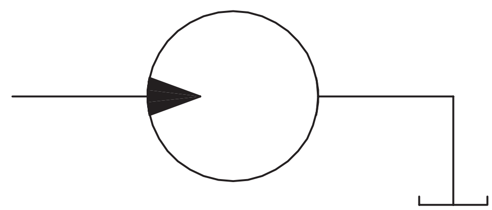
Hydraulic Motors

Hydraulic motors are rated in cubic inches per revolution. For example, a motor may have a displacement of 50 cubic inches. This means that 50 cubic inches of oil is required to rotate the motor shaft 1 revolution. The displacement affects the speed and torque a motor can develop. The larger the displacement, the more torque can be developed by the motor and the slower the speed. The torque developed by the motor is also determined by the pressure.

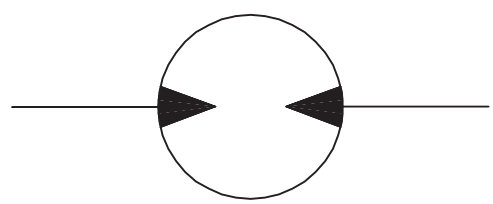
Motor symbols with a single internal arrow indicate that the motor turns in one direction only. The motor shown to the right is internally drained. This means that the oil that bypasses internally and collects behind the shaft seal is drained to the motor outlet. The tank line pressure should not exceed the pressure rating of the shaft seal.



Single Direction Motor

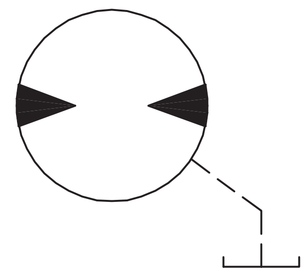
Most hydraulic motors that are built today are bi-directional. Many times on the hydraulic schematic, it may be shown as a unidirectional motor because the machine itself only runs in one direction. On systems where the motor rotates in both directions, one of two things is done to prevent blowing the shaft seal:

- A high pressure shaft seal is used
- The motor is externally drained.



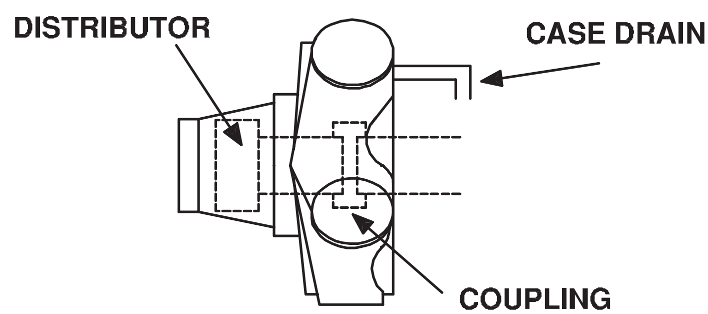
Bi-Directional Motor

Some of the internal gear type motors (Char-Lynn, for example) do have high pressure seals and external drains are not required. Vane and piston type motors usually have external drain lines. These drain lines should be piped directly back to tank terminating below the fluid level. The drain line should not be piped in with return lines. Maximum pressure in the drain line should not exceed 5-25 PSI, depending on the type motor being used.



Radial Piston Motors

Radial piston motors are used on low speed, high torque applications. This motor operates very much like a car engine. A rotary valve spool, also known as a distributor, directs fluid to and from the motor pistons. The distributor shaft is coupled to the motor drive shaft.



If the coupling wears then the motor can get out of time. Just like a car engine it may run very erratically or not at all. On some motors you can remove the distributor and check the coupling for wear. Be sure to observe the timing marks on the distributor and motor drive shaft when removing.

