Eaton®
Medium Duty Piston Pump

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Principle of Operation

Model 72400 Variable Displacement Piston Pump Servo Controlled

Medium Duty Hydrostatic Drive Principle of Operation

There are many methods used to transmit engine power to the driven wheels of a vehicle. These methods range from the standard manual shift to the more sophisticated automatic transmission and now to the latest method of propelling vehicles, hydrostatic propulsion drive.

The main advantage of the hydrostatic propulsion drive is the infinite speed ratios that can be obtained by being able to control the piston pump camplate angle from the neutral position to full camplate forward or reverse position. The direction and speed of the vehicle can be changed without changing the rotation of the pump

Once the fundamentals of the closed loop propulsion system are understood, the operating principles of the more complicated propulsion systems can be readily understood.

The type of propulsion drive principle described consists of a manual servo controlled variable piston pump with a gerotor charge pump and a fixed displacement motor.

Cam Angle Neutral Position

The Eaton PV-MF closed circuit (loop) hydrostatic transmission is considered to be in neutral when there is no output flow being generated by the variable displacement pump as its shaft, internal components, and charge pump are being driven. Therefore, with no flow available to the motor, the pump is at rest with no transmission output. Because of the variable displacement pump being driven continuously, several functions must be maintained.

Hydraulic fluid used in the hydrostatic transmission is made available from a reservoir, through a filter, and then to the inlet of the pump's charge pump. The charge pump is driven by the main pump's input shaft.

Flow rates of the charge pump are dictated by its displacement and driven speed.

The charge pump provides several functions to the hydrostatic circuits:

a) Provides flow to keep circuit primed and make up internal leakages.

b) Provides flow under pressure for maintaining back pressure on pump/motor pistons.

c) Provides flow under pressure for hydraulic control purposes.

d) Provides cooled and cleansed fluid for temperature control and flushing.

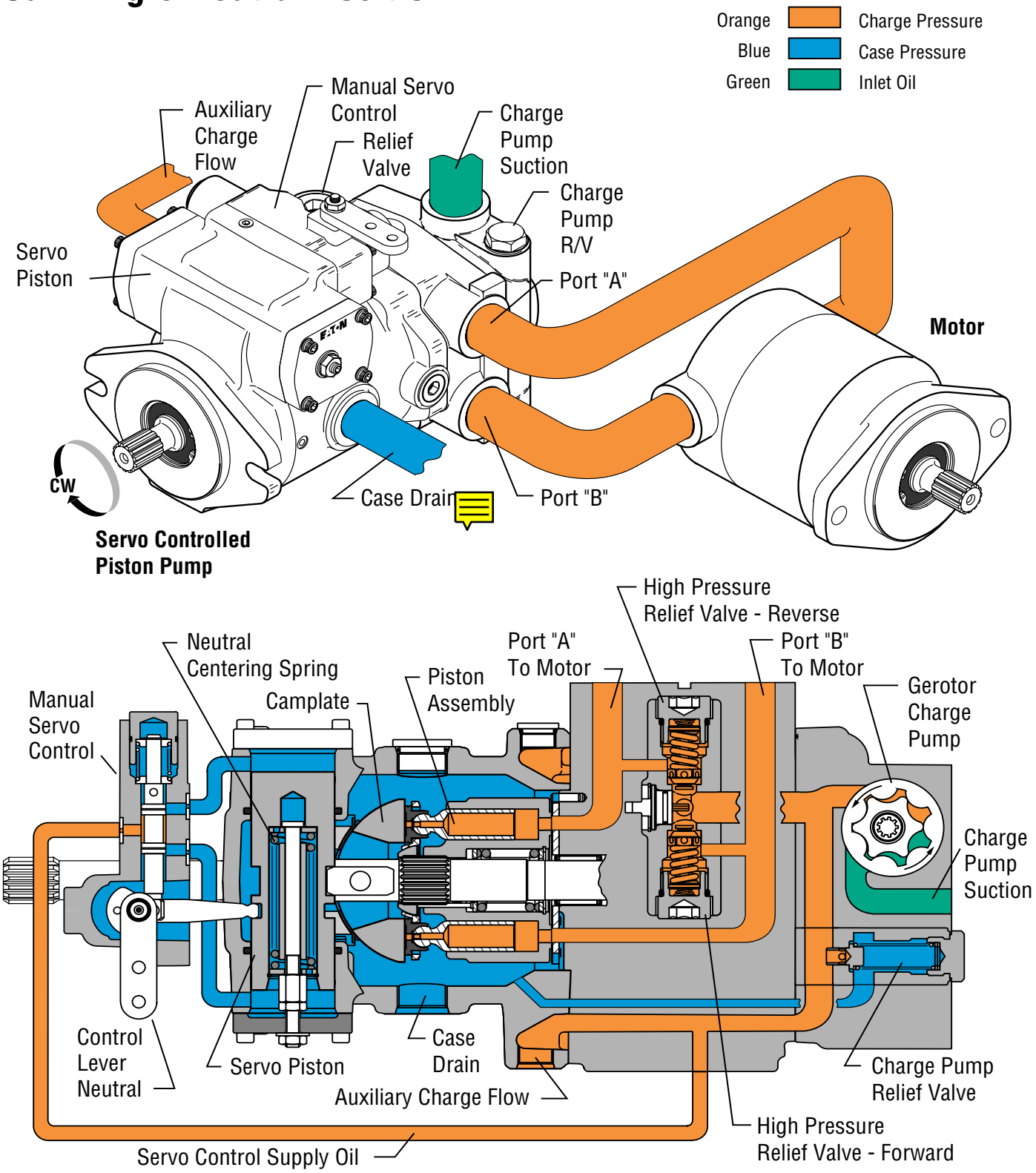
Fluid from the charge pump is directed through the two dual purpose system relief and check valve located in the pump backplate.

