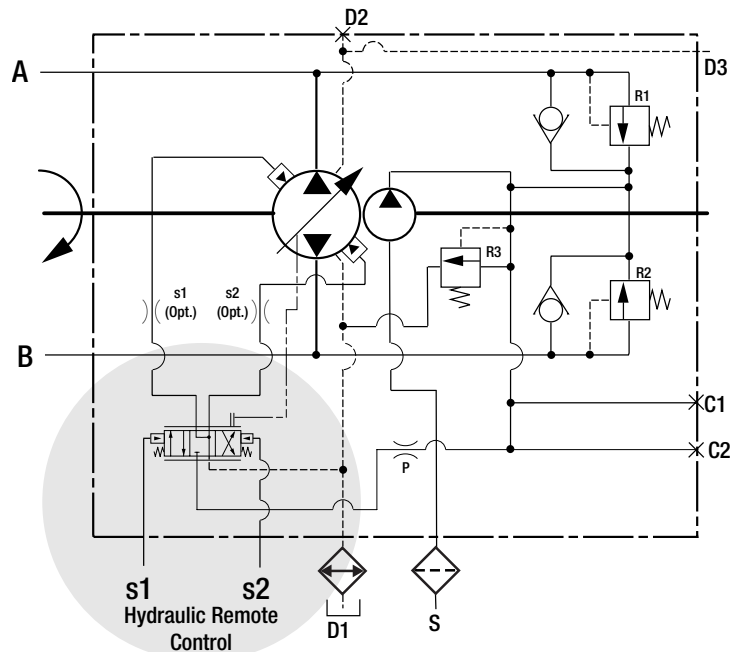
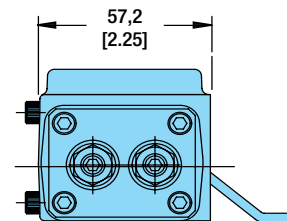
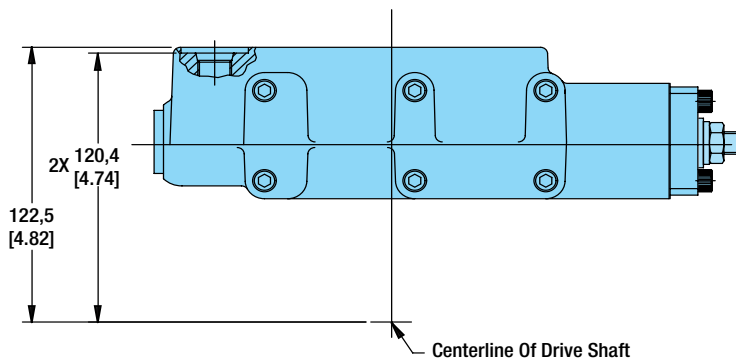
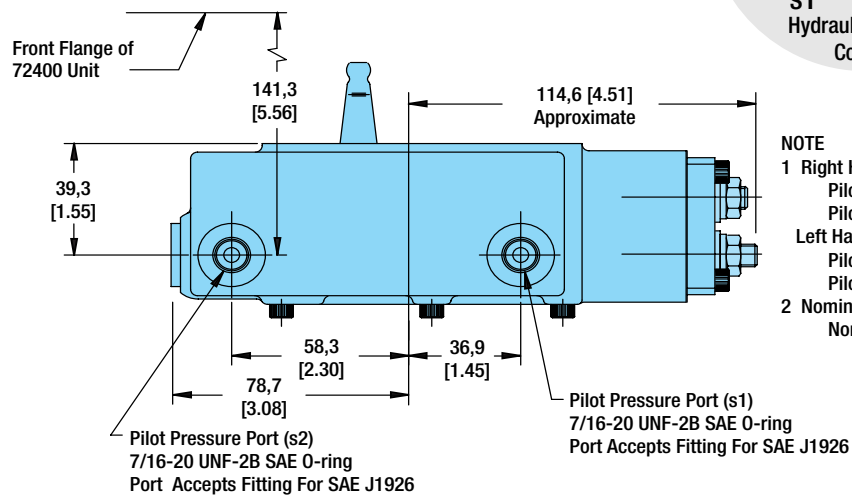
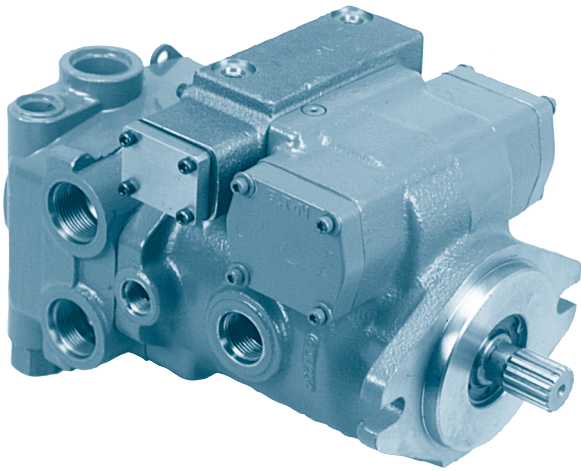
The destroke valve provides an emergency return to neutral and must be energized in order for the pump to stroke. If at any time power is interrupted to the solenoid, the pump will destroke to neutral.



72400

Hydraulic Remote Control

Code Position 16,17



NOTE

1 Right Hand (Clockwise) Rotation

Pilot Press Port -1 Pressurized...flow From System Press Port -B

Pilot Press Port -2 Pressurized...flow From System Press Port -A

Left Hand (Counter Clockwise) Rotation

Pilot Press Port -1 Pressurized...flow From System Press Port -A

Pilot Press Port -2 Pressurized...flow From System Press Port -B

2 Nominal Threshold Pressure 5 bar [72.5 PSI]

Nominal Max Displacement Pressure 15 bar [217.6 PSI]

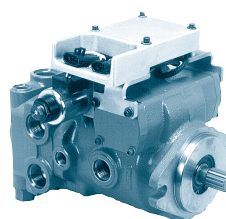
Hydraulic Remote Control Conversion Kit

Order Part Number 72400-919

Includes: Control sub-assembly (1pc), Socket head cap screws (6 pc), Control housing gasket (1pc)

72400 Electronic Proportional Displacement Control

Code Position 16,17



Model Code	Model Code Description	Typical Input Devices	Nominal Command Input Impedance of Electronics Module
	Command Input Signal		
EE	1 to 6 Vdc Potentiometric	Joysticks or Potentiometers with a resistance between 160 ohms and 50K ohms.	500K Ohms
EG	± 20 mA Current loop (4-20 mA)	Programmable Logic Controllers (PLC)	250 Ohms
EL	± 100 mA differential	Torque motor servo valve current drivers	28 Ohms
EC	12 Volts	Requires customer supplied electronics	
ED	24 Volts		

The Electronic Proportional (EP) displacement control is ideal for applications requiring electronic pump displacement control. The EP displacement control provides the flexibility of three command input choices. Control components include a proportional solenoid actuated valve assembly and an electronic solenoid driver module mounted on the pump. The control driver module converts a command input signal to a proportional current output to the proportional solenoids resulting in a proportional pump displacement.

