ANNULAR SAFETY SYSTEM FOR CASED WELL

This invention relates to an annular safety system for a cased well.

The known annular safety systems for gas lift wells utilize complicated and expensive assortments of packers, sidepocket mandrels, gas lift valves and safety valves. These annular safety system installations require pressurized gas or production in tubing casing annular flow passages with inaccessible safety valves positioned below one or two packers. Well servicing tools cannot be lowered into some of the installations on wireline because of restrictions or abrupt offsets in the flow conduits.

We have now devised an annular safety system for a cased well, which system requires no gas lift valves or side pocket mandrels, and only one packer. Pressurized lift gas or production does not flow in the tubing casing annulus. All safety valves used are above the only packer required and are thus easily retrievable. Full bore tubings are utilized permitting wireline servicing tools to be lowered through the production tubing.

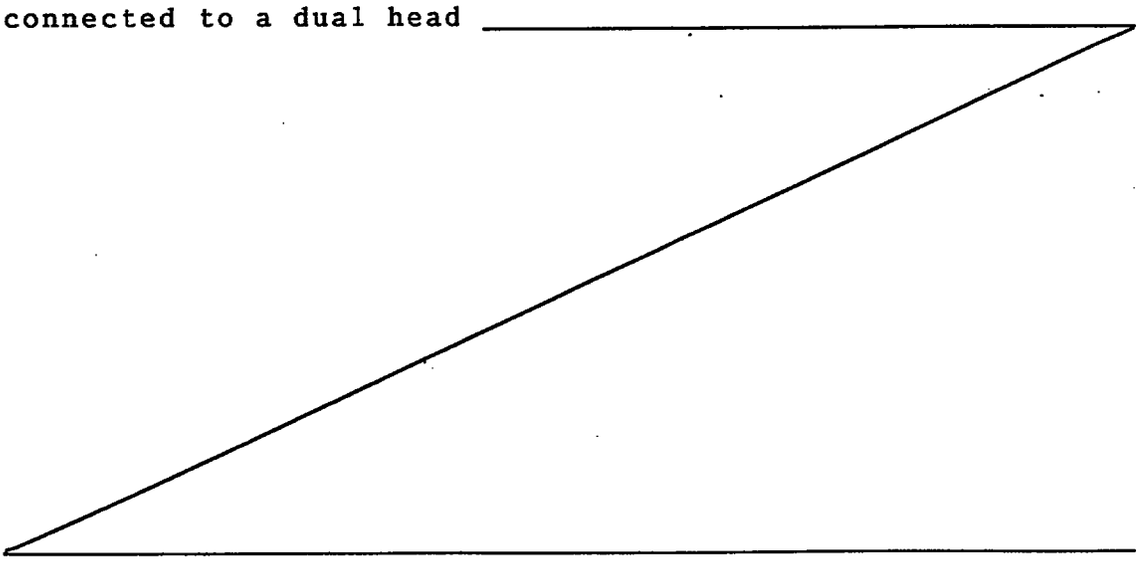
According to the present invention, there is provided an annular safety system for a cased well comprising:

(a) packer means for anchoring and sealing in said casing, said packer means having outlet ports for flow from inside to outside said packer means;

(b) a landing nipple connected below said packer means; and

(c) operating seal unit means for operating said packer means to anchor and seal in said casing, said operating seal unit means sealingly engaging and extending through said packer means to form an annular flow passage communicating with said packer means outlet ports, said operating seal unit means including: a dual head having primary and secondary well tubing connected thereto, a valve permitting downward flow and automatically preventing upward flow in said secondary well tubing, a primary flow conduit therein connected to said dual head and having a flow passage communicating said primary tubing through said landing nipple with said well casing below said packer means, said primary flow conduit having a safety valve therein operable to prevent upward flow in said primary conduit, lockable locator means on said primary flow conduit for landing and releasably locking in said landing nipple, and annular flow passages therein for communicating said secondary tubing with said annular flow passage through said packer means.

The annular safety system of this invention utilizes a packer which is hydraulically operable to anchor and seal in a well casing. Suspended below the packer is a landing nipple. Primary and secondary well tubings are connected to a dual head



on a unique operating seal unit, which extends through the packer to releasably lock in the landing nipple. An inline valve in the secondary tubing above the dual head permits downward flow and prevents upward flow. The operating seal unit, which also operates the packer to anchor and seal in well casing, contains a primary flow conduit communicating with the primary well tubing and annular flow passages communicating with the secondary well tubing. The annular flow passages in the operating seal unit and flow passages through and around the packer conduct pressurized lift gas from the secondary tubing to around the landing nipple to comingle with liquid in the casing which is aerated to flow (lifted) upwardly in the primary tubing. The primary flow conduit includes a novel emergency connector disconnected by rotation and an hydraulically operable safety valve which may be operated to prevent upward flow through the primary conduit in the operating seal unit. When it is desirable to stop upward flow in the primary conduit and primary tubing, gas pressure in the secondary tubing is reduced and any upward flow is automatically prevented by the inline valve. The safety valve in the primary conduit is operated to close preventing upward flow of aerated liquid in the primary conduit and primary tubing.

