

# Literature Review on Design and Working of 3 Way Pilot Operated Diaphragm Controlled Hydraulic Control Valve

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**Abstract**—Most flow applications require regulating the flow of liquid and usually the parameter of flow is pressure. This paper focuses on the design assembly and working of a 3 way pilot operated diaphragm controlled hydraulic control valve. A 3 way pilot operated hydraulic control valve is used in this study for reducing the pressure on the main line, sustaining the pressure on the main line and quick pressure relief for a by-pass line. This study has been carried out on a 2" line with a bronze 2" diaphragm operated hydraulic control valve a brass pilot with pressure adjustment range of 0.7 bars to 6.5 bars. Through the study, I also found about the chaotic behaviour of the pilot with the sudden variation in the upstream pressure of the main line.

**Keywords**— 3 way pilot, upstream pressure, diaphragm operated hydraulic control valve.

## I. INTRODUCTION

A hydraulic valve is a device which properly directs the flow of a liquid medium through a hydraulic system.

Hydraulic valve are available in a variety of sizes and according to multiple international standards. They are available in different mounting styles such as the threaded connections and flanged connections. Hydraulic valves are sub divided into three main categories- directional control valves, pressure control valves and flow control valves. All valves operate a different function in the hydraulic system. Check valves permit free flow in one direction and block flow in the opposite direction. The directional control valve is used to pass on the pressure medium or flow in an orderly manner to a particular direction. Pressure control valves switch (or control) at a certain pressure while the switching pressure may be adjusted on the valve. Flow control valves regulate the flow and this is done by adjusting the size of the bores or orifices.

### Hydraulic Flow Control Valve

Our study was carried on a diaphragm operated hydraulic flow control valve. Diaphragm valves get their name from a flexible disc which comes into contact at the top of the valve body to form a seal. A diaphragm is a flexible,

pressure responsive element that transmits force to open, close or limit the flow through a valve.

The valve that I chose for testing uses a moulded diaphragm. It has an aluminium insert to which EPDM rubber is moulded. This bronze hydraulic control valve with brass pilot is used for general water supply system, filtration network and systems subjected to sudden demand changes with medium pressure rating. The 3 way brass pilot with unique diaphragm enables precise pressure control.

## II. MATERIALS

Table.1: Brass Pilot Parts List

Part No	Part Name
1	Pilot Base
2	Pilot Base Cap
3	Stem Cylinder
4	Stem Cylinder O-ring
5	Stem
6	Stem O-ring
7	Diaphragm Seat
8	Diaphragm
9	Actuator
10	Spring
11	Spring Button
12	Nut
13	Adjusting Screw

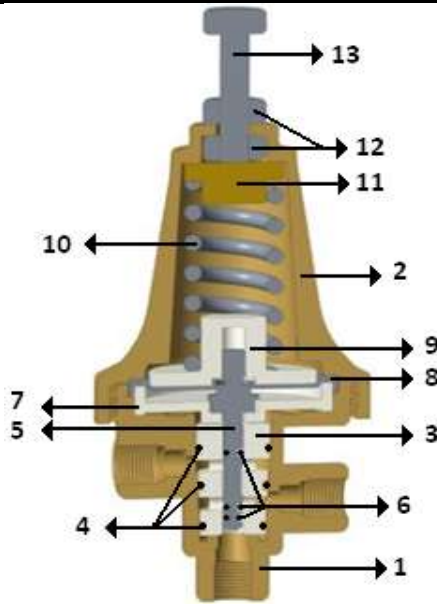


Fig.1: Pilot Sectional View

Table.2: HCV Parts List

Part No	Part Name
1	Body
2	Cover Plate
3	Valve Lid
4	Spring
5	Bolt

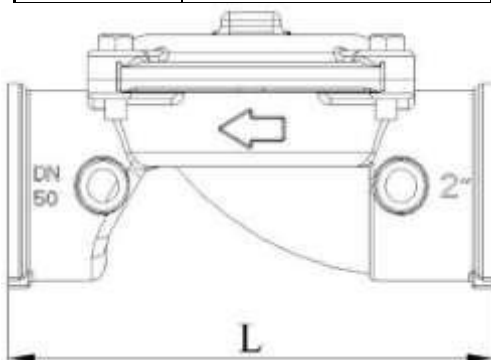


Fig.2: HCV Direction of flow

**Operating Conditions**

The pilot and hydraulic flow control valve selected have been made to work for below mentioned conditions:

- 1). Pressure Reducing Valve
- 2). Pressure Sustaining Valve
- 3). Quick Pressure Relief Valve

In this edition, the working of pilot with control valve has been studied to make the valve work as a pressure reducing valve.

