ABSTRACT

A subsurface safety valve system for controlling the flow of production oil and/or gas fluids through a well pipe. The valve assembly is installed in the well pipe a predetermined depth below the surface. A wireline connects the valve assembly to surface facilities which include apparatus for maintaining sufficient tension on the wireline to hold the valve assembly to permit the valve assembly to close. A valve element closes off flow of fluids through the valve assembly by upward movement of a valve element actuator, the same direction as the upward flow of the production well fluids.

24 Claims, 5 Drawing Figures
BACKGROUND OF THE INVENTION

The present invention concerns subsurface safety valves for use in well production pipe strings and, in particular, subsurface safety valves controlled from the surface. The well production pipe string provides a flow path to the surface for well fluids produced from subsurface formations.

Many of the present methods for controlling subsurface safety valves from the surface require recompilation procedures which are often very expensive in existing wells. Subsurface valves which are controlled by hydraulic communication from the surface through a control pipe or line are seriously limited as to depth, because the hydrostatic pressure created by the control liquid in the control pipe (unless precharged gas loading is used to overcome the hydrostatic pressure). In addition, undetected leaks in the control pipe may cause premature valve closure. In the present invention, a subsurface valve is operated by a wireline which connects the valve to the surface. It is controlled at the surface but does not require the complicated downhole equipment required in the hydraulic power systems used to control subsurface valves from the surface. It has the advantageous features of being operable independent of the pressure in the well and independent of the depth at which it is located and it avoids expensive downhole operations. The valve also has the desirable feature of closing in the same direction as the fluid movement, namely, upward through the well bore. Such upward closure movement is desired because when the valve closes, pressure below the valve closure will be higher than that above the closure. This additional force upward assists the valve actuator which closes the valve element. Since the force which keeps the valve element open is downward, provision has been made so that the upward tension applied by the control wireline causes a downward force on the actuator for the valve element.

SUMMARY OF THE INVENTION

A subsurface safety valve assembly positionable in a well pipe used to produce oil and/or gas fluids and controllable by a wireline which extends to the surface, includes a valve element having an open position and a closed position to permit and prevent flow of fluids, respectively, through the well pipe and means attachable to a wireline and connected to the valve element for maintaining the valve element in its open position when a predetermined force is applied to the wireline and for permitting the valve element to move to its closed position upon removal of the force on the wireline.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 schematically illustrates the safety valve system of the present invention;

FIG. 2 is a vertical view, partly in section, of the valve assembly shown in FIG. 1;

FIG. 3 is a sectional view taken along lines 3—3 of FIG. 2; and

FIGS. 4 and 5 are vertical views, partly in section, of another embodiment of the safety valve assembly in its open and closed positions, respectively.
chamber 61 containing a compression spring 62 is formed below sleeve piston 55. Shoulder 49c limits the downward movement of sleeve piston 55. Compression spring 62 abuts the lower end 55a of sleeve piston 55 and a shoulder 63 formed by the nose portion 51 of lower section 49d and biases or urges sleeve piston 55 upwardly.

Oppositely disposed windows 56 are formed in the walls of sleeve piston 55 to accommodate the outer periphery of ball valve 54. The inner wall section of sleeve piston 55, perpendicular to windows 56 and adjacent thereto are milled to form oppositely disposed flat surfaces 57 which engage the flat surfaces of ball valve 54. Actuating pins 58 are fixed in the flat walls of the sleeve piston and extend into eccentrically located slots 59 formed in the flat surfaces of ball valve 54, such that upward movement of sleeve piston 55 causes ball valve to rotate on its axis and close off the flow passageway through tubular members 49a and 49b. Downward movement of sleeve piston 55 from the closed position of ball valve 54 causes the ball valve to rotate to its open position shown in FIGS. 2 and 3.