The operating seal unit may be unlocked from the landing nipple for retrieval to surface by wireline operation or rotated to disconnect if it cannot be unlocked by wireline.

The invention provides an annular safety system for a well produced by gas lift having primary and secondary tubings with a valve in each tubing for preventing upward flow.

The invention also provides an annular safety system for a well produced by gas lift which utilizes a retrievable operating seal unit having a primary flow conduit for production flow and annular flow passages for lift gas flow.

The invention further provides an annular safety system for a gas lift well wherein the operating seal unit is inserted for locking and is released for retrieval by wireline operation.

The invention also provides an operating seal unit for an annular safety system for a gas lift well which includes an emergency disconnect operated by rotation.

In order that the invention may be more fully understood, embodiments thereof will now be described by way of example only with reference to the accompanying drawings, wherein:

Figures 1A, B and C together are a schematic drawing in elevation and partial section of an embodiment of annular safety system of this invention positioned in well casing before the packer has been operated to anchor in and seal with the casing.

Figures 2A,B,C,D,E and F together are a schematic drawing in elevation and partial section of an embodiment of the invention positioned in well casing showing the packer anchored in well casing and the operating seal unit locked in the landing nipple below the packer.

Fig. 3 is a drawing of the cross section along line 3-3 in Fig. 2.

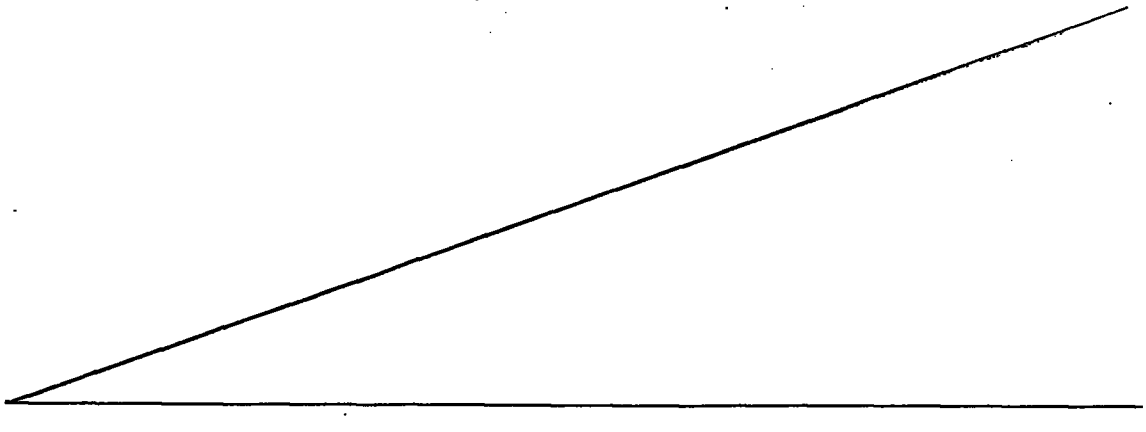


Fig. 4 is a cross sectional drawing along line 4-4 in Fig. 2.

Figs. 5A and 5B together is an elevational drawing in partial section of the lower portion of the operating seal unit showing the automatic lockable locator landed in the landing nipple.

Fig. 6 is a cross sectional drawing along line 6-6 of Fig. 5A.

Fig. 7 is a drawing in cross section along line 7-7 of Fig. 5A.

Fig. 8 is a drawing similar to Figs. 5A & B showing the automatic lockable locator unlocked by wireline.

Fig. 9 is a drawing, also similar to Figs. 5A & B, showing the rotatable connector being rotated to disconnect from the automatic lockable locator.

Shown in Figs. 1A, B and C is the annular safety system of this invention positioned in well casing 10. The system includes a primary well tubing 11, a secondary well tubing 12 with an inline valve 13, both tubings are connected into an operating seal unit 14 and the operating seal unit sealingly engages the upper end of a packer 15. Connected below the packer is a landing nipple 16.

