Introduction

Counterbalance valves are one of the most misunderstood products in the hydraulic industry. Many people tend to complicate the task of selecting a counterbalance valve and as such avoid opportunities. The goal of this Technical Tips Section is to hopefully eliminate some of this confusion and help you chose the correct valve for your application. It is only a guide! It is not meant to be your only method of input, nor is it meant to replace good hydraulic common sense and reasoning.

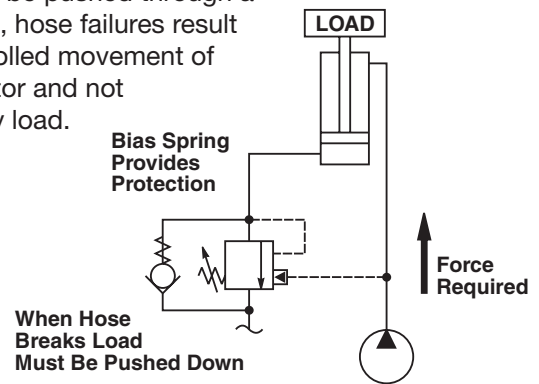## Application

DO I NEED A COUNTERBALANCE VALVE?

A counterbalance is generally used for one or more of the following purposes:

Control an Overrunning Load – It restricts the flow from an actuator, thus forcing the load to be pushed through the restriction and providing control of the potential runaway load. This also helps in the prevention of cavitation.

Control in Critical Metering Applications – The outward restriction also helps to gain control of systems with varying loads and speeds.

Holding a Load – Much like a pilot operated check valve, a load is held in one direction until the appropriate pilot pressure is available unseat the check and pass fluid.

Help Protect Against Hose Failures – Since the fluid must be pushed through a restriction, hose failures result in a controlled movement of the actuator and not a runaway load.

LOAD

Bias Spring
Provides
Protection

Force
Required

When Hose
Breaks Load
Must Be Pushed Down

NOTE: Counterbalance Valves are only needed if the application calls for varying loads or varying speeds. If the load and speed are fixed, flow control valves and pilot operated check valves may be substituted at generally a lower cost.

Operation

An understanding of the general operation of a counterbalance valve is required before proceeding further into valve selection.

The counterbalance valve is a pressure control device and functions as follows: Pressure is developed at the Work Port of the holding valve when the actuator is pressurized. This pressure acts on the differential area, and the force generated is counteracted by the bias spring. When there is sufficient pressure present to overcome the spring setting, the poppet begins to shift, allowing fluid to pass through the valve port to tank via the control valve.

To assist in the shifting of the poppet, an external pressure source (generally the opposite side of the actuator) is connected to the pilot port of the counterbalance valve. This pressure is applied to the pilot area and assists the differential area in opening the valve. The pilot assist reduces load pressure required to open the valve, and allows for a reduction in the horsepower required to move the load. If the load attempts to "run away" (move faster than the pump can supply flow), the pilot signal will diminish and the piston will begin to close restricting flow to tank and thus controlling the load. The counterbalance piston will maintain a position that maintains a positive pilot signal and will control the descent of the load.

Valve
Port

Differential
Area

Pilot
Port

Work
Port

By-Pass
Check

Bias Spring
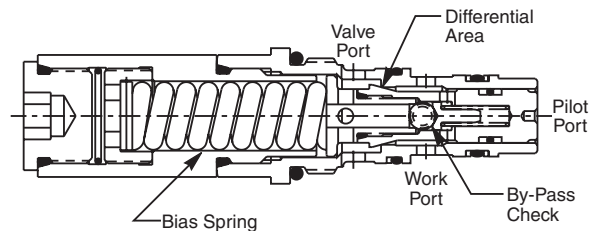
An added feature of the counterbalance valve is its built-in thermal relief characteristic. A temperature rise can cause thermal expansion of the hydraulic fluid trapped between the actuator and the counterbalance valve's poppet. As the pressure increases and reaches the bias spring setting, the poppet unseats and a few drops of oil are allowed to escape through the valve port of the counterbalance valve. This relieves the thermal expansion of oil, allowing the counterbalance valve to continue holding the load in the same position.

When the flow is reversed to the actuator, then pressure unseats the built-in bypass check portion of the counterbalance valve allowing flow to pass from the valve port to the work port. When no pressure is applied to either port of the counterbalance valve, the load is held in place.