The lower end of a sleeve piston 67 contains an annular shoulder which is slidable along the wall 64 of cylindrical member 50 in the space indicated at 64a. The annular shoulder contains a sealing ring 68 which engages the interior of wall 64. The upper reduced diameter sleeve portion 69 of piston 67 is slidable in the bore of an upper section 52 of the valve assembly which is threaded to tubular member 44. Sleeve portion 69 engages a seal 72 located in the bore wall of section 52. A pressure chamber 73 is formed thereby which fluidly communicates with chamber 60 through opening 65 and passageway 66. Fluid outlet ports 70 are provided in the upper end of piston 67 and an upwardly extending latching spear 71 is arranged on the uppermost end of piston 67.

The wall of lower tubular member 49b contains a screened port 74 for passage of well fluids into and from spring chamber 61. Spear 71 of piston 67 is connected to wireline 46 by the overshot latching means 45, the operation of which is well known to the art. Chamber 73, passageway 66, and chamber 60, together with hydraulic fluid contained therein form a closed hydraulic system.

The operation of the embodiment of the subsurface safety valve illustrated in FIGS. 1, 2, and 3 is as follows. Valve assembly 40 is run in tubing string 15 and latched therein in accordance with conventional procedures. When installing the valve assembly sleeve piston 55 is in its uppermost position under the bias of compression spring 62 and piston 67 is in its lowestmost position and ball valve 54 is closed. The closed hydraulic system has been filled with hydraulic fluid. Wireline seal 22 in lubricator tube 21 is open and overshot latch 45 is run on wireline 46 and latched to spear 71 of piston 67. Piston 25 in lubricator tube 21 is attached to wireline 46. Seal 22 is closed on wireline 46 and hydraulic pressure from source 25 is supplied through conduit 27 and inlet 23 to the underside of piston 25 moving piston 25 upwardly in lubricator tube 21 and applying thereby a tensional force to wireline 46. The upward force on wireline 46 causes piston 67 to move upwardly forcing hydraulic fluid in chamber 73 to move into chamber 60, thereby forcing sleeve piston 55 downwardly to its lowestmost position against stop shoulder 49c and causing ball valve 54 to rotate to its full open position shown in FIGS. 2 and 3. A predetermined tensional force is maintained on wireline 46 by fluid pressure supplied from source 26 to maintain ball valve 54 in its open position. Hydraulic fluid is also supplied through conduit 28 to wing valve 20 to maintain valve 20 open. Well fluids flow from formation 12 through open safety valve assembly 40, tubing string 15, and flow line 19. Loss of hydraulic pressure from lubricator tube 21 releases the tensional force on wireline 46 which permits compression spring 62 to move sleeve piston 55 upwardly thereby rotating ball valve 54 to its closed position. Well fluids below ball valve 54 also pass through screened port 74 to add additional force against the underside of sleeve piston 55 to aid in closing the ball valve.

Paraffin scraper 43, attached to wireline 46, may be pulled upwardly. The lower tube pipe 15 whenever it is deemed necessary to remove paraffin from the wall of the well pipe. Wireline 46 is unlatched from and latched to the valve assembly in a manner well known in the art.

Another embodiment of the subsurface safety valve assembly, generally designated 80 is shown in FIGS. 4 and 5. Only the lower changed portion of the valve assembly is illustrated. The upper portion of the valve assembly is the same as the upper portion of the valve assembly illustrated in FIGS. 2 and 3. A tubular member 81, having an opening 82 in the lower end, has positioned in its upper end a concentric tubular member 83 which comprises a lower section 83a, an enlarged diameter upper section 83b (equivalent to cylindrical member 50 of FIGS. 2 and 3) and an annular shoulder 84 formed therewith. Upper section 83b forms a space 85 (equivalent to space 64a of FIGS. 2 and 3) in which a piston, not shown, such as 67 shown in FIGS. 2 and 3 reciprocates. A fluid passageway 86 is formed between tubular member 81 and section 83b.