The charge pump/check valve combination introduces fluid to both sides of the hydrostatic circuits and fills or primes all lines, valves, etc. between the pump and motor. When the circuit is primed, the charge pump flow dumps across the charge pump relief valve to the pump housing to aid in cooling and flushing the pump. The fluid then returns to the reservoir through a heat exchanger (optional).

The charge pump relief valve maintains a minimum charge pressure level (17.24 to 20.68 bar [250 to 300 PSI]).

The connection between the servo piston and the camplate allows the variable displacement pump to be held in a positive neutral position by the neutral centering spring located in the servo piston. The variable camplate must be maintained in a true neutral location to prevent reciprocation of the pistons in the pump cylinder barrel.

Figure 1 —
Cam Angle Neutral Position



Servo Control Function

Transmission output is initiated by movement of the variable displacement pump control lever (Figure 2). As the lever is rotated, it moves the servo control spool first from its spring centered position, allowing pressurized charge pump flow or control pressure past the spool to one side of the servo piston. The pressurized servo piston pushes against the camplate, causing the camplate to rotate to a position out of neutral (Figure 3). Fluid in the servo piston side with the spring under compression is exhausted through the control valve spool to the pump housing.

The position taken by the variable camplate is determined by the location of the control lever from its neutral position. Maximum displacement of the pump is attained when the control lever is moved to its extreme position. As the camplate attains any position selected by the control lever by the connecting feedback link and servo piston (Figure 2a), it relocates the control valve spool to a metering position. The spool meters the fluid between the spool and servo piston to hold the camplate in its desired location. Speed of camplate movement can be varied by controlling the flow rate to the servo piston by the appropriate selection of control orifice diameter.

As the variable camplate is moved from its neutral position, a reciprocating action is created by the pistons in the pump cylinder barrel, generating a flow. Flow rate is determined by length and frequency of strokes.

