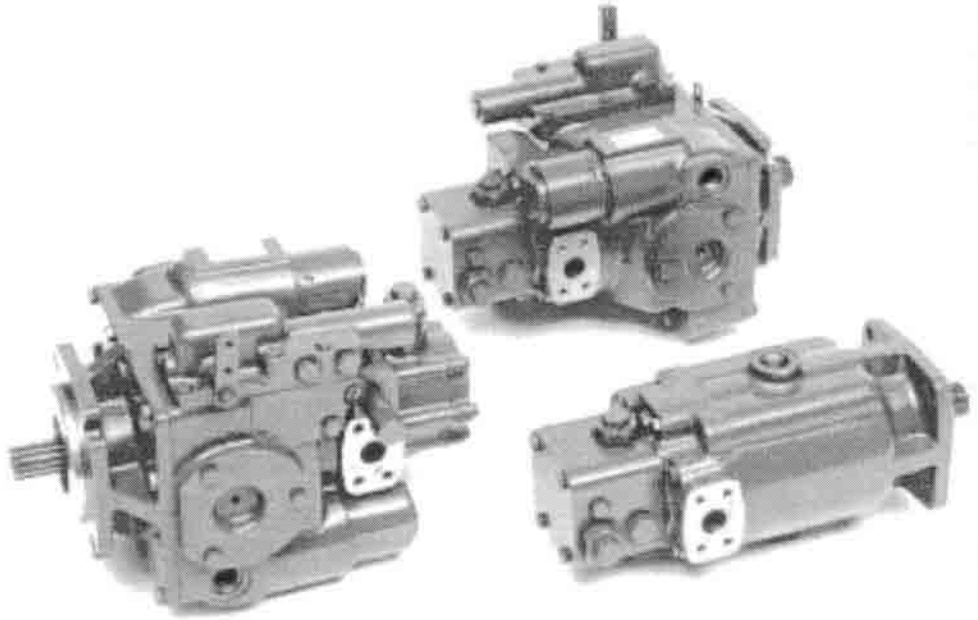


S

Eaton®

Hydrostatic Transmission Controls

EATON



**Hydrostatic Transmission Controls
Models 33-76**

We Manufacture

Solutions

Hydraulic Solutions

Hydraulic Solutions

Introduction

The purpose of this publication is to explain the function and operation of the various control options available for the Eaton Model 33 thru Model 76 hydrostatic units.

Included is information on installation, performance and description of operation for the control options.

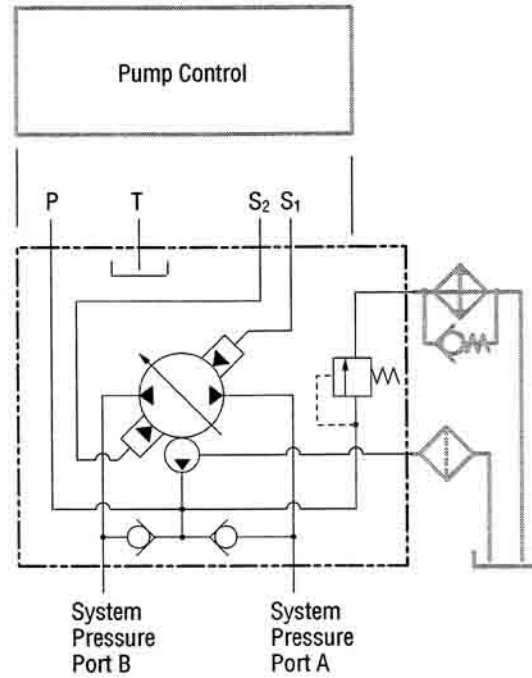
If you need additional information or assistance, contact your local Eaton representative or the applications group of Eaton Corporation, Hydraulics Division, 15151 Highway 5, Eden Prairie, Minnesota 55344, Telephone (612)937-7254.

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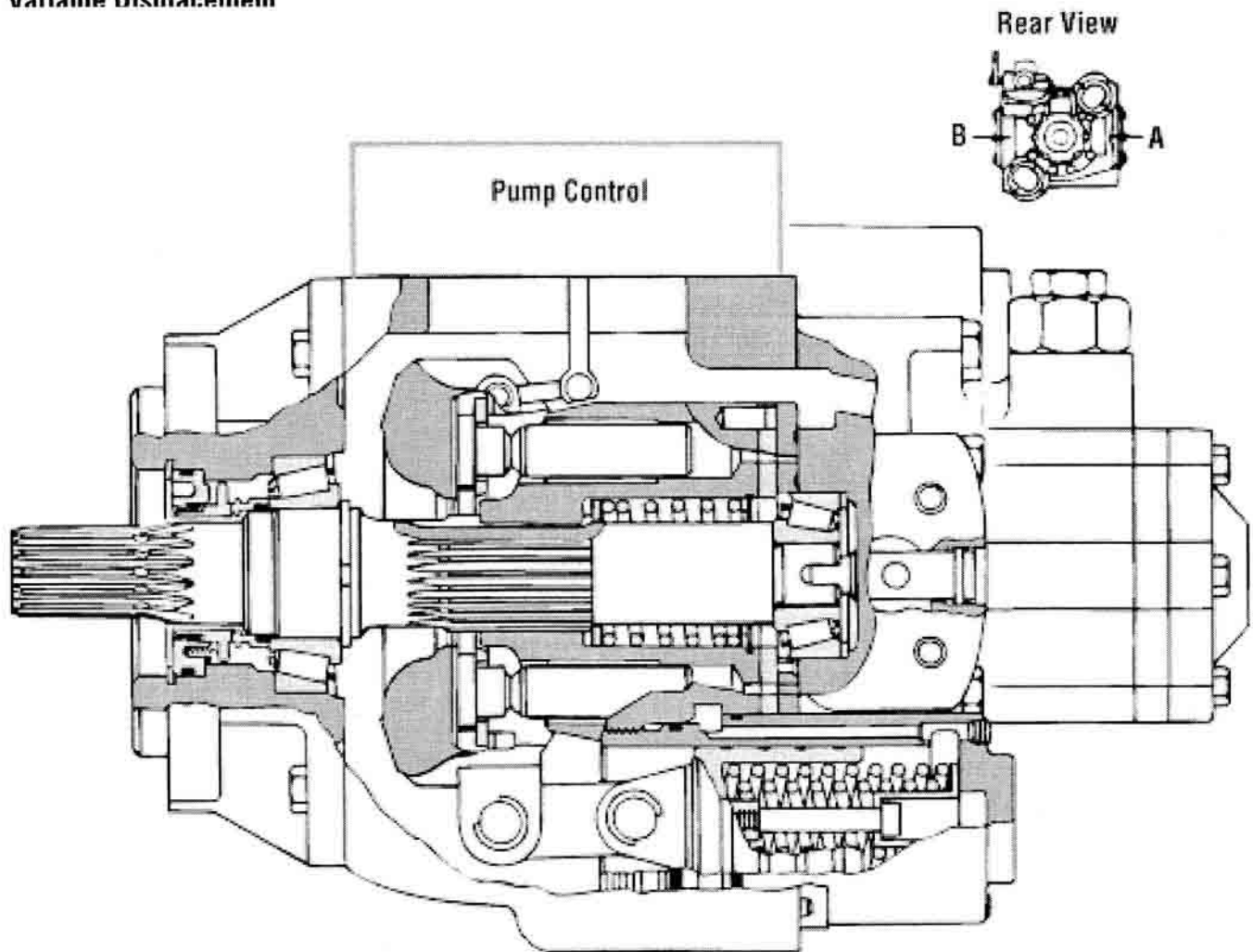
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* Fits all Eaton model 33 thru 76 variable pumps and variable motors.

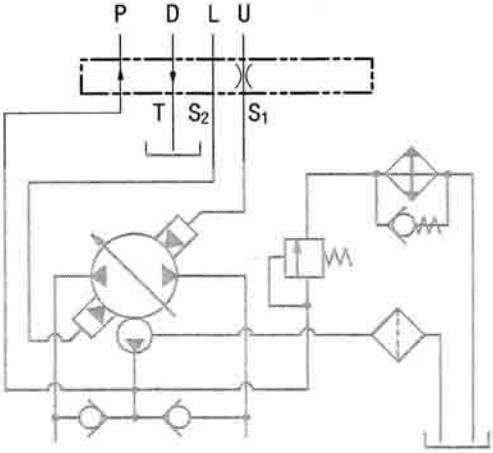
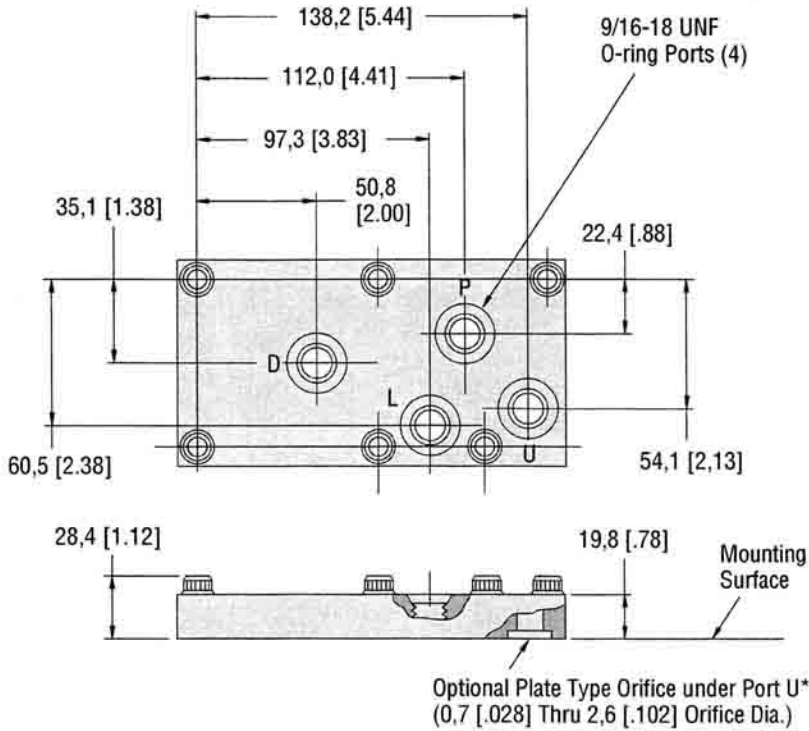
Variable Displacement Pump Controls



Variable Displacement



Port Plate



The port plate is available for all Eaton Model 33 through Model 76 variable displacement pumps and variable displacement motors. The port plate permits remote control of the pump or motor when used in conjunction with a three-position, four way valve.

- I Pressurization of port 'U' will result in flow from port 'A' with input shaft rotating CCW and flow from port 'B' with input shaft rotating CW.
- II Pressurization of Port 'L' will result in flow from port 'B' with input shaft rotating CCW and flow from port 'A' with input shaft rotating CW.

Pressurization of port 'U' will result in swashplate being positioned at maximum displacement.

Pressurization of port 'L' will result in swashplate being positioned at minimum displacement.

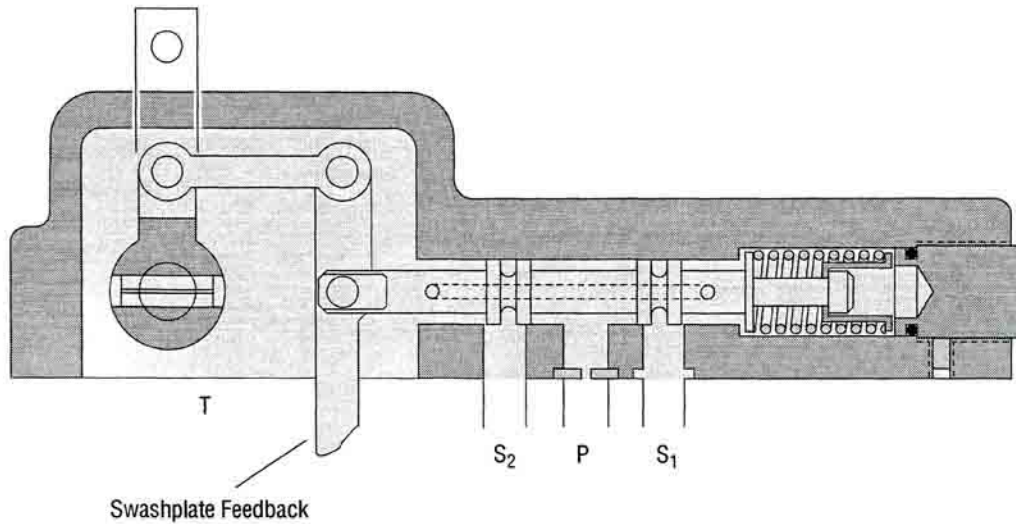
The port plate mounts directly on the variable pump or motor control valve mounting surface. All control ports are No. 6 straight thread O-ring boss.

These ports are labeled for identification; (P) for control pressure; (D) for case drain (T- Tank); (U) for upper servo (S1); and (L) for the lower servo (S2).

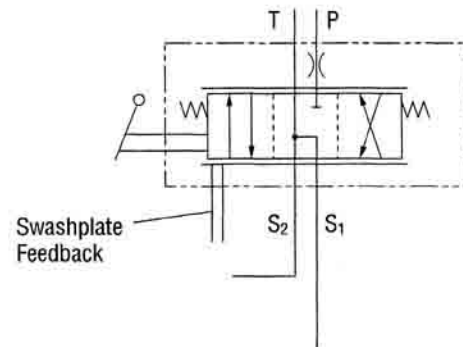
Variable Pump Flow Logic

Pump Input Shaft Rotation	CW		CCW	
Pressurized Port	"U"	"L"	"U"	"L"
Port "A" Flow	In	Out	Out	In
Port "B" Flow	Out	In	In	Out

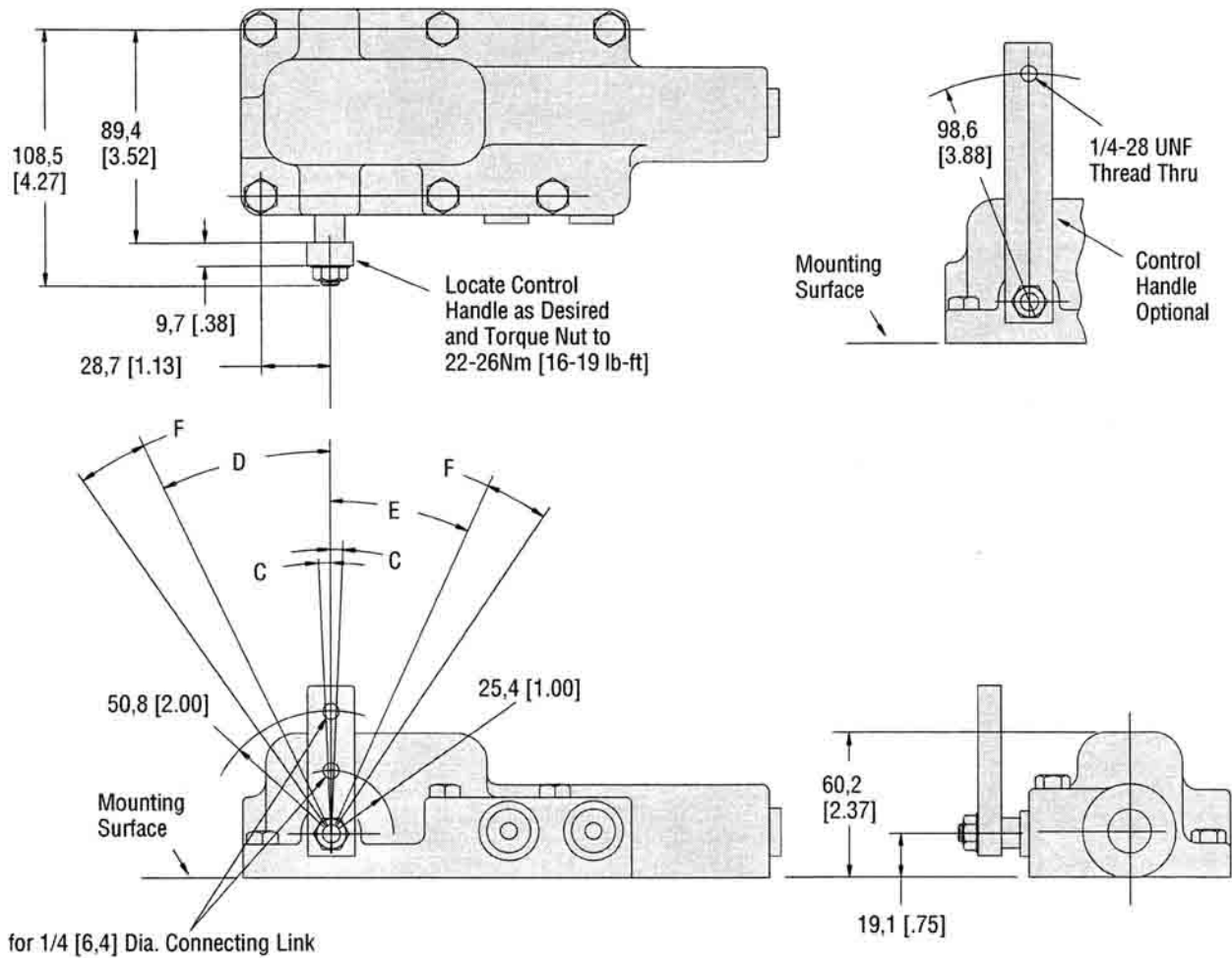
Manual Displacement Control



The manual displacement control is a mechanical servo control valve with direct position feedback. As the control lever is rotated, it positions the control spool, pressurizing one of the two servo pistons which control the swashplate angle. The rate of swashplate movement and consequently vehicle acceleration, can be varied by selection of the appropriate size control orifice. The manual displacement control has two control spool options. The standard control spool provides a 5 degree neutral zone (± 2.5 degrees). The wide band neutral option has an 8 degree neutral zone (± 4.0 degrees).



Manual Displacement Control



C — Neutral zone (zero flow)

F — Maximum allowable control handle overstroke. Radial position of control handle to shaft is optional at 7-1/2° increments. 1,13 Nm [10 lb-in] torque required for full control handle travel (0,34 - 2,37 Nm [3 - 21 lb-in] with optional detent). Total applied torque not to exceed 16,95 Nm [150 lb-in].

