APPLICATION FOR PATENT

Title: Multiple Spring Subsurface Safety Valve

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FIELD OF THE INVENTION

[0001] The field of this invention is subsurface safety valves and more particularly those intended for use in deep applications where closure depends on overcoming hydrostatic pressure in a well.

BACKGROUND OF THE INVENTION

[0002] Subsurface safety valves are commonly used to prevent unwanted flow from reaching the surface and causing a dangerous condition. A common design involves a flapper that is held open by a flow tube. A control line from the surface extends to a piston in the housing of the safety valve which is coupled to the flow tube. Applied pressure on the piston shifts the flow tube down against a flapper that rotates about a pivot that is generally spring loaded. The advancing flow tube comes down in front of the rotated flapper and the safety valve remains in the open position as long as pressure is maintained in the control line from the surface. The act of opening the safety valve by moving the flow tube also compresses a closure spring. The closure spring is designed to overcome the anticipated hydrostatic pressure in the control line as well as frictional resistance in the piston seals and weight of parts. As the placement depth gets higher, such as depths in the order of 15,000 to 20,000 feet and beyond, the force required for the closure spring to overcome the anticipated hydrostatic pressures increases dramatically.

[0003] There are design parameters that affect the size of the closure spring to handle increasing hydrostatic pressures that are present in greater depth applications. There is a finite limit to the length of the valve housing to be able to get it into position. One approach to shortening the length of the valve was to use a series of shorter springs between two points each guided around a rod, as illustrated in USP 5,564,675. One of the problems with this design is that it decreased the flow area of the flow tube for a given

outside dimension of the valve housing to make such a spring assembly fit in the housing. Another approach using an insert safety valve that lands on a landing collar was to separate the springs from the valve body only to latch them together when the valve body was seated downhole on the landing collar. This design shown in USP 4,524,830 used a 90 degree ball valve and a complex landing collar design that still had to reduce the flow area through the valve to allow for the spring loaded connecting link between the spring assembly and separate valve body. Other safety valve designs that don't use flappers and have multiple springs for different purposes are shown in US Patents 3,889,751 and 4,428,557.

[0004] The present invention works within the design constraints of maximizing the flow passage size in the safety valve flow tube while being constrained on the outside dimension by well conditions and still having enough force to overcome hydrostatic pressure in a deep set safety valve. Springs are independently supported in the valve housing and are arrayed in a vertical stack to each push against the flow tube and the hydrostatic pressure that exerts a down force that tends to hold the valve open. With removal of applied pressure the spring assembly is strong enough to overcome hydrostatic pressure that is in the well or in a control line in installations with the safety valve installed in depths that can exceed 20,000 feet with minimal or no reduction in flow area through the flow tube.

SUMMARY OF THE INVENTION

[0005] A subsurface safety valve that features vertically stacked springs that are each independently supported in the valve housing, or housings, and each having an opposite end that bears on a shoulder connected to the flow tube is described. When mounted this way their applied force is additive as they are in effect mounted in parallel between the housing and the flow tube for overcoming hydrostatic pressure in deep set applications that can exceed 20,000 feet. The stacking also allows the cross-sectional area of the flow tube to be maximized for a given housing outside diameter dictated by well conditions.

BRIEF DESCRIPTION OF THE DRAWINGS

[0006] FIG. 1 is a section view of a safety valve in a closed position with the springs extended; and

[0007] FIG. 2 is the view of FIG. 1 with the springs compressed and the safety valve in the open position.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0008] FIG. 1 shows a housing assembly **10** with supports **12** and **14** on which springs **16** and **18** respectively bear. A flow tube **20** has a passage **22** through it and a lower end **24** that is disposed near a flapper **26** that is shown against its seat **28**. Springs **16** and **18** when compressed by applied pressure in a control line driving a piston connected to the flow tube **20** (all of which except the flow tube **20** are not shown as their design is known to those skilled in the art and which are not the central focus of the invention) are pushed in compression by downward movement of the flow tube **20** that moves shoulders **30** and **32** to push the flapper **26** away from its seat **28**. As long as pressure is maintained in the control line (not shown) the springs **16** and **18** will stay compressed. If pressure is released or leaks out of the control line and/or bypasses the associated piston (not shown) the force transmitted by the springs **16** and **18** will be strong enough to push the flow tube **20** up hole allowing the flapper **26** to come up against the seat **28.** In deep set applications the force will be enough because the force transmitted by springs **16** and **18** will be additive as they both push up the flow tube **20** by pushing independently against their respective shoulders **30** and **32** that extend off the flow tube **20**.

[0009] While two stacked springs are shown, more than two can be used. The stacking of the springs allows amplification of the force to act against hydrostatic pressure in the control line while allowing the passage **22** to be as large as possible for a given constraint of outside diameter of the housing assembly **10** in the surrounding wellbore. While coiled springs are illustrated other spring types such as Bellville washer stacks can be alternatively used. The housing assembly **10** as well as the flow tube **20** can

be made in a single piece or can be modular with threaded connections as illustrated in the FIGS 1 and 2.

[0010] FIG. 2 illustrates the springs **16** and **18** compressed and the flapper **26** behind the flow tube **20** and away from its seat **28**.

[0011] The above description is illustrative of the preferred embodiment and many modifications may be made by those skilled in the art without departing from the invention whose scope is to be determined from the literal and equivalent scope of the claims below.

We claim:

1. A valve for downhole use, comprising:

at least one housing having a flow path therethrough;

a valve member mounted and subject to a biasing assembly for selectively opening and closing said flow path;

said biasing assembly comprising a plurality of biasing members arranged in a generally axial orientation in said housing and each supported proximate to one end by said housing and operatively coupled to said valve member proximate to an opposite end.

2. The valve of claim **1**, wherein:

said biasing members comprise springs;

said springs are disposed outside said flow path.

3. The valve of claim **1**, wherein:

said biasing members comprise springs;

said springs are coiled springs.

4. The valve of claim **1**, wherein:

said biasing members comprise discrete springs in axial alignment one above another;

said valve member is defined by a flow tube with said springs bearing directly or indirectly on said flow tube.

5. The valve of claim **4**, wherein:

said flow tube operates a flapper that rotates a quarter turn.

6. The valve of claim **4**, wherein:

said flow path extends through said flow tube and said springs are mounted outside said flow tube.

7. The valve of claim **4**, wherein:

said springs overcome a hydrostatic force acting on said flow tube at mounting depths of said housing of more than 20,000 feet.

8. The valve of claim **4**, wherein:

said housing and said flow tube are modular.

9. The valve of claim **4**, wherein:

said housing and said flow tube are each made of one piece.

10. The valve of claim **1**, wherein:

said biasing members comprise springs;

said plurality of springs comprises two springs.

11. The valve of claim **2**, wherein:

said springs are coiled springs.

12. The valve of claim **11**, wherein:

said valve member is defined by a flow tube with said springs bearing directly or indirectly on said flow tube.

13. The valve of claim **12**, wherein:

said flow tube operates a flapper that rotates a quarter turn.

14. The valve of claim **13**, wherein:

said flow path extends through said flow tube and said springs are mounted outside said flow tube.

15. The valve of claim **14**, wherein:

said springs overcome a hydrostatic force acting on said flow tube at mounting depths of said housing of more than 20,000 feet.

16. The valve of claim **15**, wherein:

said housing and said flow tube are modular.

17. The valve of claim **16**, wherein:

said plurality of springs comprises two springs.