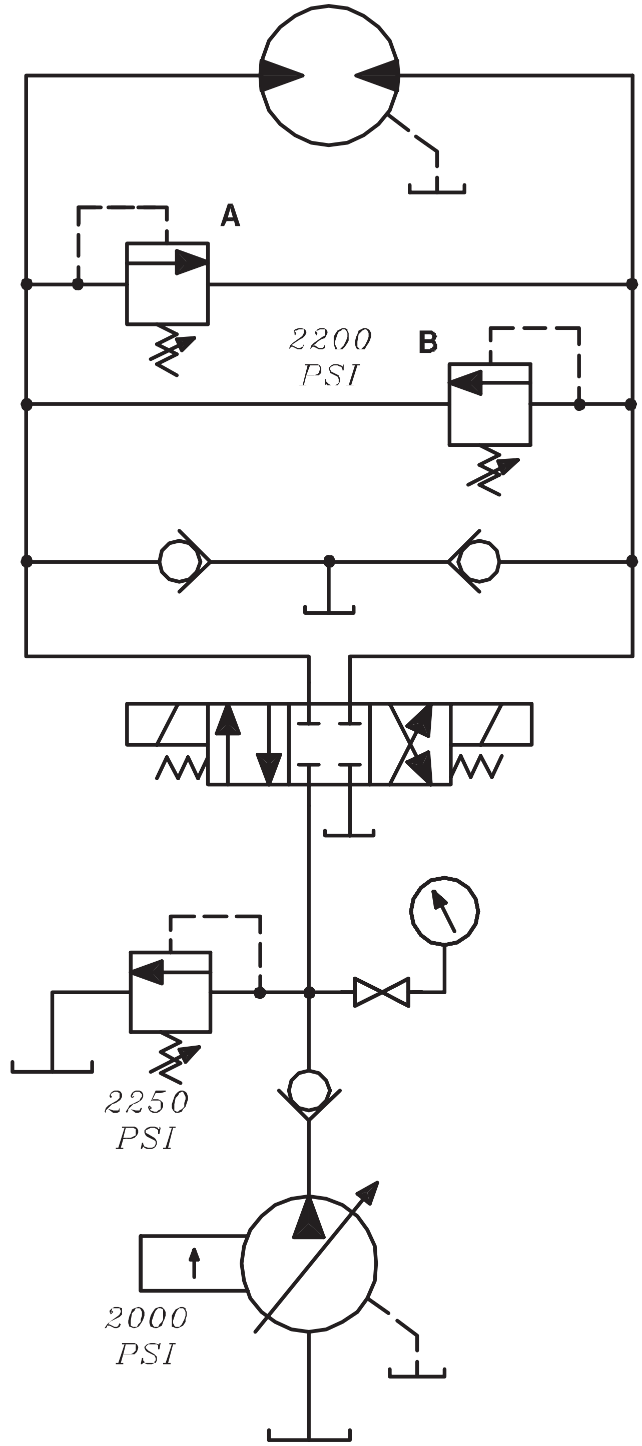
When the motor shaft is horizontal as shown, the top drain connection should be used to keep fluid in the motor case at all times. Case pressures in radial piston motors can be slightly higher than the vane and piston motors. On the Staffa motor, the standard shaft seal is rated at 45-50 PSI.

On many radial piston motors, the outlet pressure must be higher than the case drain pressure. A back pressure check valve may be required for this purpose. When the motor is braking there must be low pressure at the motor inlet to prevent cavitating and destroying the motor.

Motors and Crossport Relief Valves

Crossport relief valves perform two functions in a hydraulic motor circuit.

- Absorb shock when initially starting the motor.
- Brake the motor when stopping.



When the directional valve in the example first energizes, oil is ported to the motor. An immediate pressure spike will occur because of the fluid deadheading into the motor. The crossport relief valve in the pressure line will open momentarily and dump the pressure spike back to tank through the directional valve.

When the valve is de-energized after driving the motor, the inertia of the moving load will tend to drive the motor. The motor will momentarily turn into a pump. Since the A and B ports are blocked, pressure will build up at the motor outlet. The relief valve in the outline line will then open and “brake” the motor to a stop.

The oil flowing out of the crossport relief valve flows back into the motor inlet. Because of the external case drain, there is less oil flowing out of the motor than what initially went in. A vacuum will be created at the motor inlet because there is less oil at the inlet than what the motor needs. The vacuum pressure pulls the oil out of the reservoir, through the check valve and into the motor.

Crossport Relief Valves in a hydraulic circuit should be:

- Located as close as possible to the hydraulic motor.
- Set 200-400 PSI above the pressure required to move the maximum load. Crossport relief valves are direct operated type relief valves. They crack open at a much lower pressure than when full open.

Crossport Relief Valve Adjustment Procedure

In any hydraulic circuit, the highest pressure valve(s) should be set first. The following procedure can be used.

1. Observe the pressure gauge while running to determine the maximum operating pressure. In the example on the previous page, the operating pressure is 1800 PSI.

2. Turn the pump off and plug off the lines going from the crossport relief valves to the hydraulic motor. Prior to removing the lines, actuate the directional valve manually in the “A” and “B” positions, allowing the pressure to bleed down to 0 PSI.