CV

Check Valves

SH

Shuttle Valves

LM

Load/Motor Controls

FC

Flow Controls

PC

Pressure Controls

LE

Logic Elements

DC

Directional Controls

SV

Solenoid Valves

PV

Proportional Valves

CE

Coils & Electronics

BC

Bodies & Cavities

TD

Technical Data

CV

Check Valves

SH

Shuttle Valves

LM

Load/Motor Controls

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Solenoid Valves

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Proportional Valves

CE

Coils & Electronics

BC

Bodies & Cavities

TD

Technical Data

Valve Series

Parker offers the four series of products outlined below:

MHC – The MHC series is a threaded cartridge style counterbalance valve. This series is ideal for incorporating into an integrated manifold or for installation directly into the port of the actuator. There are various flow rates and pilot ratios available for the MHC Series.

CB101 – The CB101 is also a threaded cartridge style counterbalance valve. It also is ideal for incorporating into an integrated manifold or for installation directly into the port of the actuator. The CB101 has an industry common cavity (C10-3) and is available in three pilot ratios.

E2 Series – The E2 Series valves are threaded cartridge style counterbalance valves. They are available in standard and Vented configurations. In the Vented configurations, the valves maintain their settings regardless of backpressure. There are various flow rates and pilot ratios available.

E2A020

MHC-010

CB101

E6B060
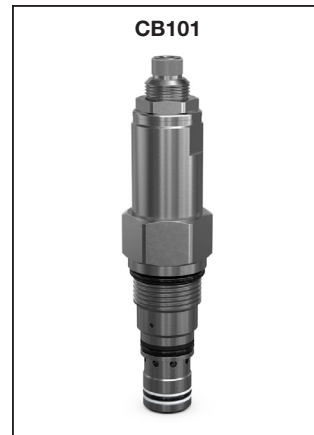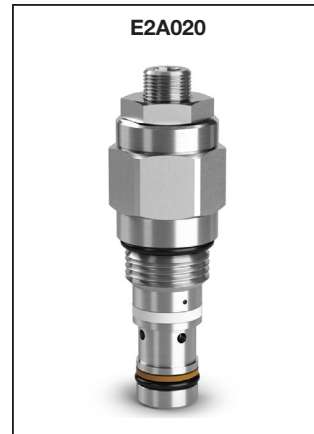
Selecting Options

Below is a brief description of the options available on the ordering information pages and a brief explanation of when each would be used.

Flow Selection – Generally the counterbalance valve is sized according to the actual flow the valve will see and not the system flow. Note that the ordering information callout is the nominal flow rate and not the maximum. In other words, refer to the pressure drop curves when sizing the valves. For example: A MHC-010 can flow 25 GPM, but is rated as a 10 GPM valve. It is possible to oversize a counterbalance valve! If the counterbalance is oversized, the annulus between the poppet and the seat is too large, thus the poppet opens too far causing instability. Remember you are gaining control by causing a restriction. If you oversize the counterbalance valve, the restriction is reduced and so is the control.
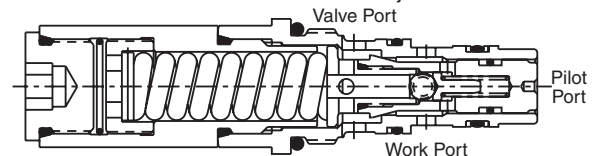
Vented versus Non-Vented – With a standard counterbalance valve, the bias spring is internally vented to tank. This means any pressure on the tank line is sensed in the bias spring chamber and additive to the setting. Thus, the pressure at the work port now must be greater than the bias spring plus the tank

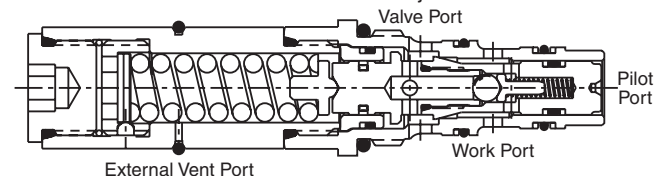pressure before the counterbalance poppet will shift allowing flow.

A vented style counterbalance valve relieves the bias spring chamber to atmosphere. Thus, the spring chamber is in no way related to the tank chamber of the counterbalance valve. So, if the pressure on the tank line is high, or if the pressure setting is critical, then a vented style counterbalance valve would be required.

Parker's counterbalance valves are externally vented. This means no extra porting or manifold costs are incurred when a vented counterbalance is needed.

