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# PRESSURE VALVES NEW SYMBOLS ACCURATELY ILLUSTRATING THEIR TRANSITORY WORKING

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**Abstract.** The paper proposes an interpretation of pressure valves used in hydraulic circuits from the point of view of control techniques. Structural models of the pressure valves highlight the classic structure components of control circuits: reference block, comparator, pressure transducer, execution elements etc. Furthermore, original symbols are proposed for the representation of pressure reducing valves to accurately illustrate their function. The new proposed symbols highlight the instantaneous opening of valve spool. Thus the drawback of standardized symbol is eliminated.

**Keywords:** pressure control valves, symbols

## 1. Introduction

The pressure control hydraulic components represent signal sending and processing elements. Within their structure the elements and values of the type structure of a control circuit are identified (figure 1) namely: block **BEL** for the input of reference value, comparator **C**, measuring element **EM**, control value, execution value, etc. It is important to specify that the control circuit ensures the control of the parameter to be directly or indirect measured. As a rule, the measuring element is on the reaction path and therefore the circuit assures the control of the value introduced in this path [1, 2, 3, 5].

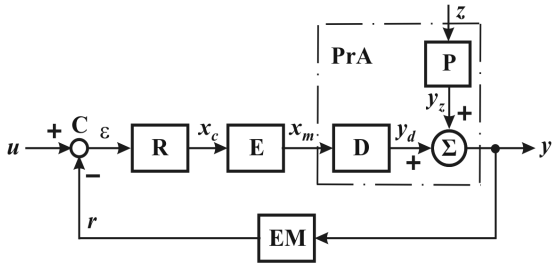



Figure 1. Structure of the control circuit

## 2. Pressure reducing valves: functional diagrams and structural models

Using the functional diagram and on the grounds of the control technique the type structure elements of a control circuit are identified within the structural model. To exemplify a direct pressure reducing valve is analyzed. The valve is of the normally open type, placed on hydraulic motor pipe [6, 7].

The functioning of a direct pressure reducing valve can be followed on the functional scheme in figure 2a, or on the structural model in figure 2b [4].

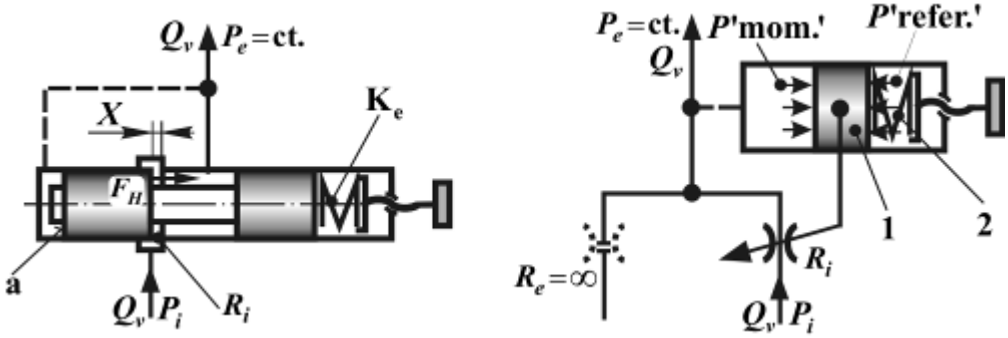
Mobile element of the valve is the spool, represented in working position characterised by opening $X$ .

Element **EM** for pressure detection is represented by surface **a** onto which the reaction pressure at the mobile element of the valve is applied.

Element **BEL** of introduction of the reference value is represented by the helical spring, the pre-compression of which enables the predetermination of the prescribed value of the valve closing pressure $P_{In}$.

Comparator **C** is represented by the mobile element of the valve, element which is in equilibrium under the elastic force $F_e = K_e \cdot (X_{In} + X)$ of the spring and force $F_P = a \cdot P$, determined by the reaction force. The flow force $F_H$ participates as a disturber element in the dynamic equilibrium of the mobile element. Comparator **1** permanently compares the instantaneous input pressure *P*'mom.' to the reference **pressure *P*'refer.',** corresponding to the instantaneous compression of compression spring **2.** The valve begins to close as the reaction pressure equals the closing pressure $P_{In}$, namely when force $F_P = a \cdot P_{In}$. The control element **E** is embodied in the variable resistance $R_e$ of the valve throttle section, which, in turn, depends on the instantaneous opening $X$ of the hydraulic spool.

The structural model in Figure 3b illustrates exactly the fact that the position of the valve mobile element, the hydraulic spool, determines the amplitude of the output resistance $R_e$ of a hydraulic bridge $C_v$ type.



