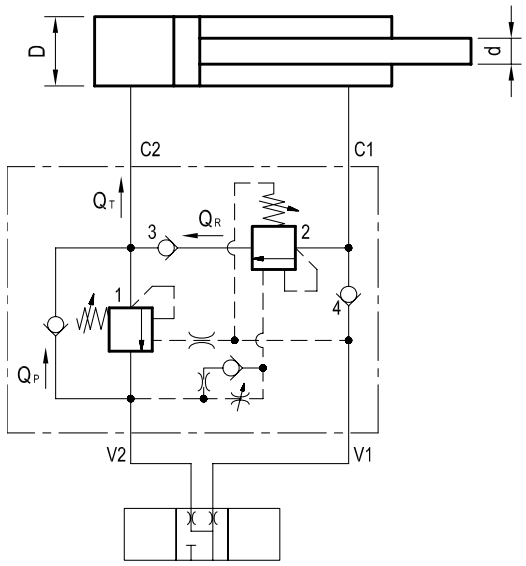
COUNTERBALANCE VALVES WITH REGENERATIVE FUNCTION

Bosch Rexroth Oil Control manufactures a variety of valves which combine a counterbalance function with regenerative circuit. They are employed to control cylinders where it is desired to shorten the extension time, without increasing the pump flow capacity. Often these valves perform also a “dual counterbalance function” on both the full bore and the cylinder rod side (see scheme), in addition to the regenerative function.

A) Basic regenerative valves: operation principles and related main formulas



φ = Cylinder Ratio, or
Cylinder bore Area / Cylinder annular Area

$$\varphi = \frac{\pi / 4 \cdot D^2}{\pi / 4 \cdot D^2 - \pi / 4 \cdot d^2}$$

The cylinder extends when the pump flow is directed to the Full Bore Side (C2) and, from this general scheme, it can be seen that the cylinder extension is possible only if the by-pass valve (2) is piloted open: in fact, valve (2) is the counterbalance valve the cylinder annular (rod) side and, since it has pressure both upstream and downstream, it needs to be of the “fully balanced” or **CCAP** type. During extension, the total inlet flow to the cylinder (Qt) is sum of the flow from the pump (Qp) plus the flow from the annular chamber, or regenerated flow (Qr), and the following basic equations apply:

Total Inlet Flow (***Qt***) to the cylinder: $Qt = (Qp + Qr)$, *and* $\left(Qt = Qp \cdot \frac{D^2}{d^2}\right)$

Regenerated flow (***Qr***), or By-Pass through valve (2): $Qr = \frac{Qp}{(\varphi - 1)}$

Examples:
a) With cylinder ratio **φ** = 2, Qr = Qp , Regenerated flow = Pump flow, and
Qt = 2 • Qp, Total flow = Twice the pump flow.

In this case, for a given pump flow, **the cylinder extension speed doubles** compared to the non regenerative circuit: cylinder extension and retraction speeds become identical.

b) With cylinder ratio **φ** = 1.5, Qr = 2 • Qp, Regenerated flow = twice the pump flow, and
Qt = 3 • Qp, Total flow = Three times the pump flow.

In this (b) case, for a given pump flow, **the cylinder extension speed becomes three times** the speed with non regenerative circuit.

NOTE: the a.m. formulas and the example (b) show the **very high level reached by the regenerated flow**, compared to the pump flow, when the cylinder ratio "**φ**" has values smaller than 2:1 (i.e. when the annular area is larger than 50% of full bore area, or when the rod diameter is relatively small compared to cylinder diameter).
It is very important to determine the actual potential level of the ***Qr*** flow in order to fit pipes and hoses of the correct size and avoid pressure losses which could be very relevant. For the same reason, it is also advisable to install the regenerative valves always close to the cylinder in order to have connection hoses and pipes as short as possible.

B) Regenerative valves with controlled regenerative mode

In many applications it may be desired, or necessary, to have both the following conditions:

a) regenerative mode for quick cylinder extension, and shorter approach times
b) non regenerative mode, with annular chamber dumped to tank,
- either for **maximum cylinder thrust**, if high force must be developed by the cylinder
- or for **lower speed**, if fine control becomes necessary.

Bosch Rexroth Oil Control manufactures a variety of valve modules with the above mentioned features. They can be classified in two main families (1) and (2):

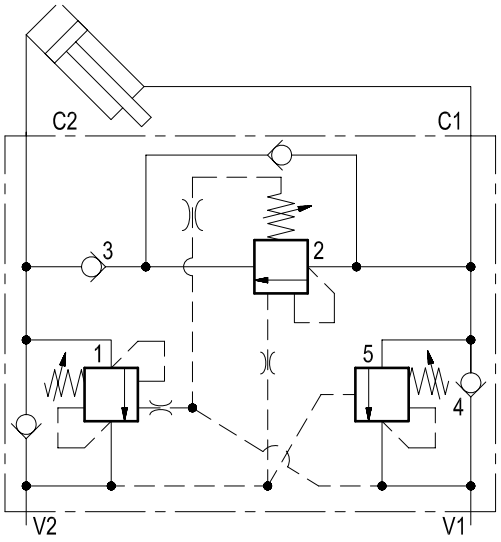
1) pressure sensitive regenerative mode;

2) regenerative mode on demand.

1) *Pressure Sensitive Regenerative Mode*

These valve modules automatically shift from regenerative into non regenerative mode at a determined level of pressure in the line V2 – C2 feeding the cylinder bore:

when extension starts, V2 pressure first pilots open the by-pass valve (2), and the regenerative circuit is activated. As the cylinder extends, if it meets higher resistance (higher load to move), the main pressure in line V2 – C2 increases, and, when resistance is high enough, also the valve (5) is piloted open. Now the flow from the cylinder annular chamber is free to return to tank through V1, and the regenerative mode is automatically cut out. The cylinder extension continues at lower speed (at pump flow speed) and the line pressure is active on the whole full bore area, without back-pressure at the rod side: the thrust developed is at its maximum level.



2) *Regenerative mode on demand*

These valve modules allow motion control at pump flow speed (or low speed) in all conditions, in order to have always fine control, and allow to engage regenerative the mode for quicker cylinder extension, with shorter cycle time, when desired and permitted by the load; normally the regenerative mode is engaged manually by the operator only when the cylinder is extended in empty conditions.

The by-pass channel, between counterbalance valve (2) and check valve (3), is connected to a channel which diverts the annular chamber oil to V1 and to tank, through the main control valve; in the scheme, this channel is controlled by a Normally Open solenoid valve, and the cylinder extension normally happens without regenerative mode, with the annular chamber oil flowing through valves (2) and (5), to V1 and to tank through the MCV. The regenerative mode can be activated on demand by energizing, and closing, the valve (5); the annular chamber oil is forced to go through valve (3), and to join the pump flow coming from valve (1).