3. Turn the main relief and both crossport relief valves fully CCW. Turn the pump compensator fully CW.

4. Turn the pump on; there should be low pressure on the gauge.

5. Turn the main relief valve adjustment CW until the correct setting is reached (2250 PSI in the example).

6. Energize the directional valve in the "A" position and turn the "A" crossport relief valve adjustment CW until the correct setting is reached (2200 PSI).

7. Energize the directional valve in the "B" position and repeat step 6 for the "B" crossport relief valve.

8. Turn the pump compensator CCW to 2000 PSI.

9. Turn the pump off and manually actuate the directional valve in both directions several times to bleed the pressure to 0 PSI. Then remove or isolate the gauge and re-connect the lines to the motor.

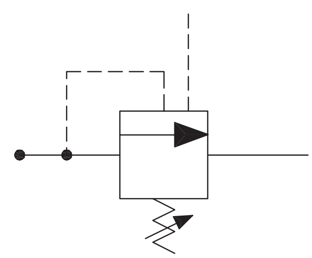
Setting Crossport Relief Valves

Brake Valve

The brake valve is a normally closed pressure control valve. The valve performs two functions in a hydraulic motor circuit.

- Prevents the motor from "running away" or overspeeding due to the inertia of the moving load.

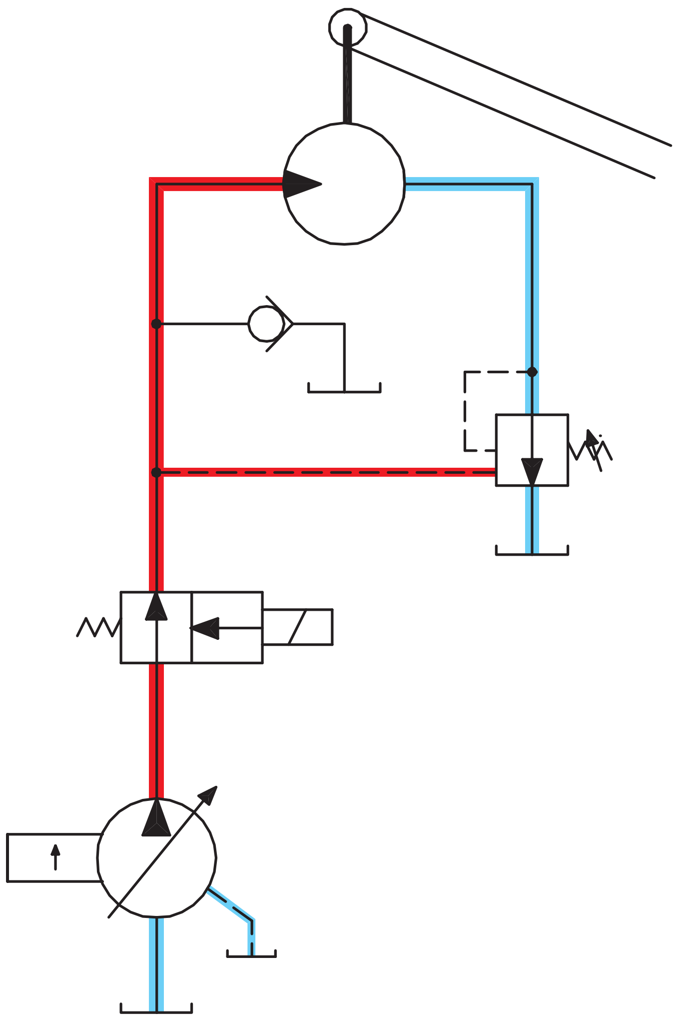
- Stops the motor smoothly.

