METHOD OF OBTAINING FLUID SAMPLES FROM A WELL BORE

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This invention relates to formation testing and, more particularly, to methods and apparatus for obtaining recovery of fluid samples from a well bore.

In the exploration for oil it is often desirable to conduct a drill stem test in a well bore while it is being drilled for potential hydrocarbon production. In a drill stem test, a testing tool is inserted into the well bore at the lower end of a string of pipe or tubing. After packing off or isolating the formations to be tested from the well control fluid (usually called mud), the tester valve is opened so that any fluids from the formations may flow into the spring of tubing. Thus when a fluid flow occurs, there are clear visual indications at the surface.

It is well known that much exploration is conducted under utmost secrecy. For this reason, when conducting a drill stem test on a well it is highly desirable to maintain the results of the test strictly confidential.

In accordance with the present invention, in a drill stem test, the fluid recovery is limited to a given sampling section of the drill pipe which is closed off prior to retrieving the sampling section at the earth's surface. The closed off sampling section when retrieved is separated into individual sample containers which are usually a length of drill pipe. Into each end of a drill pipe prior to separation, a neutral displacement agent is injected to displace any trace of fluid recovery from the ends of the pipe and the pipe ends are sealed before separation. Thereafter, upon separation, the fluid recovery in a sealed pipe length can be transported to any suitable or desired location for examination in the privacy of a laboratory.

Apparatus in accordance with the present invention includes end connections called subs which attach to the joint of the pipe and to one another. Means are provided for injecting a neutral displacement agent to the interconnection between coupled subs and sealing off the passages in the subs after the fluid sample has been displaced.

Accordingly, it is an object of the present invention to provide new and improved apparatus and methods for conducting drill stem tests where the results of the test can be confined between sealed ends of a container or length of drill pipe.

Still another object of the present invention is to provide new and improved methods and apparatus for conducting drill stem tests to obtain discreet fluid samples between the ends of a length of drill pipe.

The novel features of the present invention are set forth with particularity in the appended claims. The present invention, both as to its organization and manner of operation together with further objects and advantages thereof, may be best understood by way of illustration and example of certain embodiments when taken in conjunction with the accompanying drawings in which:

FIG. 1 illustrates a string of tools in a well bore for practicing the present invention;
FIG. 2 illustrates a view in cross-section of apparatus embodied in the present invention; and
FIG. 3 is a view taken along line 3—3 of FIG. 2.

FIGURE 1 illustrates apparatus embodying the invention where a drill or tubing string 11 is lowered from the surface of the earth into a well bore 12. At the lower end of the drill string 11 is a conventional testing tool string 13 such as the type illustrated and described in U.S. Pat. No. 2,901,091. The usual drill stem testing tool string 13 includes a flow tube with a normally-closed valve (not shown) and a packer element 14. The packer element 14, when actuated, expands into sealing engagement with the borehole wall. After the tester valve is opened, fluid flows from below the packer 14 through its flow tube and into the tubing string. Pressure recorders (not shown) in the tool string 13 measure and record pressures. As shown in FIG. 1, a perforated anchor 15, for admitting well fluid to the flow tube is also used for engaging the bottom of the well bore for expanding the packer in a conventional manner.

It will be appreciated that hook-wall packers (not shown) which can be set without a bottom hole anchor could be employed rather than the type described.

In the present invention, one or more of the tubing string sections 16—18 adjacent to the tester 13 are separated from one another by a pair of releasably connected isolation sub A and B. These isolation subs, as will hereinafter be more fully explained, serve to enclose within the ends of a section of tubing a fluid sample so that there is no external indication of the presence or absence of fluid when the subs are disconnected at the surface. The enclosed fluid samples then can be safely transported to any suitable location for a private examination and analysis.

Referring now to FIGURE 2, each isolation sub A and B has a similar construction including threaded box and pin ends 19 and 20 for connection in a string of tubing. Each sub has similar longitudinal flow passages 21a and 21b extending longitudinally through the respective subs are each has a similar valve 22a and 22b provided for the respective passages. Valve 22a, shown in its normal open position, has a body portion 23a threadedly received in a valve bore 24a and has a tapered valve portion 25a provided with O rings. When the valve body 23a is rotated, the valve portion 25a seats in a valve seat 26a in a sub unit to block or close off the fluid passageway 21a. Rotation of the valve body 23a is accomplished by means of a wrench or the like applied to the body 23a through a cylinder bore 27a opening to the exterior. Thus, the valve has a control portion exposed to the exterior of the sub. The body portion 23a of the valve 22a is provided with an O ring to seal within a cylinder bore 27a. A snap ring 28a received in a snap ring groove prevents the valve body from leaving the valve bore 27a. Valve 22b has a similar arrangement.