Variable Pump Flow Logic

Pump Input Shaft Rotation	CW		CCW	
Control Handle Rotation	"D" (CCW)	"E" (CW)	"D" (CCW)	"E" (CW)
Port "A" Flow	Out	In	In	Out
Port "B" Flow	In	Out	Out	In

Control Handle Rotation

Model	Manual Control Valve				Manual Control Valve with Wide Band Neutral			
	C	D	E	F	C	D	E	F
33	2°30'	21°0'	21°0'	11°30'	4°15'	22°45'	22°45'	9°45'
39	2°30'	23°45'	23°45'	8°45'	4°15'	25°45'	25°45'	6°45'
46	2°30'	23°45'	23°45'	8°45'	4°15'	25°45'	25°45'	6°45'
54	2°30'	28°30'	28°30'	4°0'	4°15'	30°30'	30°30'	2°0'
64	2°30'	28°30'	28°30'	4°0'	4°15'	30°30'	30°30'	2°0'
76	2°30'	22°0'	22°0'	10°30'	4°0'	23°45'	23°45'	8°45'

Manual Displacement Control

Control Orifice Size Selection

A plate orifice installed in the control valve, or internal pressure override, regulates the speed that the displacement can be changed. The plate orifice can be changed to meet desired size to meet the vehicle requirements.

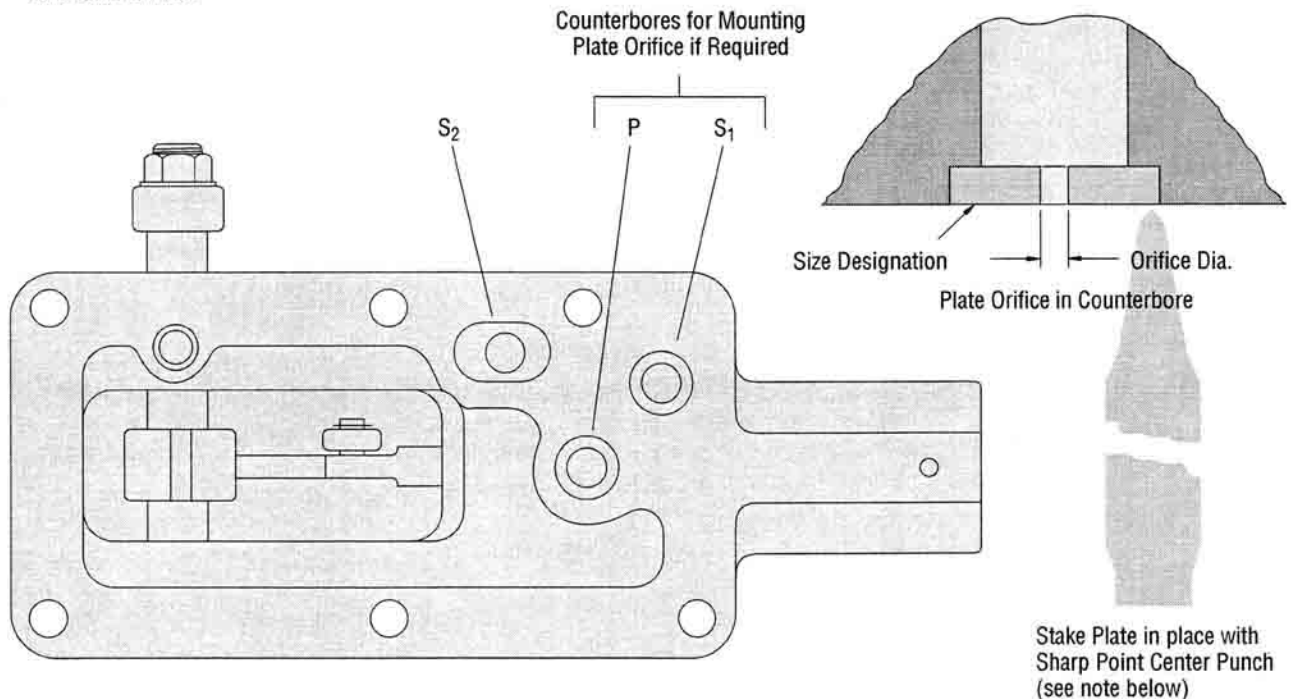
The table below gives the time it takes for each model pump to go from neutral to full stroke with each size orifice. Time is given in seconds, and orifice diameter either mm (millimeter) or [in.] (inch).

Calculated Response Time

The time it takes, in seconds, for a pump to go from neutral to full stroke.

Orifice Dia. mm [in.]	Model 33	Model 39	Model 46	Model 54	Model 64	Model 76
0,71 [.028]	3.24	3.75	3.75	6.57	6.57	7.48
0,91 [.036]	1.96	2.27	2.27	3.97	3.97	4.52
1,12 [.044]	1.31	1.52	1.52	2.66	2.66	3.03
1,32 [.052]	* .94	* 1.09	* 1.09	1.90	1.90	2.17
1,45 [.057]	.78	.90	.90	1.58	1.58	1.80
1,65 [.065]	.60	.70	.70	1.22	1.22	1.39
1,85 [.073]	.48	.55	.55	* .97	* .97	* 1.10
2,39 [.094]	.29	.33	.33	.58	.58	.66
2,59 [.102]	n/a	n/a	n/a	.49	.49	.56
No Orifice	.25	.29	.29	.47	.47	.54

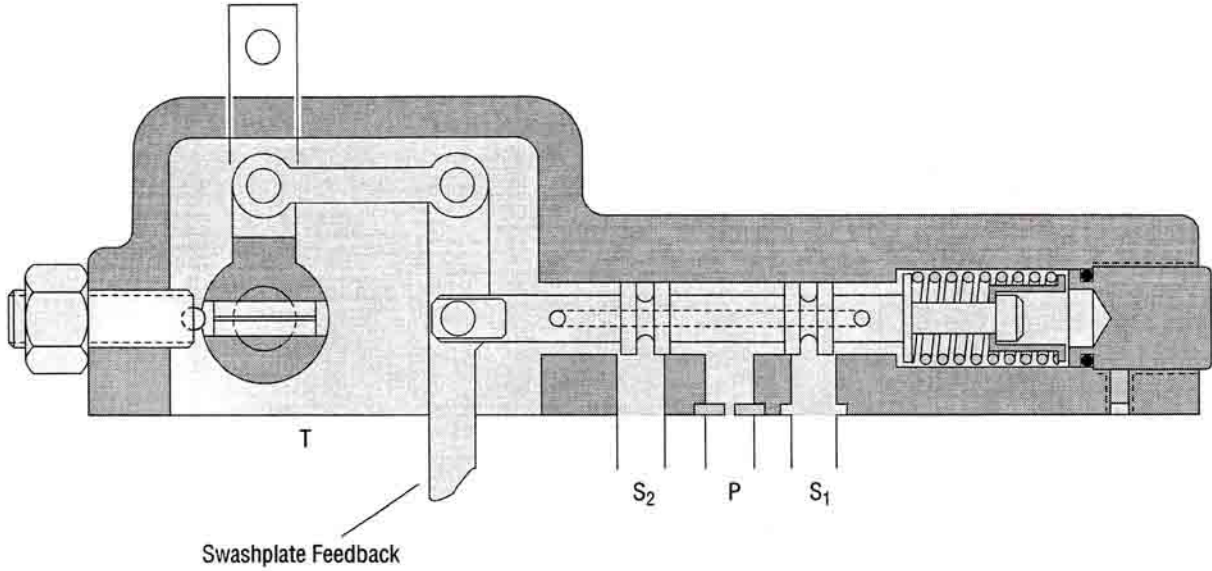
* Standard Orifice



Note: The number stamped on the orifice plate is the orifice diameter (size) in thousandths of an inch, example: 44 = 1,12mm [.044 in] orifice diameter.

Install an orifice so that its size can be read, then stake in place, 3 times, with a sharp point center punch.

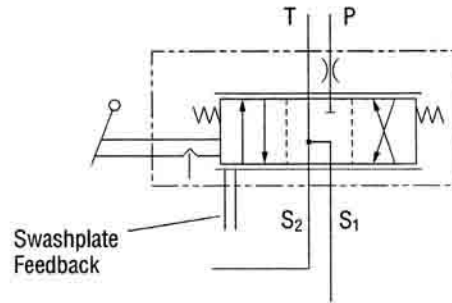
Manual Displacement Control with Neutral Detent



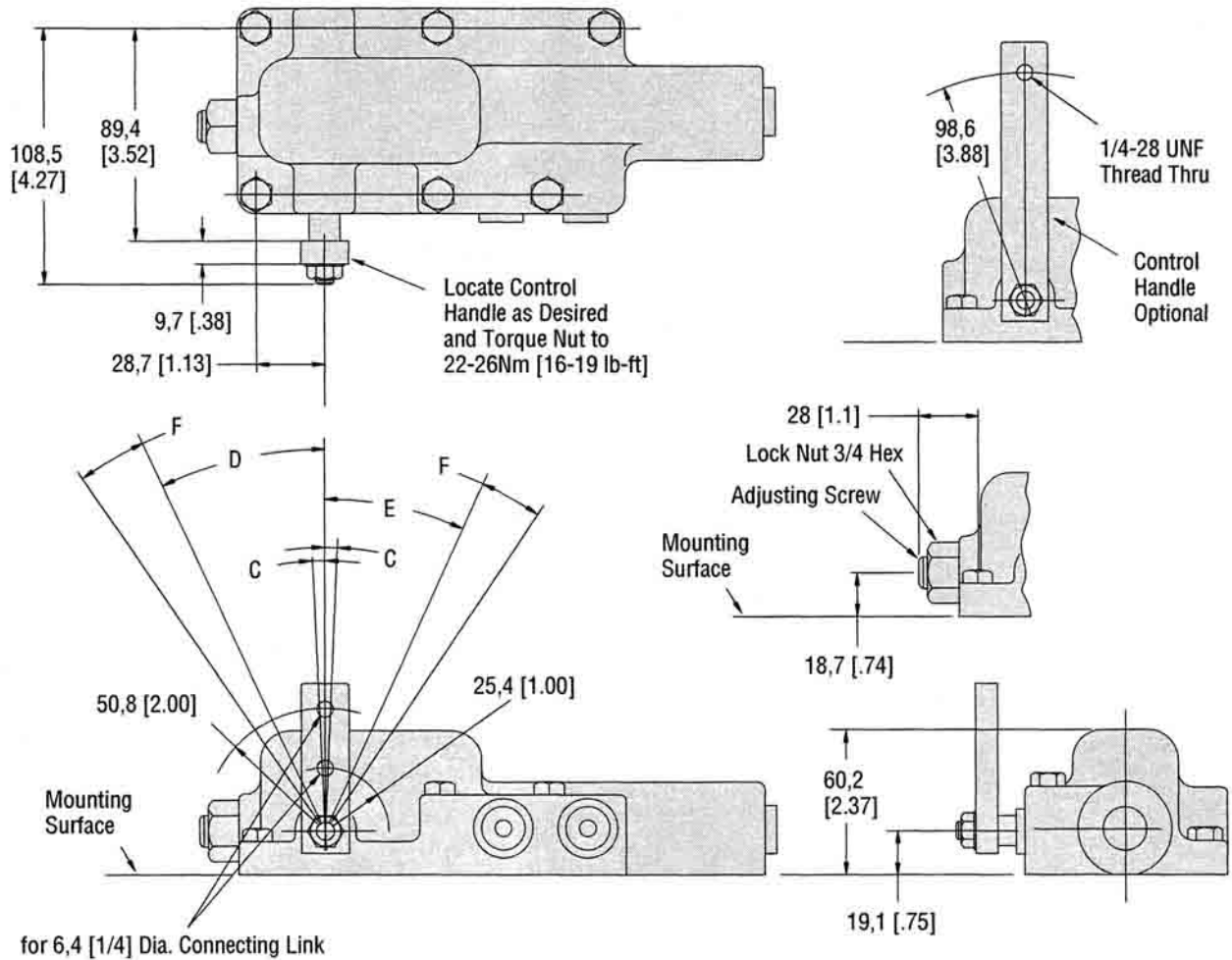
The neutral detent option provides the operator with a positive neutral feel, signaling when the transmission is in neutral.

The neutral detent consists of a spring biased, ball plunger unit that seats in a recess on the control linkage at the neutral position. The spring preload is adjustable. This allows the operator to select the amount of neutral feel desired within a range of 0,34 - 2,37 Nm [3-21 lb-in] of control shaft torque.

To permit proper operation the manual displacement control with neutral detent uses the wide band neutral control spool.



Manual Displacement Control with Neutral Detent



for 6,4 [1/4] Dia. Connecting Link

C—Neutral Zone (Zero Flow)

D—Flow from port 'B' with input shaft rotating CCW and flow from port 'A' with input shaft rotating CW.

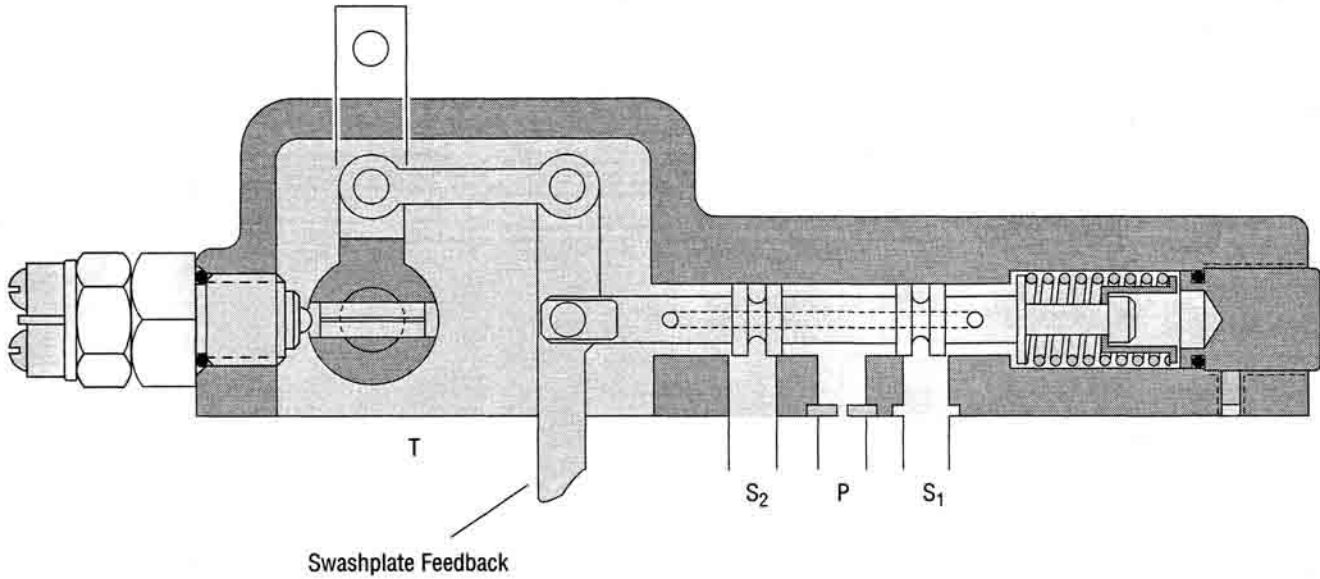
E—Flow from port 'A' with input shaft rotating CCW and flow from port 'B' with input shaft rotating CW.

F—Max. Allowable control handle overstroke. Radial position of control handle to shaft is optional at 7-1/2° increments. 1,13 Nm [10 lb-in] torque required for full control handle travel (2,37 Nm [21 lb-in] with detent option) total applied torque not to exceed 17 Nm [150 lb-in].

Control Handle Rotation

Manual Control Valve with Wide Band Neutral				
Model	C	D	E	F
33	4°15'	22°45'	22°45'	9°45'
39	4°15'	25°45'	25°45'	6°45'
46	4°15'	25°45'	25°45'	6°45'
54	4°15'	30°30'	30°30'	2°0'
64	4°15'	30°30'	30°30'	2°0'
76	4°0'	23°45'	23°45'	8°45'

Manual Displacement Control with Neutral Lock-Out Switch

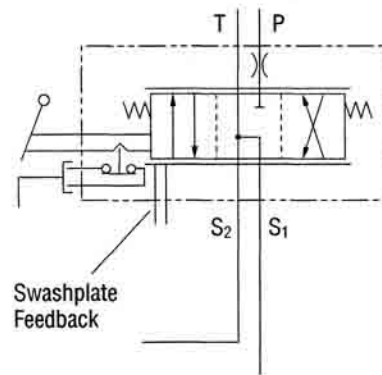


The neutral lockout switch consists of an electrical switch installed on the manual displacement control. This switch is released at the neutral position of the control lever and actuated if the lever is rotated either direction. This control also provides a slight detent feel at neutral, giving some of the benefit of the neutral detent.