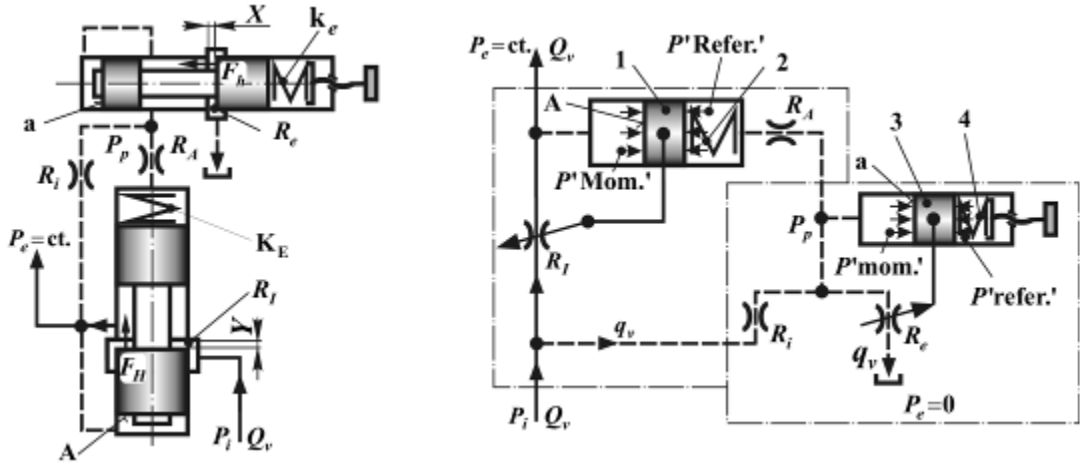

a) b)

Figure 2. Direct pressure reducing valve

To conclude, the compression spring is an element used to introduce the reference value, and the valve spool acts both as measuring element and comparator, and control element.

Piloted valves can be analyzed in the same way. To exemplify, figure 3 presents the functional scheme (figure 3a) and the structural model (figure 3b) of a piloted reducing valve. The pilot valve is a normally closed valve. The reference pressure *P'*refer.', i.e. the opening pressure is controlled through the initial pre-compression of the compression spring of rigidity $k_e$. In steady-state, the reference pressure *P'*refer.' at the main valve results to be approximately equal with the instantaneous reference pressure *P'*refer.' of the pilot valve.

The difference is given by the pressure required to compress the spring of the main valve. The rigidity spring $K_E$ is relatively weak its role being to overcome the friction at the main valve spool.




a) b)

Figure 3. Piloted pressure reducing valve

Therefore, its compression during functioning leads to small variations of its elastic force, and subsequently, it has a little impact upon the reference pressure *P'*Refer.'. The input resistance $R_i$ filters the pressure variations originating from the circuit, while resistance $R_A$ isolates the two sub-systems, namely the main valve from the pilot valve. This way the variations specific to the two sub-systems are prevented from passing to the other system.

## 3. Illustration of the functioning of the pressure control valves by specific symbols

The drawback of standardized symbol consists in the fact that for the normally open valves the size of the spool opening (in zero position) is not indicated. Moreover, both for the normally closed and normally open valves the symbol cannot illustrate the variations of the valve opening during operation. This can be illustrated by means of the

symbols proposed in figure 4 for the normally closed valves, and in figure 5 for the normally open valves.

These symbols highlight the active edges of the valve body and of its mobile element, for example the hydraulic spool.

The active edge of the spool is represented by the straight line segment which comes in continuation to the tip of the broken arrow symbolizing the spool.

The active edge of the arrow body is represented through the vertical segment of the broken line which is represented in the lower part of the square symbol of the valve, body, namely its output. The distance between the two active edges represents the opening of the valve, i.e. the width of the valve throttle section (hatched area).

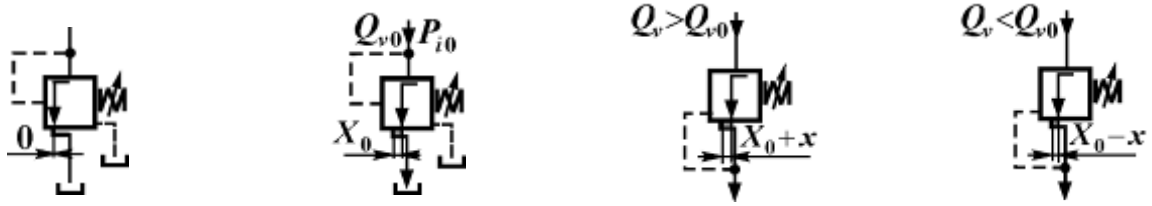
The following remark concerning the valves is very important: the compression spring maintains the zero position, by reducing the opening of the normally closed valves and increasing the opening of the normally open valves. Therefore, the feedback pressure always acts contrary to the action of the valve spring.