Figure 2a - Detail of Control Lever and Camplate Connection

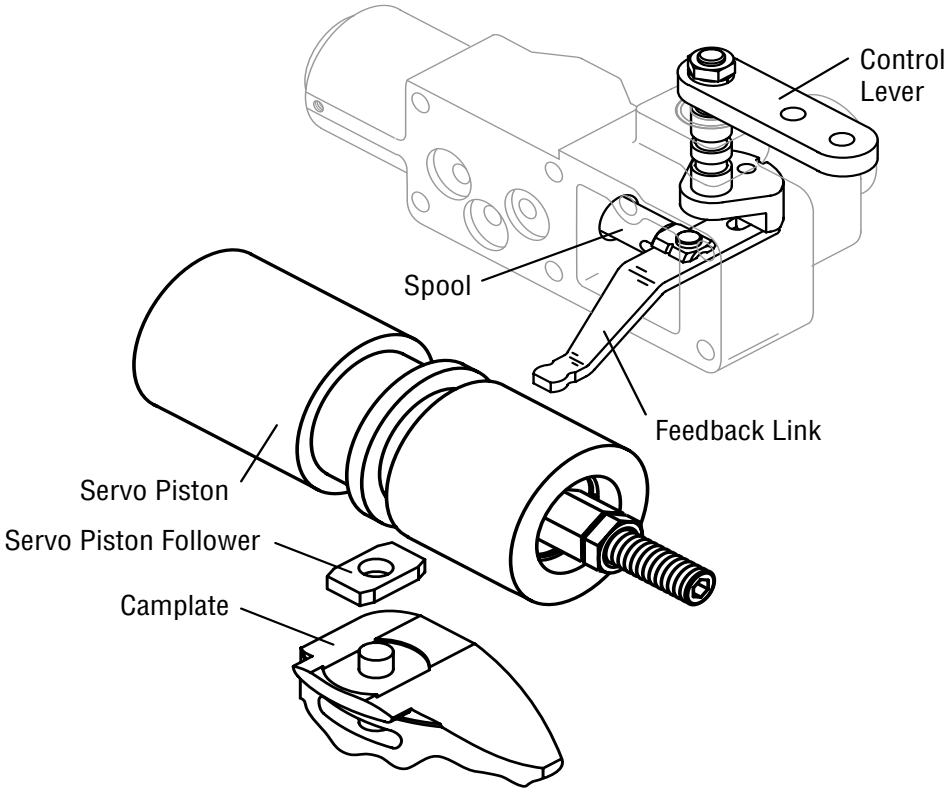
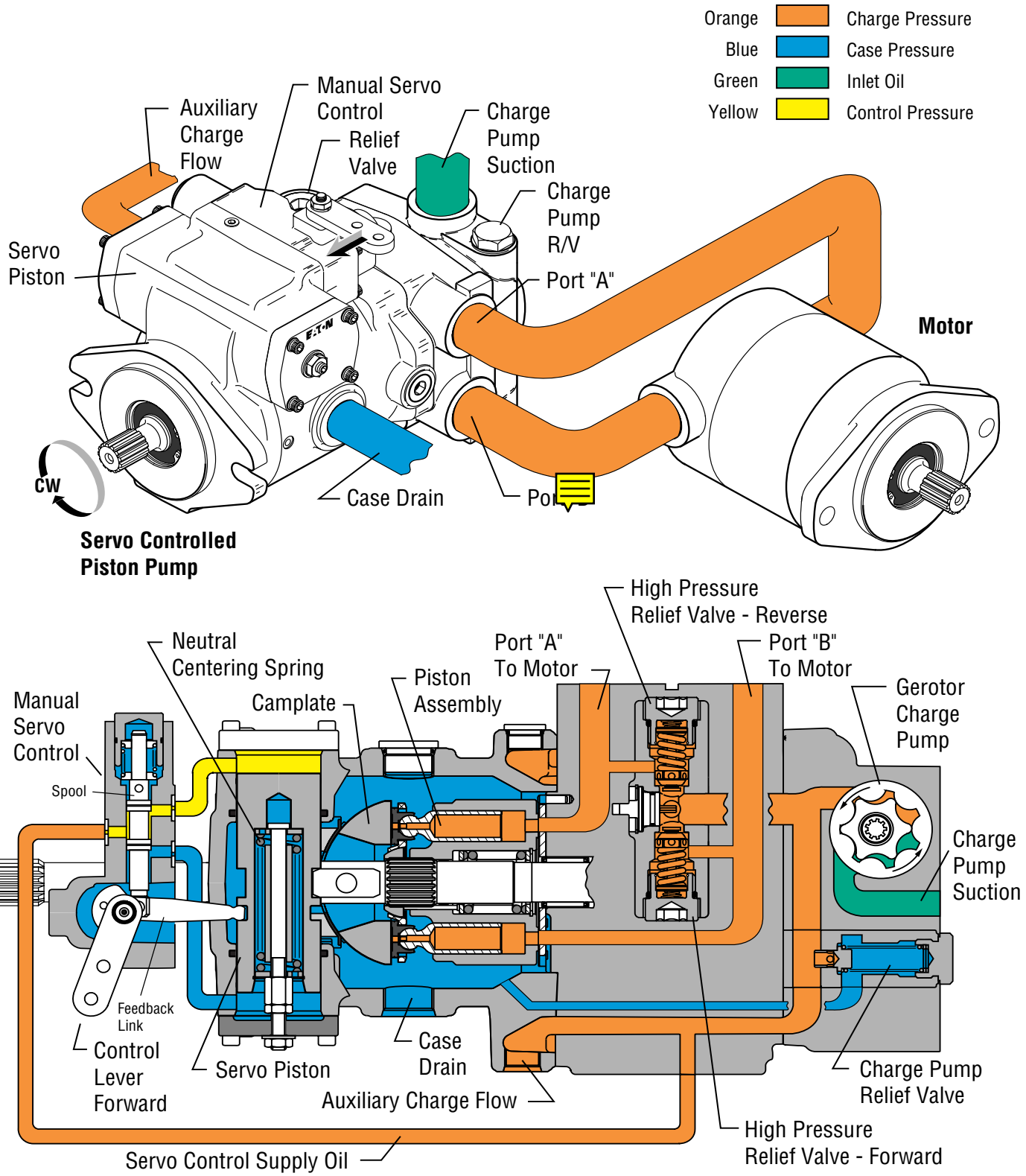


