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WELL SAFETY VALVE

It is well known to utilize an elastomer seal in a hydraulic piston and cylinder assembly in a safety valve such as shown in U.S. Patent Nos. 4,161,219 and 4,049,052. However, elastomer seals are limited as to the temperatures in which they can operate, the pressures which they can withstand, the corrosive environment in which they can operate, and the length of time before they must be replaced. GB-2 109 895A discloses a metal-to-metal seal used in a piston and cylinder actuating assembly in a subsurface safety valve. However, it is difficult to manufacture metal-to-metal seals which will seal under all pressure conditions and which will seal against gases.

Our copending application GB-2 121 090A is directed to a hydraulic actuating means for actuating a subsurface well safety valve which avoids the use of elastomer seals and can be used in both high and low pressure and high and low temperature applications and in the presence of corrosive fluids and gases.

According to the aforesaid copending application a well safety valve for controlling fluid flow through a well conduit includes a housing and a valve closure member moving between open and closed positions by providing an improved hydraulic actuating means for actuating the valve closure member; at least one cylinder is provided in the housing with a piston movable in each cylinder; the cylinder on one side of the piston is in communication with a hydraulic control fluid passageway and the cylinder on the second side of the piston is in communication with fluid pressure in the valve housing; the cylinder includes a first valve seat on one side of the piston and a second valve seat

on the second side of the piston; a first valve element is connected to one side of the piston and adapted to seat on the first valve seat when the piston moves away from the first valve seat, and a second valve element is connected to the second side of the piston and adapted to seat on the second valve seat when the piston moves away from the second valve seat. The piston, valve seats and valve elements are all of metal.

Hence in a well safety valve according to the aforesaid copending application the first and second valve seats are on opposite sides of the piston and the first and second valve elements are connected to opposing sides of the piston.

We have now found that a positive seal for sealing off the hydraulic actuating means even if fluid leaks by the piston can be achieved by providing first and second valve seats positioned both on one side of the piston, and first and second valve elements which are connected both to said one side of the piston.

The present invention accordingly provides a well safety valve for controlling the fluid flow through a well conduit and including a housing and a valve closure member moving between open and closed positions, and hydraulic actuating means for actuating the valve closure member, comprising a cylinder in the housing, a metal piston movable in the cylinder, said piston connected to and moving the valve closure member, said cylinder on a first side of the piston being in communication with a hydraulic control fluid passageway, and said cylinder on a second side of the piston being in communication with pressure in the safety valve, said cylinder including first and second spaced metal valve seats both positioned on one side of the piston, and first and second metal valve elements connected to said one side of the piston and spaced

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from each other to alternately seat and unseat on the first and second valve seats, respectively, as the piston alternately moves in the cylinder.

The spaced metal valve seats in the cylinder and the metal valve elements connected to the piston will provide a positive seal in both directions for the double acting piston. The construction avoids the use of elastomer seals and can be utilised in both high and low pressure and high and low temperature situations.

A preferred embodiment of the present invention will now be described by way of example with reference to the accompanying drawings, Figures 1, 2, 3A of which are reproduced from GB-2 121 090A and are included here for the purposes of disclosure, and Figure 4 which illustrates the embodiment of the subject matter of the present invention.

In the drawings:-

Figure 1 is an elevational view, in quarter section, of a well safety valve utilizing hydraulic actuating means and shown in the open position,

Figure 2 is an enlarged cross-sectional view of the hydraulic actuating means of Figure 1 with the hydraulic piston being in its full upward position,

Figure 3 is an exploded perspective view of the hydraulic actuating means,

Figure 3A shows a modified type of piston, and

Figure 4 an enlarged cross-sectional view similar to Figure 2, but showing the hydraulic actuating means of the present invention.

Figures 1, 2, 3A of the drawings will now be described in detail to explain the background to the subsequent description of the embodiment of the present invention shown in Figure 4.

Referring now to Figure 1, a subsurface tubing safety valve 10 includes a body or housing 12

which is adapted to be connected in a well tubing to permit well production therethrough under normal operating conditions, but in which the safety valve 10 may close or be closed in response to abnormal conditions.

The valve 10 includes a bore 14, an annular valve seat 16 positioned about the bore 14, and a valve closure element such as a flapper valve 18 connected to the body 12 by pivot pin 20. Thus, when the flapper valve 18 is in the upward position and seated on the valve seat 16, the safety valve 10 is closed blocking flow upwardly through the bore 14 and well tubing.

A sliding longitudinal tubular member 22 is telescopically movable in the body 12 and through the valve seat 16. As best seen in Figure 1, when the tubular member 22 is moved to a downward position, the tube 22 pushes the flapper 18 away from the valve seat 16. Thus, the valve 10 is held in the open position so long as the tube 22 is in the downward position. When the tube is moved upwardly, the flapper 18 is allowed to move upwardly onto the seat 16 by the action of a spring 24 and also by the action of fluid flow moving upwardly through the bore 14 and behind the flapper 18.