The EP displacement control has been designed to withstand the rigors of off-highway equipment environmental conditions.

EP Displacement Control Features

- Ease of installation
- Automotive style environmentally sealed Metri-Pack connectors
- Operates from 12 or 24 Vdc power supply
- External fuse (customer supplied):
3A for 12 Vdc system, 1A for 24 Vdc system
- Three choices for command input signal
- Operating temperature range -40° C to +85° C
- Control driver module encapsulated for environmental protection
- Closed loop current control compensates for resistance change of the proportional solenoids due to temperature variations
- Return to neutral for loss of power, or loss of command input signal
- Mechanical feedback of swashplate position for closed loop control
- External neutral adjustment
- Manual override capability
- Control drive module qualification per SAE J1455, SAE J1113, CISPR 25

Control Driver Module Qualification
(Contact Eaton for Specific Levels)

- SAE J1455 - Recommended Environmental Practices for Electronic Equipment Design

Humidity/Temperature Extreme Cycling
Salt Spray
Splash & Immersion
Steam Cleaning/High Pressure Wash
Vibration
Mechanical Shock
Temperature Cycling
Load Dump Transients
Inductive Load Switching Transients

- SAE J1113 - Electromagnetic Susceptibility Measurement Procedures for Vehicle Components

EMI/EMC - Conducted & Radiated Immunity

- CISPR 25 - International Electrotechnical Commission "Limits and Methods of Measurement of Radio Disturbance Characteristics for the Protection of Receivers used on Board Vehicles".

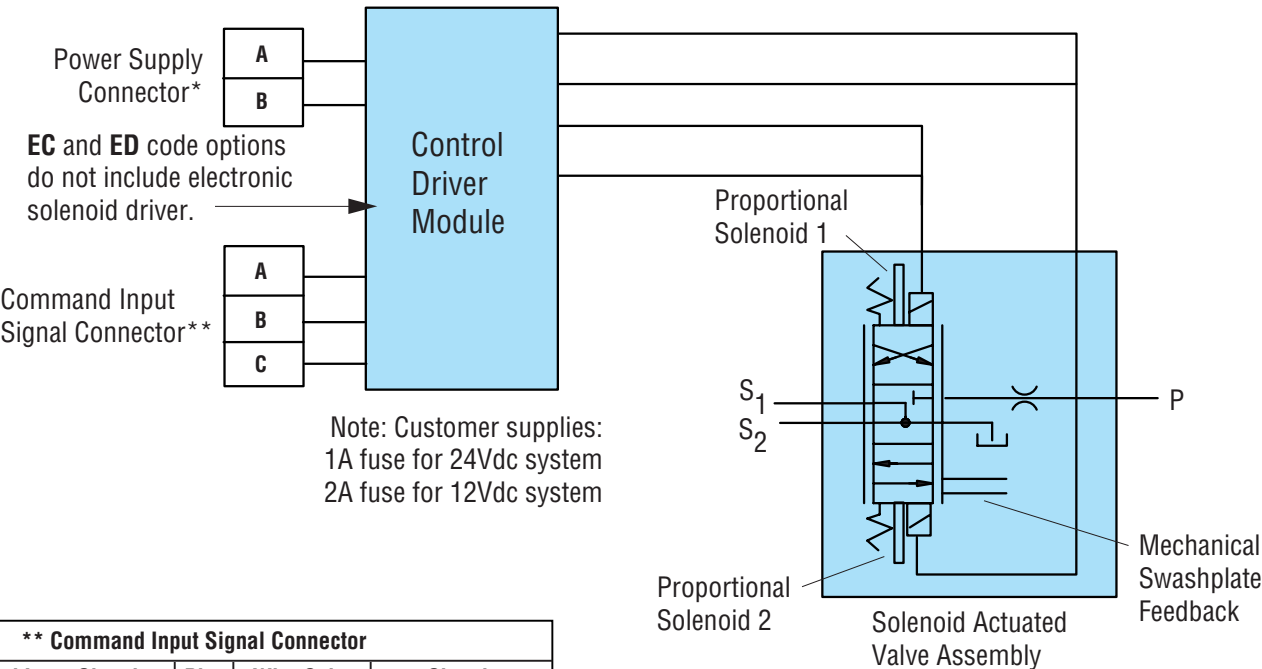
EMI /EMC - Conducted & Radiated Emissions

72400

Electronic Proportional Displacement Control

Code Position 16,17 (EE, EG, EL) Cont.

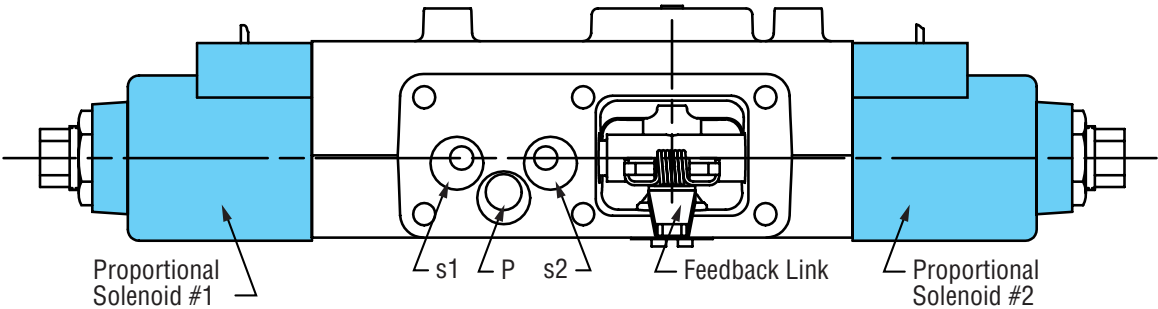
Interface Schematic



** Command Input Signal Connector			
Command Input Signal	Pins	Wire Color	Signal
1 to 6 Vdc Potentiometric	A	Black	Ref Low - 1 Vdc
	B	Green	Command (wiper)
	C	Red	Ref Hi - 6 Vdc
± 20 mA Current loop (4-20 mA)	A	Orange	Loop Return
	B	White	Loop In
	C	No Connection Required*	
± 100 mA differential	A	Blue	Loop Return
	B	White	Loop In
	C	No Connection Required*	

* Mating connector kit 990762-000 contains plug to be used to seal mating end connector.