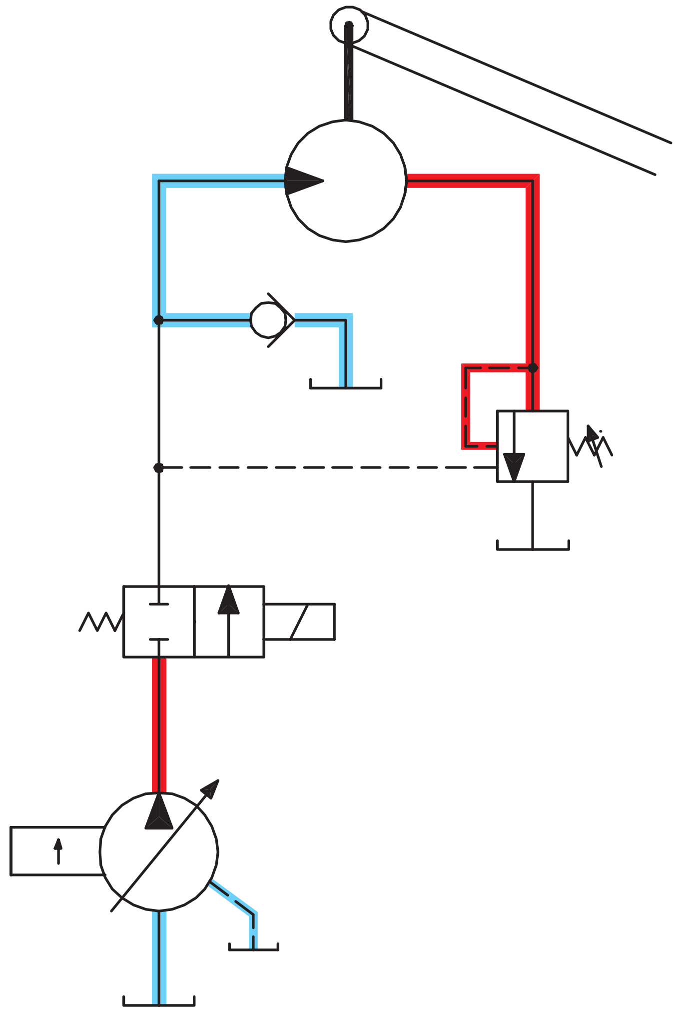


There are two pilot lines that control the brake valve. The valve works exactly the same as the counterbalance valve shown on page 3-48 of the "Pressure Controls" section. The external remote pilot line is ported to a much larger area of the valve spool than the internal pilot line. The area difference is usually a 3:1 or 4:1 ratio. Since the remote line pressure acts on a larger area, it will shift the valve open at a lower pressure than will the internal pilot pressure. The remote line is pressurized when driving the motor. The internal line pilot pressure will open the valve when braking and stopping the motor. The major manufacturer of these valves is Sun Hydraulics. On their valve the adjustment is rotated clockwise to *decrease* the pressure setting. Consequently turning the adjustment counter-clockwise will *increase* the pressure required to open the valve.

Example

When the directional valve solenoid is energized, pilot pressure is directed to shift the brake valve open. The motor can now rotate and drive the conveyor. If the conveyor starts driving the motor shaft faster than the pump flow does, the pressure in the remote line will drop. The brake valve spool will shift partially closed, restricting the oil coming out of the motor. This prevents the motor from over speeding or running away.



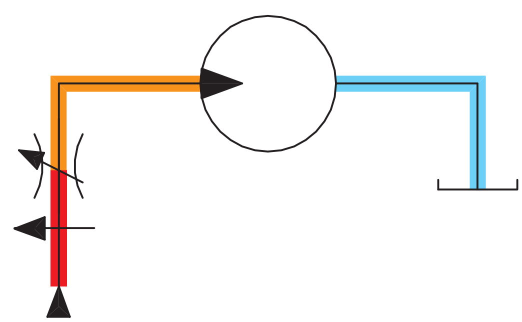


When the directional valve is de-energized, pump flow is blocked to the motor. The motor will tend to continue rotating. Pressure will now build at the outlet of the motor in the internal pilot line. A higher pressure is required to shift the valve spool open. For example, if the valve has a 4:1 ratio and the remote line pressure opened the valve at 250 PSI, then 1000 PSI would be required in the internal pilot line to hold the spool open. The 1000 PSI back pressure at the motor outlet brakes and eventually stops the motor. As the motor is braking, a vacuum occurs at the motor inlet. Oil flows from the reservoir, through the check valve and into the motor, preventing cavitation.

Motor Speed Control

For precise speed control of a motor a meter in or meter out circuit should be used. On motor drives where the load constantly changes, a pressure compensating control should be used. A pressure compensating flow control will maintain a constant flow through the valve regardless of pressure changes in the system.

Internally Drained Motors



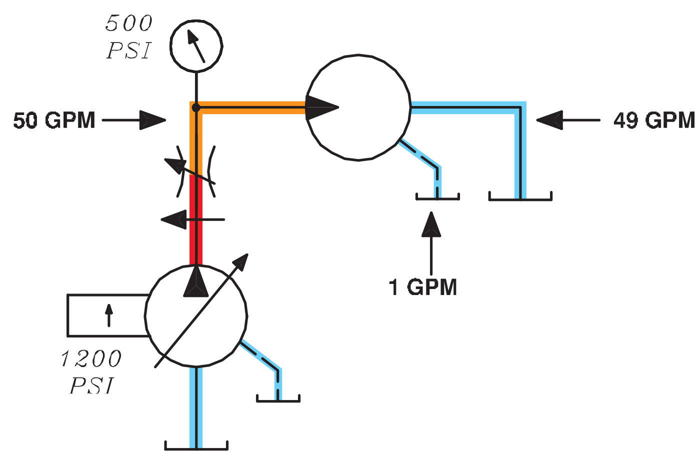
On internally drained motors, a meter in flow control will generally control the speed as well as meter out flow control. This is because any bypassing is drained to the outlet of the motor.