Figure 2 — Servo Control Function



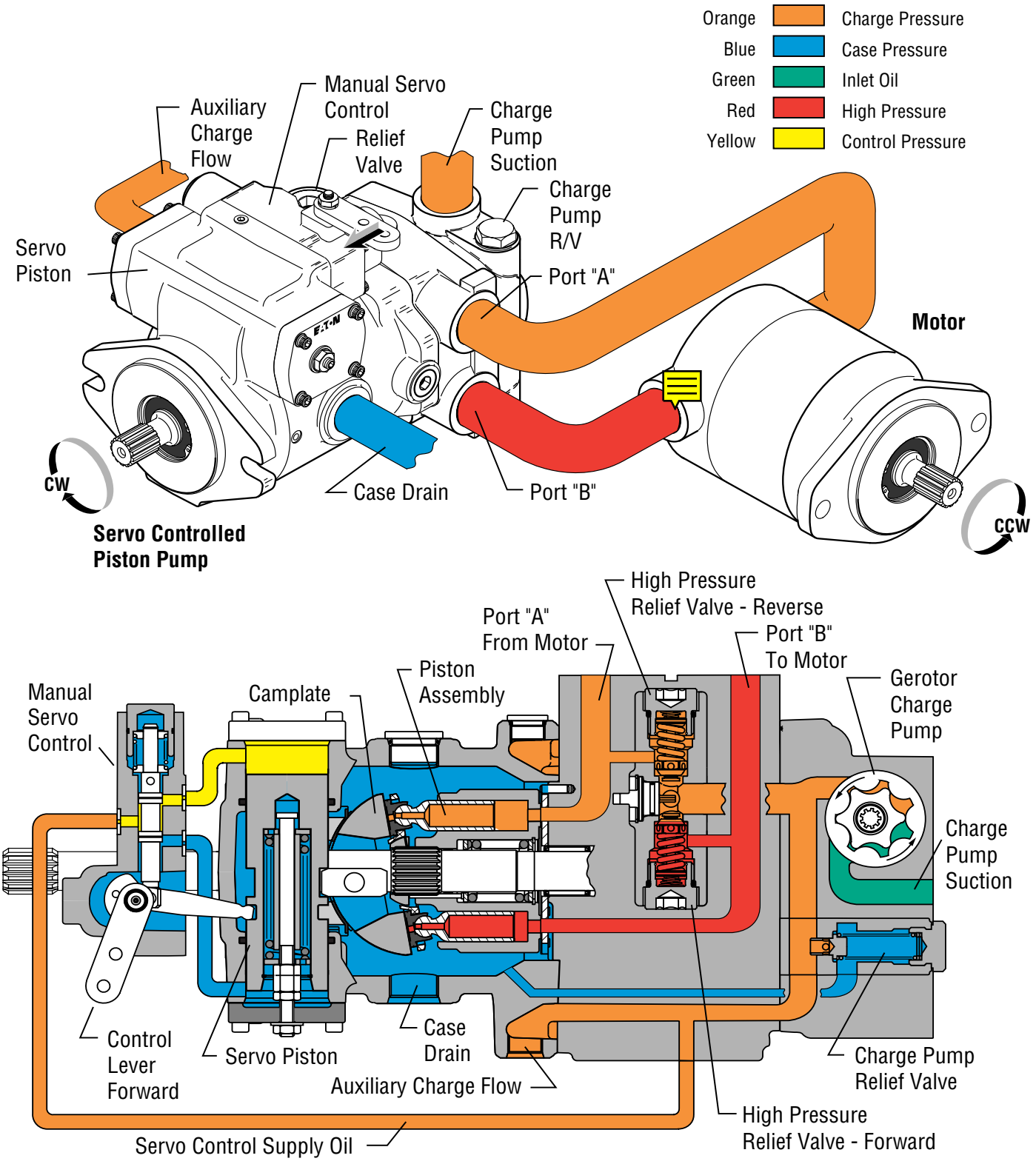
Cam Angle Forward Position

As the control lever is slowly moved forward the vehicle starts a forward movement (Figure 3). As the camplate begins to move, the piston assemblies start to reciprocate in the piston block. As the control lever continues a forward movement, the cam angle increases, the pistons reciprocate further, more oil is being pumped, and the speed of the vehicle is increased. The control lever can be moved forward until a full cam angle is reached, which also achieves maximum volume of oil being discharged from the pump. When the camplate begins to move, the relief valve on the discharge or pressure side seats because of the higher pressure differential. The other relief valve serves as a charge check, remaining open on the intake or low pressure side to continue supplying the closed loop system with charge oil.

The motor in this case is a fixed displacement type delivering a constant output torque for a given pressure throughout the speed range of the motor. The speed of the motor is dictated by the volume of oil discharged from the pump. A low camplate angle delivers a small volume of oil, causing the motor to turn slowly. As the camplate angle increases, the speed of the motor increases till the maximum camplate angle is reached.

The movement of the pump camplate in either the forward or reverse position controls the direction of the motor rotation.