Solenoid Actuated Valve Assembly



Model 72400

72400

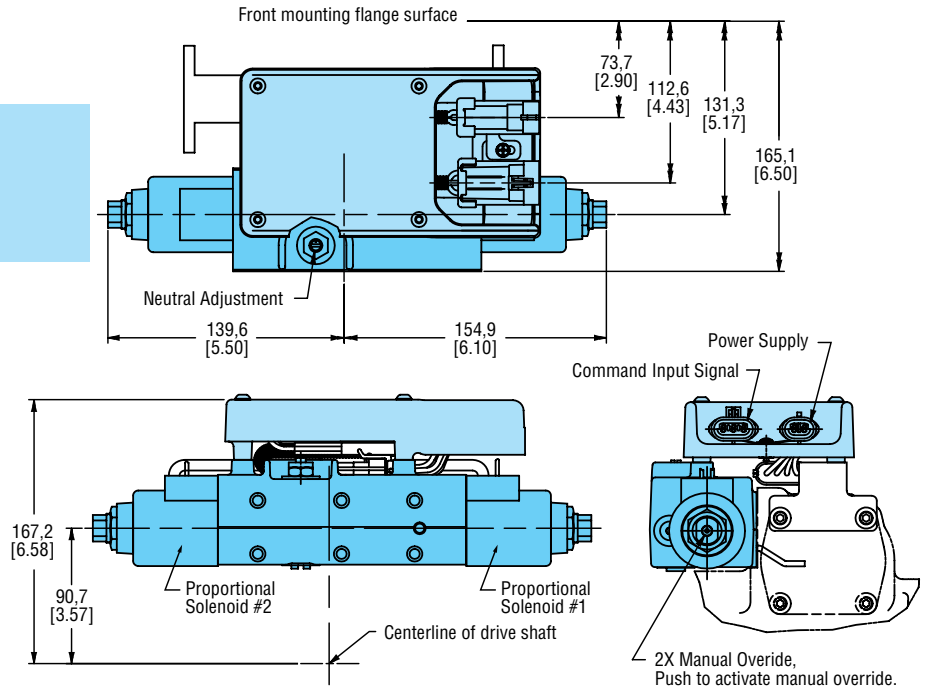
Electronic Proportional Displacement Control

Code Position 16,17

(EE, EG, EL) Cont.

Mating Connector Kit: Eaton P/N 990762-000***Recommended:** Wire Size 16-18 AWG,
Cable Dia. 2.03 - 2.80 mm**Kit includes:**Mating Connectors for 2-pin Power Supply Connector,
3-pin Command Input Signal Connector

*Delphi/Packard

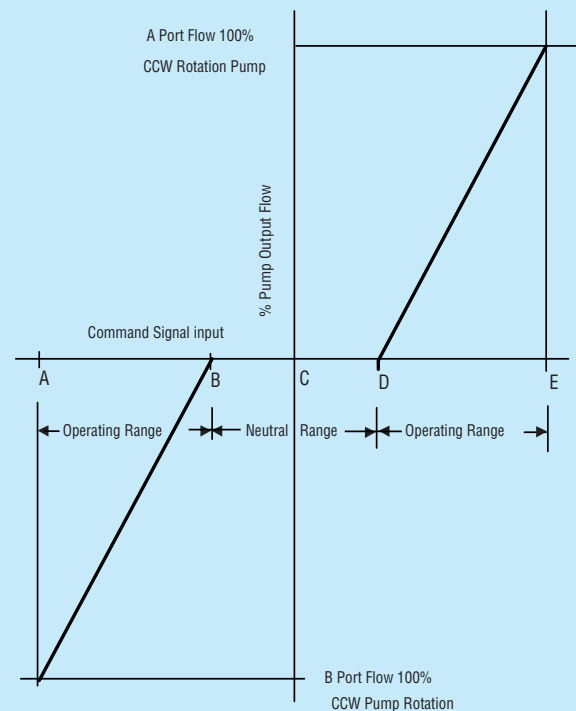
Mating Connector Part Numbers:Recommended: Wire Size 16-18 AWG,
Cable Dia. 2.03 - 2.80 mm
Reference Source: Pioneer-Standard Electronics 1-800
257-66131) Power Supply 2-pin connector
Connector P/N 1205 2641
Terminal P/N 1204 8074
TPA P/N 1205 2634
Cable Seal 1204 80862) Command Input Signal 3 Pin Connector
Connector P/N 1211 0293
Terminal P/N 1204 8074
TPA P/N 1205 2845
Cable Seal 1204 8086

Note: In order to assure the most reliable installation and operation of any electronic control, proper installation methods should be followed with respect to interconnection wiring harness, command signal devices, fusing, and input power switching. Proper care should be taken to prevent damage to all electrical and electronic components due to abrasion, moving objects, heat, moisture or other environmental hazards. For safety critical applications, Eaton recommends that a switch be installed in line with (+ Battery) power to the module so that power may quickly be disconnected in case of emergency. A 2 ampere slow blow fuse should always be installed in the + battery line. It is recommended that during initial start-up and checkout, the machine be placed on jack stands to prevent inadvertent movement of the machine.

Command Input Signal	A (max)	B (min)	C	D (min)	E (max)
1 to 6 Vdc	1.5 Vdc	3.3 Vdc	3.5 Vdc	3.7 Vdc	5.5 Vdc
4-20 mA*	-20 mA	-4.5 mA	0 mA	+4.5 mA	+20 mA
±100 mA	-100 mA	-7.5 mA	0 mA	+7.5 mA	+100 mA

*Note: The +20 mA command input signal configuration operates the pumps in one direction. The customer has to change the polarity on the -20 mA signal to operate the pump in the opposite direction.