There are advantages to both meter in and meter out circuits. An advantage to the meter in circuit is that there is little or no back pressure at the motor outlet. This reduces the pressure required at the motor inlet to turn the load. Another advantage to the meter in circuit is that the pump compensator or relief valve pressure is not always present at the motor inlet as it is in a meter out circuit. Anytime a load that tends to "run away" is driven, a meter out control should be used.

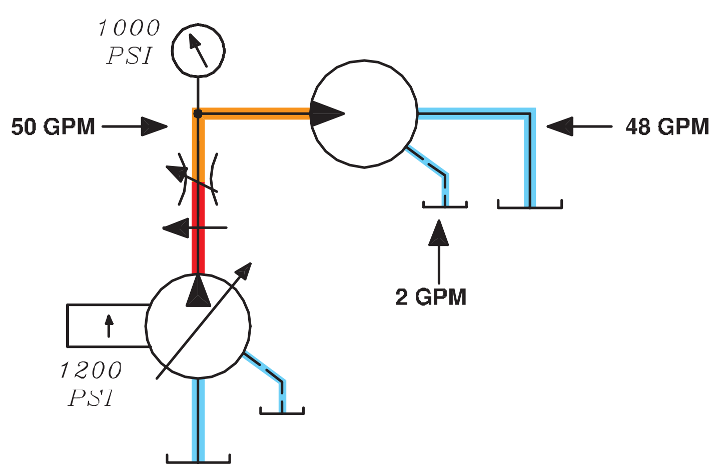
Externally Drained Motors

Meter In

In the circuit shown, a pressure compensating flow control is set to meter 50 GPM to the motor. With the pressure required to move the load at 500 PSI, 1 GPM is flowing out the case drain. 49 GPM is actually used to rotate the motor shaft.

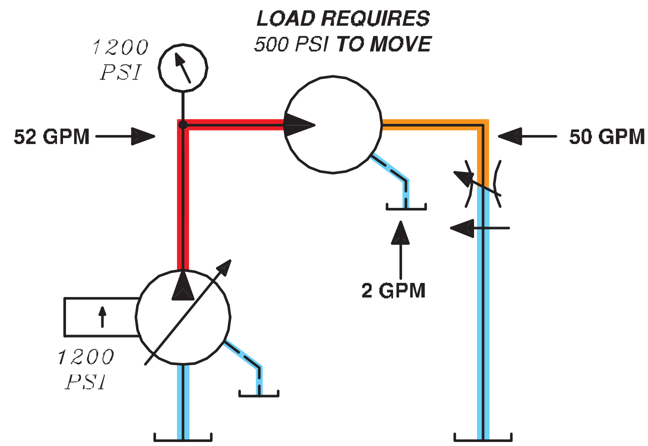


When the pressure increases to 1000 PSI to drive the motor, flow through the flow control stays the same, 50 GPM. Because the pressure is higher the motor will bypass more fluid. Only 48 GPM is used to drive the motor. The motor will slow down.

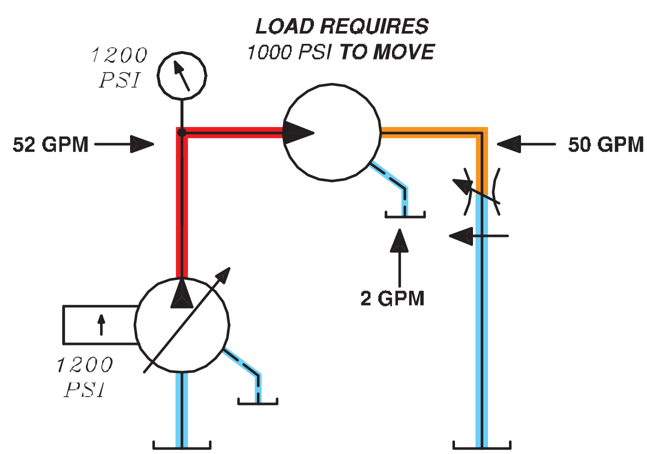


Meter Out

The flow control is now connected in the tank line and set for 50 GPM. Back pressure created by the flow control causes the pressure to rise to the compensator setting, even though it only takes 500 PSI to drive the smaller load. System pressure (1200 PSI) causes the motor to bypass 2 GPM. The meter out flow control only affects the oil that exhausts out of the motor, 50 GPM. 50 GPM is used to drive the motor at this time.