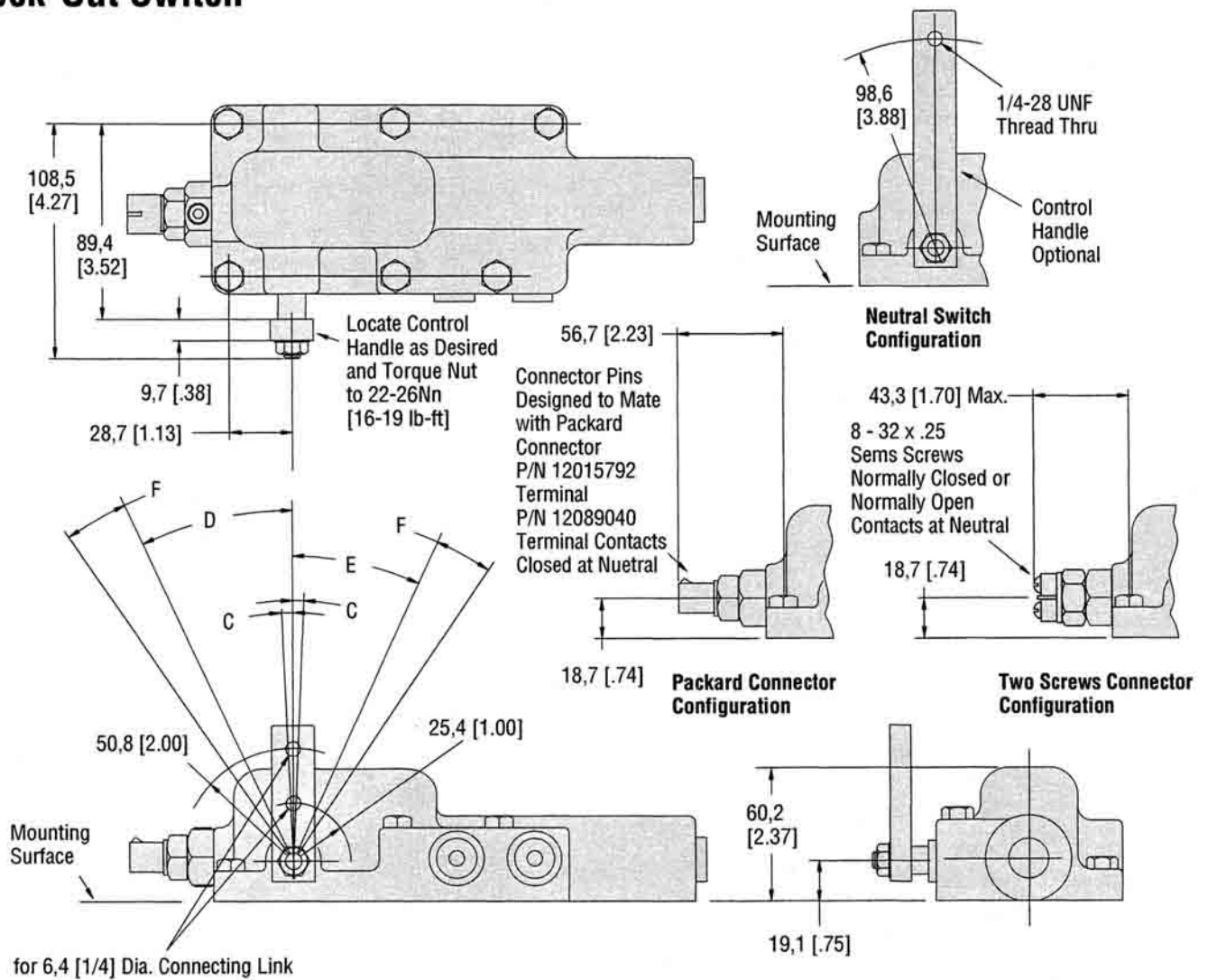
With the proper circuit the neutral lockout switch can serve as an electrical lockout to prevent the operator from starting the engine or activating an auxiliary function unless the pump has been commanded to neutral.

The neutral lockout switch is available both normally open and normally closed up to 24 volts. The wide band neutral control spool is used with all manual displacement controls with the neutral lock-out switch option.

In systems where an Eaton heavy duty variable pump and variable motor are used, a normally open neutral lockout switch can be combined with a variable motor pressure response control with stroking valve to provide maximum acceleration and torque from a standing start (see Eaton patent No. 4951462).



Manual Displacement Control with Neutral Lock-Out Switch



C—Neutral Zone (Zero Flow)

D—Flow from port 'B' with input shaft rotating CCW and flow from port 'A' with input shaft rotating CW.

E—Flow from port 'A' with input shaft rotating CCW and flow from port 'B' with input shaft rotating CW.

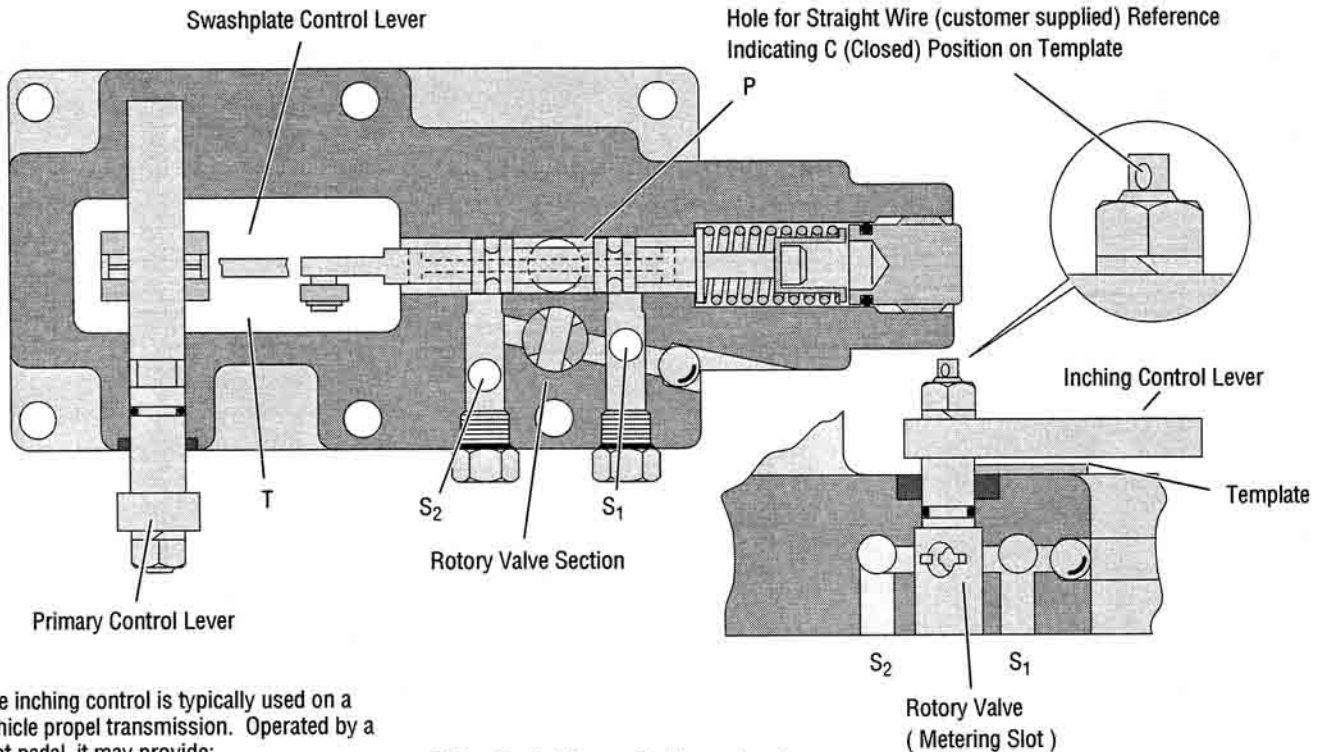
F—Max. Allowable control handle overstroke. Radial position of control handle to shaft is optional at 7-1/2° increments. 1,13 Nm [10 lb-in] torque required for full control handle travel (2,37 Nm [21 lb-in] with detent option) total applied torque not to exceed 17 Nm [150 lb-in].

Control Handle Rotation

Manual Control Valve with Wide Band Neutral

Model	C	D	E	F
33	4°15'	22°45'	22°45'	9°45'
39	4°15'	25°45'	25°45'	6°45'
46	4°15'	25°45'	25°45'	6°45'
54	4°15'	30°30'	30°30'	2°0'
64	4°15'	30°30'	30°30'	2°0'
76	4°0'	23°45'	23°45'	8°45'

Manual Displacement Control with Inching



The inching control is typically used on a vehicle propel transmission. Operated by a foot pedal, it may provide:

- (1) Smooth acceleration to a speed setting preselected by the manual displacement control handle.
- (2) Coasting smoothly to a stop while maintaining a set speed command.
- (3) Emergency stopping with “clutch” and brake pedals (the brake does not have to overcome the hydrostatic drive).
- (4) Inching the vehicle with foot control for implement connection etc.
- (5) Control of vehicle speed with a foot pedal from a set speed for matching load conditions.

The control operates by cross porting the servo cylinders thru a metering orifice.

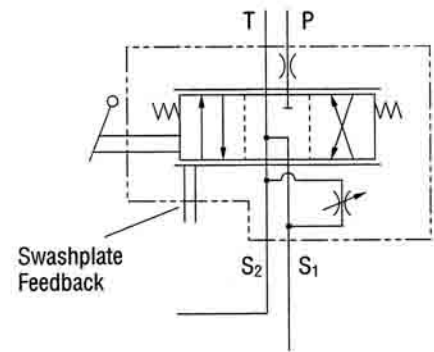
The manual displacement pump control with inching control is like having two separate control stations in a single control valve housing. The manual displacement control is identical to and operates in the same manner as the standard manual displacement pump control. The displacement control lever must be actuated first as it is the primary source of input for both direction, and to maintain a commanded swashplate angle. The inching control portion of the control is usually used as the secondary, but may also be used as a primary source of control.

When the inching control is used as the primary source of control, the standard portion must be actuated first to set the pump to a preferred direction of swashplate movement. The inching control is used to meter the control pressure between the control pressure ports and can only command the swashplate position in the previously biased direction. Metering slots in the inching valve rotary spool provide the operator with very smooth acceleration and deceleration of the system.

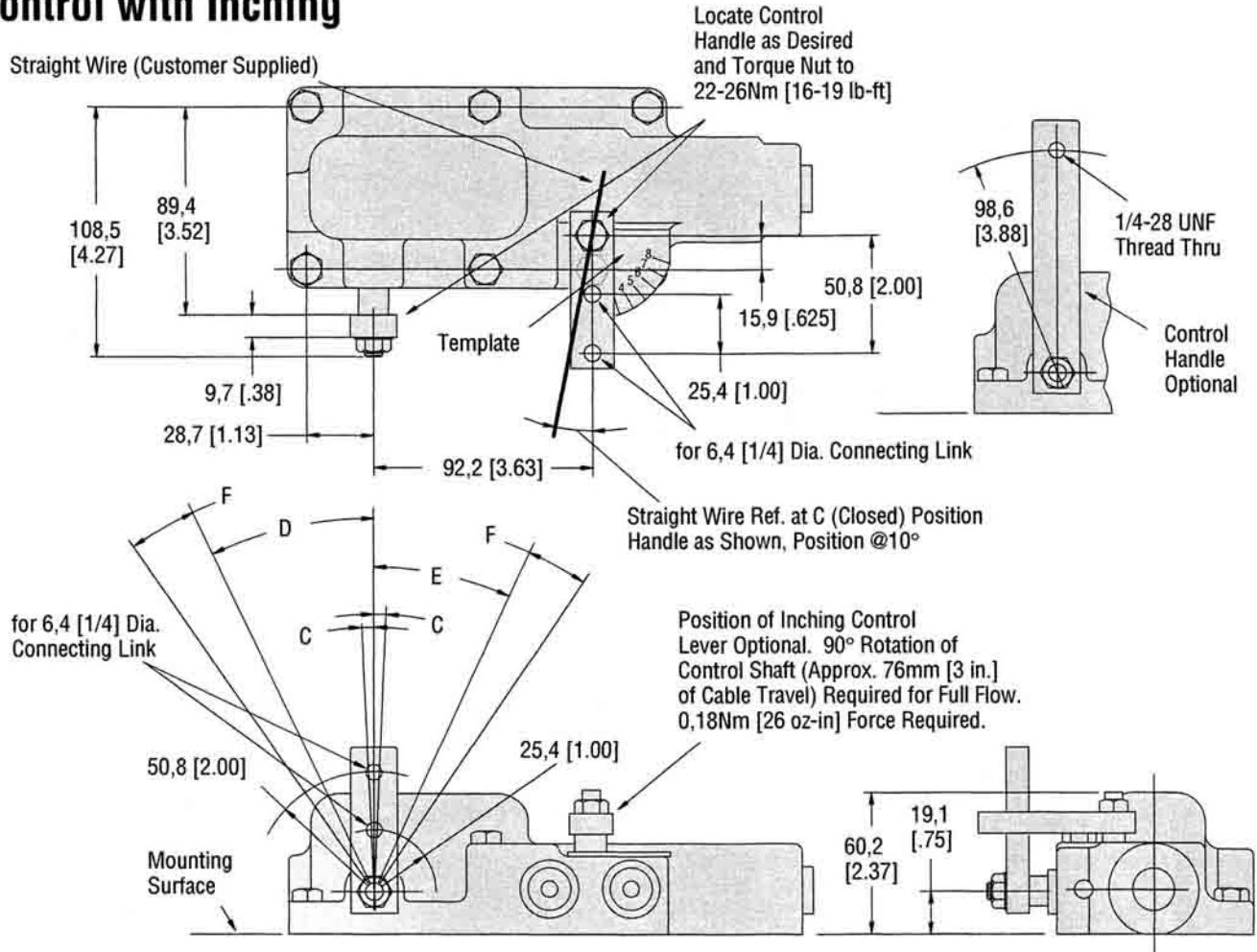
When this type of control is used, the plate orifice located in the control valve housing inlet must be limited to a 1,85 [.073] maximum size for proper inching control function.

In the neutral position, control pressure is blocked off by the manual displacement control valve spool. The rotary inching control spool is also shown in the closed position. This position is identified externally by a drilled hole located near the top of the inching valve control shaft. It is closed (as shown above) when perpendicular to the control valve housing and full open when in line with the housing.

Both of the spring loaded servo pistons are ported to the pump case when the manual displacement control spool is in the neutral position.



Manual Displacement Control with Inching



When the manual displacement control valve handle is positioned to command maximum displacement (or full swashplate angle), the control spool is moved to port control pressure to the S₁ or S₂ servo pistons.

With the manual displacement control handle in the maximum position, the control spool will remain in the full open ported position and not perform a metering function. The inching control can now be used to regulate the control pressure to the servo piston and position the swashplate to the desired position.

If the manual displacement control valve handle is positioned for less than maximum displacement, the inching control will only function between neutral position and the swashplate angle commanded by the manual displacement control valve.

When both valves are in the maximum position, the control pressure is ported directly back to the pump case through the inching control and the manual displacement

control valve housing (note the drain hole through the center of the manual displacement control spool, see section drawing page 14).

When the servo piston is ported to case, the servo piston spring force and the pressure forces on the swashplate will return the swashplate to the centered or neutral position. When the inching control spool is returned to the metering position, the control pressure will be regulated to the servo piston to maintain swashplate position.

See Flow Logic Chart Below

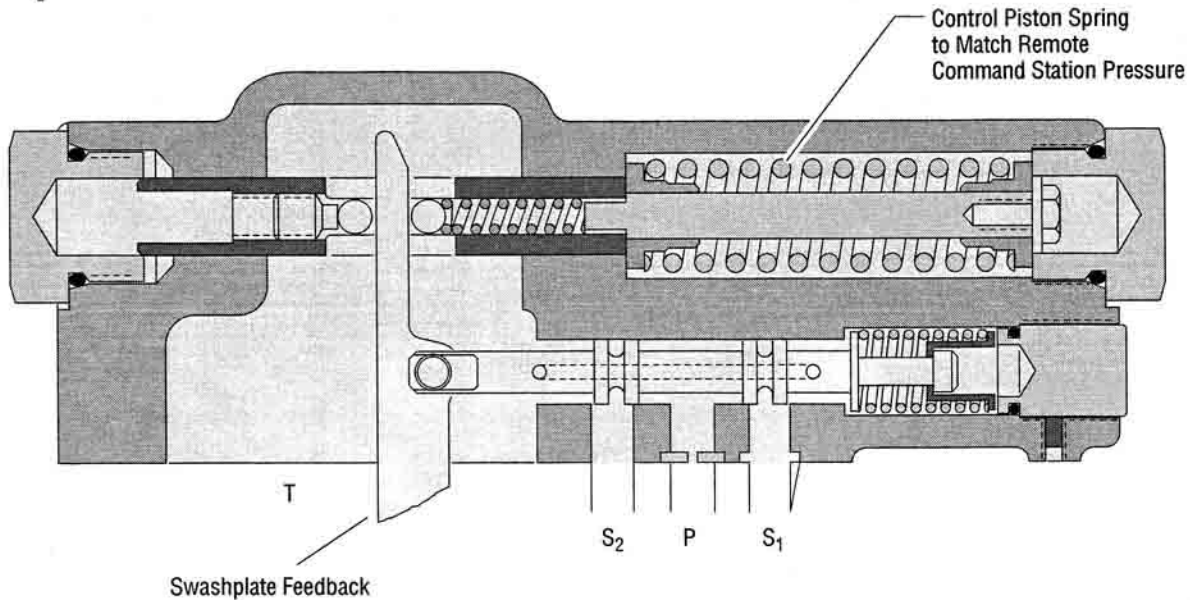
C—Neutral Zone (Zero Flow)

F—Max. allowable control handle overstroke. Radial position of control handle to shaft is optional at 7-1/2° increments. 1,13 Nm [10 lb-in] torque req'd for full control handle travel (2,37 Nm [21 lb-in] with detent option). Total applied torque not to exceed 16,95 Nm [150 lb-in].

Control Handle Rotation

Model	Manual Control Valve				Manual Control Valve with Wide Band Neutral			
	C	D	E	F	C	D	E	F
33	2°30'	21°0'	21°0'	11°30'	4°15'	22°45'	22°45'	9°45'
39	2°30'	23°45'	23°45'	8°45'	4°15'	25°45'	25°45'	6°45'
46	2°30'	23°45'	23°45'	8°45'	4°15'	25°45'	25°45'	6°45'
54	2°30'	28°30'	28°30'	4°0'	4°15'	30°30'	30°30'	2°0'
64	2°30'	28°30'	28°30'	4°0'	4°15'	30°30'	30°30'	2°0'
76	2°30'	22°0'	22°0'	10°30'	4°0'	23°45'	23°45'	8°45'

Hydraulic Remote Pump Control



The hydraulic remote pump control makes it possible for the machine operator to control speed by changing pump displacement via a remote pilot pressure signal. The angle of the swashplate, that determines pump displacement, is proportional to the pilot pressure. Typical pressure requirements are from ,69-10,35 Bar [10 to 150 PSI] providing a swashplate angle from 0° to 18°.

The direction of flow, and therefore the direction of the vehicle, is reversed by applying the control pressure to the opposite inlet port of the Hydraulic Remote Pump Control.

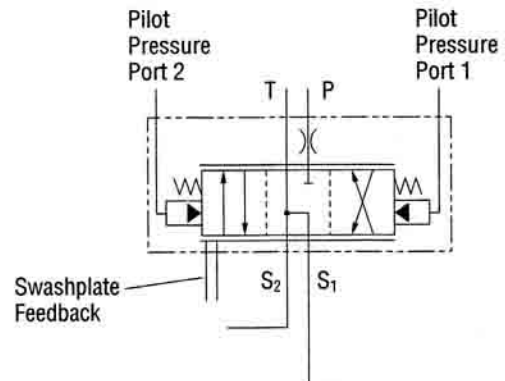
The Hydraulic Remote Pump Control is readily adaptable in the following applications:

- Where remote transmission control is needed
- Where control cables or linkages are not feasible
- Where electronic controls cannot be used.