MHC-010-S*S* Non-Vented Counterbalance Adjustable

Valve Port

Pilot Port

Work Port

MHC-010-V*S* Vented Counterbalance Adjustable

Valve Port

Pilot Port

Work Port

External Vent Port

Selection Options (Continued)

Pilot Ratio – The pilot ratio is the ratio of the pilot area versus the differential area poppet. Thus, the higher the pilot ratio, the less pressure that is needed to assist the load pressure in unseating the poppet. This means there is less restriction to the overrunning load, resulting in less horsepower required and more control of the load. So higher pilot ratio equates to less restriction to the overrunning load, less control and less horsepower required. Lower ratio equates to more restriction to the overrunning load, more control and more horse-power required. The pilot ratio decision is one of Horsepower versus Control. For reference the most popular ratio is 3:1.

Pilot Ratio

10:1
6:1
4:1
1:1

Less
Control/Horsepower

More
Control/Horsepower
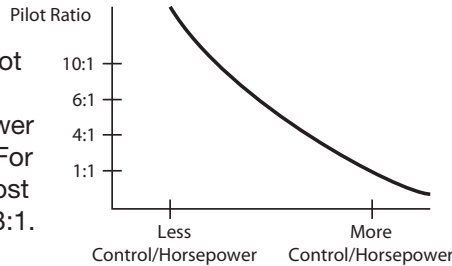
Sample Ratios:

10:1
Primary function is motor control and hose break protection
Loads moving at fast speeds and positioning is not critical

7.5:1, 6:1 and 5:1
Most popular starting ratio

4:1 and 3:1
Positioning is critical such as a pick and place application
Greater stability

1:1   Motor control application

ADJUSTMENT TYPE

Parker offers counterbalance valves with adjustable and non-adjustable pressure settings. The non-adjustable or shimmed version is recommended for most applications as it prevents tampering or improper adjustment by uneducated end users.

SELECTING SETTINGS

There are three basic settings to consider before finalizing a counterbalance valve for your application.

Holding Setting – The holding setting is sometimes referred to as the counterbalance setting. It is the maximum load setting you expect the counterbalance to hold. Note that the counterbalance valve should be set for the absolute maximum hold pressure required. Also note that counterbalance valves are restrictive type devices and as such are not ideal for low pressure applications, such as those below 750 psi. The holding setting is the setting you choose when selecting a counterbalance valve.

Thermal Setting – Counterbalance valves have a built-in thermal relief valve that compensates for the expansion of oil, due to temperature, by bleeding off excess pressure. In other words, the thermal setting is the pressure that the counterbalance will unload at if no pressure is present at the pilot port. Obviously, this setting should be above the holding setting. The Parker **MHC** counterbalance valves are automatically set 1000 psi above the holding setting of the valve. *You do not specify this setting, only the holding setting.*
For the **CB101** Series, you do specify the Thermal/Crack setting in the model code. The holding setting (maximum load induced pressure) is 70% of that specified setting. Example: Hold at 3000 psi, crack at 4285 psi. For the **E2** Series, you specify the Thermal/Crack setting in the model code. The crack setting (maximum load induced pressure) should be 1.3 times the hold. Example: Hold at 210 Bar, crack at 273 Bar.

Pilot Area – The pilot pressure required to lower the cylinder when fully loaded and unloaded can also be determined before applying the valve. The pilot pressure can be determined by the below equation:

$$P_P = (T_S - L) / R_P$$

P_P = Pilot Pressure
T_S = Thermal Setting
L = Induced Load
R_P = Pilot Ratio

Example:

The maximum load is 3000 psi. A 6:1 Pilot Ratio was chosen and the thermal relief setting is the standard 1000 psi over load setting. What is the pilot pressure required to retract the cylinder if it is fully loaded? What pilot pressure is required to retract the cylinder if there is no load?

LOAD   NO LOAD
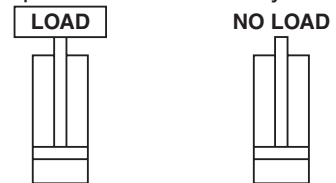
FULLY LOADED:

P_P = (4000 psi – 3000 psi) / 6
P_P = 1000 psi / 6
P_P = 167 psi

Thus, any time the pilot line sees at least 167 psi, the cylinder could lower the load.

UNLOADED:

P_P = (4000 psi – 0 psi) / 6
P_P = 4000 psi / 6
P_P = 667 psi Bar

Thus, at least 667 psi will be needed to lower the cylinder when it is unloaded.

Motor Controls

Counterbalance valves are used in motor circuits to stop overrunning loads and prevent cavitation. Since hydraulic motors leak internally, the counterbalance valve by itself cannot be used to hold the load. So, a mechanical brake is used to hold the load on the motor in place, as shown below. Some typical applications include winches, swing drives, conveyor control and traction drives. For applications in closed loop motor circuits, vented spring cavities are required.