General Relationship between Command Signal Input and Pump Flow

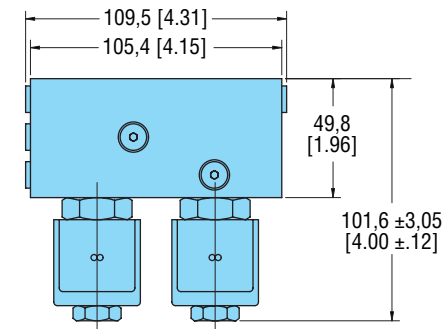
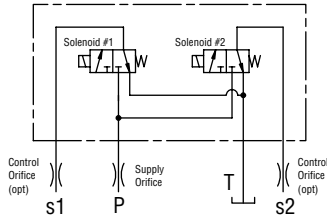
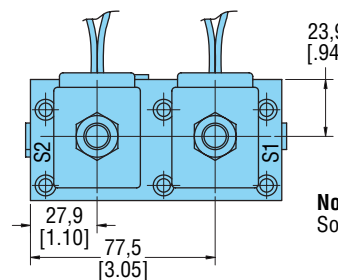


Model 72400

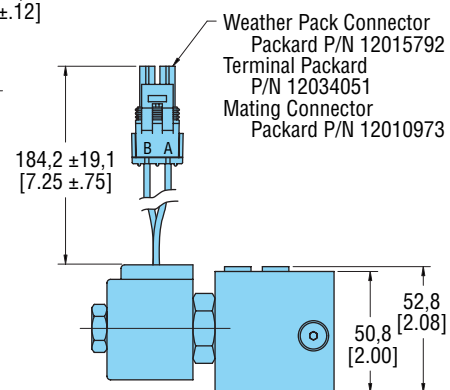
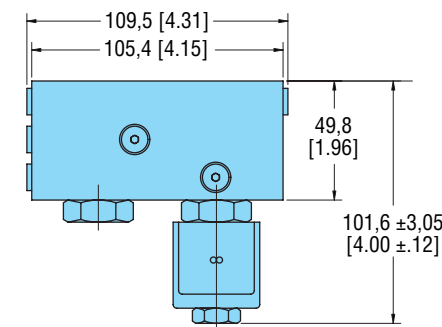
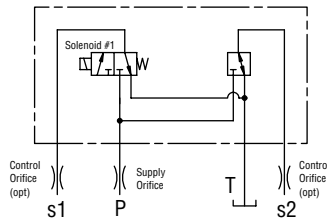
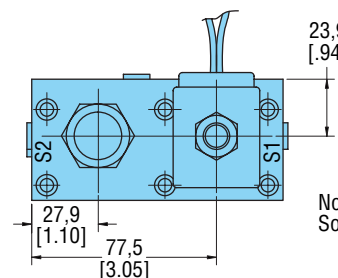
72400

Solenoid Operated Control

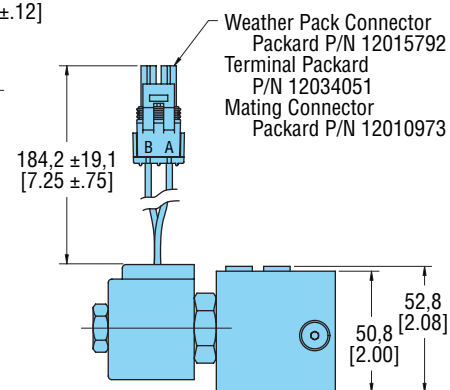
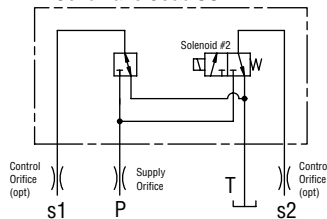
Code Position 16,17

Schematic Code **SA****Code SA**
Drawing Shown.

Note:
Solenoid Coil Specifications
Voltage: 12 Vdc
Watts: 20 (Nominal)

Schematic Code **SB****Code SB**
Drawing Shown.
The **SC** Code has Solenoid
in place of plug and plug
in place of Solenoid.

Note:
Solenoid Coil Specifications
Voltage: 12 Vdc
Watts: 20 (Nominal)

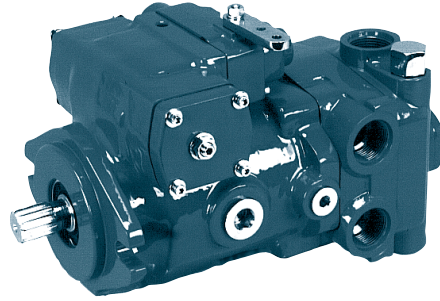
Schematic Code **SC**

72400

Adjustable Displacement Limiter

Code Position 24, 25 and Selection BB

- Externally Adjustable Displacement
- Settings are Maximum Displacement of the Pump to Zero
- Independent Adjustment for Both Main Ports
- Field Adjustable
- Available in Kit Form (see page 62)



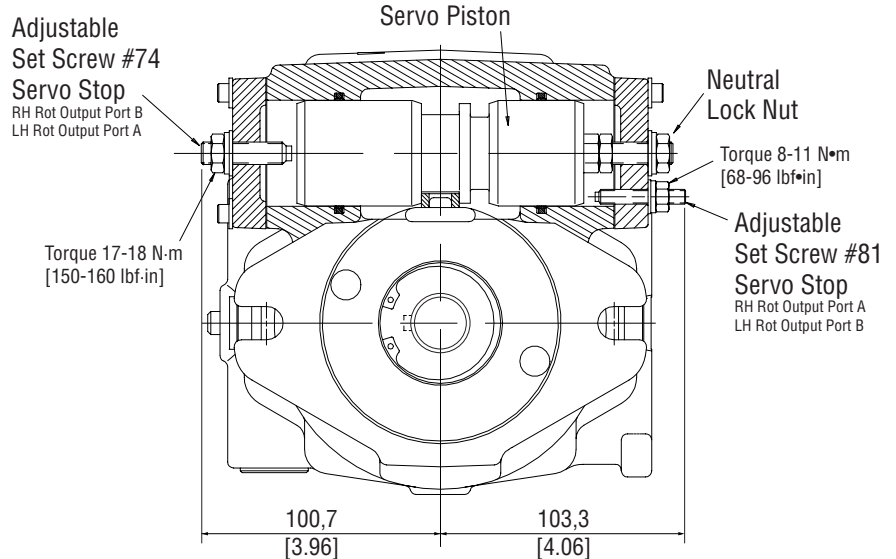
All factory units shipped with adjustable stops are set at maximum pump displacement.