Fig. 2 shows the landing nipple has profiled grooving 16a, a landing surface 16b, a seal bore 16c and a connector 16d. The primary and secondary tubings are connected into a dual head 17 on operating seal unit 14 (see also Fig. 3). Connected to the dual head and extending downwardly is a primary flow conduit 18

having a flow passage 19 in communication with the primary well tubing flow passage. A surface controlled subsurface safety valve 20 (see also Fig. 4) of the type disclosed in U.S. Patent Number 4,723,606, issued 9 February, 1988 to Michael B. Vinzant et al is included in the primary flow conduit and shown in the closed position. The safety valve includes a lock out 21 for locking this safety valve in open position to permit two way flow through the primary flow conduit. Also connected to dual head 17 is a control line 22 from surface communicating through dual head flow passage 17a with safety valve 20 for operating the safety valve. Extending downwardly from the lower end of the safety valve is a spacer pipe 23 connected into a closed sleeve valve 24, which is sealed above and below operating flow ports 25 in lower packer mandrel 26 by resilient seals 27 engaging seal bore 26a.

An outer conduit 28 is connected on and extends downwardly from dual head 17 around safety valve 20 and connects to outer conduit extension 29 having resilient seals 30. Seals 30 sealingly engage seal bore 31a in upper packer mandrel 31 which is connected on lower packer mandrel 26. Spacer pipe 32 extends downwardly from sleeve valve 24 to connect to seal unit 33 having resilient seals 34 which are sealingly engageable in landing nipple seal bore 16c. Rotatable connector 35 and automatic lockable locator 36 are connected to seal unit 33 with guide 37 connected on lockable locator 36. Fig. 2 shows the lockable locator and operating seal unit have been inserted through the packer to automatically land and have been locked in landing nipple profiled grooving 16a.

In Fig. 2, outer conduit 28 and conduit extension 29 form an annular flow passage 38 with primary flow conduit 18. Flow passage 38 is in communication with dual head flow passage 17b (to secondary tubing 12) and annular flow passage 39 formed by spacer pipe 23 passing through upper and lower packer mandrels 31 and 26. Annular flow passage 39 is further in communication through outlet flow ports 40 with annular flow passages between the outside of the packer and well casing 10 to below landing nipple 16.

Figure 5 shows the automatic lockable locator 36 connected to spacer pipe 32 by rotatable connector 35. Locator 36 has keys 41 which have landed in landing nipple profiled grooving 16a positioning operating seal unit 14 for operation in the invention annular safety system.

Locator 36 has a housing 42 having a number of openings 42a. A key 41 is mounted for radial movement in each opening and each key is urged outwardly by a spring 43 mounted around longitudinally moveable sleeve 44 having expanding surface 44a and a profiled groove 44b, -- see also Figure 7.

As shown in Figures 5 and 6, rotatable connector 35 is connected in upper housing threads 42c by mating threads 45a on fingers 45b of collet 45, which is positioned on collet mandrel 46 by bolts 47. Housing threads 42c and mating threads 45a are modified buttress in form. The collet mandrel has projections 46a extending between the collet fingers for rotating the collet latch when the operating seal unit and primary flow conduit 18 are rotated. There is a shoulder on each projection 46b engageable with a shoulder 42b in housing 42. The collet mandrel

is also provided with a support surface 46c for engaging collet finger threads 45a in housing threads 42c.

Figure 5 shows sleeve 44 is positioned in housing 42 by frangible pins 48 in a position where expander surface 44a is not inside keys 41 and the keys are radially moveable in openings 42a, permitting operating seal unit 14 and primary flow conduit 18 to be inserted into and moved downwardly in the packer until key surface 41a engages landing nipple profiled grooving landing surface 16b. Frangible pins 49 position collet mandrel 46 in sleeve 44.

Collet 45 is mounted around collet mandrel 46 and longitudinally moveable a small distance thereon as holes 45c in the collet are larger than bolts 47 positioning the collet on the collet mandrel. When collet mandrel 46 is moved downwardly through collet 45, shearing pins 48 and moving sleeve 44 downwardly in housing 42, threads 45a engaged in threads 42c hold the collet stationary until mandrel support surface 46c moves downwardly to a position not supporting the collet fingers and bolts 47 contact the lower edge of holes 45c. Continued downward movement of collet mandrel 46 and collet 45 repeatedly cams threads 45a inwardly from engagement with threads 42c to "ratchet" downwardly through threads 42c until shoulder 46b contacts shoulder 42b and expanding surface 44a is inside keys 41 locking locator 36 in landing nipple 16 as shown in Fig. 2 to prevent upward or downward movement of primary flow conduit and operating seal unit 14 in the landing nipple or packer.