Operation

Free flow to the motor is allowed through the internal check valve. In the controlled flow direction, the oil passes across a metering poppet. The position of the metering poppet is determined by an external pilot signal from the other side of the motor. In an open loop motor circuit, this pilot signal will be a 1:1 ratio. The reason an equal ratio pilot signal is utilized is to provide positive control as well as to release mechanical brakes (when used in a braking circuit). In applications where the motor will see overrunning loads in both directions (such as a traction drive circuit), a dual MMB or two single MMB valves must be used.

Brake Applications

300 PSI

Mechanical Brake

LOAD   2000 PSI
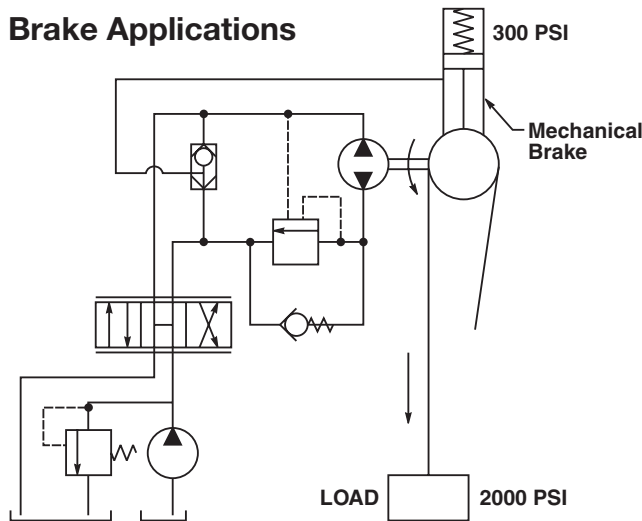
When the directional control valve is shifted, hydraulic pressure (usually 300 psi) releases the mechanical brake and allows the load to be moved. The counterbalance valve needs to provide adequate back pressure to open the brake, then immediately counterbalance the load. Ideally, the brake will be disengaged before the motor begins to rotate. If this sequence is not achieved, the motor will try to rotate against the applied brake reducing the life of the brake. This would be the equivalent of trying to drive with your emergency brake applied. Remember that hydraulic motors are equal area devices. So, in an effort to avoid the

movement of the motor prior to the release of the brake, an equal area ratio counterbalance is used. To demonstrate let's look again at the above example with a 10:1 Ratio Counterbalance valve installed and a maximum thermal setting of 3000 psi.

10:1 Example

NO LOAD

$$P_P = (T_S - L) / R_P$$
$$P_P = (3000 \text{ psi} - 0 \text{ psi}) / 10$$
$$P_P = 3000 \text{ psi} / 10$$
$$P_P = 300 \text{ psi}$$

2000 PSI LOAD

$$P_P = (T_S - L) / R_P$$
$$P_P = (3000 \text{ psi} - 2000 \text{ psi}) / 10$$
$$P_P = 1000 \text{ psi} / 10$$
$$P_P = 100 \text{ psi}$$

Thus, when there is no load on the motor, the counterbalance opens at 300 psi, or just as the brake is being released. When there is a 2000 psi load on the motor, the counterbalance will start to open with a pilot pressure of 100 psi. The brake requires 300 psi, so the motor can start to rotate before the brake is released, causing wear on the brake. To offset this problem, you could increase the maximum thermal setting to 5000 psi, but this is very inefficient.

1:1 (Equal Area) Example

Equal area counterbalance valves are used primarily in brake applications to avoid the wear problem described above. With an Equal Area counterbalance valve, there is no thermal relief valve, and there is no differential area to work on. In other words, the counterbalance valve only opens when the pilot pressure is greater than the valve setting. The applied load has nothing to do with the pilot pressure required. Thus you will want to choose a pressure setting for the equal area counterbalance valve that is just slightly above the brake release pressure (usually 350 psi).

In our example, the valve would be set at 350 psi. This would allow the brake to release before the counterbalance allows the load to move. Since the equal counterbalance valve always opens at 350 psi pilot pressure and is not dependent on the load, it is the best valve for brake applications.

Large Pressure Spike Application – Keep in mind that equal area counterbalance valves do not have a built-in thermal relief valve. As such, if there are large pressure spikes caused by the stopping of heavy loads, then a ratioed counterbalance, such as a 10:1 should be used. In most cases these are non-brake type applications.

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Technical Data

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HVS and MSDE Divisions