Figure 3 — Cam Angle Forward Position



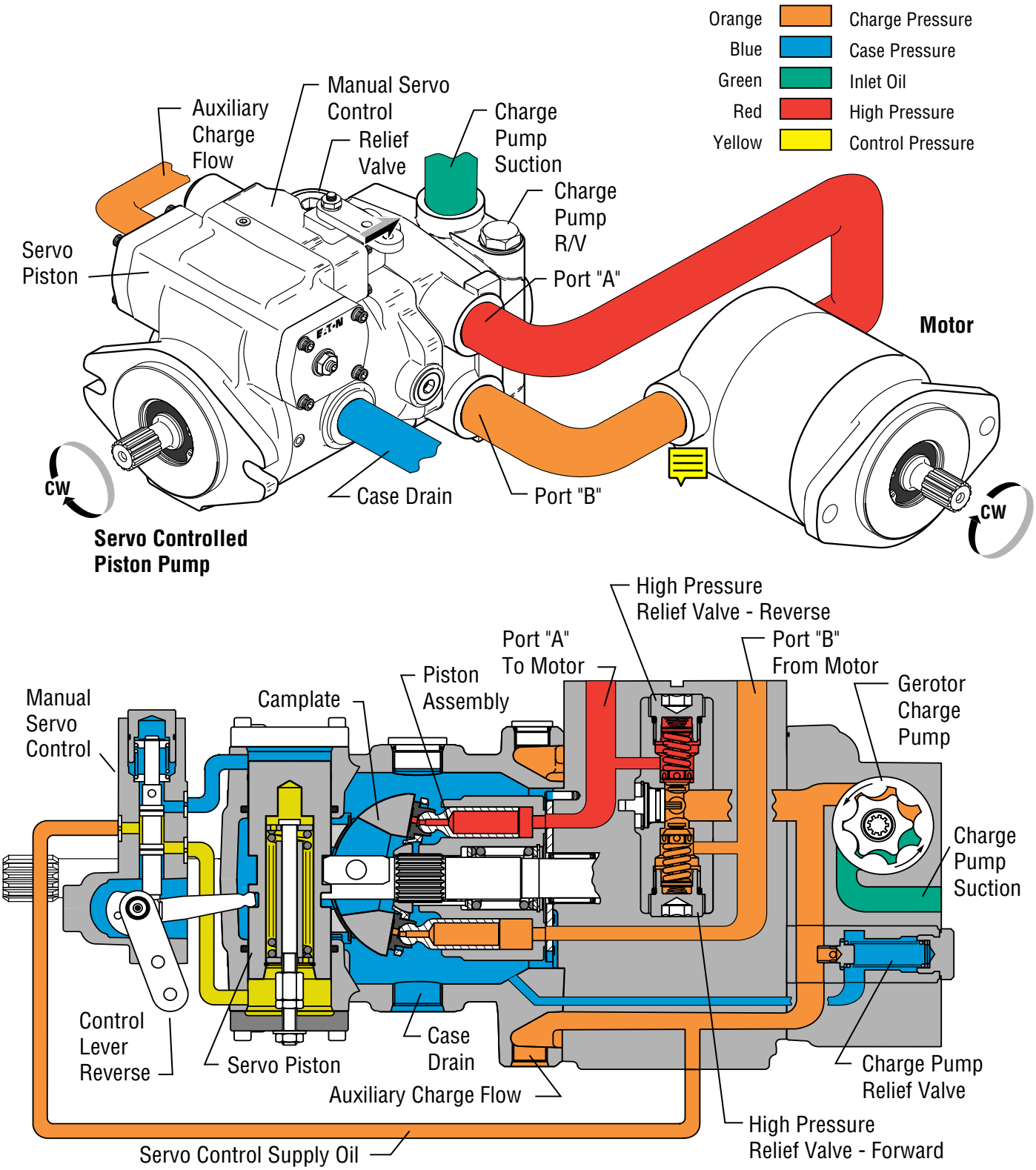
Cam Angle Reverse Position

When the control lever is slowly moved to the reverse position, the vehicle starts a reverse movement (Figure 4). As the camplate begins to move, the piston assemblies start to reciprocate in the piston block. As the control lever continues a reverse movement, the cam angle increases, the pistons reciprocate further, more oil is being pumped, and the speed of the vehicle is increased.

The control lever can be moved in reverse until a full cam angle is reached, achieving a maximum volume of oil discharged from the pump. When the camplate begins to move, the relief valve on the discharge or pressure side seats because of the higher pressure differential. The other relief valve serves as a charge check, remaining open on the intake or low pressure side to continue supplying the closed loop system with charge oil.

In the reverse position the pump shaft still rotates in the same direction, but the discharge of oil from the pump is reversed, thus reversing the motor rotation.