The Eaton Hydraulic Remote Pump Control is compatible with:

- All Eaton Variable Pumps (Models 33-76)
- Other Eaton Control Options
- Most commercially available hydraulic command stations

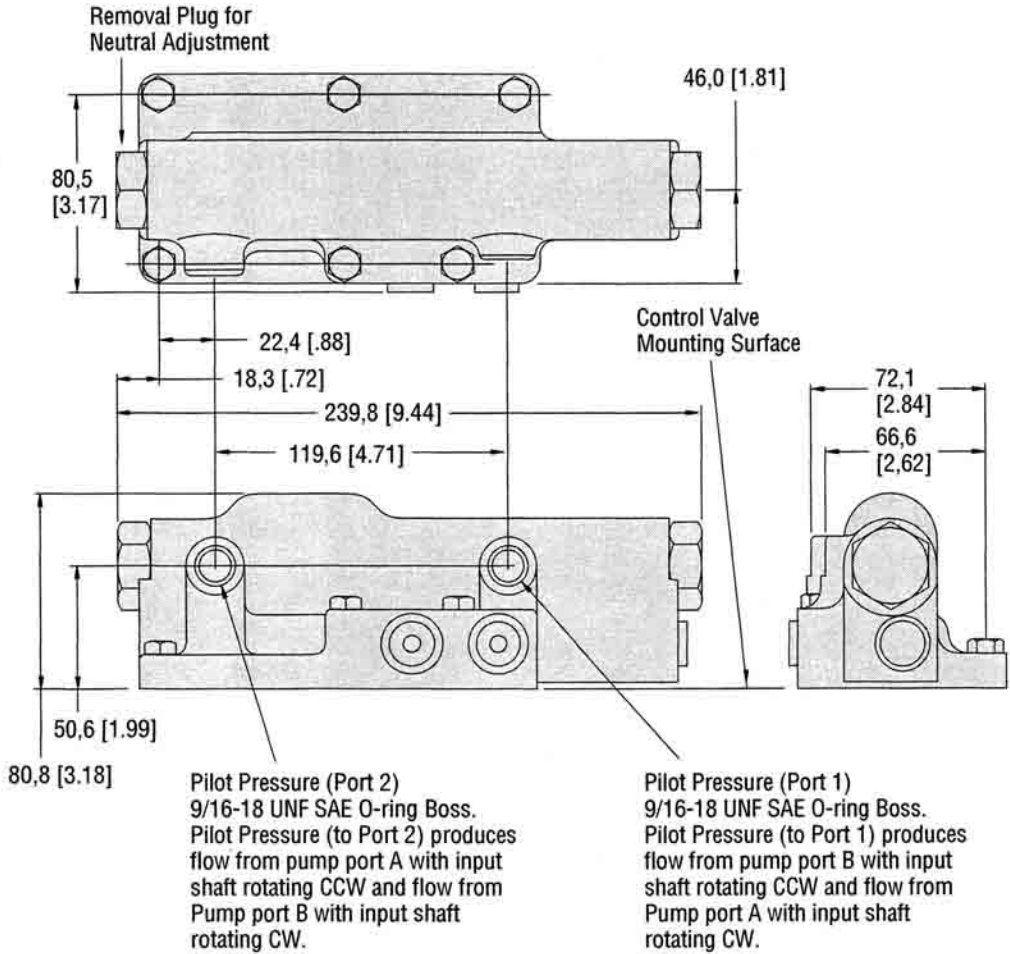
The hydraulic remote pump control is a three position, four-way closed center (spring centered) hydraulically activated servo control. This control, like the manual displacement control, also uses the positive feedback linkage connected directly to the swashplate.



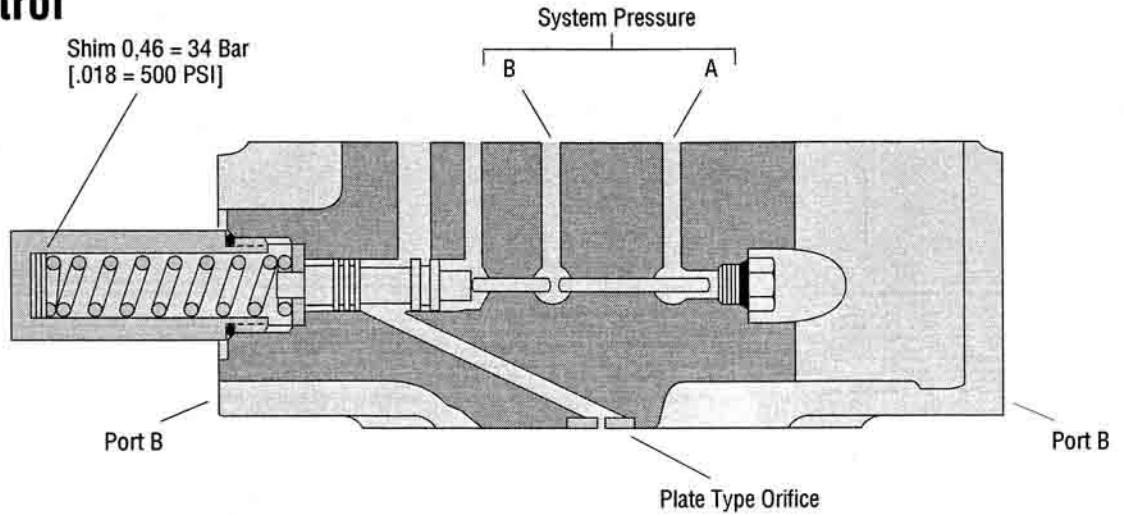
The control spool is activated to position the swashplate by regulating the remote pilot pressure to the control piston. There are various manufacturers of command stations that can be used to supply this remote pilot pressure. The variable pilot pressure required to activate the upper control piston is governed by spring force and spring rate. There are several control piston springs available to match the pressure characteristics of the remote pressure regulating command station.

- 0,69 - 10,35 Bar [10 - 150 PSI]
- 3,44 - 12,41 Bar [50 - 180 PSI]
- 4,96 - 14,96 Bar [72 - 217 PSI]
- 13,79 - 24,13 Bar [200 - 350 PSI]

Hydraulic Remote Pump Control



Internal Pressure Override Control



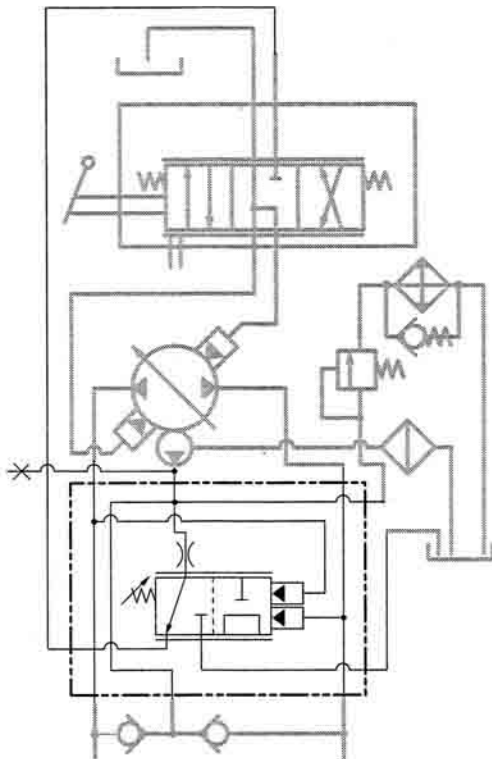
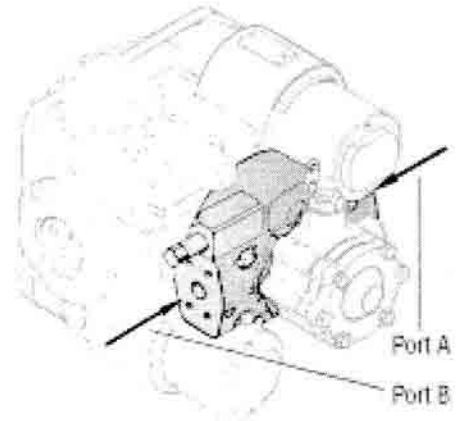
The internal pressure override control (IPOR) monitors system high pressure to protect the hydrostatic pump and system from overloads for extended periods of time.

Normal pump and system operation is performed by the operator's command to the manual displacement control valve. If system pressure exceeds the setting of the IPOR, which is in series with the manual displacement control valve, the pressure usually available for servo piston control for swashplate positioning is interrupted by the IPOR.

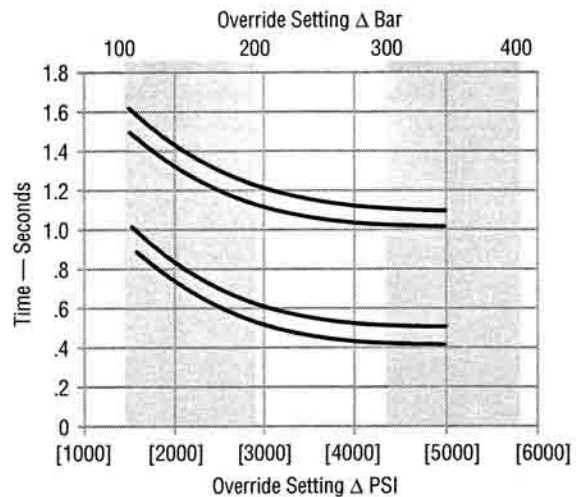
This allows the variable swashplate of the pump to modulate toward neutral, to a setting less than the operator's command, maintaining a maximum torque and a variable output flow.

The pressure range is shim adjustable from 69-414 Bar [1000 to 6000 PSI]

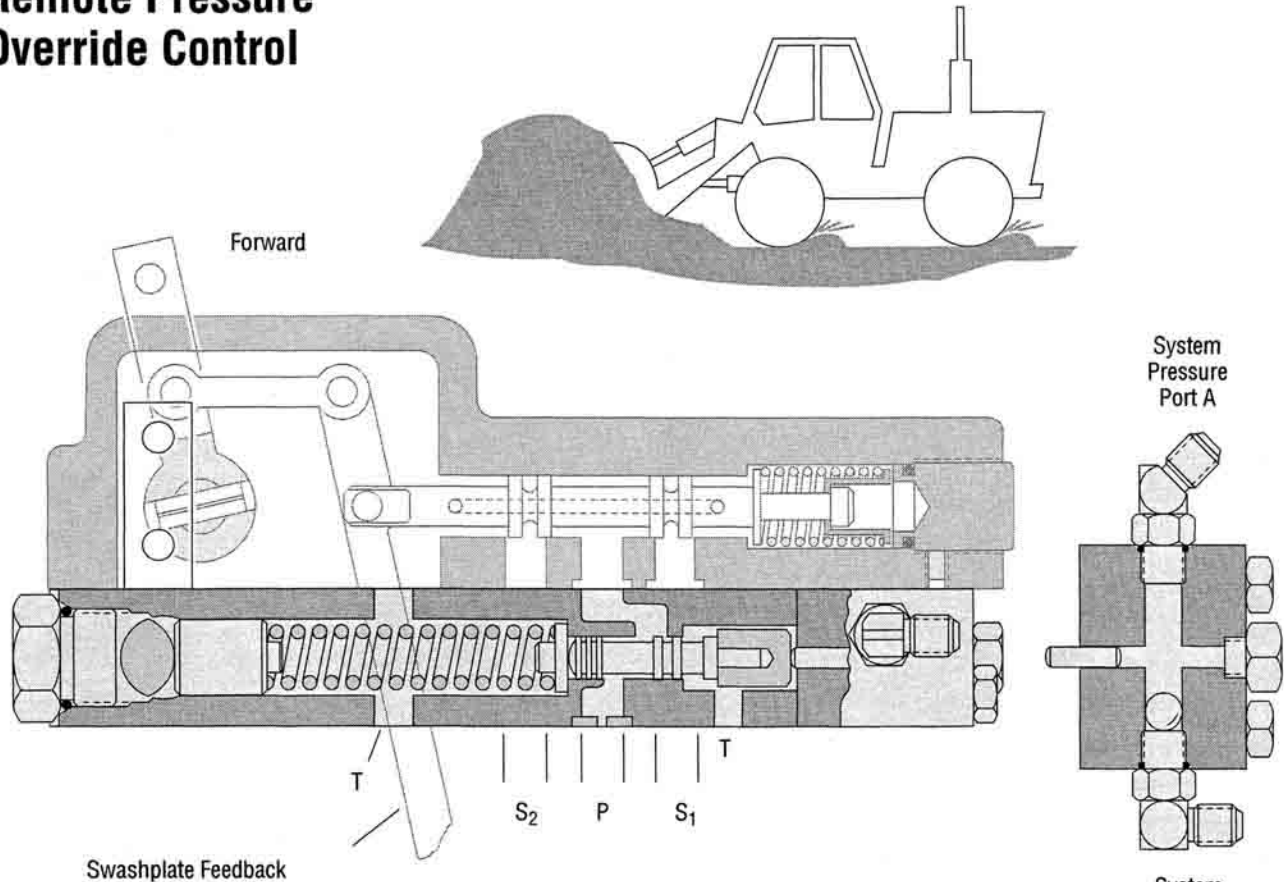
The IPOR is available for all model 33 thru 76 variable displacement axial piston pumps.



Pressure Response — Seconds v.s. Pressure Override Setting Δ Bar [PSI]
Full Displacement to Zero Displacement



Remote Pressure Override Control



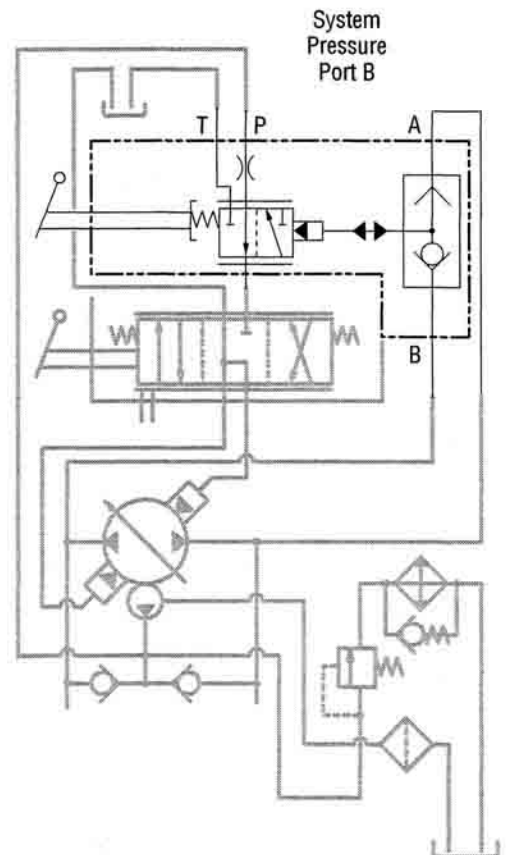
The adjustable pressure override control (POR) provides a means to remotely adjust the pressure setting of the POR valve. This control may be used in applications requiring variable system pressure protection to prevent overloads and excessive heat generation. This valve operates the same as a standard internal pressure override valve (IPOR). See page 18 for a description of the IPOR/POR control function. The minimum pressure setting is 103 Bar [1500 PSI].

The upper portion of the diagram shows a vehicle in a near stalled or stalled condition. When in this condition, high system pressure equals the POR control valve setting. System pressure shifts the POR spool and interrupts control pressure to the pump control valve. The control valve is then drained to the pump housing.

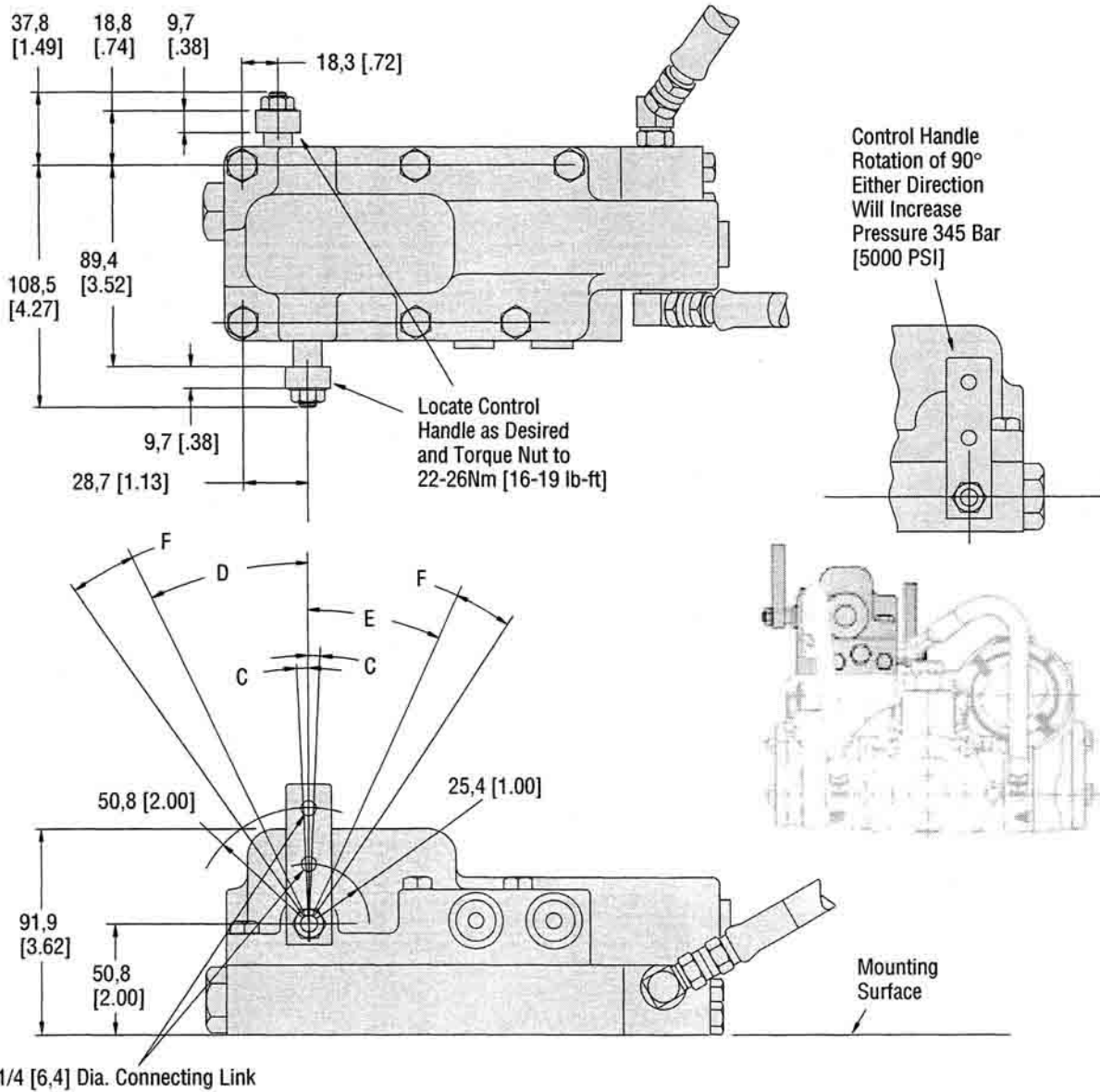
Whenever the control pressure is interrupted, servo piston spring force will automatically destroke the swashplate to the angle required to maintain system pressure at the POR setting.