To install the annular safety system of this invention in a cased well, sleeve 44 is positioned on collet mandrel 46 by

installing pins 49 and in housing 42 of automatic lockable locator 36 by installing pins 48 as shown in Fig. 5. The packer with landing nipple only may be lowered into the well and operated to anchor and seal in the well casing at the proper depth. The operating seal unit may be lowered later on well tubing to seal, land and be locked in the landing nipple and seal in the packer or the operating seal unit may be installed to seal in the packer and locked in the landing nipple on surface for lowering together on well tubing to proper depth for operating the packer. To install the operating seal unit in the packer on surface for lowering together, operating seal unit 14 is inserted into packer 15, sealingly engaging seals 34 in seal bore 16c, seals 27 in seal bore 26a above and below operating flow ports 25 and seals 30 in packer mandrel seal bore 31a until key landing surfaces 41a engage landing surface 16b in landing nipple profiled grooving. The operating seal unit is moved downwardly in the packer to shear pins 48 and move expander surface 44a downwardly inside keys 41, locking the keys in landing nipple profiled groove 16a as shown in Fig. 2. The packer and operating seal unit are lowered to packer operating depth in the well on primary and secondary tubings connected to the operating seal unit with control line 22 alongside the tubings. On reaching packer operation depth, control line 22 is pressurized to open safety valve 20, flow passage 19 is plugged below sleeve valve 24, the sleeve valve is opened using wireline tools and pressurized fluid is introduced into primary tubing 11 to flow through operating flow ports 25 to operate the packer to anchor

in and seal with well casing 10. The plug is removed from flow passage 19.

Liquid to be produced has risen in casing 10 around landing nipple 16 and into primary flow conduit passage 19. The well may now be produced by gas lift on increasing pressure in control line 22 to flow through dual head flow passage 17a into safety valve 20 and open the safety valve to permit flow upwardly in flow passage 19. Pressurized lift gas is introduced into secondary tubing 12 to flow downwardly through dual head flow passage 17b into annular flow passages 38 and 39 and outside packer 15 through outlet ports 40. Lift gas continues to flow downwardly around packer 15 through the annular flow area between the outside of packer 15, landing nipple 16 and the inside of casing 12 to below the landing nipple. Lift gas comingles with liquid in casing 10 around the landing nipple to aerate and lift the liquid upwardly through primary conduit flow passage 19, into primary tubing 11 and to surface.

If while producing the well by gas lift, the control line or secondary tubing is ruptured, the inline valve will prevent pressurized gas from flowing upwardly in the secondary tubing and reduction of pressure in the control line will permit safety valve 20 to close and prevent upward flow in the primary tubing.

In the event it is desirable to cease gas lift production of the well and retrieve operating seal unit 14, lift gas flow down the secondary tubing is stopped and any upward flow in secondary tubing 12 is prevented by inline valve 13. Pressure is then decreased in control line 22 sufficiently to permit safety valve 20 to close, and prevent upward lifted flow in flow

passage 19. A positioning tool (not shown) is lowered into lockable locator 36 on wireline to engage profiled grooving 44b in sleeve 44 and move the sleeve downwardly, shearing pins 49, to the position shown in Fig. 8. Sleeve expanding surface 44a has been moved from inside keys 41 unlocking the keys from landing nipple grooving 16a. The operating seal unit may be lifted to disengage keys 41 and seals 34 from landing nipple 16 and seals 27 and 30 from the packer mandrel. The operating seal unit may now be lifted further to surface.

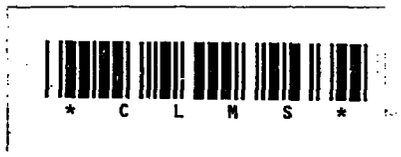
It should be obvious to those skilled in annular safety valve art, that the operating seal unit would function to accomplish the objects and benefits of the present invention if it did not include rotatable connector 35.

If sleeve 44 cannot be moved to a not expanding position in lockable locator 36 by wireline or lifting the operating seal unit with sleeve 44 in not expanding position does not or cannot disengage keys 41 from landing nipple 16, an operating seal unit provided with a rotatable connector 35 can be rotated to disconnect from lockable locator 36 and permit operating seal unit 14 to be lifted from landing nipple 16 and packer 15 and further to surface.

Fig. 9 shows a lifting force has been applied to the operating seal unit 14 while rotating the seal unit, collet mandrel 46, collet 45 and sleeve 44 in housing 42 to move collet threads 45a upwardly in housing threads 42c. If sleeve 44 will not rotate, pins 49 will be sheared by rotation of collet mandrel 46 in sleeve 44 and the sleeve will not be moved upwardly in

housing 42. If pins 49 are not sheared by rotation and sleeve 44 is moveable upwardly, it will move upwardly with mandrel 46.