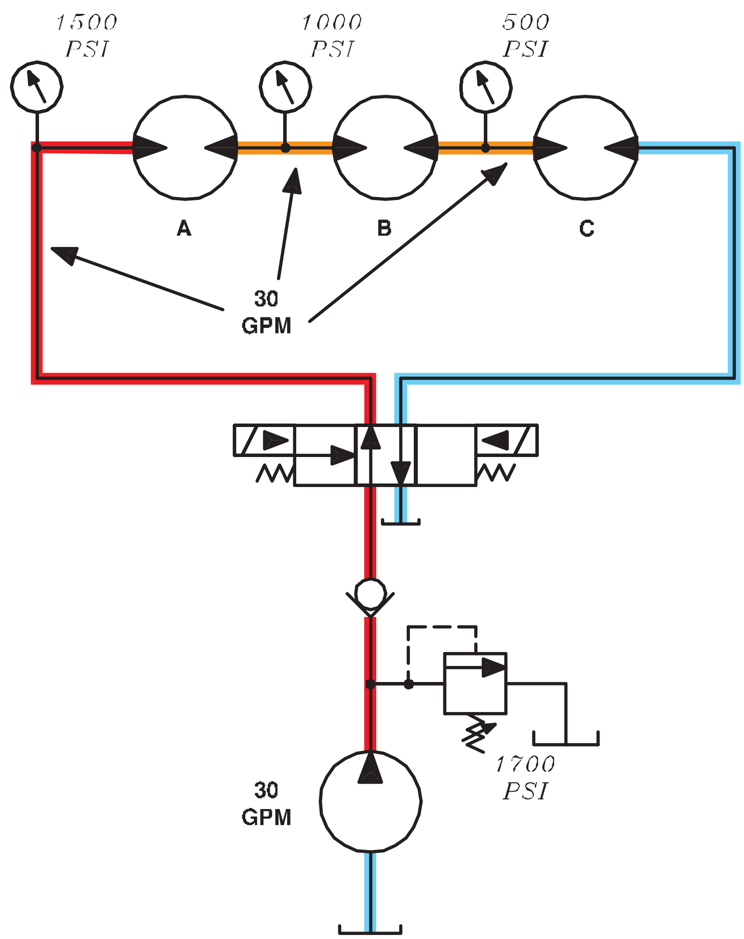
It now requires 1000 PSI of the total system pressure to drive the larger load. Pressure at the motor inlet stays at 1200 PSI because of the restriction created by the flow control. Since the pressure at the motor inlet has not changed, case drain flow remains at 2 GPM. Should the motor become worn and bypassing increase, the speed will remain the same because the meter out flow control maintains 50 GPM at the motor's outlet.



Motors In Series

Internally Drained Motors

Hydraulic motors that are connected in a series arrangement will all turn at the same speed. The oil that flows into the first motor (30 GPM), also flows into the second motor. The oil that exhausts out of the second motor (30 GPM) flows into the third motor.



Motors that are connected in series are usually used on lightly loaded applications. The pressure at the inlet of the “A” motor has to be high enough to drive all three motors. In the example, 500 PSI is required to drive motor C. The 500 PSI exerts a back pressure on the outlet of motor B. Before motor B can turn, the pressure has to be high enough to overcome the 500 PSI back pressure, plus whatever is required to turn it’s own load (500 PSI). Therefore, 1000 PSI is required at the inlet of motor B.