The connections between the hydraulic valve and the pilot are done as shown in figure 3. The pilot is marked with numbers 0-1-2-3 at the ports. The following is the description:

- 0- Upstream

- 1- Downstream
- 2- Atmosphere
- 3- Control Chamber

The valve maintains a constant pre-set downstream pressure regardless of upstream pressure or flow fluctuations. The hydraulic valve is controlled by the pilot. The pilot has a spring loaded diaphragm as shown figure 1, which is sensitive to downstream pressure. The pilot spring is pre-set to downstream pressure which is explained in the working section below. The pilot maintains a constant downstream pressure by gradually opening and closing the hydraulic valve at any flow rate. When no flow exists in the system, it closes itself automatically. The diagram shown below shows the connection of different ports of the hydraulic control valve with the pilot.

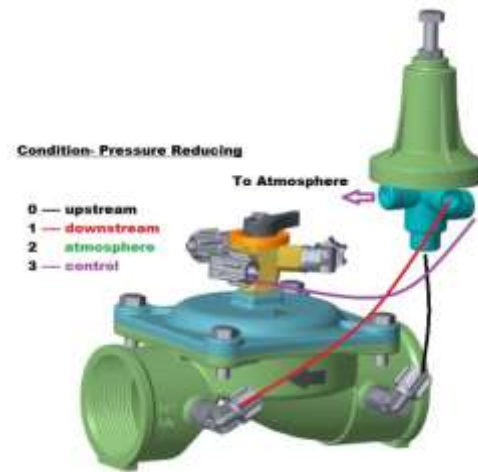


Fig.3: Valve Connection Diagram

**III. WORKING**

Initially, the adjusting screw of the pilot is set free which means there is no force on the spring. When the line is opened, the water flows through the valve. Since the upstream, downstream and control chamber of hydraulic valve are connected to the pilot, it comes into action because of flow of water. The water from the upstream and downstream enters the pilot from port '0' and '1'. The downstream water forces the spring to move back which in turn moves the shaft of pilot due to which the ports '0' and '3' come into contact. The water then flows towards the upper section of the diaphragm called the control chamber. This flowing water maintains pressure on the HCV diaphragm and shuts the valve.

Now we gradually adjust the downstream pressure using the pressure adjusting screw on the pilot. When we screw in clockwise direction, it compresses the spring. Now the water flowing through the port '1', coming from downstream side has to work against the spring force. When the downstream pressure becomes greater than the

spring force, the spring and assembly moves which in turns connect the port '0' and '3' again. The amount of water flowing through port '3' depends on the pressure difference of the downstream and the spring force. When the required water gets accumulated and generates pressure on diaphragm of HCV in the control chamber, the diaphragm lowers and closes the valve partially maintaining the set downstream pressure equivalent to that of the spring force. At this stage, equilibrium is achieved and the downstream pressure remains constant. This happens at every set pressure and with the fluctuations in the inlet pressure i.e. increases of decrease in the pressure. Figure 4 shows the different working positions of the diaphragm of the hydraulic valve i.e. the control chamber.

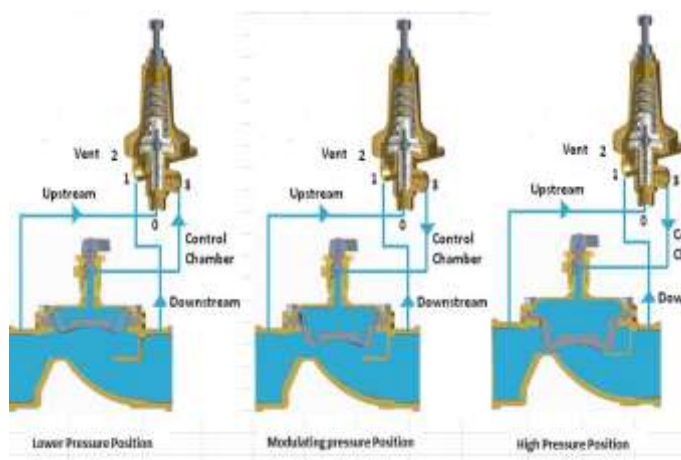


Fig.4

#### IV. RESULTS AND DISCUSSION

With the working of hydraulic valve with pilot, we can maintain a particular downstream pressure which is as per requirement of the end user whether it is in the field of agriculture, landscaping and piping systems for storing or discharge of water. The user just needs to adjust the pressure adjustment screw to get the required downstream pressure in the case where the upstream pressure gets more than the required downstream pressure.

During the working, we encountered certain issues related to the pilot which in turn is about the accuracy of the valve. A pilot is considered good when it is working at the set downstream pressure with a tolerance of  $\pm 0.1$  bars.

During the study and performing the practical, another way of improving the accuracy of the valve is to select a downstream port at about a meters length of the downstream section. The reason to do this is that the flow gets linear and is apparently **more** uniform.

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