The lower sub unit B is provided with another valve 30 (FIG. 3) which controls fluid flow to a passageway 31 in fluid communication with and opening to the longitudinal passageway 21b. The valve 30, which is normally closed, includes a body 32 threadedly received in a bore 33 with a valve element 34 having O rings providing a seal with a valve seat 35 in the sub. The valve body 32 similarly is provided with an O ring 36 and snap ring retainer 37 and similarly is controlled from the exterior of the sub. Another transverse passage 38 opens midway of the valve body 32 and is connected to a conventional pressure fitting unit 39. When the valve 30 is opened, as by unlatching of the valve body, the pressure fitting 39 and the transverse bore 31 are placed in fluid communication.

In the apparatus as thus far described, well fluid can flow through the tester 13 through the sub units A and B and into the various sections 16—18 of tubing string. At the upper end of the testing section above the uppermost isolation sub, a relief valve 40 is provided. As shown in FIG. 2, the relief valve 40 includes a generally cylindrical housing 42 with a longitudinally extending bore 43 having upper and lower counterbore sections.
44 and 45. In the lower end of the housing 42, the counterbore 45 is closed by a ported plug 46 which has an upwardly facing valve seat 47. An undersized cylindrical element 48 is disposed within the lower counterbore 45 and has a downwardly facing valve surface 49 provided with an O ring. A spring element 50 is provided to normally urge the cylindrical element 48 to a position facing the port in plug 46. When the cylindrical element is displaced from the plug 47, the annulus 51 between the cylindrical element 48 and counterbore 45 permits a fluid bypass. The cylindrical element 48 is provided with upstanding spacer elements 52 to maintain the bore 43 open when the cylindrical element 48 is pushed upwardly. The central bore is connected by transverse ports 53 to the exterior of the housing 42.

The trip or relief valve 40 has a plunger element 54 with portions 55 and 56 respectively received in the upper counterbore 44 and central bore 43. The plunger element 54 is held in the upper position by a shear ring 57. A hammer portion 58 of the plunger element 54 when struck with a go-devil or the like dropped through a tubing string shears the ring 57 and displaces or transfers the plunger portion 55 to a second position. The portion 55 of the plunger in central bore 43 is provided with spaced O ring seals 59 which straddle the transverse ports 53 in the second position of the plunger and thereby close the ports from fluid flow. A depending portion 60 of the plunger element is arranged to engage the upper end of the cylindrical element 48 in the second portion to limit downward travel of element 54 and insure the proper positioning of seals 59 to either side of ports 53.

In operation, the test tool string 13 is lowered into the well bore, at the end of a string of tubing or pipe, the test valve of the tool string 13 being closed. Above the test tool string 13 are sections of tubing 16, 17, 18 each having a sub-unit A and B respectively secured to the ends. Adjacent sub-units A and B are threadedly interconnected. At the top of the test sections of tubing, a relief valve 40 is connected above a sub-unit A.

At the level where the test is desired, the packer is actuated into scaling engagement with the well bore and the test valve of tool string 13 opened permitting formation fluids isolated below the packer to flow into the tubing sections 16–18. The hydostatic pressure of the well fluid (mnd) above the packer acts on element 48 in the relief valve to keep the valve closed. Thus, a fluid sample is recovered within sections 16–18 only as the flow upwardly into the tubing string being prevented by relief valve 40.

After permitting fluid to flow for a suitable period of time, the test valve of the tool string 13 is closed thus closing off the ends of the sampling section and the packer disengages from the well bore.

While the tubing string is being retrieved from the well bore, if the pressure of the fluids within sections 16–18 exceeds the hydostatic pressure, the relief valve 40 allows the fluid under pressure in the tubing sections 16–18 to bleed off into the annulus. Because of the large volumes of mud, this bleed off is but a trace and does not reveal the test results. At a point where the relief valve is about 100 feet below the surface, the go-devil is dropped through the tubing string and engages the hammer element in the relief valve to retain the relief valve in a closed position. The seals 59 of the relief valve positively close.

The relief valve and first sub A and B are then brought to the surface where they are available for disconnection. At this point, valve 30 is opened and a grease gun or any other source containing a neutral displacement agent is connected to the pressure fitting 31. Gases are displaced from sub A and B. Following this valves 22a and 22b of sub A and B are closed. It is noted that it may be desirable to sequence the steps as follows: initially close valve 22b of sub unit B and permit grease flow into passageway 21a of sub A; close valve 22a of sub A; open valve 22b of sub B for injection of grease followed by closing of valve 22b of sub B.

After displacing the recovery fluid from the releasably interconnected sub-units A and B with a neutral agent, the threaded connection between the sub-units A and B is broken. The lower set of isolation on the joint of pipe is then brought to the surface. Valve B is closed and as described above, a suitable neutral displacement agent is pumped via valve 30 to displace any recovery fluid between the units through sub A. Thereafter, the valve 22a of sub A is closed, valve 22b of sub B is opened and displacement fluid injected followed by closing of valve 22b in sub B. The threaded connection between the sub-units A and B is then broken.