If the system pressure remains below the POR valve setting (normally set at 34 Bar [500 PSI] below system relief valve setting), the control pressure will not be interrupted to the pump control.

When the high system pressure demand is lowered below the POR setting, the POR biased spring will shift the POR spool back to the open position. Control pressure will resume to position the swashplate back to the original commanded position.



Pressure Override Control



C- Neutral zone (zero flow)

D—Flow from port 'B' with input shaft rotating CCW and flow from port 'A' with input shaft rotating CW.

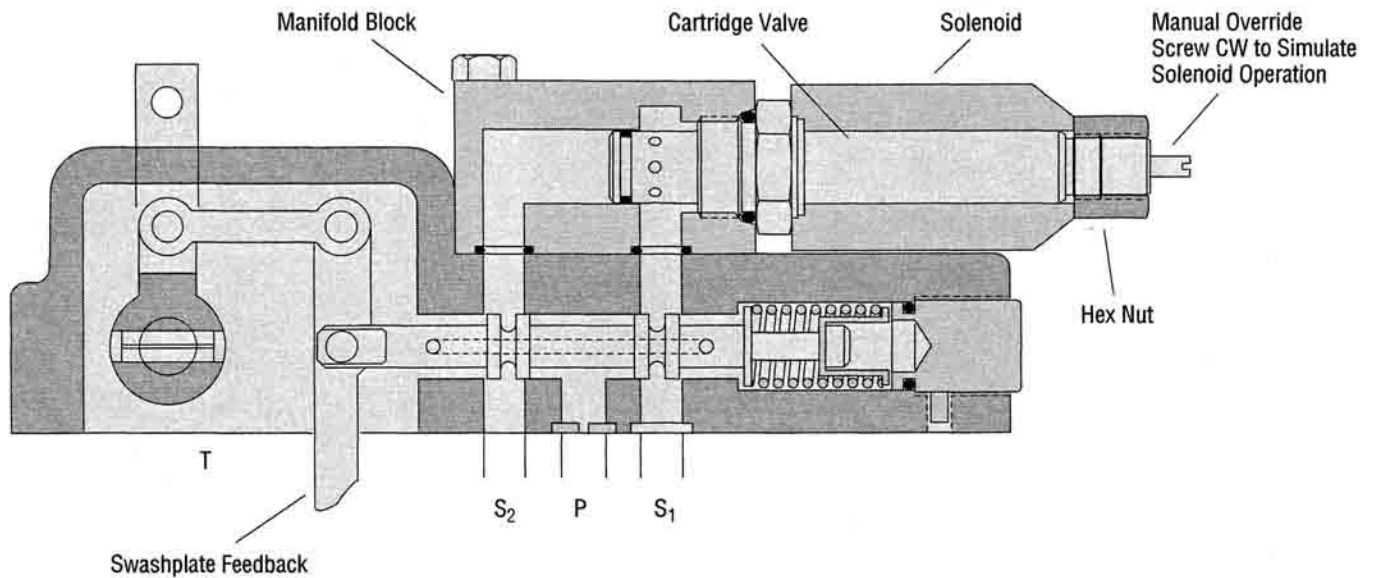
E—Flow from port 'A' with input shaft rotating CCW and flow from port 'B' with input shaft rotating CW

F—Max. Allowable control handle overstroke. Radial position of control handle to shaft is optional at 7-1/2° increments. 1,13 Nm [10 lb-in] torque required for full control handle travel (2,37 Nm [21 lb-in] with detent option) total applied torque not to exceed 17 Nm[150 lb-in].

**Remote Pressure Override
Manual Control Handle Rotation**

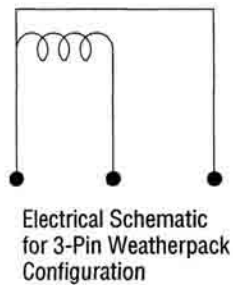
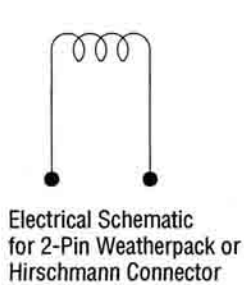
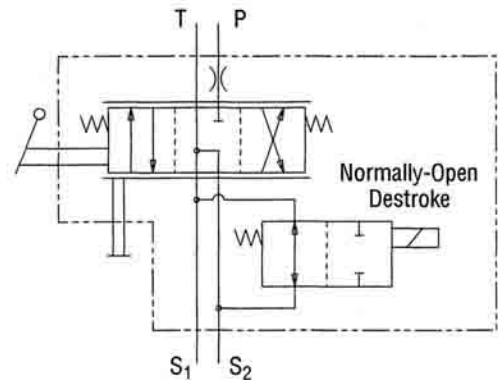
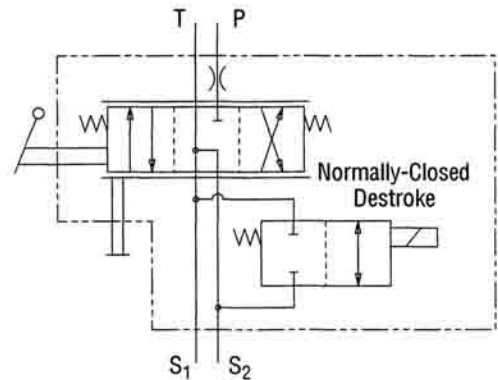
Model	C	D	E	F
33	3°45'	15°30'	15°30'	17°0'
39	3°45'	17°30'	17°30'	15°0'
46	3°45'	17°30'	17°30'	15°0'
54	3°45'	20°15'	20°15'	12°15'
64	3°45'	20°15'	20°15'	12°15'
76	3°45'	17°15'	17°15'	15°15'

Manual Control with Destroke Valve

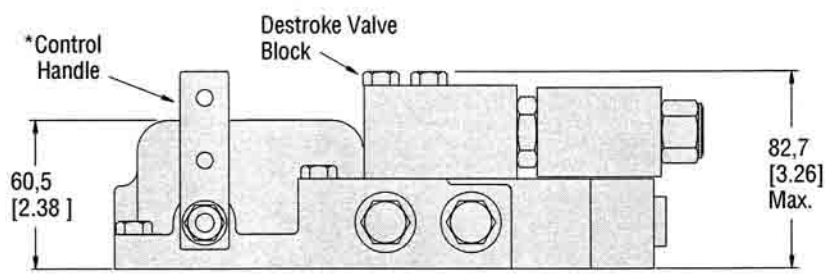
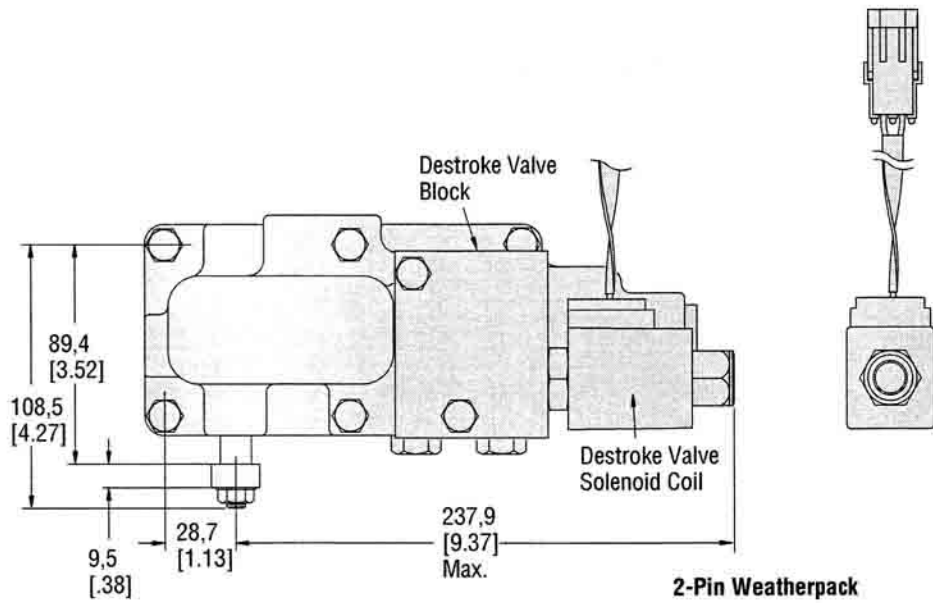
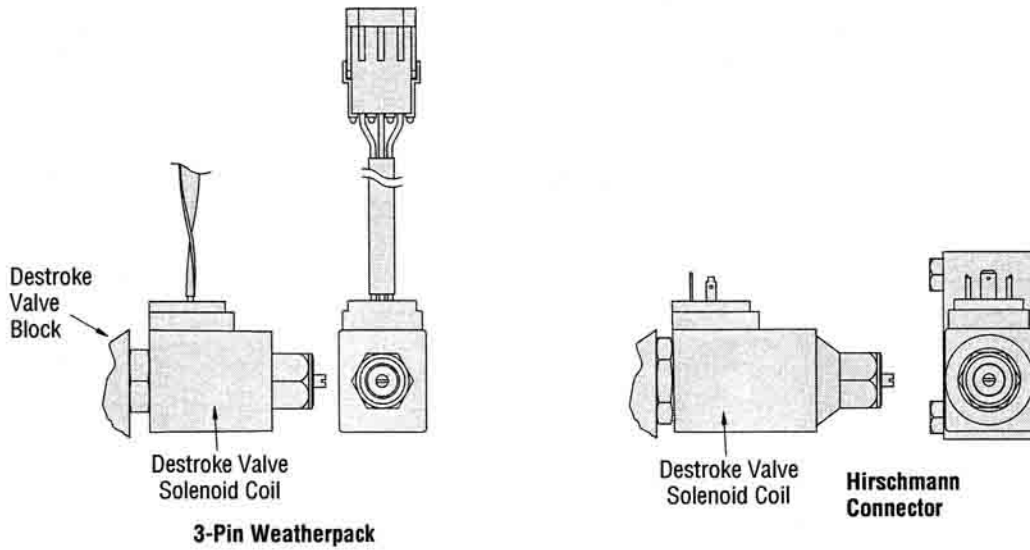


The heavy duty Destroke Control is a solenoid valve mounted on the standard variable pump control. When energized, the valve cross-ports control pressure allowing centering springs to bring the pump out of stroke. It can be energized with a single switch, push-button, or dead man's switch. The solenoid coil is available in 12 volt or 24 volt DC and normally open and normally closed configurations. A manual override is available on the solenoid valve.

The heavy duty Destroke Solenoid valve is available to field convert the standard variable pump control into a destroke control.

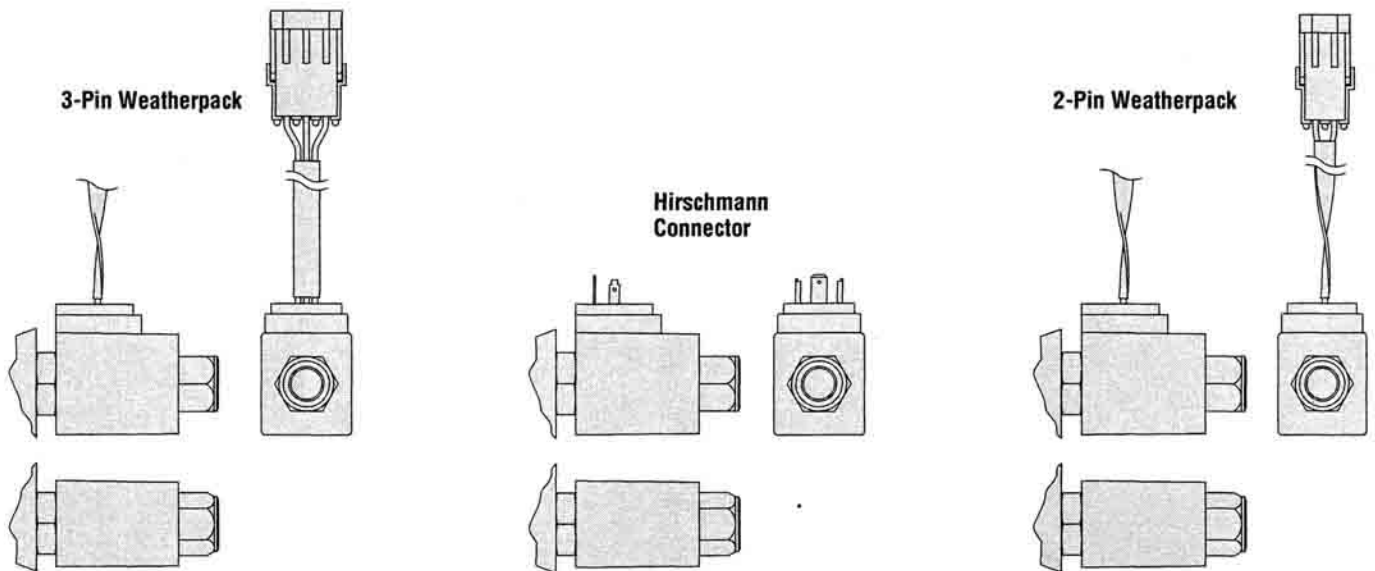
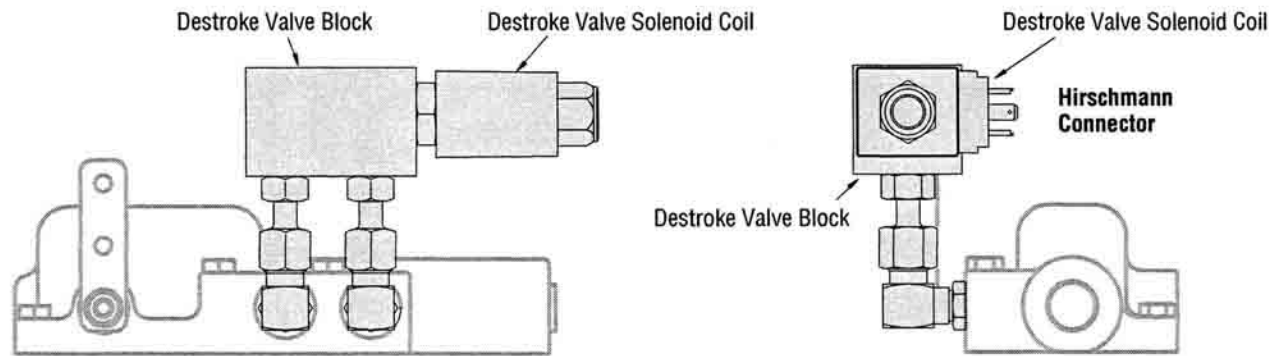
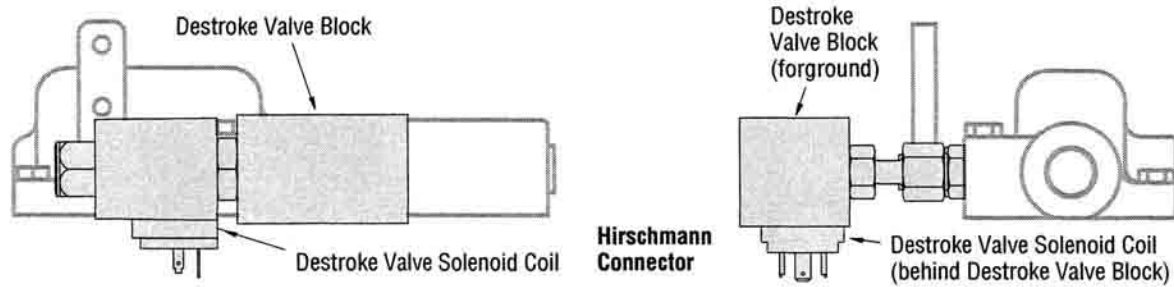
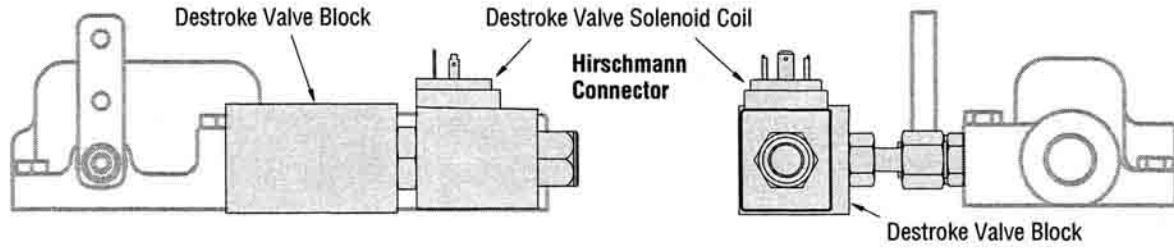