Figure 4 — Cam Angle Reverse Position

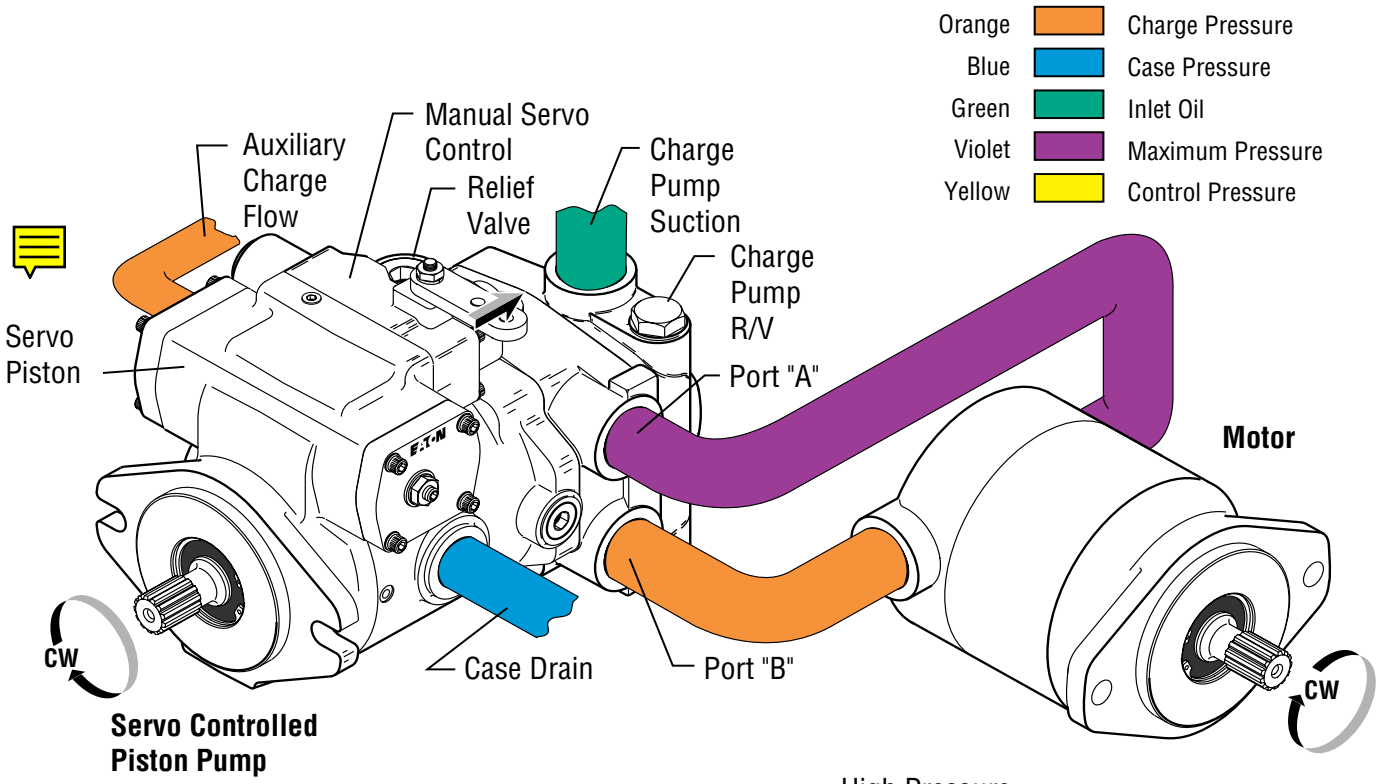


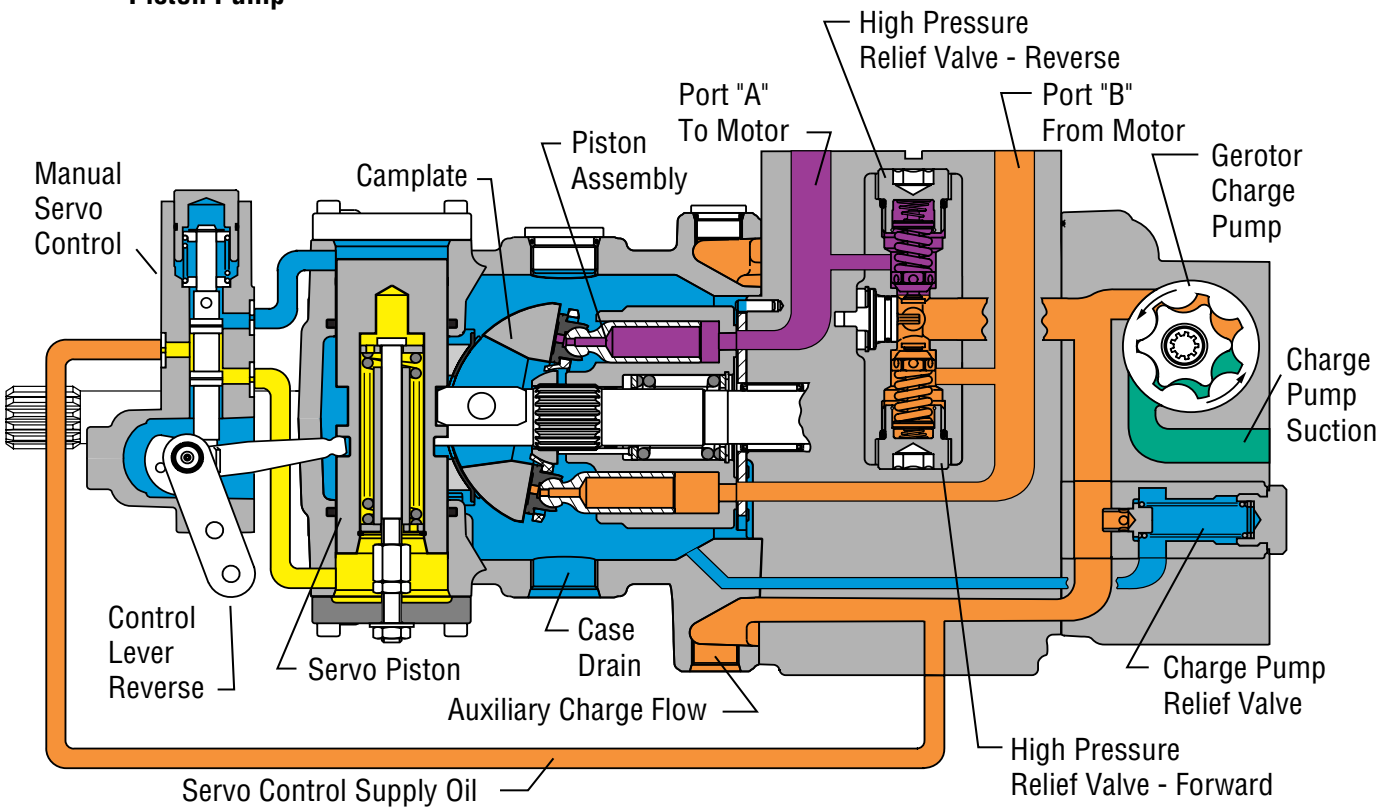
Cam Angle Reverse Position with Relief Valve Cross Relieving

Figure 5 shows the camplate in the full reverse position with the relief valve cross relieving. The function of the system relief valve is to relieve the pressure side of the system of excessive high pressure when the vehicle encounters a heavy load or stalls out.