The tubular member 22 is biased in an upward direction by a suitable means which may include a spring 26 for yieldably urging the member 22 in an upward direction to release the flapper 18 for closing the valve 10. The safety valve 10 is controlled by the application or removal of a pressurized fluid, such as hydraulic fluid, through a control path or line, such as one or more control lines 32 extending to the well surface or the casing annulus, which supplies pressurized fluid to the top of one or more pistons 40 which in turn act on the tubular member 22 to move the tubular member 22 downwardly forcing the flapper 18 off the seat 16 and into the full open position. The piston

40 may be an annular piston or may be a plurality, e.g. two, of circular pistons 40 positioned in the housing 12 and connected to the tubular member 22 by a connection 42. The safety valve 10 is controlled by the application or removal or pressurized fluid through the control lines 32 and a fluid passageway 46 to supply hydraulic control pressurized fluid to the cylinder 48 and the top of the piston 40. The bottom of the piston 40 is exposed to fluid pressure in the bore 14 which acts against the bottom of the piston 40 for biasing the tubular member 22 to the closed position when fluid control pressure is removed from the control line 32.

The above description is generally as disclosed in GB-2 121 090A mentioned above. However, the prior art, which has utilized a metal piston 40, such as in the form of cup seals, is difficult to manufacture to obtain desirable sealing under all pressure conditions and particularly in sealing gases. Furthermore, in some applications, the metal piston 40 is subject to wear and tear in its hostile environment and may leak. The present invention is directed to providing positive valve element seals connected to the piston 40 which will provide a positive seal in both directions for the double acting piston 40, and will provide a working hydraulic actuator even in the event that the piston 40 deteriorates to a condition which allows a considerable fluid bypass between the piston 40 and cylinder 48.

Referring now to Figures 1 and 2,the cylinder 48 includes a first metal valve seat 50 on one side of the piston 40 and in communication with the fluid control passageway 46 whereby hydraulic control fluid can flow to and actuate the top of the piston 40 through the valve seat 50. A second metal valve seat 52 is provided on the cylinder 48 on the second side of the piston 40 through which fluid pressure in the

safety valve and tubing can flow to the bottom side of and actuate the piston 40. A first metal valve element 54 is provided connected to the first side of the piston 40 and is adapted to seat on the first valve seat 50 to provide a positive seal when the piston 40 moves away from the first valve seat 50 (Figure 1). A second metal valve element 56 is connected to the second side of the piston 40 and is adapted to seat on the second valve seat 52 and provide a positive seal when the piston 40 moves away from the second valve seat 52 (Figure 2). Preferably, the valve elements 54 and 56 are connected to the piston 40 by ball and socket universal connections 58 and 60 respectively, for allowing the piston 40 to align itself properly in the cylinder 48 without binding. The piston 40 merely provides a dynamic seal in the cylinder 48 sufficient to cause movement of the piston 40 in the cylinder 48 to actuate the sliding tube 22. The valve elements 54 and 56 provide a static and positive seal when they are seated on their respective valve seats 50 and 52. Therefore, with the use of the positive valve elements 54 and 56 leakage of fluids past the piston 40 will not cause the hydraulic actuating system to become inoperative so long as the piston 40 seals sufficiently in the cylinder 48 to move the valve elements 54 and 56 to their seated positions. Once the valve elements 54 and 56 are in the seated position, fluid pressure acting on the back side of the elements 54 and 56 will positively seat and keep the valve elements 54 and 56 seated. The piston 40 may be in the form 41 shown in Figure 3A which is a conventional turbulent seal which has a minimum of sealing action. In fact the piston 40 could be merely a smooth elongated rod with a sufficiently close fit in the cylinder 48 whereby the pressure drop acting across the piston would move the valve elements 54 and 56 into their seated position.

Figure 3 is an exploded perspective view of two hydraulic piston and cylinder actuators which are identical and wherein the numbers of the second actuating means utilize the suffix "a" to correspond to like parts. Thus, the cylinders 48 and 48a are threadably secured at their upper ends to a housing member 13 and are enclosed by semi-circular housing members 15, which are secured to member 13 by suitable bolts 17.

In operation, when hydraulic control fluid is supplied through the line 32 fluid will flow into the passageway 46 and into the cylinder 48 above the piston 40 moving the piston 40 downwardly which in turn carries the sliding tube 22 downwardly to open the flapper 18. Downward movement of the piston 40 carries the valve element 54 downwardly until it contacts and seats on valve seat 50 (Figure 1) to provide a positive seal and further fluid pressure in the fluid passageway 46 acts on the back of the valve element 54 to hold it in the sealed position. When it is desired to close the valve, the pressure in the hydraulic control line 32 is reduced thereby reducing the pressure in the hydraulic passageway 46 and on the top of the valve element 54. The fluid pressure in the bore 14 of the safety valve 10 is in communication with the cylinder 48 and the bottom of the piston 40 and along with the spring 26 biases the piston 40 in an upward direction until, as best seen in Figure 2, the valve element 56 is seated on the valve seat 52 to provide a positive seal in the upward direction. Thereafter, the fluid pressure in the well tubing and bore 14 acts on the back of the valve element 56 to maintain it in a sealed position on the valve seat 52.

