

Load holding valves **made simple**



Load holding valves, also known as counterbalance valves, are a small but important part of any mobile machine. Though simple in design, their application can frustrate even the most skilled and experienced engineers. Having a basic understanding of load holding valve operation and application allows engineers to improve the stability while reducing cost in mobile equipment.



Why use load holding valves?

Load holding valves provide these basic functions:

- 1. Load holding** prevents the uninitiated movement of an actuator on a machine that requires the boom to remain in one position for extended periods of time. For example, an individual using a cherry picker to work on utility lines would be frustrated if the boom drifted downward. The load holding valve's poppet design limits the movement to almost zero. This gives the employee confidence that they can complete their work without boom drift.
- 2. Load control** provides a counterbalance when lowering a load and prevents the actuators from running ahead which causes uncontrolled movement or pump cavitation. When lowering a load, it is crucial that the operator maintains complete control of the actuator. For example, a telescopic handler lowers a brick pallet and the load accelerates with the assistance of gravity and potentially becomes unstable. A properly applied load holding valve prevents this from occurring.
- 3. Load safety** prevents uncontrolled actuator movement in the event of a hose failure. All hoses have a fixed life and are often the first component in a hydraulic circuit to fail. Without a valve positioned and set correctly, a boom or winch can free fall creating a very dangerous situation.

At their core, load holding valves are an extremely important safety related device. By preventing dropped or uncontrolled loads — whether the load is logs, dirt, or even a person — load holding valves keep worksites safe.

Basic operation of load holding valves

To easily understand how to apply load holding valves, it is important to understand how they work. Figure 1 shows a basic hydraulic circuit where a directional valve is being used to raise and lower a load vertically.

A standard load holding valve is placed between the line running from the directional valve to the cylinder's rod end. Although known by many different names, a standard load holding valve is described as a "pilot-assisted relief valve with a free flow check". As the operator is raising the load, the valves will direct flow to the cylinder's rod end. In the upward direction, the load does not run ahead. For this reason, the flow from the valve passes through the free flow check portion of the load holding valve and lifts the load by retracting the cylinder.

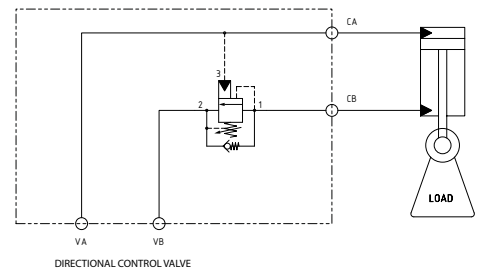


Figure 1

Lowering the load presents greater challenges as the operator is trying to move the load in the same direction as gravity but in a controlled fashion. With the added acceleration of gravity, the load has the tendency to run ahead of the control and pump. Without the use of a load holding valve, the operator may lose control of the load or the boom may become unstable.

A load holding valve provides the needed control by relieving flow from the rod end of the cylinder. When the operator intends to keep the load still and has the directional control in the closed position, the free flow check prevents fluid from moving from the rod end of the cylinder and holds the load in position.

As the operator lowers the load and directs flow to the bore end of the cylinder, pressure is applied to the load control valve through the pilot line. The combined pressure from the pilot on the bore end of the cylinder and the load pressure from the rod end of the cylinder opens the load holding valve allowing flow from the cylinder to tank and lower the cylinder.

As the load begins to lower and accelerate, the pilot line pressure decreases and begin to close the load holding valve. This prevents the load from running away. With the valve closed, the pilot pressure increases and the load holding valve opens allowing the load to lower in a controlled fashion. Using a load holding valve that meters this flow in a controlled manner is critical in designing a stable and efficient load holding system.

Load holding valves for standard applications

Engineers can meet the requirements in a wide variety of load holding applications using a standard load holding valve. There are two design types of standard load holding valves on the market. They are known as (1) direct acting and (2) differential area design.

With each of these designs, the valve has a single poppet to meter flow from the cylinder to the directional valve, and the load pressure works against this poppet. The difference in the two designs, which is critical to boom stability, relates to the spring force required to reseal the valve.

Figure 2 shows that direct acting valves have a large poppet area working against the load pressure. Because of this large poppet area, greater spring force is required to reseal the poppet. This direct acting design is common among the million types of relief valves applied every year in standard hydraulic circuits.

In contrast, a differential area load holding valve, shown in Figure 3, applies back pressure to the poppet which offsets the load pressure and results in a smaller, annular effective area of the poppet. Therefore, less spring force is required to reseal the poppet.

Spring force is important because it directly affects the stability of the valve. A higher spring rate is an advantage in many applications where unstable loads introduce varying induced pressures. The higher spring rate prevents the valve from reacting too quickly and over-opening which causes boom bounce or audible instability.

Differential valves, with a lower spring rate, are prone to rapid opening. While this can be advantageous for some higher flow applications, the rapid opening often leads to instability which results in boom bounce or high-pitched squealing. The rapid opening also makes the valves more sensitive to changes in temperature, wear, and general mechanically induced friction.

Load-holding valves for highly dynamic machines

For machines with high dynamic loads—such as on a concrete pumping truck with multiple booms—a machine designer needs to look beyond the standard valve. In the example of a concrete pumping truck, heavy concrete is being pushed through multiple booms changing the loads significantly as portions of the booms are empty, or full of dense concrete. Stabilizing these loads takes a more advanced valve.

The machine designer has a couple of choices when presented with extremely unstable conditions, either restrict the flow or use a two-stage load control valve. The initial restriction is removed once the movement is stable. A restrictive valve operates by restricting the opening causing the oil to be driven across an orifice. This is inefficient because it generates heat and makes it difficult to control the actuator speed.

The two-stage valve creates an initial restriction which is then removed as the valve stabilizes and the pilot pressure increases (see Figure 4).

Improving machine design with load holding valves

To ensure safety and security of operation, it is paramount the system's valves are assembled correctly and in the right place on the machine. They also must be secure in their cavity to prevent loosening or unscrewing. Industry common cavities with large bearing areas transmit torque between the load holding valve and manifold.

By using a larger mating surface, the common cavities reduce assembly torque. Higher torque can result in manifold deformation which could generate contamination or reduce security of assembly.

There are several common opportunities when choosing the right load holding valve that will make a difference in a new machine. The right valve, boom stability, productivity, and safety are able to be improved. Noise at start up and potential for contamination can be reduced and designs simplified. All ways to save in the construction and the operation of mobile equipment makes the right valve a worthwhile investment.

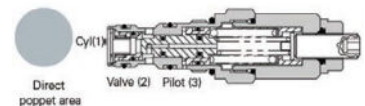


Figure 2. A direct acting load holding valve allows the load pressure to work against the full area of the poppet

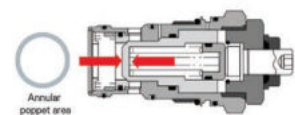


Figure 3. Load pressure works against a smaller, annular area of the poppet in a differential area load holding valve

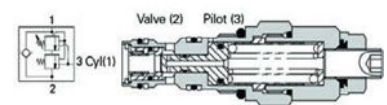


Figure 4. Counterbalance pressure in the two-stage valve reduces instability

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