When the maximum pressure exists and surrounds the closed loop system relief valve, it starts to open internally. Due to high pressure, the large spring in the relief valve compresses and opens an orfice allowing oil to bypass and take a pressure drop. The opposite relief valve serving as a check valve opens and allows the oil to flow to the intake side of the pump.

Figure 5 —
Cam Angle Reverse Position with Relief Valve Cross Relieving

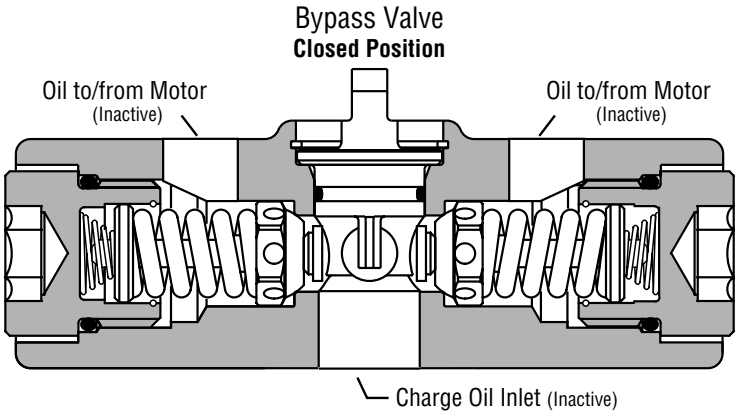




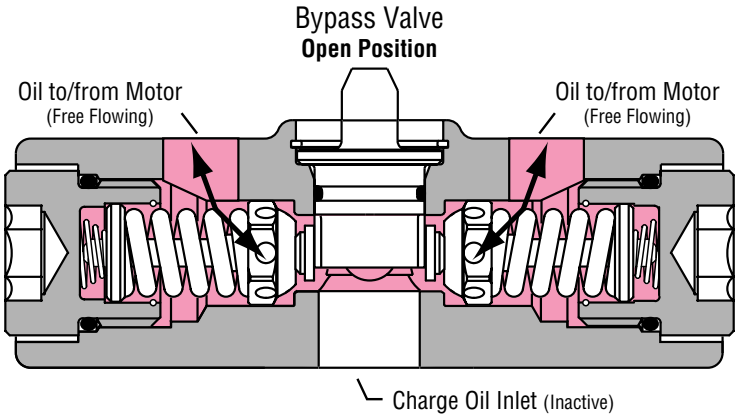
Operation of Bypass Valve

Pink — Free Circulating Fluid
Blank — Inactive Fluid

Engine not Running -
Hydrostatic
Closed Loop
Inactive



Motor
Turning Only -
Hydrostatic
Closed Loop
Open



The purpose of the bypass valve is to allow the movement of a disabled vehicle or to move a vehicle a short distance without starting the engine. When a hydrostatic driven vehicle is shut down, it is virtually impossible to move the vehicle without opening the hydrostatic closed loop circuit. If an attempt is made to push the vehicle, the hydraulic motor becomes a pump trying to pump oil to the hydrostatic pump. This creates a hydraulic lock between the motor and the pump. To overcome this condition, a bypass valve has been installed between the high pressure relief valves in the backplate of the piston pump. The bypass valve is a plug that contains a rotating stem which has a flat spade end that fits between the two ends of the high pressure relief valves. When the bypass valve is in the "closed position", the relief valves are also in the closed position as shown in the top illustration. When the bypass valve stem is rotated 90 degrees, the flat spade end spreads the relief valves to the "open position" as shown in the lower illustration. This allows the oil in the hydrostatic closed loop to "bypass" around the high pressure relief valves inside the pump backplate. The bypassing of oil inside the pump backplate will allow the motor to rotate freely when the vehicle is moved a short distance. The bypass valve is intended only for moving a vehicle a very short distance and is not intended for towing a vehicle behind a truck or tractor. Note: Serious damage to the hydrostatic drive will result if the vehicle is towed.

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