Single & Double Chamber Valve – Design Comparison

Single Chamber (SC) Design

Hydraulic control valves are utilized for implementation of specific control functions in the water supply systems, such as pressure & flow control, remote open\close, water level control in tanks and reservoirs and many others.
The valve designed in a way that will enable optimal adaptation to as many of the control functions it is used for, with as little limitations as possible. Possible limitations are lower reliability, higher energy losses, complicated and costly maintenance and higher production costs.
The design that is considered as most optimal by the majority of valve-manufacturers world wide is one that incorporates one control chamber, located above a diaphragm or a piston actuator (Single Chamber design). With this design, the pressure in the line is pressing on the plug at the bottom part of the internal trim while the same pressure is applied (via the pilot system) into the control chamber above the larger area diaphragm. The valve is kept closed due to the higher force from top.
The valve will open when the pilot system allows the pressure from the control chamber to be discharged, and force created by the pressure acting from below pushes the trim up.
Single Chamber design is characterized by:

- Simple valve design
- The control pilot loop is connected only to the bonnet of the valve
- The downstream pressure is acting on the bottom side of the valve actuator
- There is no internal sealing between the valve actuator and the water running through the valve.

Limitations of using SC valves:

This design is proved to be most efficient but for a few cases:

1. When the line pressure is too low, to create enough lifting force that can overcome the internal trim weight, the bearing and internal sealing friction and the spring forces.
2. When a proportional pressure reduction function is required (this function is very difficult to implement with a SC valve)
3. For cases when a very-fast closure is required (as in a case of a fast acting check-valve). In such a case there is a need to neutralize the downstream pressure acting below the actuator and decelerates the downward movement of the internal trim.
   NOTE: in most cases too fast valve closure may cause a water-hammer\surge risk to the system and should be avoided.

Double Chamber (DC) Design

To perform the above mentioned control applications, many valve manufacturers have developed the double chamber valve design, which fundamentally is adding a partition between the flow in the valve and the bottom part of the valve actuator. This way, a second control chamber is created between the partition and the valve diaphragm\piston.
This second chamber allows for:

a. Applying an auxiliary, high pressure source to the bottom chamber (while venting the pressure from the top chamber) to force the internal trim to move up and open the valve, even if the main line pressure is lower than the minimal opening pressure.
b. Cancel the affect of the downstream pressure below the diaphragm actuator by venting the bottom chamber. This enables the construction of proportional pressure reducing control application and enables fast valve closing reaction when pressure is applied to the top control chamber.

Limitations of using SC valves:

The DC design is used, as previously mentioned, for the implementation of very specific tasks, and is not required for most frequently used control functions. Furthermore, this DC design has quite a few drawbacks compared with the standard SC design:

1. A more complex structure makes the valve cost of ownership (difficult maintenance, cost of spare parts, down-time etc.) and purchasing costs, higher.
2. As the shaft, connecting the valve diaphragm or piston actuator the the sealing plug, has to pass through the bottom DC partition, a sealing mechanism is required so to prevent the line pressure from leaking in and out of the bottom chamber. The seals, sealing adjacent to the moving shaft add substantial mechanical friction that oppose the valve opening and closure movements. DC valves will normally have higher minimal operating pressure and will require a high minimal differential pressure in order to close.
3. Immobilizing the affect of the downstream pressure, acting on the bottom side of the valve actuator result putting out of action one of the main forces that assist the valve in its opening. Having a DC valve without applying auxiliary pressure to its lower chamber would result substantially higher pressure\energy losses in comparison to the single chamber valve.
4. A double chamber valve will suffer from reduced reliability due to internal seals tear & wear that will consequently cause internal leakage, increased friction and possible trim seizure. The only way to avoid this phenomena is by periodically replacing the seals and polishing the shaft (= even higher maintenance costs).
5. Double chamber valves can not operate with the most common type of pilot system called "2-way" systems (in opposed to "3-way" systems. The difference between the two types will be explained in a different article).

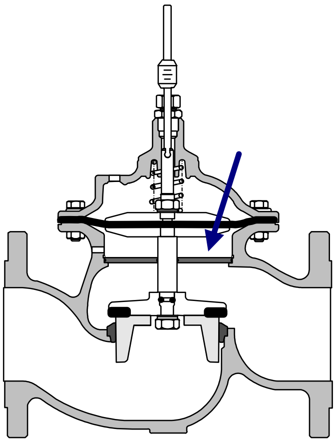
Due to these limitations and others, most valve manufacturers would prefer to produce single chamber valves as standard, and convert them to double chamber structure only if required.

Converting Single-Chambered valves to Double-Chamber structure:
It is seldom that a valve needs to be converted from one design form into another. Most common case is that the valve is used in the same application as it was supplied. However, in some cases the flexibility is required (especially for the local agent who is required at time to supply design x when he has in stock design y).