A concentric sleeve member 88, which includes an upper enlarged diameter section 88a and a lower reduced diameter section 88b, is slidably arranged in the lower end of tubular member 81. The connection between the upper and lower sections 88a and 88b forms a downwardly facing shoulder 87. Upper section 88a forms a sleeve piston in the annulus between tubular member 81 and section 83a which is slidable between upper shoulder 84 and a lower shoulder 89 formed on the inner wall of tubular member 81. Seals 90 and 91 engage the walls of section 83a and tubular member 81, respectively. Reduced diameter section 88b extends downwardly through opening 82 and below the lower end of tubular member 81. The annulus above sleeve piston 88a between tubular member 81 and lower section 83a forms a chamber 92 and the annulus below the sleeve piston 88a between tubular member 81 and section 88b forms a spring chamber 93. A compression spring 94 is confined in chamber 93 and abuts shoulder 87 and a lower shoulder 95 formed at the lower end of tubular member 81. In FIG. 4 sleeve member 88 is illustrated in its lowestmost position. Fluid entry ports 99 are formed in section 88b just above the lower end thereof. An upwardly facing cup-shaped seal member 96 is attached to the lower end of section 88b by bolt 97 and washer 98. When section 88b is in its lowestmost position ports 99 are below the lower end of tubular member 81 and open to well fluid flow. The upper annular edge 100 of seal member 96 abuts and seals against the lower end, 101 of tubular member 81 when
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5 section 88b is raised to its uppermost position as shown in FIG. 5. In this upper position, ports 99 are positioned within the lower end of tubular member 81 and fluid flow through the valve assembly is closed off. A screened port 102 is provided in section 88b for entry of well fluid to chamber 93 below section 88a. After the valve has closed as shown in FIG. 5 well pressure below the valve assists in maintaining the valve closed.

In operation of the embodiments shown in FIGS. 4 and 5 when hydraulic fluid pressure in chamber 92 is released by releasing tension on wireline 46, as previously described herein with respect to the embodiment shown in FIGS. 1, 2, and 3, spring 94 moves sleeve member 88 upwardly moving ports 99 within tubular member 81 and forcing seal member 96 to seal against the lower end of tubular member 81.

While connectors 30 and 31 in conduits 27 and 28 are described as heat sensitive, in that they would dissolve or disintegrate under a high temperature to cause release of fluid pressure in conduits 27 and 28 and the resulting closure of the subsurface valve assembly and the wing valve, other devices sensitive to, for example, increased pressure or impact might be used instead. The nose portion 51 of lower tubular member 49, and the upper section 52 both threaded to tubular member 44 and cylindrical member 50 threaded to tubular member 49a are shown as separate components in order to facilitate construction of the valve assembly. Any one or all of these components may be formed integral with the tubular member to which it is screw threadedly connected.

Further, instead of the piston-cylinder-fluid pressure arrangement for maintaining a correct tension on the wireline, shown and described herein for purposes of illustration, other arrangements may be used. Thus, the wireline could be directly connected to a surface winch or drum on which the torque and thereby the correct tension on the wireline may be maintained by, for example, a hydraulic gear pump or other suitable means. Other means, such as pressure or impact responsive means, for automatically releasing tension on the wireline may be substituted for or used together with the heat sensitive means illustrated. Of course, tensional force on the wireline may be released manually.

Other changes and modifications may be made in the illustrative embodiments of the invention shown and/or described herein without departing from the scope of the invention as defined in the appended claims.

Having fully described the apparatus, objects, advantages, and operation of my invention, I claim:

1. A subsurface safety valve assembly controllable by a wireline which extends to the surface and positionable in a well pipe which provides a flow path to the surface for well fluids produced from subsurface formations comprising:
   a movable valve element having an open position to permit flow of fluids through said flow path and a closed position to prevent flow of fluids through said flow path;
   valve element actuating means attachable to said wireline and connected to said valve element for maintaining said valve element in its open position when a predetermined tensional force is applied to said wireline and for permitting said valve element to move to its closed position upon removal of said tensional force on said wireline;
   fluid pressure means responsive to said tensional force applied to said wireline for actuating said valve element to its open position; and
   biasing means for moving said valve element to its closed position upon removal of said tensional force on said wireline.