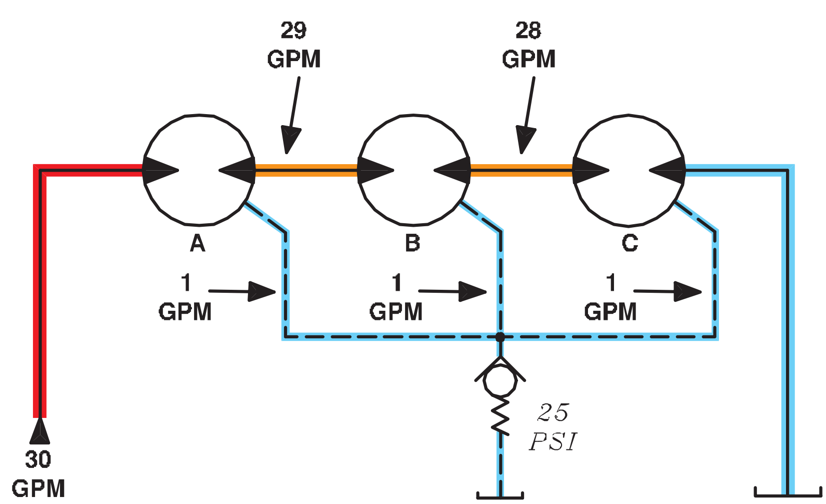
The 1000 PSI at the inlet of B exerts a back pressure on motor “A”. If the load on motor A requires 500 PSI, then 1500 PSI is needed to drive all three motors.

Any bypassing of internally drained motors is ported to the inlet port of the next motor (except motor C in the forward direction). The bypassing of one motor will not effect the other two. For example, if motor A is bypassing, motors B and C continue to receive 30 GPM. Motor A will turn slower than B and C in this case.

Motors that are internally drained all have a maximum back pressure rating at the motor outlet. If this pressure is exceeded, the shaft seal will blow out. Many times series motors are externally drained for this reason.

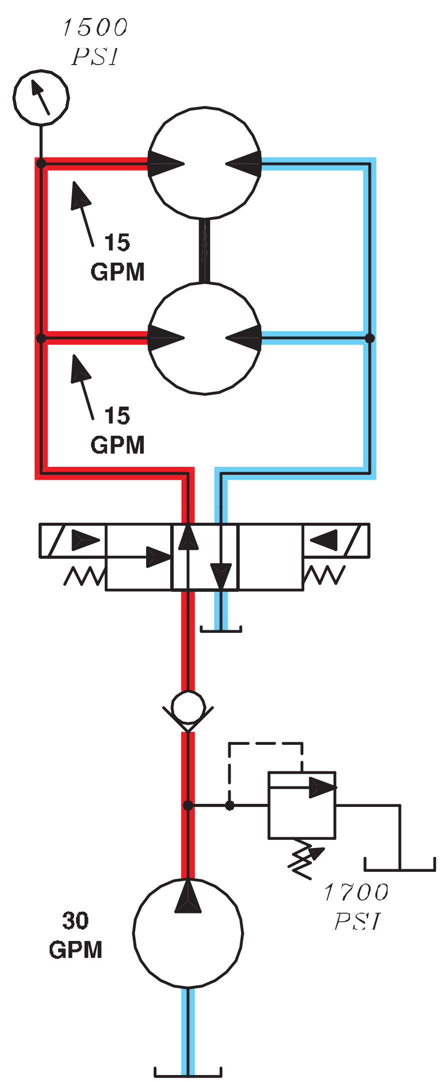
Externally Drained Motors

The bypassing of externally drained motors will affect the flow going into the next motor. In each of the motors, 1 GPM of leakage is flowing out of the case drain line. In this case motor A will turn slightly faster than B, and B will turn a little faster than C. The check valve will maintain oil in the motor cases.



On gear and vane type motors, the oil that flows out of the case drain is only the oil that bypasses the non moving components (port plates, seals, and bearings). This flow may not change that much over a period of time. On piston type motors, the oil bypasses the moving pistons. This flow can be checked to determine which motor is bypassing.

On series motors, any motor that stalls will prevent the other motors from turning. To check the motors, turn the system off and make sure the pressure in all lines is at 0 PSI. Disconnect the hose at the outlet of the first motor. Run the line into a container or back to the reservoir and start the system. Do not hold the line as the test is made. If the motors turns then that motor is obviously good. Reconnect the hose, and make the same check with the next downstream motor. Continue checking each motor outlet line until the bad motor is found.



The other consideration on series motors that stall is that the load may exceed the pressure available at the inlet of the first motor. The system should be observed for a mechanical jam.