The above description of a well safety valve and the hydraulic actuating means for actuating the valve closure member is as disclosed in GB-2 121 090A. An embodiment of the hydraulic actuating means of the

present invention will now be described with reference to Figure 4 of the drawings.

Referring now to Figure 4, an embodiment of the present invention is shown in which like parts to those in Figure 2 are similarly numbered with the suffix "b". Referring now to Figure 4, the cylinder 48b includes a first metal valve seat 50b on one side of the piston 40b. A second metal valve seat 52b is provided on the cylinder 48b on the same side of the piston 40b as the valve seat 50b. A first metal valve element 54b is provided connected to said one side of the piston 40b and is adapted to seat on the first valve seat 50b to provide a positive seal when the piston 40b moves downwardly and towards the first valve seat 50b. A second metal valve element 56b is connected to said one side of the piston 40b and is adapted to seat on the second valve seat 52b and provide a positive seal when the piston 40b moves upwardly and away from the second valve seat 52b. Preferably, the valve elements 54b and 56b are comprised by a single valve member 53 which is connected to the piston 40b by a ball and socket universal connection 58b. In addition, a centralizer 49 is provided connected by a ball and socket universal connection 60b on the second side of the piston 40b for aligning the piston 40b in the cylinder 48b. As in Figures 1 to 3A, the piston 40b merely provides a dynamic seal in the cylinder 48b sufficient to cause movement of the piston 40b in the cylinder 48b to actuate the sliding tubular member 22. The valve elements 54b and 56b provide static and positive seals when they are seated on the respective valve seats 50b and 52b. Once the valve element 54b or 56b is in the seated position, the fluid pressure acting on the back side of the element 54b or 56b will positively seat and keep the valve element 54b or 56b seated. Again, the

piston 40b may be of the opposing metal cup type or a labyrinth seal 41 shown in Figure 3A or even a smooth elongated rod having a sufficiently close fit in the cylinder 48b to provide a pressure drop sufficient to move the valve elements 54b and 56b into their seated position. The operation of the hydraulic actuating mechanism of Figure 4 is similar to that described in connection with the operation of the actuator in Figures 1-3.

While the present invention has been described in connection with a subsurface tubing safety valve having a flapper type valve closure member, it is understood that the present invention may be used with other types of safety valves and other valve closure members.

CLAIMS

1. A well safety valve for controlling the fluid flow through a well conduit including a housing and a valve closure member moving between open and closed positions, and hydraulic actuating means for actuating the valve closure member, comprising a cylinder in the housing, a metal piston movable in the cylinder, said piston connected to and moving the valve closure member, said cylinder on a first side of the piston being in communication with a hydraulic control fluid passageway, and said cylinder on a second side of the piston being in communication with pressure in the safety valve, said cylinder including first and second spaced metal valve seats both positioned on one side of the piston, and first and second metal valve elements connected to said one side of the piston and spaced from each other to alternately seat and unseat on the first and second valve seats, respectively, as the piston alternately moves in the cylinder.

2. A well tubing safety valve for controlling the fluid flow through a well conduit and including a tubular housing having an axial bore therethrough and a valve closure member moving between open and closed positions for controlling the fluid flow through the bore, a longitudinal tubular member telescopically moving in the housing coaxially with the bore for controlling the movement of the valve closure member, and hydraulic actuating means for actuating the valve closure member comprising a generally longitudinally extending cylinder in the housing, said cylinder having its upper end in communication with a hydraulic control fluid passageway and having its lower end in

communication with the pressure in the axial bore of the safety valve, a metal piston movable in the cylinder in response to fluid movement through the cylinder acting on and moving said piston, said piston connected to and moving said valve closure member, said cylinder including a first metal valve seat on one side of the piston, a first metal valve element connected to one side of the piston adapted to seat on the first valve seat when the piston moves towards the first vlve seat, and a second metal valve element connected to the one side of the piston and adapted to seat on the second valve seat when the piston moves away from the second valve seat.

3. A well safety valve according to Claim 1, or Claim 2, wherein said first and second valve elements are comprised by a single valve member.

4. A well safety valve according to any one of Claims 1 to 3, including a centraliser connected by a universal connection to the other side of said piston for aligning said piston in said cylinder.

5. A well safety valve according to Claim 1 or Claim 2, including a universal connection between the piston and said valve elements.

6. A well safety valve substantially as hereinbefore described with reference to Figure 4 of the accompanying drawings.