2. A subsurface safety valve assembly controllable by a wireline which extends to the surface and positionable in a well pipe which provides a flow path to the surface for well fluids produced from subsurface formations comprising:
   a movable valve element having an open position to permit flow of fluids through said flow path and a closed position to prevent flow of fluids through said flow path;
   valve element actuating means attachable to said wireline and connected to said valve element for maintaining said valve element in its open position when a predetermined tensional force is applied to said wireline and for permitting said valve element to move to its closed position upon removal of said tensional force on said wireline;
   said actuating means comprising:
   fluid pressure means responsive to said tensional force applied to said wireline for actuating said valve element to its open position; and
   biasing means for moving said valve element to its closed position upon removal of said tensional force on said wireline;

3. A valve assembly as recited in claim 2 in which said third tubular member contains a shoulder on its outer surface for limiting downward movement of said sleeve piston.

4. A valve assembly as recited in claim 3 including a screened port formed in said third tubular member fluidly communicating the interior of said valve assembly and the space in which said biasing means is arranged.

5. A subsurface safety valve assembly controllable by a wireline which extends to the surface and positionable in a well pipe which provides a flow path to the surface for well fluids produced from subsurface formations comprising:
   a movable valve element having an open position to permit flow of fluids through said flow path and a
closed position to prevent flow of fluids through said flow path; 
valve element actuating means attachable to said wireline and connected to said valve element for maintaining said valve element in its open position when a predetermined tensile force is applied to said wireline and for permitting said valve element to move to its closed position upon removal of said tensile force on said wireline; 
said valve element comprising a ball valve and said actuating means comprising: 
a first outer tubular member having an inwardly extending enlarged upper portion; 
a second upper inner tubular member concentric to and spaced from said first tubular member having an outwardly extending enlarged upper portion; 
a third inner lower tubular member concentric to and spaced from said first tubular member; 
said ball valve being positioned between said second and third tubular members; 
a first sleeve piston arranged between said first tubular member and said second and third tubular members and said ball valve; 
biaising means arranged between said first tubular member and said third tubular member and abutting the lower end of said sleeve piston to urge said sleeve piston upwardly; 
means connecting said first sleeve piston and said ball valve capable of rotating said ball valve (1) from an open to a closed position upon movement of said first sleeve piston upwardly and (2) from a closed to an open position upon movement of said first sleeve piston downwardly; 
a first fluid chamber formed between the lower end of said enlarged portion of said second tubular member and the upper end of said first sleeve piston and between said first and second tubular members; 
a second sleeve piston slidably on the inner wall of said second tubular member and having an inner extending enlarged lower portion slidably on the inner wall of said enlarged upper portion of said first tubular member; 
a second fluid chamber formed between the lower end of the enlarged portion of said first tubular member and the upper end of the enlarged portion of said second sleeve piston and between the inner wall of said second tubular member and outer wall of said second sleeve piston; 
a fluid passageway formed between the inner wall of said first tubular member and the outer wall of the enlarged upper portion of said second tubular member fluidly communicating with said first and second fluid chambers; and 
the upper end of said second sleeve piston being attachable to said wireline whereby when a tensional force is applied to said wireline, fluid is forced from said second fluid chamber through said passageway into said first fluid chamber to force said first sleeve piston downwardly against the bias of said biasing means to rotate said ball valve to its open position. 
6. A valve assembly as recited in claim 5 in which the wall of said sleeve piston contains oppositely disposed openings for accommodating said outer periphery of said ball valve. 
7. A subsurface safety valve assembly controllable by a wireline which extends to the surface and positionable in a well pipe which provides a flow path to the surface for well fluids produced from subsurface formations comprising: 
a movable valve element having an open position to permit flow of fluids through said flow path and a closed position to prevent flow of fluids through said flow path; 
valve element actuating means attachable to said wireline and connected to said valve element for maintaining said valve element in its open position when a predetermined tensile force is applied to said wireline and for permitting said valve element to move to its closed position upon removal of said tensile force on said wireline; 
said actuating means comprising: 
a first tubular member; 
a second tubular member within, concentric to and spaced apart from said first tubular member; 
a sleeve piston extending upwardly into the space between said first and second tubular members and downwardly through the lower end of said first tubular member and having upper and lower positions, the lower portion of said sleeve piston being spaced from said first tubular member; 
said valve element being positioned on the lower end of said sleeve piston and capable of sealingly engaging the lower end of said first tubular member; 
the lower end of said sleeve piston containing openings above said valve element to permit fluids to flow through said valve assembly when said sleeve piston is in its lower position; 
a closed fluid pressure system responsive to tensional force applied to said wireline for applying a downwardly directed fluid pressure force to said sleeve piston; and 
biaising means arranged in the space between said first tubular member and said sleeve piston adapted to bias said sleeve piston upwardly. 
8. A subsurface safety valve assembly controllable by a wireline which extends to the surface and positionable in a well pipe which provides a flow path to the surface for well fluids produced from subsurface formations comprising: 
a movable valve element having an open position to permit flow of fluids through said flow path and a closed position to prevent flow of fluids through said flow path; 
valve element actuating means attachable to said wireline and connected to said valve element for maintaining said valve element in its open position when a predetermined tensile force is applied to said wireline and for permitting said valve element to move to its closed position upon removal of said tensile force on said wireline; 
said valve element comprising a cup-shaped seal and said actuating means comprising: 
a first tubular member having an inwardly extending enlarged upper portion; 
a second tubular member within, concentric to and spaced apart from said first tubular member and having upper and lower portions; 
a first sleeve piston extending upwardly into the space between said first and second tubular members and downwardly through the lower end of said
first tubular member and having upper and lower positions;
said cup-shaped seal being arranged on the lower end of said first sleeve piston and capable of sealingly engaging the lower end of said first tubular member;
the lower end of said first sleeve piston containing openings to permit fluids to flow through said valve assembly when said first sleeve piston is in its lowest position;
biasing means arranged between said first tubular member and said first sleeve piston adapted to bias said sleeve piston upwardly;
a first fluid chamber formed by the space between said first tubular member and the lower portion of said second tubular member above said first sleeve piston;
a second sleeve piston slideable on the inner wall of said second tubular member and having an inner extending enlarged lower portion slideable on the inner wall of said enlarged upper portion of said first tubular member;
a second fluid chamber formed between the lower end of the enlarged portion of said first tubular member and the upper end of the enlarged portion of said second sleeve piston and between the inner wall of the upper portion of said second tubular member and the outer wall of said second sleeve piston;
a fluid passageway formed between the inner wall of said first tubular member and the outer wall of the upper portion of said second tubular member fluidly communicating with said first and second fluid chambers; and
the upper end of said second sleeve piston being attachable to said wireline whereby when a tensional force is applied to said wireline fluid is forced from said second fluid chamber through said passageway into said first fluid chamber to force said first sleeve piston downwardly against the bias of said biasing means until said openings in said first sleeve piston are below the lower end of said first tubular member.