See re-adjustment instructions below.

To Calculate Displacement Required

The displacement required divided by displacement of one turn of set screw equals the number of turns of set screw to obtain displacement.

Example for 3.00 in³/r re-adjustment:
 $2.0 \text{ in}^3/\text{r} \div .2854 \text{ in}^3/\text{r} =$
 7 turns of set screw



Displacement per Turn		
2.48 in ³ /r Pump Displacement @ Full Cam		
Turns of Set Screw	Item #81 Stop	Item #74 Stop
1	.2359 in ³ /r	.2022 in ³ /r
2	.47 in ³ /r	.40 in ³ /r
3	.71 in ³ /r	.61 in ³ /r
4	.94 in ³ /r	.81 in ³ /r
5	1.18 in ³ /r	1.01 in ³ /r
6	1.42 in ³ /r	1.21 in ³ /r
7	1.65 in ³ /r	1.42 in ³ /r
8	1.89 in ³ /r	1.62 in ³ /r
9	2.12 in ³ /r	1.82 in ³ /r
10	2.36 in ³ /r	2.02 in ³ /r
10.5	2.48 in³/r	2.13 in ³ /r
11	N/A	2.22 in ³ /r
12	N/A	2.43 in ³ /r
12.3	N/A	2.48 in³/r

Displacement per Turn		
2.48 in ³ /r Pump Displacement @ Full Cam		
Turns of Set Screw	Item #81 Stop	Item #74 Stop
1	.2359 in ³ /r	.2022 in ³ /r
2	.47 in ³ /r	.40 in ³ /r
3	.71 in ³ /r	.61 in ³ /r
4	.94 in ³ /r	.81 in ³ /r
5	1.18 in ³ /r	1.01 in ³ /r
6	1.42 in ³ /r	1.21 in ³ /r
7	1.65 in ³ /r	1.42 in ³ /r
8	1.89 in ³ /r	1.62 in ³ /r
9	2.12 in ³ /r	1.82 in ³ /r
10	2.36 in ³ /r	2.02 in ³ /r
10.5	2.48 in³/r	2.13 in ³ /r
11	N/A	2.22 in ³ /r
12	N/A	2.43 in ³ /r
12.3	N/A	2.48 in³/r

To Re-Adjust Displacement

- 1 Loosen nut on adjustable set screw #81 servo stop. Screw stop in until it touches the servo piston. Back the screw out (number of turns required) to obtain the flow required. Refer to chart for displacements. Lock adjustment with nut. Torque nut 8 to 11 N·m [68 to 96 lbf·in].
- 2 Loosen nut on adjustable set screw #74 servo stop. Screw stop in until it touches the servo piston. Back the screw out (number of turns required) to obtain the flow required. Refer to chart for displacements. Lock adjustment in place with nut. Torque nut 17 to 18 N·m [150 to 160 lbf·in].

Metric Conversion: Displacement in³/r X 16.387 = cm³/r

72400 Adjustable Displacement Limiter Kits

Field Installed Kits

One side Kit #72400-938

Two sides Kit #72400-940

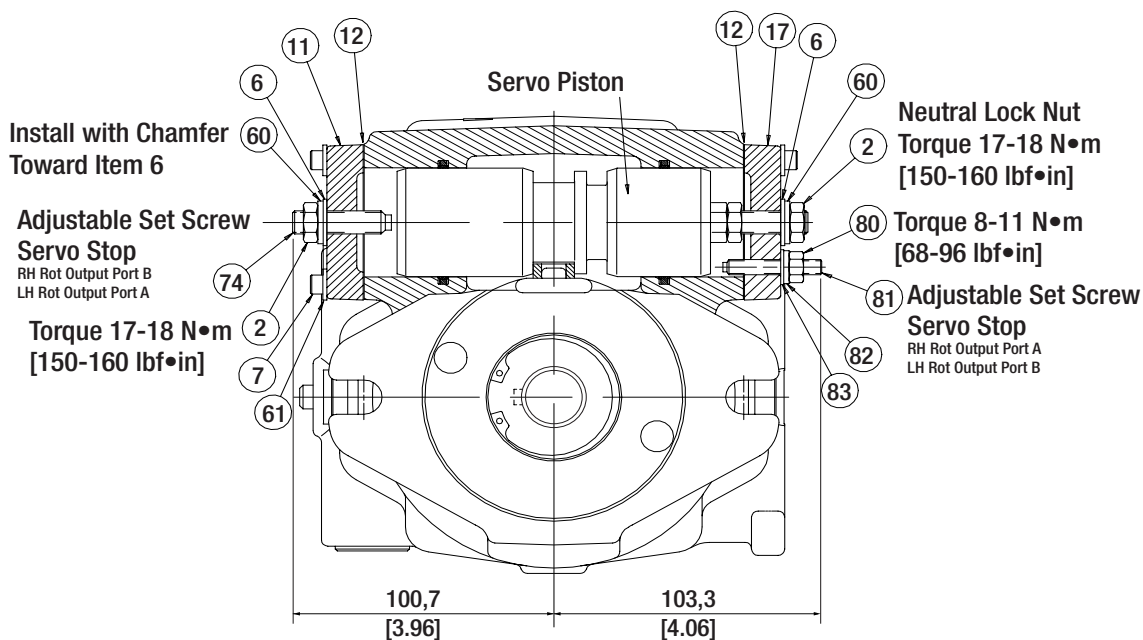
Disassembly

- 1 Remove the four cap screws (Item #7) and washers (Item #61) retaining the existing cover plate (Item #11) opposite neutral set screw.
- 2 After removing existing cover plate (Item #11) and cover gasket, measure the distance from the servo piston to the surface of housing for reference for neutral setting.
- 3 Remove neutral setting nut (Item #2).
- 4 Remove the four cap screws retaining the existing cover plate (Item #17).
- 5 The cover plate (Item #17) is screwed onto the servo piston bolt. When removing the cover plate, count the amount of turns it takes to remove cover for reassembly. Also remove existing gasket (Item #12).