Motors in Parallel

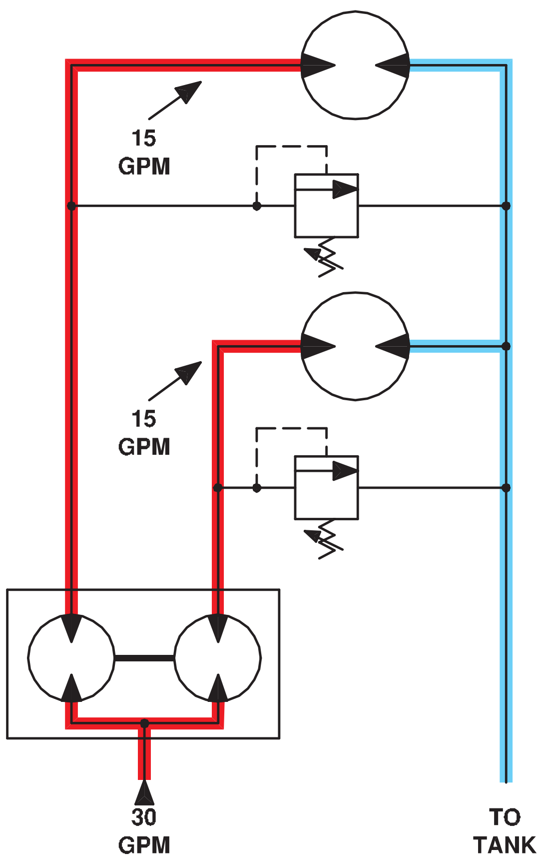
Motors connected in a parallel arrangement are normally used to drive heavy loads. Motors connected in parallel must have a common load or use a flow divider. Otherwise, the oil will take the path of least resistance and drive the motor with the lightest load.

The advantage of connecting motors in parallel is that system pressure is available to drive each motor. This was not the case with series connected motors. In the example, 1500 PSI is acting on each motor to move the load. Twice the torque to drive the load can be developed with two motors in parallel. Remember, that with hydraulic motors torque depends on the pressure and cubic inch displacement. Twice the displacement is available with two motors than with a single motor.

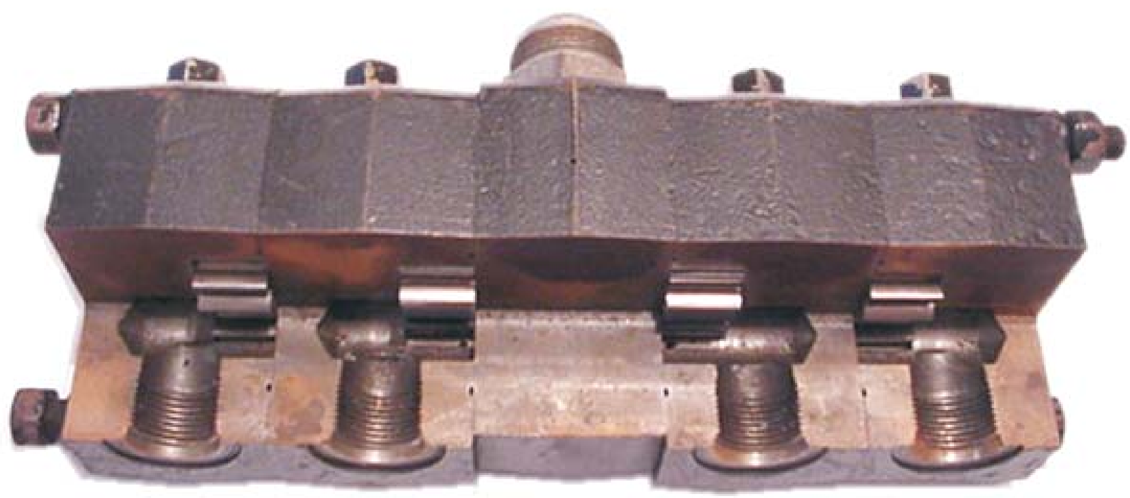
Motors in parallel will split the incoming pump flow. With the pump delivering 30 GPM, 15 GPM will flow into each motor. One motor cannot turn without the other since they are driving a common load.

Flow Dividers and Parallel Motors

To drive parallel motors at the same speed that do not have a common load, a flow divider is used. Pressure compensating flow controls can also be used, however a flow divider is more common.



The flow divider normally consists of two or more gear sets in a single housing. Some dividers use a sliding pool to divide the flow. The gear sets have a common shaft between them. A 50/50 ratio divider will split the inlet volume equally to the outlet ports. Flow dividers can also be used to synchronize the speed of two cylinders that do not have a common load.



Flow Divider

Many times the relief valves shown in the schematic are located in the flow divider housing. The purpose of the relief valves is twofold:

- Absorb Shock

- Allow one motor to continue turning if one motor stalls.

The reliefs should be set 400 PSI above the pressure required to drive each motor. See the crossport relief valve section for the proper adjustment procedure.