9. A subsurface safety valve system for controlling flow of fluids through a well pipe which provides a flow path to the surface for upwardly flowing well fluids produced from subsurface formations comprising:
a valve assembly arranged in said well pipe including a valve element having an open position to permit flow of fluids through said flow path and a closed position to prevent flow of fluids through said flow path and valve element actuating means connected to said valve element and including means movable downwardly for actuating said valve element to its open position and biasing means movable upwardly to urge said valve element to its closed position; and
a wireline attached to said actuating means for maintaining said valve element in its open position when a predetermined tensional force is applied to said wireline, said biasing means of said actuating means moving said valve element to its closed position upon removal of said tensional force on said wireline.

10. A subsurface safety valve system as recited in claim 9 including means connected to said wireline for releasably maintaining said tensional force on said wireline.

11. A valve system as recited in claim 9 in which said actuating means comprises:
fluid pressure means responsive to said tensional force applied to said wireline for actuating said valve element to its open position; and
biasing means for moving said valve element to its closed position upon removal of said tensional force on said wireline.

12. A valve system as recited in claim 9 in which said actuating means comprises:
a first outer tubular member;
a second upper inner tubular member concentric to and spaced from said first tubular member;
a third inner lower tubular member concentric to and spaced from said first tubular member;
said valve element being positioned between said second and third tubular members;
said sleeve piston arranged in the space between said first tubular member and said second tubular member and said third tubular member and said valve element;
means connecting said sleeve piston to said valve element for moving said valve element (1) from an open to a closed position upon movement of said sleeve piston from its lower to its upper position and (2) from a closed to an open position upon movement of said sleeve piston from its upper to its lower position;
a closed fluid pressure system responsive to said tensional force applied to said wireline for applying a downwardly directed fluid pressure force to said sleeve piston to move said sleeve piston upwardly and move said valve element to its open position; and
biasing means arranged in the space between said first and third tubular members for urging said sleeve piston upwardly and move said valve element to its closed position.