Installing Servo Stops

- 1 Place new gasket (Item #12) onto the housing on the neutral setting screw side of the servo piston. Hold in position with a small amount of petroleum jelly.
- 2 Screw new cover plate (Item #17) onto servo piston bolt the same number of turns as it took to remove it. Install the four cap screws (Item #7) and washers (Item #61) to retain cover plate. Torque 4,5 to 5,4 N-m [40 to 48 lbf-in].
- 3 Install seal washer (Item #6), washer (Item #60) and jam nut (Item #2). Torque nut 17 to 18 N-m [150 to 160 lbf-in]. At this time, check the distance from the servo piston to housing surface on opposite side. It should be the same as previously measured at disassembly. If not the same, loosen jam nut and with a hex key wrench, adjust and re-torque nut.
- 4 Install new cover plate (Item #11) and retain with four cap screws (Item #7) and washers (Item #61). Torque 4,5 to 5,4 N-m [40 to 48 lbf-in].
- 5 Insert adjustable servo stop set screw (Item #81) in until it touches the servo piston. Back the screw out to obtain the flow required. Refer to chart for displacements. Lock adjustment into place with seal washer (Item #83), washer (Item #82), and jam nut (Item #80). Torque nut 8 to 11 N-m [68 to 96 lbf-in].
- 6 Insert adjustable servo stop set screw (Item #74) in until it touches the servo piston. Back the screw out to obtain the flow required. Refer to chart for displacements. Lock adjustment into place with seal washer (Item #83), washer (Item #82), and jam nut (Item #80). Torque nut 17 to 18 N-m [150 to 160 lbf-in].

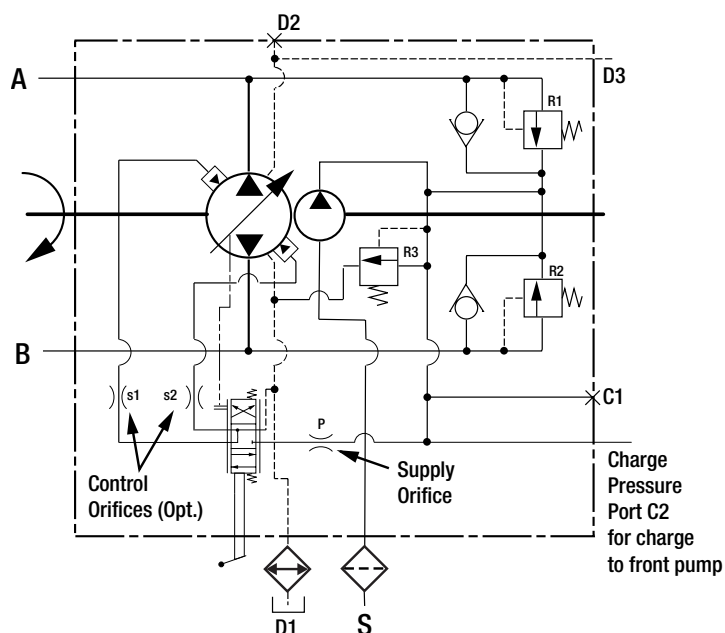
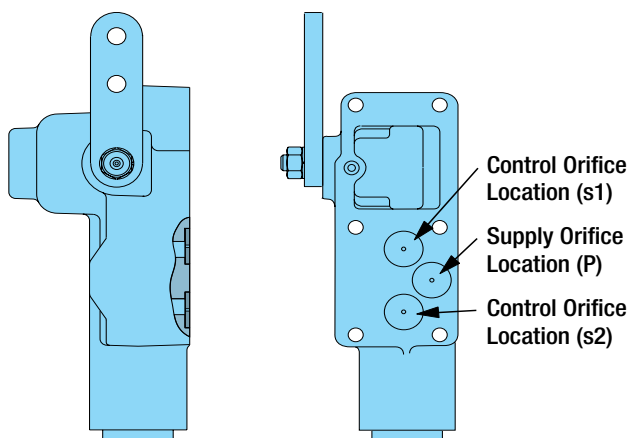
Adjustable Servo Stop Kit Parts			Kit #72400-938	Kit #72400-940
Item #	Part Number	Description	Qty.	Qty.
2	16024-6	Jam Nut	1	2
6	16254-6	Seal Washer	1	2
11	72400-651	Cover Plate	1	1
12	72400-621	Cover Gasket	1	2
17	72400-771	Cover Plate		1
60	16254-26	Washer	1	2
74	16139-624	Set Screw	1	1
80	16022-4	Jam Nut		1
81	16139-424	Set Screw		1
82	16254-24	Washer		1
83	16254-4	Seal Washer		1



72400

Supply and Control Orifice

Code Position 19 and 20



Calculated Time from Neutral to Full Stroke (seconds)

Supply Orifice Size mm [in]	Control Orifice Size, mm [in]							None
	0,71 [0.028]	0,81 [0.032]	0,91 [0.036]	1,02 [0.040]	1,12 [0.044]	1,32 [0.052]	1,45 [0.057]	
0,71 [0.028]	1.245	1.148	1.085	1.043	1.015	0.983	0.972	0.946
0,81 [0.032]	1.199	1.089	1.013	0.961	0.925	0.881	0.866	0.828
0,91 [0.036]	1.173	1.053	0.968	0.907	0.863	0.808	0.788	0.736
1,02 [0.040]	1.157	1.031	0.939	0.871	0.821	0.756	0.731	0.662
1,12 [0.044]	1.147	1.017	0.920	0.847	0.792	0.718	0.688	0.602
1,32 [0.052]	1.136	1.001	0.899	0.820	0.758	0.670	0.633	0.510
1,45 [0.057]	1.133	0.996	0.892	0.810	0.745	0.652	0.611	0.465
1,65 [0.065]	1.129	0.991	0.885	0.801	0.734	0.634	0.589	0.408
1,85 [0.073]	1.128	0.988	0.881	0.796	0.727	0.624	0.576	0.364
None	1.125	0.984	0.875	0.787	0.716	0.606	0.553	0.138

Note: Proper orifice selection must be determined by actual testing.

Component Selection

The long service life of Eaton hydrostatic transmissions is largely dependent on the proper selection and installation of the components necessary for transmission operation.