Manual Control with Destroke Valve Manifold Mount



* See page 7 for control handle rotation specifications

Manual Control with Destroke Valve Non-Manifold Mount



Heavy Duty Hydrostatic Pump Anti-Stall Control

Operation

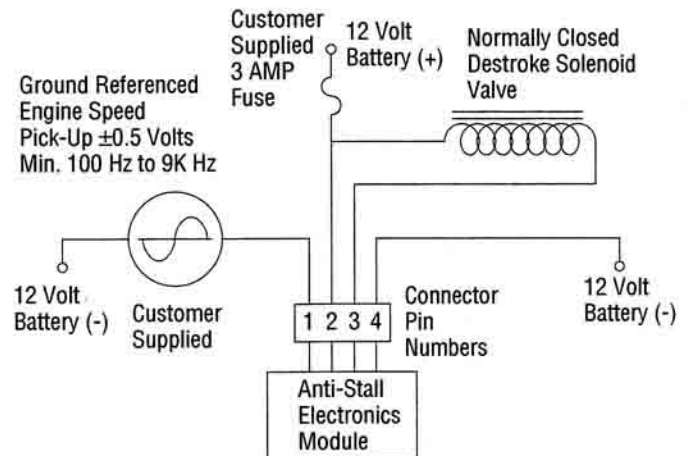
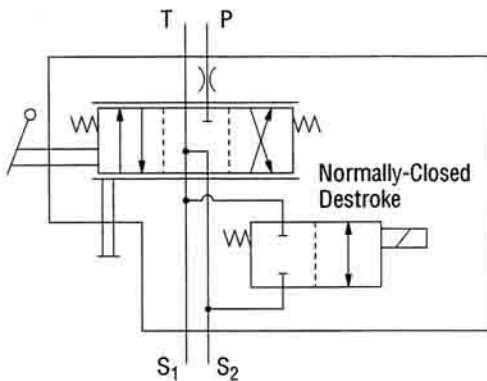
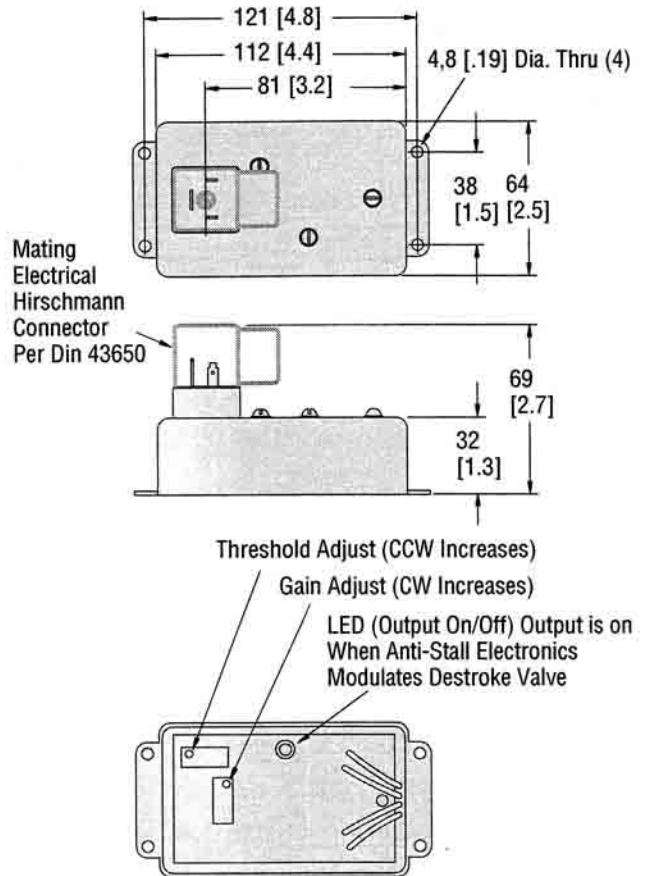
Eaton's Anti-Stall Electronics Module drives the destroke valve. The electronic circuit monitors engine speed. When engine speed drops below a set point or threshold, the Electronic Anti-Stall Control pulse width modulates a normally closed destroke valve. The amount of modulation is proportional to the error between the set point engine speed and the actual engine speed. This modulation of the destroke solenoid valve reduces the pump displacement.

Features and Benefits

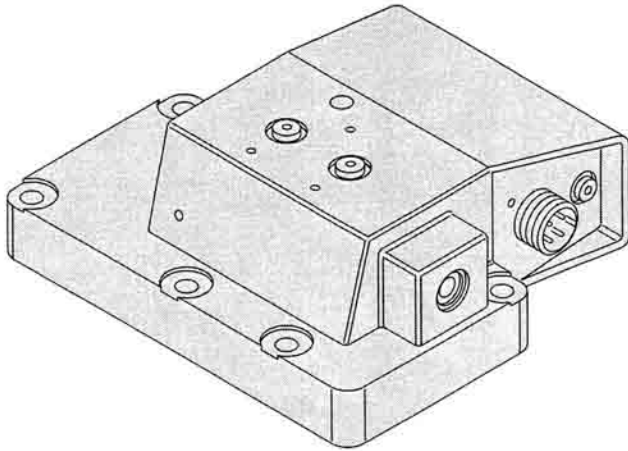
- Fits all Eaton heavy duty hydrostatic pumps.
- Anti-Stall prevent stalling the drive engine or excessively loading it down. This allows the machine to operate at full power while the operator concentrates on other areas.
- Operates in forward or reverse.
- Designed for rugged mobile application.
- Anti-Stall Electronics Module operates on 12 volts DC.
- LED output indicates destroke valve control.
- Threshold adjustment provides engine set point reference.

Customer Supplies

- Engine speed Sensing (can be magnetic pick-up, electronic tach, or alternator output).
- 12 volt power source
- 3 amp fuse
- Wiring



Electrohydraulic Stroke Control (ESC)



The ESC eliminates the mechanical interconnection between the operator and the pump. A simple potentiometer or joystick can be located near the operator, with an electrical cable running to the control on the hydrostatic pump. The control is directly interchangeable with the manual displacement control.

Features

- Convenient Remote Control**
 Simple electrical connection eliminates all mechanical links, rod, and cables.
- Low Electrical Power**
 Approximately 1/8 watt required for full control (± 1.4 volts using parallel coils).
- Fail Safe**
 Internal mechanical feedback returns pump to neutral with loss of electrical control.
- Versatile**
 Dual torque motor coils permit remote control from two locations, or interconnections to give steering-type control.
- Accurate Control**
 The torque motor armature and flapper move in a frictionless fashion (no sliding fits) so that threshold and swashplate positioning accuracy are excellent.
- Manual Override**
 The control has a manual lever to permit operation with no electrical power.

Description of Operation

Input to the ESC is electrical current through the torque motor coils. This current produces a torque on the armature/flapper that is ultimately balanced out by deflection of the feedback spring due to swashplate movement.

The ESC works as follows (refer to Figure 1 below): When the electrical input current changes, the torque balance at the armature/flapper is upset. This causes the flapper to move toward one nozzle. The fluid flowing to this nozzle through the upstream orifice is the diverted and moves the spool. As the spool moves, the feedback wire that engages the center of the spool is deflected. This creates a feedback torque on the flapper that causes spool displacement to be proportional to the magnitude of torque unbalanced at the input.

As the swashplate approaches the command displacement, the force from the swashplate feedback spring, together with the torque from the feedback wire, overbalance the electrical input torque. This causes the flapper to move towards the opposite nozzle. Nozzle flow is then diverted, moving the valve spool back to its centered position.

As the valve spool approaches its null position, the swashplate will stop moving. Final equilibrium is reached when the force from the feedback spring just balances the electrical input torque. This gives pump displacement proportional in both magnitude and direction to the electrical command.

The valve spool in the ESC is underlapped to drain and over-lapped to pressure. The underlap, in conjunction with the servo piston return springs, gives a positive neutral deadzone.

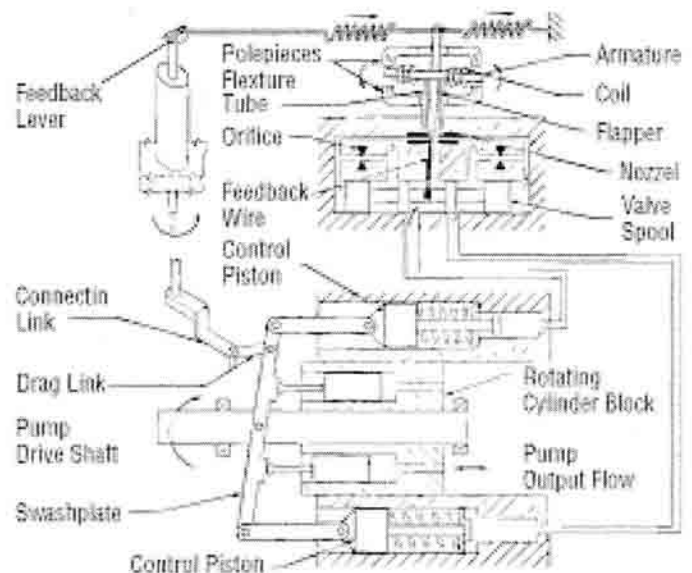


Figure 1

Electrohydraulic Stroke Control

Specifications

Full Rated Electrical Input

± 50 ma DC, series coil
 ± 100 ma DC, single or parallel coil

Coil Resistance

28 OHMS each nominal at 21° C [70° F] (± 10% tolerance)
 Resistance of each coil increases 7.8 OHMS per 55°C [100°F] temperature rise

Nominal Voltage for Full Control

± 2.8 volts single or series coil, ± 1.4 volts parallel coil

Nominal Electrical Power for Full Control

± 0.14 watts series or parallel coils, ± 0.28 watts single coil

Null

Externally Adustable*

Percent of Full Rated Current

Neutral Region	± 12 - 15%
Hysteresis	≤ 6%
Threshold	≤ 2%
Linearity	≤ 8%
Symmetry	≤ 8.5%
Dynamic Response	≥ 1.34 Hz @ 3 db
Phase Lag @ 90°	≥ 2.3 Hz
Long Term Null Stability	± 7%*

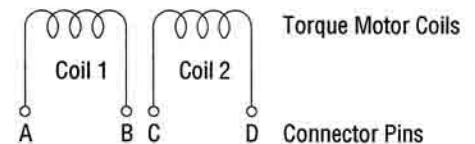
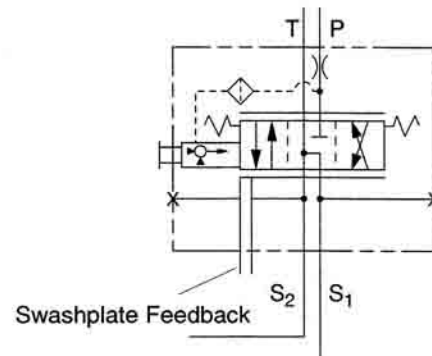
Current Required for Max. Displacement

Model 33	± 70 ma
Model 39	± 83 ma
Model 46	± 83 ma
Model 54	± 100 ma
Model 64	± 100 ma
Model 76	± 80 ma

Nominal Maximum ± 12.5 l/min [±12.5 cis]
 @ 14 bar [200 PSI]

Control Flow Supply

Rated Charge Pump Pressure 11 to 27,5 bar
 [160 to 400 PSI]



Nominal Charge Pump Pressure

13,8 ± 1,4 bar [200 ± 20 PSI]

Recommended Min. Viscosity

10 cSt [60 SUS]

Recommended Max. Viscosity

2158 cSt [10000 SUS]

Standard Seal Material

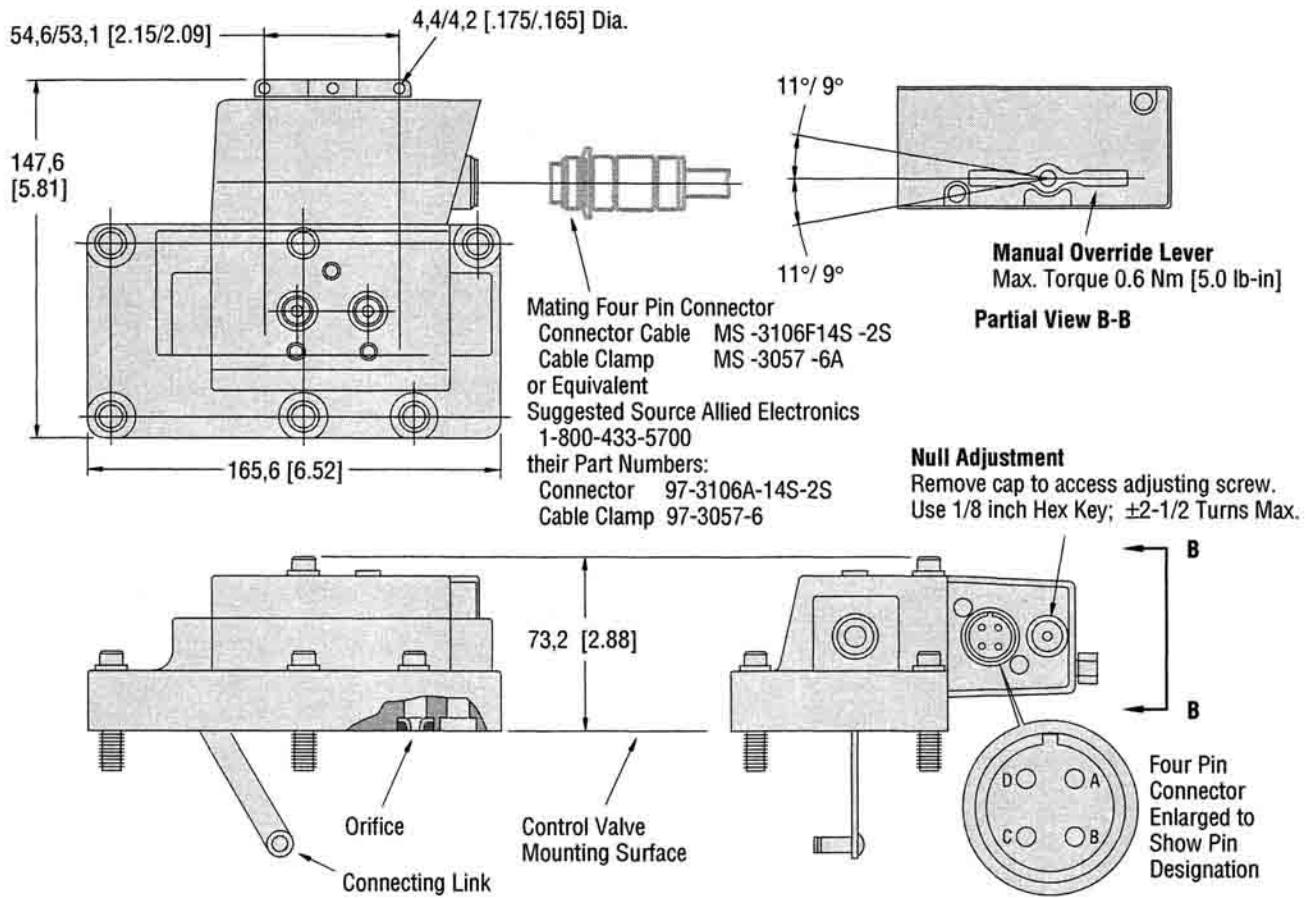
Buna "N"

Recommended Temp. Range

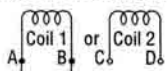
-29°C to +93°C [-20°F to +200° F]

*Mechanical null adjustment provide. Adustment sensitivityapproximately 20% change/half turn; Full ±100% null adjustment available.

Electrohydraulic Stroke Control

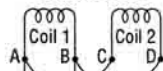


Single Coil Configuration



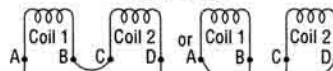
Current Input

Parallel Coil



Current Input

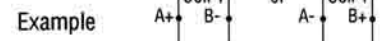
Series Coil



Current Input

Current Input

In the chart below the "+" and the "-" sign by the pin reflect the polarity of current input.

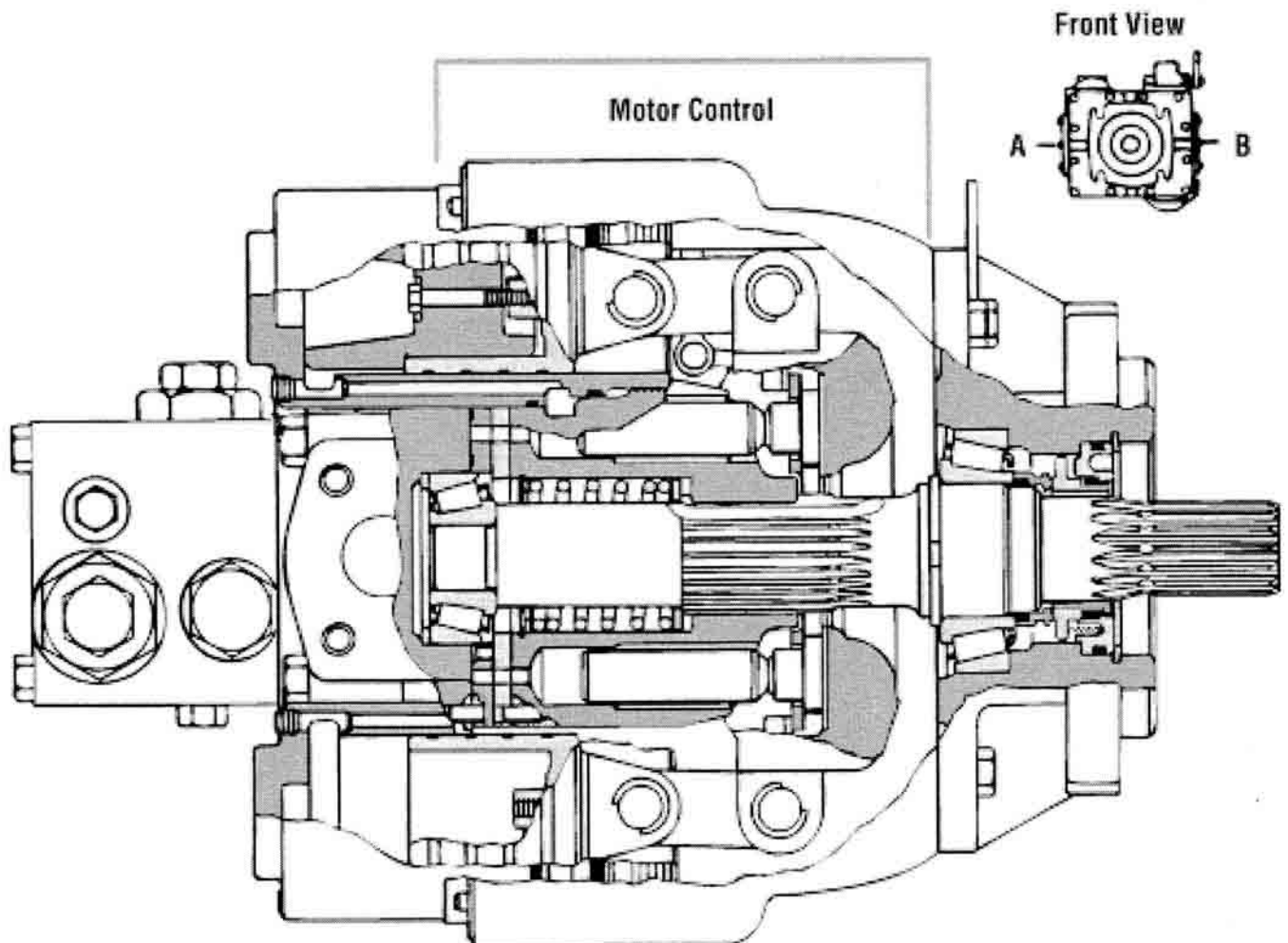
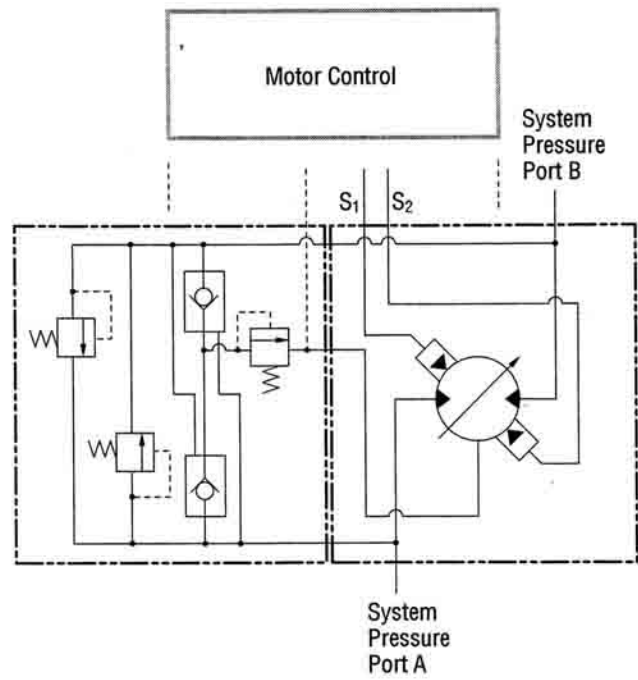