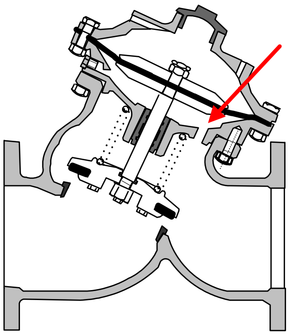
There are three main methods for implementing double-chamber design from single-chamber one (refer to the attached drawings):

1. The common method is by replacing the internal valve trim and adding a intermediate chamber between the valve body and the diaphragm\bonnet assembly (used by "Cla-Val", "Hawle" and similar)
2. A second method (most common in "Y" pattern valves such as "Bermad", "Vamex" etc.), is for valves that their standard design is double chamber, and the standard converson to single chamber is by opening bores in the bottom chamber. This way the valve hydraulically acts as single chamber (downstream pressure acts on the bottom side of the diaphragm). Conversion back to double chamber is done by re-plugging the bores and opening a side port into the bottom chamber. The advantage of doing things this way is the complete unity in the parts used for both designs. However the dramatic disadvantage is that the same negative aspects of the double chamber design (high internal friction, risk for seizure, complex structure and difficult\expensive maintenance), remain in the standard single-chamber applications.
3. The third method is patented by Dorot Automatic Control Valves ltd. and is implemented in the Dorot Series 300 control valves. Here the basic control valve is highly reliable, easy to maintain single chamber valve, with no internal sealing and with very low internal friction forces. The valve is converted into double chamber design by a simple addition of a separation disc below the diaphragm. This way enables unity in the main valve parts used for both designs, simple and easy maintenance in both designs and superb reliability in the standard most common designs.

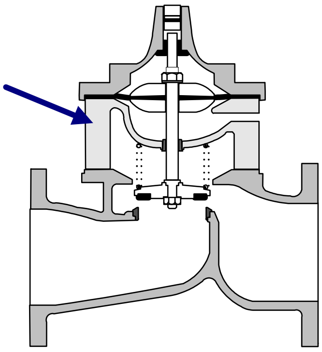
Further information can be obtained from the Dorot Technical Support department at **asaf_h@dorot.com**.



Dorot Series 300 valve, converted to DC design by adding aseparation disc



"Y" type valve, converted to single chamber design by opening bores in the bottom chamber



Typical conversion to double chamber in common globe type valves

Summary

There are two main designs common with hydraulic controlled "Globe" and "Y" type valves:

- Single-chamber, that is characterized by one control chamber above the valve actuator and line pressure acting on the bottom side of the actuator.
- Double chamber which has an additional second chamber below the diaphragm.

For most commonly used control applications it is enough and often required to use single chamber valve design. Double chamber design is required in just a few of the control applications and should be used only in such cases as it may create reliability and operational problems if used when not required.

Only Dorot Series 300 valves can be converted into double chamber structure (when required) by adding a simple innovative separation disc and without having to change the valve structure or harming the integrity of the standard single chamber operation.

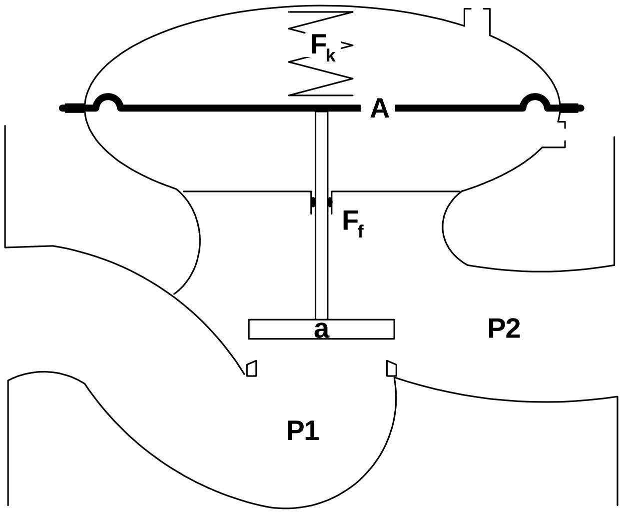
Appendix

Pressure-Loss differences explained through force equilibrium calculation

Double Chamber Valve

Open Force:	
P1 · a	Upstream pressure acting on the plug area from below

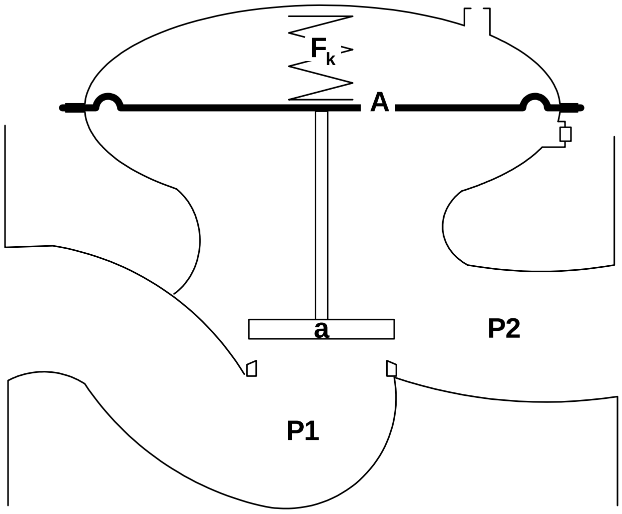
Forces That Resist the Opening:	
P2 · a	Downstream pressure acting on the plug area from top
F_f	Friction force in the bottom chamber sealing mechanism



Single Chamber Valve

Open Force:	
P1 · a	Upstream pressure acting on the plug area from below
P2 · A	Downstream pressure acting on the diaphragm area from below

Forces That Resist the Opening:	
P2 · a	Downstream pressure acting on the plug area from top
F_k	Spring force



Summary:

1. Opening forces are bigger in single chamber valves:
   $(P1 \cdot a + P2 \cdot A) > P2 \cdot a$
2. The forces resisting the opening in single chamber valves are smaller:
   $(P2 \cdot a + F_k) < (P2 \cdot a + F_f + F_k)$

The balance can be changed in double chamber valves only by admitting high enough pressure into the bottom chamber. Without doing so, the pressure losses and minimal operation pressure for this valve design would be high.