The following components are necessary for transmission operation:

1. Variable Displacement Pump
2. Fixed or Variable Displacement Motor
3. Reservoir
4. Filter
5. Charge Pump Inlet Line
6. Pump and Motor Case Drain Lines
7. High Pressure Lines
8. Heat Exchanger
9. Heat Exchanger Bypass Valve
10. Reservoir Return Line

1. Variable Displacement Pump

Eaton hydrostatic variable displacement pumps are an axial piston design. They are equipped with standard SAE mounts, shafts and port connections.

2. Fixed or Variable Displacement Motor

Eaton hydrostatic motors are an axial piston design. They are equipped with standard SAE mounts, shafts and port connections.

3. Reservoir

The reservoir is an important part of the hydrostatic transmission system. It should provide adequate oil storage and allow easy oil maintenance.

The reservoir must hold enough oil to provide a continuous oil supply to the charge pump inlet. It must also have enough room for the hydraulic oil to expand as the system warms up. Consider charge pump flow when sizing the reservoir: One half (.5) minute times (X) the maximum charge pump flow should be the minimum oil volume in the reservoir. Maintaining this oil volume will give the oil a minimum of thirty (30) seconds in the reservoir. This will allow any entrained air to escape and contamination to settle out of the oil.

To allow for oil expansion, the reservoir's total volume should be at least six tenths (.6) minute times (X) the maximum charge pump flow.

The reservoir's internal structure should cut down turbulence and prevent oil aeration.

The line returning flow to the reservoir should be fitted with a diffuser to slow the incoming oil to 1 to 1.2 meters [3-4 feet] per second to help reduce turbulence. The return flow line should also

be positioned so that returning oil enters the reservoir below the liquid surface. This will help reduce aeration and foaming of the oil.

The reservoir should have baffles between the return line and suction line. Baffles prevent return flow from immediately reentering the pump.

A sixty mesh screen placed across the suction chamber of the reservoir will act as a bubble separator. The screen should be placed at a 30° angle to the horizon.

The entrance to the suction line should be located well below the fluid surface so there is no chance of air being drawn into the charge pump inlet. However, the suction line entrance should not be located on the bottom of the reservoir where there may be a buildup of sediment. The suction line entrance should be flared and covered with a screen.

The reservoir should be easily accessible. The fill port should be designed to minimize the possibility of contamination during filling and to help prevent over filling. There should be a drain plug at the lowest point of the reservoir and it should also have a clean-out and inspection cover so the reservoir can be thoroughly cleaned after prolonged use. A vented reservoir should have a breather cap with a micronic filter.

Sealed reservoirs must be used at altitudes above 2500 feet. These reservoirs should be fitted with a two- way micronic filter pressure cap to allow for fluid expansion and contraction.

In both cases the caps must be designed to prevent water from entering the reservoir during bad weather or machine washing.

A hydrostatic transmission with a well designed reservoir will run quieter, stay cleaner and last longer.

4. Filter

A filter must be used to keep the hydraulic fluid clean. Either a suction filter or a pressure side filter may be used. The filter must be a no-bypass type. System oil particle levels should not exceed ISO 18/13. Refer to Eaton Hydraulic Fluid Recommendations.

Recommended beta ratios for each filter type are listed below:

Suction Filter $\beta_{10} = 1.5$ to 2.0

Pressure Side Filter $\beta_{10} = 10$ to 20

When a suction filter is used, its flow capacity must be large enough to prevent an excessive pressure drop between the reservoir and charge pump inlet. The pressure at the charge pump inlet port must not be less than 0.80 bar absolute [6 in. Hg.] at normal continuous operating temperatures.

5. Charge Pump Inlet Line

The inlet line to the charge pump should be large enough to keep the pressure drop between the reservoir and charge pump inlet within the limits described in the filter section. Fittings will increase the pressure drop, so their number should be kept to a

minimum. It is best to keep fluid velocities below 1,25 meters [4 feet] per second.

Fluid and temperature compatibility must be considered when selecting the inlet line.

6. Pump and Motor Case Drain

The case drain lines should be large enough to limit the pump and motor case pressures (Medium Duty to 2 bar [25 PSI]) at normal operating temperatures. Fluid and temperature compatibility must also be considered when selecting the case drain lines.

7. High Pressure Lines

The high pressure lines that connect the pump and motor must be able to withstand the pressures generated in the high pressure loop.

8. Heat Exchanger

Use of a heat exchanger is dependent on the transmission's duty cycle and on machine layout. The normal continuous operating fluid temperature measured in the pump and motor cases should not exceed 80½C [180½F] for most hydraulic fluids. The maximum fluid temperature should not exceed 107½C [225½F].

The heat exchanger should be sized to dissipate 25% of the maximum input power available to the transmission. It must also be sized to prevent the case pressures in the pump and motor from getting too high. Medium duty case pressure up to 2 bar [25 psi], at normal operating temperatures, are acceptable.

9. Heat Exchanger Bypass Valve

The heat exchanger bypass valve is a pressure and/or temperature valve in parallel with the heat exchanger. Its purpose is to prevent case pressures from getting too high. The heat exchanger bypass valve opens when the oil is thick, especially during cold starts.

10. Reservoir Return Line

The same general requirements that apply to case drain lines apply to the reservoir return line.

Installation Requirements

The mounting orientation of pumps and motors is unrestricted provided the case drain of the pump and motor remain full. Position the case drain such that it assures an oil level at or above unit center line at start-up. The case drain line that carries the flow leaving the pump or motor should be connected to the highest

drain port on each of the units. This assures that the pump and motor cases remain full.

The combined torque required to turn two or more pumps must not exceed the torque rating of the input drive shaft of the front piston pump.

Installer to provide centering and a secure neutral for pump swashplate control shaft.

An external support is recommended for all tandems.

Open Loop Circuits

Eaton pumps and motors may be used in open loop circuits under certain operating conditions. Consult your Eaton representative for details.

Hydraulic Fluid Recommendations

Introduction

The ability of Eaton hydrostatic components to provide the desired performance and life expectancy depends largely on the fluid used. The purpose of this document is to provide readers with the knowledge required to select the appropriate fluids for use in systems that employ Eaton hydrostatic components.

One of the most important characteristics to consider when choosing a fluid to be used in a hydraulic system is viscosity. Viscosity choice is always a compromise; the fluid must be thin enough to flow easily but thick enough to seal and maintain a lubricating film between bearing and sealing surfaces. Viscosity requirements for Eaton's Heavy Duty Hydrostatic product line are specified later in this document.