Figure 4 presents a pressure relief valve designed to maintain approximately constant the input pressure $P_i$. The valve is represented during the following working phases:

Figure 4a – position zero, characterized by the absence of the oil pressure $P_i = 0$. Under these conditions, the valve is closed ($X = 0$), and the flow through the valve is nil $Q_v = 0$.

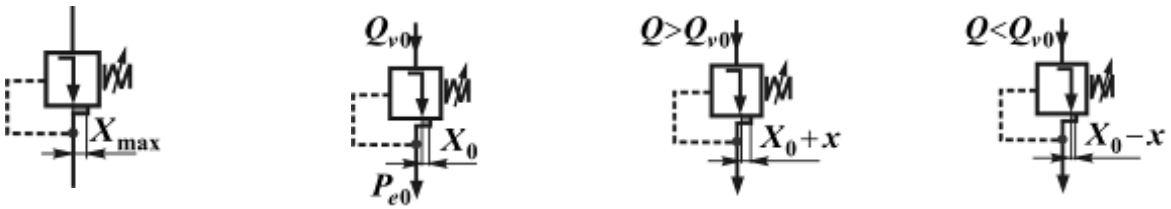
Figure 4b – steady-state position when an input pressure $P_{i0}$ higher than the valve opening pressure $P_{De}$ is provided, providing that the valve opening be $X_0$, and the flow through the valve $Q_{v0}$.

Figure 4c – the passing of an additional flow through the valve $Q_v + q_v > Q_{v0}$ generates an additional opening $X_0 + x$, and an increase in the input pressure $P_{i0} + p_i$, due to a supplementary compression of the valve spring.



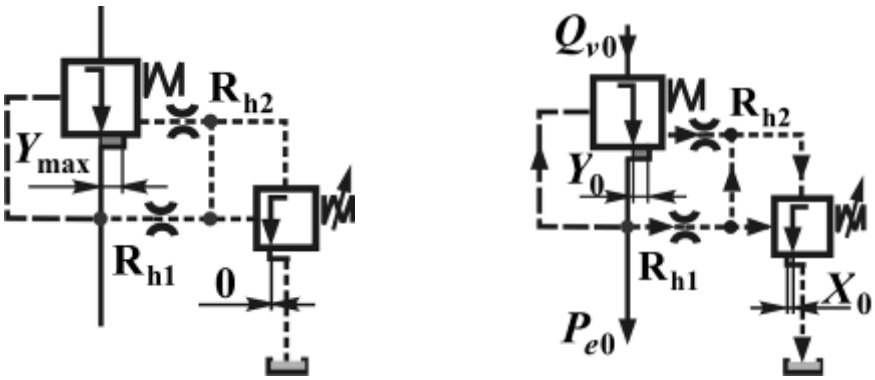

a) b) c) d)

Figure 4. Normally closed valves working phases




a) b) c) d)

Figure 5 Normally open valves working phases




a) b)

Figure 6. Piloted reducing valve

Figure 4d – the reduction of the flow through the valve $Q_v - q_v < Q_{v0}$ leads to the reduction of the valve opening, $X_0 - x$, and subsequently to the reduction of the input pressure $P_{i0} - p_i$, due to the decompression of the valve spring.

Figure 5 presents a pressure reducing valve designed to maintain approximately constant the output pressure $P_e$. The valve is represented during the following working phases:

Figure 5a – position zero, characterized by the absence of the oil pressure $P_i = 0$. Under these conditions, the valve is completely open ($X = X_{max}$), its hydraulic resistance being minimal.

Figure 5b – steady-state position when an output pressure $P_{e0}$ higher than the pressure $P_{în}$ is provided at which the valve starts to close, providing that the valve opening be $X_0$, and the flow through the valve $Q_{v0}$.

Figure 5c – the passing through the valve of an additional flow $Q_v + q_v = Q_{v0}$ generates an additional opening $X_0 + x$, and a decrease in the output pressure $P_{e0} - p_i$, due to a supplementary decompression of the valve spring.

Figure 5d – the reduction of the flow through the valve $Q_v - q_v < Q_{v0}$ leads to the reduction of the valve opening, $X_0 - x$, and subsequently to the increase of the input pressure $P_{e0} + p_i$, due to the compression of the valve spring.

Piloted reducing valves can be symbolized using the previously proposed symbols for the normally closed and normally open valves. Figure 6a illustrates the zero position, while figure 6b illustrates the steady-state working position, when both the pilot valve and the main valve are open.

## 4. Final conclusions

To conclude, from a functional point of view, pressure valves are automatic control systems the structure of which allows the identification of the elements specific to these control circuits.

Moreover, a series of original symbols are used to represent the pressure reducing valves, accurately illustrating their working. These symbols highlight the increase / decrease instantaneous valve opening depending on disturbance, respectively crossing flow rate.

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