13. A valve system as recited in claim 12 in which said third tubular member is provided with a shoulder on its outer wall for limiting downward movement of said sleeve piston.

14. A valve system as recited in claim 13 including a screened port formed in said third tubular member fluidly communicating the interior of said valve assembly and the space in which said biasing means is arranged.

15. A valve system as recited in claim 14 including means connected to said wireline for releasably maintaining said tensional force on said wireline.

16. A valve system as recited in claim 9 in which said valve element comprises a ball valve; and said actuating means comprises:
a first outer tubular member having an upper portion of decreased inner diameter;
a second upper inner tubular member concentric to and spaced from said first tubular member having an upper portion of increased inner and outer diameters;
a third inner lower tubular member concentric to and spaced from said first tubular member;
said ball valve being positioned between said second and third tubular members;
a first sleeve piston arranged between said first tubular member and said second and third tubular members and said ball valve;

biasing means arranged between said first tubular member and said third tubular member and abutting the lower end of said first sleeve piston to urge said first sleeve piston upwardly;

means connecting said first sleeve piston and said ball valve capable of rotating said ball valve (1) from an open to a closed position upon movement of said first sleeve piston upwardly and (2) from a closed to an open position upon movement of said first sleeve piston downwardly;

a first fluid chamber confined between the lower end of said upper portion of said second tubular member and the upper end of said first sleeve piston and between the lower portions of said first and second tubular members;

a second sleeve piston having an upper portion slidable on the inner wall of the upper portion of said first tubular member and having a lower portion of increased diameter slidable on the inner wall of said upper portion of said second tubular member;

a second fluid chamber confined between the lower end of the upper portion of said first tubular member and the upper end of the lower portion of said second sleeve piston and between the inner wall of the upper portion of said second tubular member and the outer wall of the upper portion of said second sleeve piston;

a fluid passageway formed between the inner wall of said first tubular member and the outer wall of the upper portion of said second tubular member fluidly communicating with said first and second fluid chambers;

the upper end of said second sleeve piston being attachable to said wireline whereby when a tensile force is applied to said wireline fluid is forced from said second fluid chamber through said passageway into said first fluid chamber to force said first sleeve piston downwardly against the bias of said biasing means to actuate the ball valve to its open position and when said tensile force on said wireline is released said biasing means forces said first sleeve piston upwardly to actuate the ball valve to its closed position and said fluid is forced from said first fluid chamber through said passageway into said second fluid chamber.

17. A valve system as recited in claim 16 in which the wall of said sleeve piston contains oppositely disposed openings for accommodating the outer periphery of said ball valve.

18. A valve system as recited in claim 9 in which said actuating means comprises:

a first tubular member;

a second tubular member within, concentric to and spaced apart from said first tubular member;

a sleeve piston extending upwardly into the space between the first and second tubular members and downwardly through the lower end of said first tubular member and having upper and lower positions, the lower portion of said sleeve piston being spaced from said first tubular member;

said valve element being positioned on the lower end of said sleeve piston and capable of sealingly en-
sional force is applied to said wireline fluid is forced from said second fluid chamber through said passageway into said first fluid chamber to force said first sleeve piston downwardly against the bias of said biasing means to move said opening in said first sleeve piston below the lower end of said first tubular member.

22. A valve system as recited in claim 21 including means connected to said wireline adjacent the surface for releasably maintaining said tensional force on said wireline.

23. A valve system as recited in claim 22 wherein said means connected to said wireline at the surface includes releasable fluid pressure means.

24. A valve system as recited in claim 23 including a paraffin scraper attached to the lower end of said wireline; said wireline being releasable from connection to said valve actuating means for pulling said paraffin scraper upwardly through said well pipe.

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