Viscosity and Temperature

Fluid temperature affects viscosity. In general, as the fluid warms it gets thinner and its viscosity decreases. The opposite is true when fluid cools. When choosing a fluid, it is important to consider the start-up and operating temperatures of the hydrostatic system. Generally, the fluid is thick when the hydraulic system is started. With movement, the fluid warms to a point where the cooling system begins to operate. From then on, the fluid is maintained at the temperature for which the hydrostatic system was designed. In actual applications this sequence varies; hydrostatic systems are used in many environments from very cold to very hot. Cooling systems also vary from very elaborate to very simple, so ambient temperature may affect operating temperature. Equipment manufacturers who use Eaton hydrostatic components in their products should anticipate temperature in their designs and make the appropriate fluid recommendations to their customers.

In general, an ISO viscosity grade 68 fluid is recommended for operation in cold to moderate climates. An ISO viscosity grade 100 fluid is recommended for operation in moderate to hot climates.

Cleanliness

Cleanliness of the fluid in a hydrostatic system is extremely important. Eaton recommends that the fluid used in its hydrostatic components be maintained at ISO Cleanliness Code 18/13 per

SAE J1165. This code allows a maximum of 2500 particles per milliliter greater than 5 μm and a maximum of 80 particles per milliliter greater than 15 μm . When components with different cleanliness requirements are used in the same system, the cleanest standard should be applied. OEM's and distributors who use Eaton hydrostatic components in their products should provide for these requirements in their designs. A reputable filter supplier can supply filter information.

Fluid Maintenance

Maintaining correct fluid viscosity and cleanliness level is essential for all hydrostatic systems. Since Eaton hydrostatic components are used in a wide variety of applications it is impossible for Eaton to publish a fluid maintenance schedule that would cover every situation. Field testing and monitoring are the only ways to get accurate measurements of system cleanliness. OEM's and distributors who use Eaton hydrostatic components should test and establish fluid maintenance schedules for their products. These maintenance schedules should be designed to meet the viscosity and cleanliness requirements laid out in this document.

Fluid Selection

Premium grade petroleum based hydraulic fluids will provide the best performance in Eaton hydrostatic components. These fluids typically contain additives that are beneficial to hydrostatic systems. Eaton recommends fluids that contain anti-wear agents, rust inhibitors, anti-foaming agents, and oxidation inhibitors. Premium grade petroleum based hydraulic fluids carry an ISO VG rating.

Hydraulic Fluid Recommendations

Viscosity Requirements

Product Line	* Minimum	Optimum Range	Maximum	ISO Cleanliness Requirements	Comments
Heavy Duty Piston Pumps and Motors	45 SUS [6 cSt]	60 - 180 SUS [10 - 39 cSt]	10,000 SUS [2158 cSt]	18/13	
Medium Duty Piston Pumps and Motors Charged Systems	45 SUS [6 cSt]	60 - 180 SUS [10 - 39 cSt]	10,000 SUS [2158 cSt]	18/13	
Medium Duty Piston Pumps and Motors Non-charged Systems	60 SUS [10 cSt]	60 - 180 SUS [10 - 39 cSt]	2,000 SUS [432 cSt]	18/13	
Light Duty Transaxles, Transmissions, Pumps and Series 1150 Transaxles	60 SUS [10 cSt]	80 - 180 SUS [16 - 39 cSt]	10,000 SUS [2158 cSt]	18/13	Automotive multi-viscosity oils and ATF are not recommended
Series 2030 Motor Axles	70 SUS [13 cSt]	100 - 200 SUS [20 - 43 cSt]	10,000 SUS [2158 cSt]	18/13	Automotive multi-viscosity oils and ATF are not recommended
Char-Lynn J, R, and S Series Motors, and Disc Valve Motors	70 SUS [13 cSt]	100 - 200 SUS [20 - 43 cSt]	10,000 SUS [2158 cSt]	18/13	
Char-Lynn A Series and H Series Motors	100 SUS [20 cSt]	100 - 200 SUS [20 - 43 cSt]	10,000 SUS [2158 cSt]	18/13	
Char-Lynn Steering Control Units, Priority and Control Valves	55 SUS [9 cSt]	100 - 200 SUS [20 - 43 cSt]	10,000 SUS [2158 cSt]	18/13	When emergency manual steering is required, maximum viscosity is 2,000 SUS [450 cSt]
Gear Pumps and Motors, and Cylinders	45 SUS [6 cSt]	60 - 200 SUS [10 - 43 cSt]	10,000 SUS [2158 cSt]	18/13	

* MINIMUM VISCOSITY APPLIES AT INTERMITTENT CONDITION OF 10% OF EVERY MINUTE.

Additional Notes:

- Fluids too thick to flow in cold weather start-ups will cause pump cavitation and possible damage. Motor cavitation is not a problem during cold start-ups, except for two speed motors. Thick oil can cause high case pressures which in turn cause shaft seal problems.
- When choosing a hydraulic fluid, all the components in the system must be considered and the optimum viscosity range adjusted accordingly. For example, when a medium duty piston pump is combined with a Disk Valve Motor the optimum viscosity range becomes 100 - 180 SUS [20 - 39 cSt] and viscosity should never fall below 70 SUS [13 cSt].

- If the natural color of the fluid has become black it is possible that an overheating problem exists.
- If the fluid becomes milky, water contamination may be a problem.
- Take fluid level reading when the system is cold.
- Contact your Eaton representative if you have specific questions about the fluid requirements of Eaton hydraulic components.

Medium Duty Piston Pump

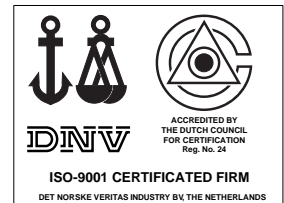


Eaton Corporation is a global manufacturer of highly engineered products that serve industrial, vehicle, construction, commercial, aerospace and semiconductor markets. Principal products include hydraulic products and fluid connectors, electrical power distribution and control equipment, truck drivetrain systems, engine components, ion implanters and a wide variety of controls. Headquartered in Cleveland, Ohio, the company has 63,000 employees and 195 manufacturing sites in 23 countries around the world. Eaton's sales for 1999 were \$8.4 billion.

Information contained in this catalog is accurate as of the publication date and is subject to change without notice. Performance values are typical values. Customers are responsible for selecting products for their applications using normal engineering methods.

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