Example

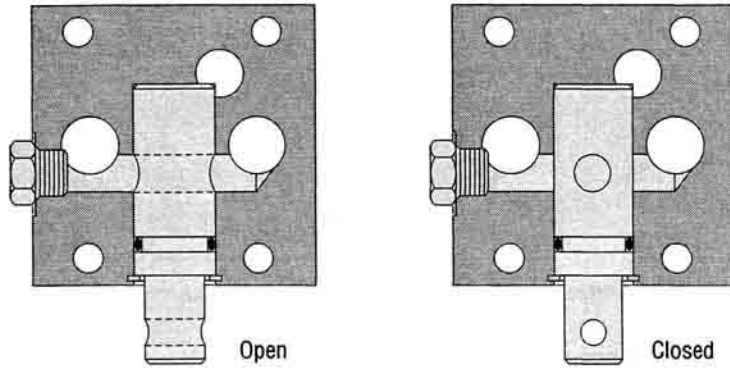
Electrical Data

With Pump Input Shaft Rotation CCW — Flow Output Port		With Input Shaft Rotation CCW — Flow Output Port	
Single Coil A and B	A+B- Flow Out A Port A-B+ Flow Out B Port	Single Coil A and B	A+B- Flow Out B Port A-B+ Flow Out A Port
Single Coil C and D	C+D- Flow Out A Port C-D+ Flow Out B Port	Single Coil C and D	C+D- Flow Out B Port C-D+ Flow Out A Port
Parallel Coil		Parallel Coil	
A and C connected	A and C+ B and D- Flow Out A Port	A and C connected	A and C+ B and D- Flow Out B Port
B and D connected	A and C- B and D+ Flow Out B Port	B and D connected	A and C- B and D+ Flow Out A Port
Series Coil		Series Coil	
B and C connected	A+D- Flow Out A Port A-D+ Flow Out B Port	B and C connected	A+D- Flow Out B Port A-D+ Flow Out A Port
Manual Override	Clockwise Lever Flow Out Port A Counter Clockwise Lever Flow Out Port B	Manual Override	Clockwise Lever Flow Out Port B Counter Clockwise Lever Flow Out Port A
Null Adjustment	Clockwise Lever Flow Out Port B Counter Clockwise Lever Flow Out Port A	Null Adjustment	Clockwise Lever Flow Out Port A Counter Clockwise Lever Flow Out Port B

Variable Displacement Motor Controls



Motor By-Pass Valve



The by-pass valve is a manually operated rotary valve which by-passes fluid from the high pressure port to the low pressure port of the hydrostatic motor.

Typical usage of the by-pass valve permits:

- (1) Shifting of multi-gear transmissions.
- (2) Moving a disabled vehicle short distances for maintenance.
- (3) Disengagement of power train for safety purposes.

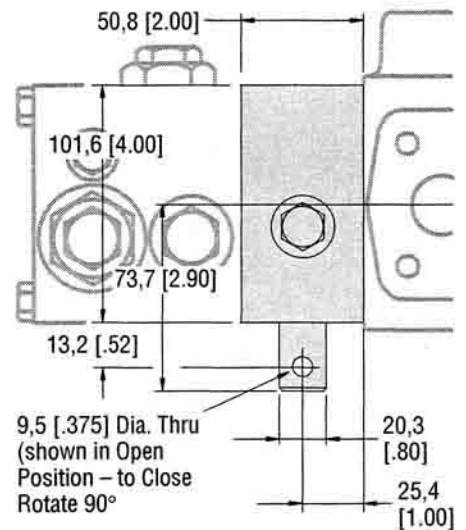
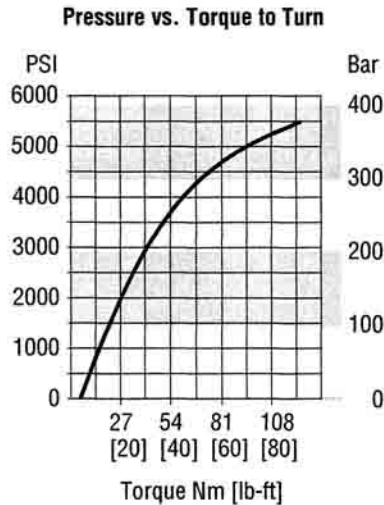
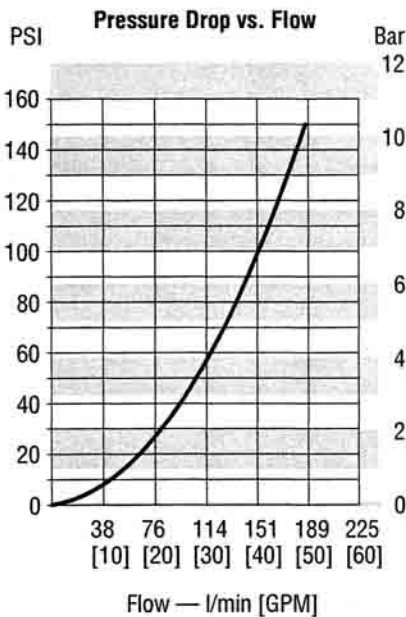
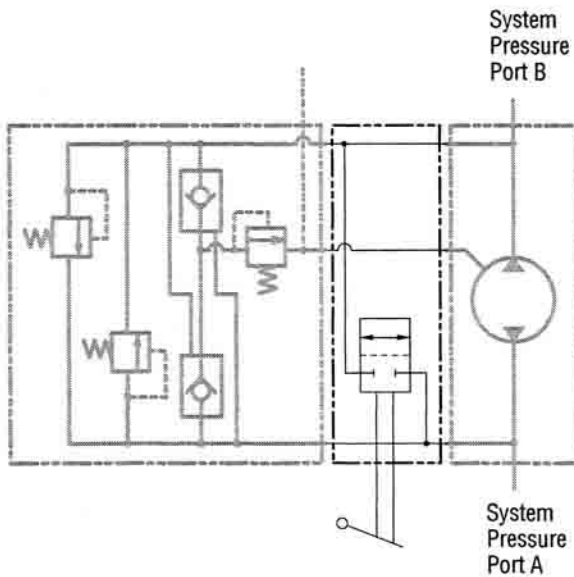
The by-pass valve can be mounted to all model 33 thru 76 hydrostatic motors, between the composite valve block and the end cover, and requires no special parts or tools. The by-pass valve can be installed remotely between high pressure lines with the addition of a special adapter plate.

Cross porting the motor allows the motor output shaft to be rotated, releasing the normal hydraulic lock characteristics of the closed circuit in a hydrostatic transmission.

The by-pass valve is designed to be used in either a full open or full closed position and should be used only when the load is stationary and the hydrostatic pump is in neutral. The valve is not to be used as a metering valve or "clutch" to control motor speed. It should not be opened when the transmission is under high pressure.

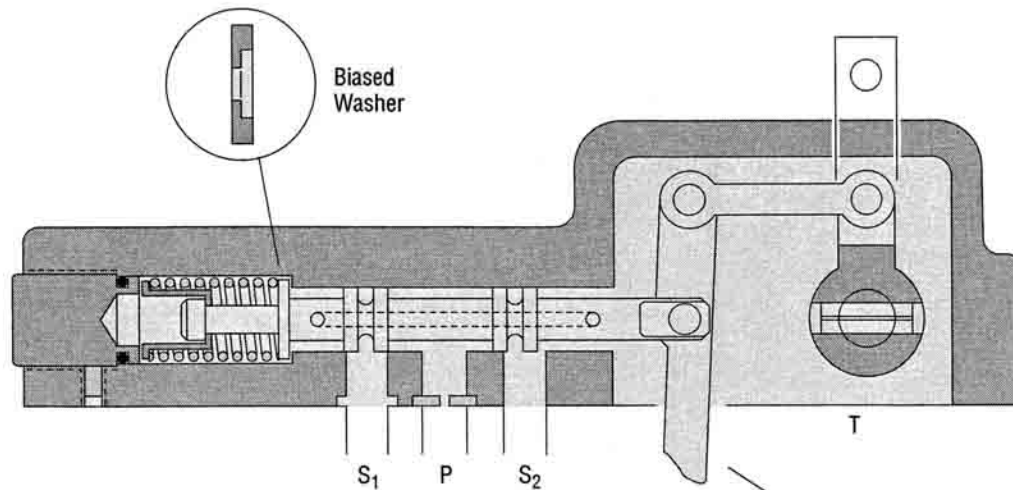
The motor by-pass valve shown on the left is in the open position. When in this position, the motor is cross ported and the motor shaft may be rotated.

The motor by-pass valve shown on the right is in the closed position. This would be the position used when the hydrostatic transmission is in normal operation.



Hydrostatic Transmission Controls

Manual Displacement Variable Motor Control



The manual displacement variable motor control is the most common type of control used on variable displacement motors. This type of control is normally actuated by direct mechanical type linkages, cables, etc.

The manual displacement variable motor control is a two position, four-way closed center (spring positioned) mechanical servo valve.

The only difference between the manual displacement variable pump and motor control, is the control spool. The spool is biased (by a recess cut into the spring washer) to full or maximum swashplate angle with no command to the control handle. This will provide control pressure for full swashplate angle for maximum torque at start-up.

The rate (speed) of swashplate movement is controlled by an orifice located in the supply pressure inlet to the control. This rate (speed) may be varied by a wide selection of orifice sizes.*

To calculate response times for variable motors, the response time will be reduced according to the ratio of swash angle travel of the motor in question to the total shown in the table.

i.e. $18^\circ \text{ max.} - 8^\circ \text{ min.} = 10^\circ$

$$\frac{10^\circ}{18^\circ} = 55.6\% \text{ of times shown.}$$

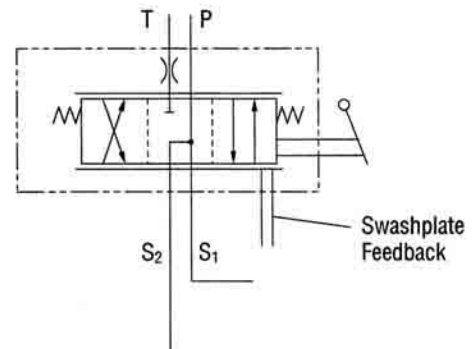
*Refer to table on page 9 for orifice sizing information.

This valve also uses a positive feedback linkage that is connected directly to the swashplate.

When the control handle is positioned for minimum swashplate angle, the control spool is moved porting control pressure to the S₂ servo piston, forcing the S₁ servo piston assembly to bottom against the top of the servo sleeve.

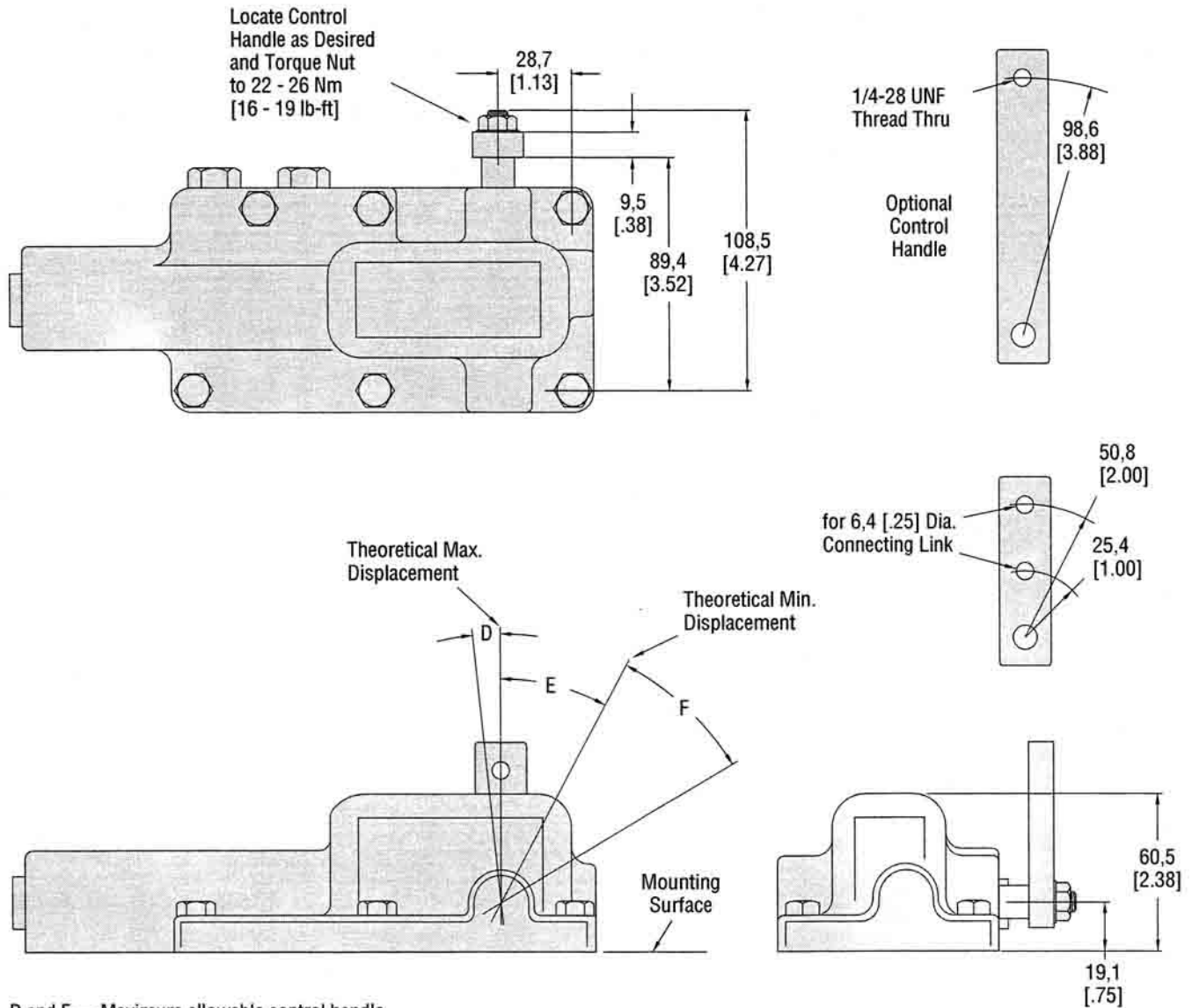
The S₁ servo piston assembly limits the swashplate minimum angle. Shims are clamped between the servo piston and the servo piston spacer to govern the minimum swashplate angle.

The motor control uses the positive feedback linkage to position the swashplate at any angle between maximum and minimum.



Hydrostatic Transmission Controls

Manual Displacement Motor Control

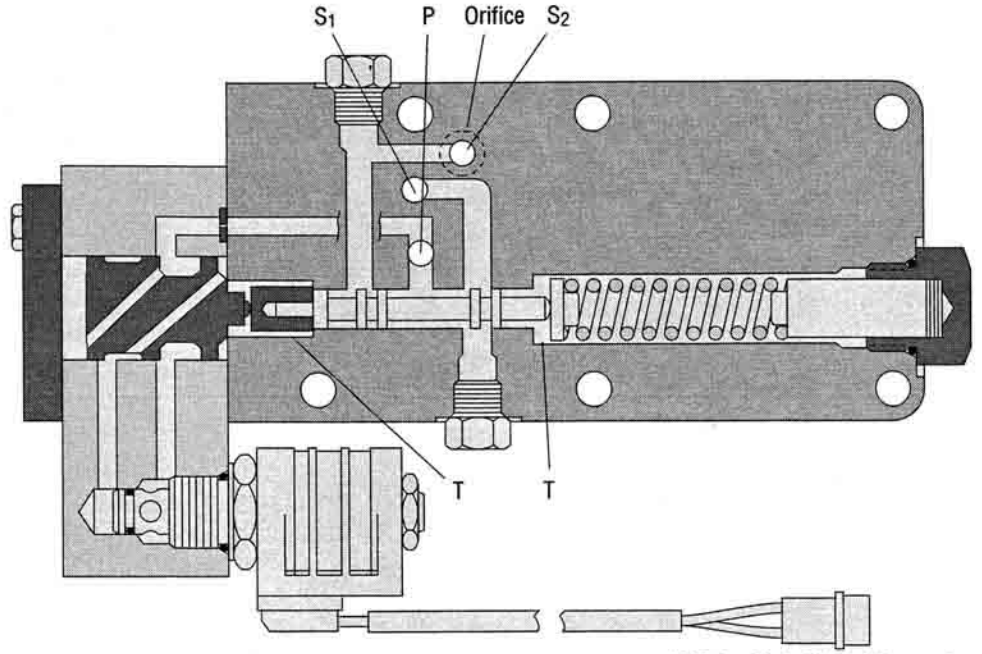


D and F — Maximum allowable control handle overstroke. Radial position of control handle to shaft is optional at 7 1/2° increments. 1,13 Nm [10 lb-in] torque required for full control handle travel. Total applied torque not to exceed 17 Nm [150 lb-in].