Continued lifting of the operating seal unit and rotation of collet threads 45a in housing threads 42c will disconnect the collet mandrel from housing 42 and release the collet mandrel and operating seal unit to be lifted from housing 42 and packer 15 to surface. If pins 49 have not been sheared, they will be sheared when the collet mandrel is lifted from housing 42.



CLAIMS:

1. An annular safety system for a cased well comprising:
(a) packer means (15) for anchoring and sealing in said casing (10), said packer means (15) having outlet ports (40) for flow from inside to outside said packer means (15);
(b) a landing nipple (16) connected below said packer means (15); and
(c) operating seal unit means (14) for operating said packer means (15) to anchor and seal in said casing (10), said operating seal unit means (14) sealingly engaging and extending through said packer means (15) to form an annular flow passage (38) communicating with said packer means outlet ports, said operating seal unit means including: a dual head (17) having primary (11) and secondary (12) well tubing connected thereto, a valve (13) permitting downward flow and automatically preventing upward flow in said secondary well tubing (12), a primary flow conduit (18) therein connected to said dual head (17) and having a flow passage (19) communicating said primary tubing (11) through said landing nipple (16) with said well casing below said packer means (15), said primary flow conduit (18) having a safety valve (20) therein operable to prevent upward flow in said primary conduit (18), lockable locator means (36) on said primary flow conduit (18) for landing and releasably locking in said landing nipple (16), and annular flow passages therein for communicating said secondary tubing (12) with said annular flow passage (39) through said packer means (15).

2. A safety system according to claim 1, wherein the operating seal unit means (14) further include means (35) connecting the lockable locator means (36) to the operating seal unit means (14), said connecting means (35) being disconnectable on rotation of said operating seal unit means (14) in said lockable locator means (36).

3. A safety system according to claim 1 or 2, wherein the dual head (17) includes a flow passage (22) therethrough for communicating control line pressure into the primary conduit safety valve (20).

4. A safety system according to claim 1,2 or 3, wherein the landing nipple (16) includes a seal bore (16c) and profiled grooving (16a) in which the lockable locator means (36) may land and be locked.

5. A safety system according to claim 1,2,3 or 4, wherein the packer means (15) further includes an upper mandrel (31) having a seal bore (31a) therein above the outlet flow ports (40) connected to a lower mandrel (26) having a seal bore therein below said outlet ports (40), said lower mandrel (26) including operating flow ports (25) therethrough below said outlet ports.

6. A safety system according to claim 5, wherein the primary flow conduit (18) includes seals (27) thereon for sealingly engaging the landing nipple seal bore and the lower packer mandrel seal bore above and below the operating flow ports (25).

7. A safety system according to claim 6, wherein the primary flow conduit (18) further includes a sleeve valve (24) therein between the seals (27) engaging the lower packer mandrel above and below the operating flow ports.

8. A safety system according to claim 5, wherein the operating seal unit further includes an outer conduit around the primary flow conduit connected to the dual head, said outer conduit having seals thereon for sealingly engaging the upper packer mandrel seal bore.

9. A safety system according to claim 4, wherein the

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lockable locator means (36) comprises:
(a) a housing (42) having openings (42a) therethrough;
(b) a key (41) mounted for radial movement in each opening, each said key having profiled grooving engageable in the landing nipple profiled grooving;
(c) a longitudinally movable sleeve (44) mounted in said housing (42) said sleeve having an expander surface (44a) thereon;
(d) spring means (43) between said sleeve (44) and each key (41); and
(e) releasable means (48) for positioning said sleeve in a first upper position in said housing where said expander is not expanding said keys; said sleeve releasable by downward movement to a second position expanding said keys (41) and further downward to a third position not expanding said keys.

10. A safety system according to claim 4, wherein the connecting means is cooperable with and housed in the lockable locator means (36), said connecting locator means comprising:
(a) a housing (42) having openings therethrough and threads therein,
(b) a key (41) mounted for radial movement in each opening, each said key having profiled grooving engageable in the landing nipple profiled grooving;
(c) a longitudinally movable sleeve (44) mounted in said housing said sleeve having an expander surface thereon;
(d) spring means (43) between said sleeve (44) and each key (41);
(e) releasable means (48) for positioning said sleeve in said housing in a first upper position where said expander is not expanding said keys, said sleeve releasable by downward movement to a second position expanding said keys and movable further downwardly to a third position not

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expanding said keys;

(f) a collet mandrel (46) releasably connected in said sleeve (44); and

(g) a collet (45) mounted around said collet mandrel (46) and positioned thereon, said collet having fingers (47), and each said finger having threads engageable in housing threads.