* Maximum motor displacement is maintained until the indicated values are exceeded.

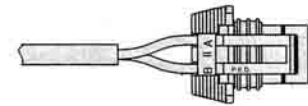
Model	E Theoretical Control Handle Travel, in Degrees, to Obtain Swashplate Angle of:																				F Over Stroke	
	D Over Stroke	18°	17°	16°	15° 30'	15°	14°	13°	12°	11°	10°	9°	8°	7°	6°	5°	4°	3°	2°	1°		0°
3341	13° 37'	—	—	—	6° 45'	7° 21'	8° 31'	9° 41'	10° 50'	11° 58'	13° 06'	14° 14'	15° 22'	16° 29'	17° 37'	18° 45'	19° 53'	21° 01'	22° 10'	23° 19'	24° 29'	31° 36'
3941	10° 18'	6° 58'	8° 12'	9° 25'	—	10° 36'	11° 46'	12° 56'	14° 05'	15° 13'	16° 21'	17° 29'	18° 37'	19° 44'	20° 52'	22° 00'	23° 08'	24° 17'	25° 25'	26° 34'	27° 44'	31° 36'
4641	10° 18'	6° 58'	8° 12'	9° 25'	—	10° 36'	11° 46'	12° 56'	14° 05'	15° 13'	16° 21'	17° 29'	18° 37'	19° 44'	20° 52'	22° 00'	23° 08'	24° 17'	25° 25'	26° 34'	27° 44'	31° 36'
5441	5° 21'	7° 15'	8° 49'	10° 19'	—	11° 48'	13° 15'	14° 40'	16° 04'	17° 28'	18° 50'	20° 13'	21° 35'	22° 57'	24° 19'	25° 41'	27° 03'	28° 26'	29° 49'	31° 13'	32° 37'	31° 37'
6441	5° 21'	7° 15'	8° 49'	10° 19'	—	11° 48'	13° 15'	14° 40'	16° 04'	17° 28'	18° 50'	20° 13'	21° 35'	22° 57'	24° 19'	25° 41'	27° 03'	28° 26'	29° 49'	31° 13'	32° 37'	31° 37'
7641	12° 13'	6° 27'	7° 34'	8° 40'	—	9° 46'	10° 50'	11° 55'	12° 58'	14° 02'	15° 05'	16° 08'	17° 11'	18° 14'	19° 17'	20° 20'	21° 24'	22° 28'	23° 32'	24° 36'	25° 40'	31° 46'

Variable Motor Stroking Valve



Solenoid is deactivated (Closed Position)

AMP Inc Mate-N-Lock Connector

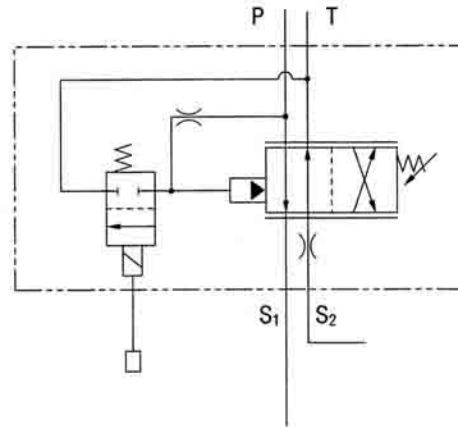


Packard Metric-Pack Connector

The Variable Motor Stroking valve is a solenoid operated valve that fits on all model 33 thru 76 variable motors. The stroking valve controls the motor to maximum displacement or to minimum displacement. This valve is a 2 position, 4 way valve that is spring biased and pilot operated by the solenoid valve.

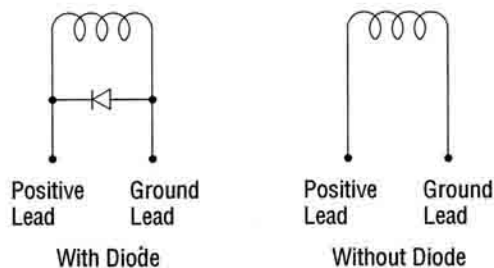
The solenoid valve is offered in 12 or 24 VDC, with or without diode and weatherpack or AMP Style connector.

To achieve low range (maximum motor displacement) the stroking valve electrical solenoid is deactivated (closed position). Pilot pressure builds up behind the large control piston to overcome the biased control spring force to shift the control spool. Control pressure is then ported to the upper servo (S1) piston, forcing the washplate to the maximum displacement position for the low operating speed range.



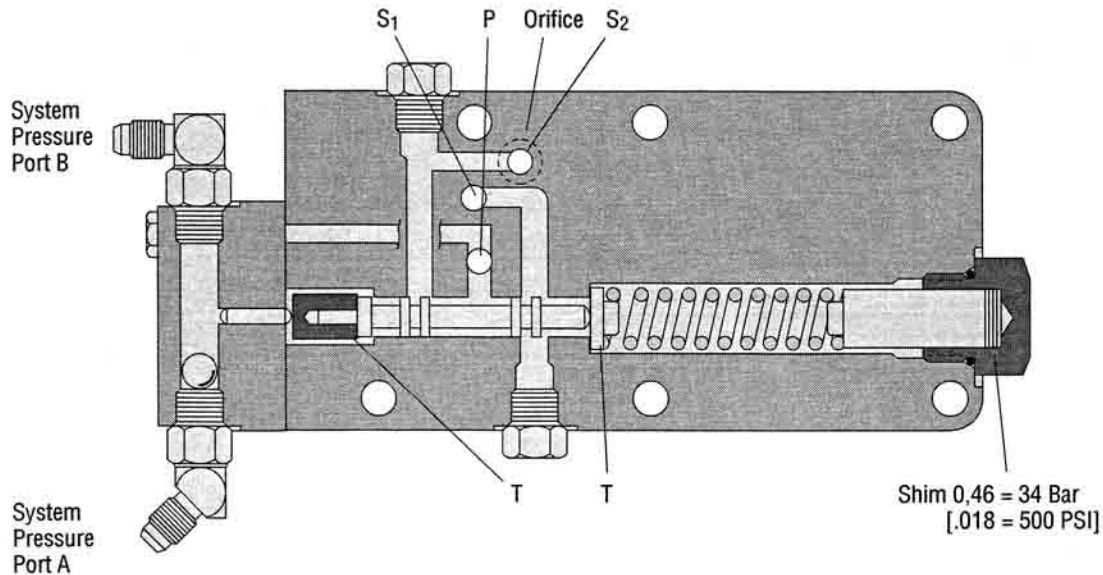
Solenoid Electrical Schematic

To achieve high range, the solenoid valve is activated (open position). In this position the control pilot pressure is ported through a small orifice, then around the control piston, through the activated solenoid valve, back through the control piston, and finally ported to the motor housing. Both ends of the control piston, are therefore, ported together. This results in no force to overcome the spring. The bias spring holds the control spool, porting control pressure to the lower (S2) servo piston, forcing the swashplate to minimum displacement for the high operating speed range.



The upper piston (S1) has spacers and shims to limit the minimum swashplate angle to meet system requirements.

Variable Motor Pressure Response Control



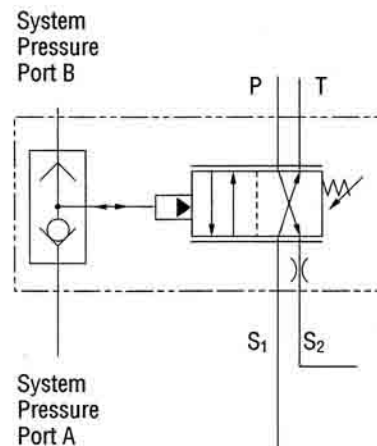
The variable motor pressure response control is a variable motor control which automatically selects the operating speed range which best suits the load. This valve is a proportional 4-way valve that is spring biased and system pressure operated. At low load levels, when the system pressure is below the set pressure, the motor is biased to minimum displacement or 'HI' range. As the load increases and the pressure reaches the preset value, the motor displacement increases, maintaining the set pressure until the motor reaches the maximum displacement or 'LO' range.

S1 servo piston to force the swashplate toward the maximum displacement position for the low operating speed range. The control spool will modulate to position the swashplate according to the load demanded when the system pressure reaches the preset value.

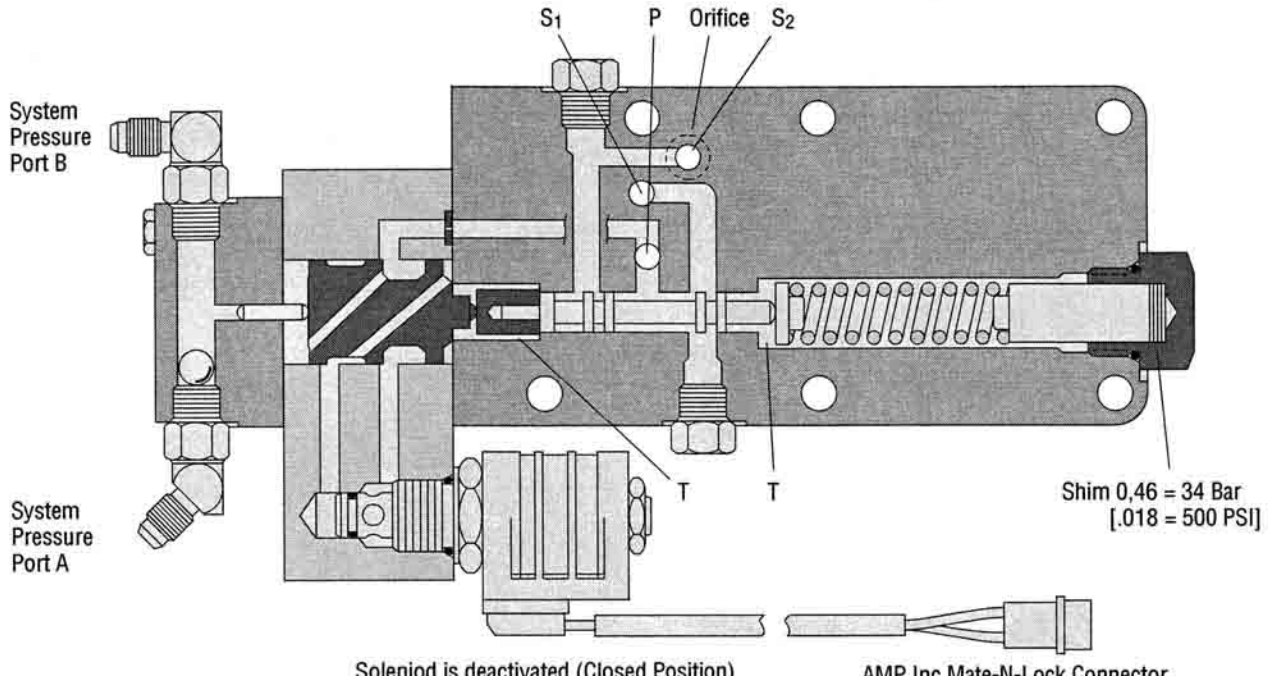
The system pressure setting used to shift the biased control spool is adjustable by shimming the control spring, with 68.9-275 Bar [1000 to 4000 PSI] the most commonly

The variable motor pressure response control is normally spring biased to the minimum displacement position for the high operating speed range. The bias spring holds the control spool in position, porting control pressure to the S2 servo piston. The servo piston spacer in the S1 servo piston limits the swashplate minimum angle. Minimum swashplate angles may be varied by adding or deleting shims.

The check ball located between the two system pressure sensing fittings acts as a shuttle valve to rectify system pressure to the sensing pin shown. System pressure acts directly against the control sensing pin through the rectifying valve. When the system pressure acting on the sensing pin area produces a force to overcome the bias spring force, control pressure will be ported to the

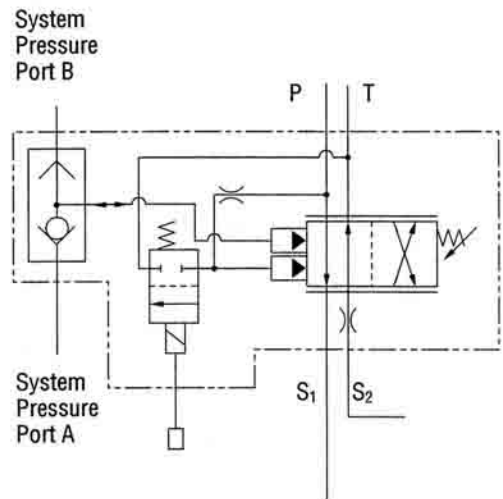
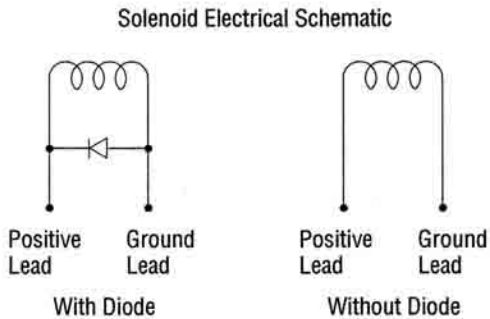


Variable Motor Pressure Response Control with Stroking Valve



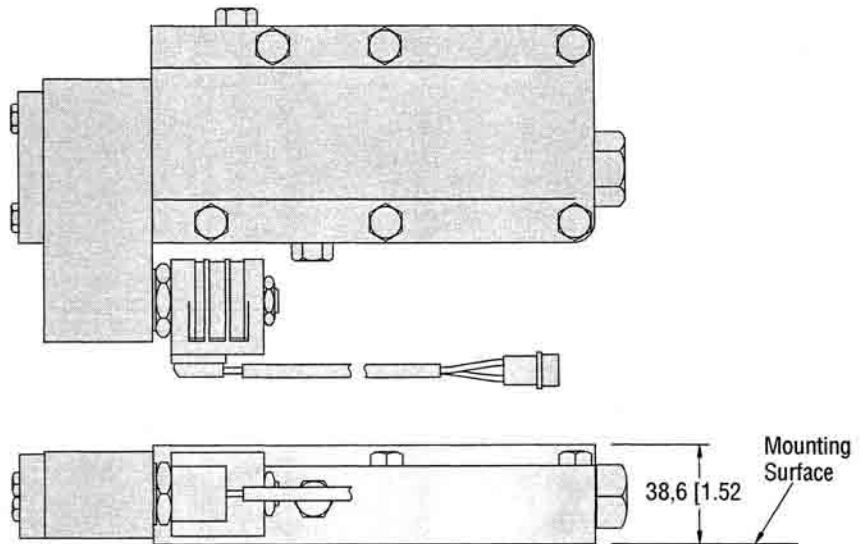
The pressure response valve with stroking valve combines the pressure response valve and the stroking valve in one control. The machine operator is allowed the choice of selecting full displacement ('LO') range or automatic pressure response control, providing the best features of both controls.

With the power "off" to the solenoid valve, the valve commands the motor to maximum displacement for 'LO' range operation as described on page 33. With the power "on" to the solenoid, the valve becomes a 'pressure response control,' as described on page 34.



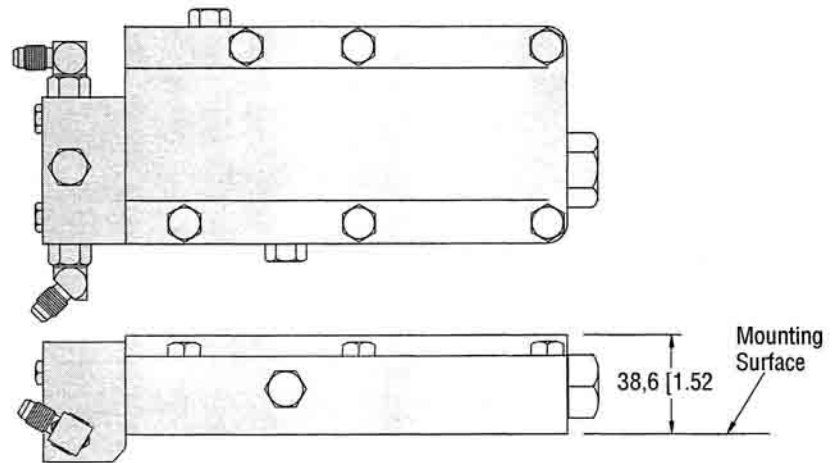
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Variable Motor Stroking Valve



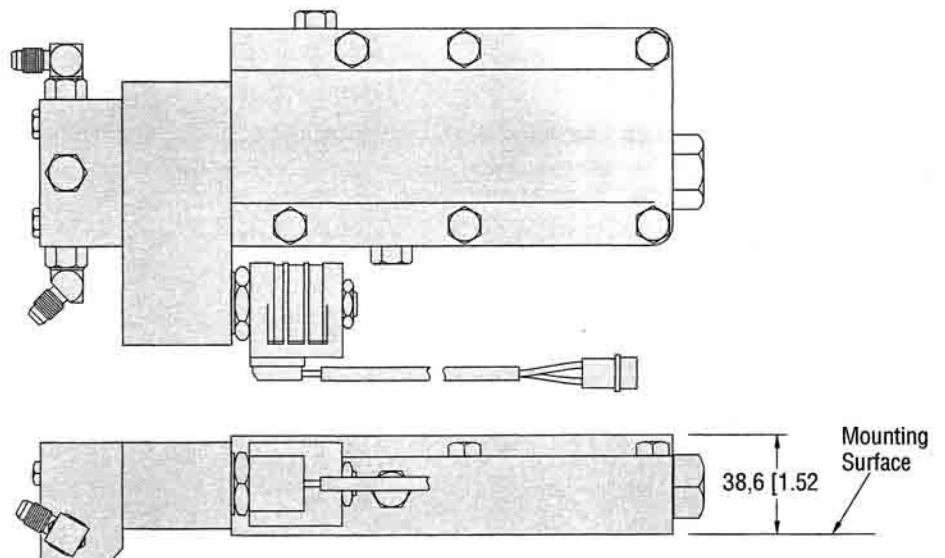
(continued from page 00)

Variable Motor Pressure Response Control



(continued from page 00)

Variable Motor Pressure Response Control with Stroking Valve



Eaton
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