It will be appreciated that the disconnected section of tubing 18 contains a fluid sample between sub-units A and B at its opposite ends and no visual indication of the presence or absence of a fluid sample is given. Each section of the tubing is thus individually isolated and individually sealed samples are obtained. Each individual sample in a tubing string then can be transported to any desired location and the sample analyzed in privacy.

While a particular embodiment of the present invention has been shown and described, it is apparent that changes and modifications may be made without departing from this invention in its broad aspects and, therefore, the aim in the appended claims is to cover all such changes and modifications as fall within the true spirit and scope of this invention.

What is claimed is:
1. A method of drill stem testing in a well bore comprising the steps of: withdrawing a fluid sample from earth formations into a sampling section in a well bore; closing off the ends of said sampling section prior to retrieving the sampling section from the well bore; bringing the closed off sampling section to the earth's surface and separating said sampling section into individual containers; and prior to separation of said sampling section, injecting a neutral displacement agent into each end of a separate container to displace any trace of fluid recovery from the ends of a container followed by sealing off of the ends of a container.
2. A method of drill stem testing in a well bore containing a well fluid comprising the steps of: packing off a section of the well bore from the well fluid for the purpose of withdrawing a fluid sample from the earth formations which are isolated from the well fluid; placing said packed off earth formations in fluid communication with a string of pipe having a sampling section including one or more individual lengths of pipe serially arranged where interconnection between the ends of each length of pipe includes a pair of subs releasably coupled to one another, each sub having a normally open closure means permitting fluid communication therebetween; clearing off the sampling section at its lowermost and uppermost ends to contain a fluid sample therebetween; bringing a length of pipe of said sampling section to the earth's surface and injecting a neutral displacement agent in the interconnection between adjacent subs while said closure means are open and displacing any fluid sample therebetween, closing said closure means, and uncoupling said subs from one another.
3. A method of drill stem testing in a well bore containing a well fluid comprising the steps of: packing off a section of the well bore from the well fluid;
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fluid for the purpose of withdrawing a fluid sample from the earth formations which are isolated from the well fluid;
placing said packed off earth formations in fluid communication with a string of pipe having a sampling section including one or more individual lengths of pipe serially arranged wherein interconnection between the ends of each length of pipe includes a pair of subs threadedly coupled to one another, each sub having a normally open closure means permitting fluid communication therethrough;
closing off the sampling section at its lowermost and uppermost ends to contain a fluid sample therebetween;
retrieving said sampling section from the well bore while bleeding off pressure of the fluid sample in the sampling section in excess of the pressure of the well fluid;
 discontinuing the bleeding off of pressure at a point while the uppermost end of the sampling section is still in the well bore;
bringing a length of pipe of said sampling section to the earth's surface and injecting a neutral displacement agent in the interconnection between adjacent subs while said closure means are open and displacing any fluid sample therebetween, closing said closure means and uncoupling said subs from one another.

4. A method of drill stem testing in a well bore containing a well fluid comprising the steps of: packing off a section of the well bore from the well fluid for the purpose of withdrawing a fluid sample from the earth formations which are isolated from the well fluid; opening a test valve to place the packed-off earth formations in fluid communication with a string of pipe having a normally closed sampling section and a sub at its lower end, the sub having a normally open closure means permitting fluid communication therethrough; closing the test valve to entrap a fluid sample in the sampling section; closing the normally open closure means in the sub when the sub is brought to the surface and before uncoupling the sampling section from the string of pipe.

5. A method of drill stem testing in a well bore containing a well fluid comprising the steps of: packing off a section of the well bore from the well fluid for the purpose of withdrawing a fluid sample from the earth formations which are isolated from the well fluid; placing said packed off earth formations in fluid communication with a string of pipe having a sampling section including one or more individual lengths of pipe serially arranged with a string of pipe having a sampling section including one or more individual lengths of pipe serially arranged where interconnection between the ends of each length of pipe includes a pair of subs threadedly coupled to one another, each sub having a normally open closure means permitting fluid communication therethrough, the sampling section having normally closed valve means at its upper end; closing off the sampling section at its lowermost end to contain a fluid sample therein; retrieving said sampling section from the well bore and bleeding off excess pressure of the fluid sample in the sampling section by opening said normally closed valve means; discontinuing the bleeding off of pressure at a point while the uppermost end of the sampling section is still in the well bore; closing the normally open closure means in each sub as each sub is brought to the surface and before uncoupling the subs from one another.

6. A method of drill stem testing in a well bore containing a well fluid comprising the steps of: isolating a section of the well bore from the well fluid for the purpose of withdrawing a fluid sample from the earth formations which are isolated from the well fluid; opening a test valve to place the isolated earth formations in fluid communication with a string of pipe having a sampling section with its upper end normally closed by a valve means and a sub at its lower end, the sub having a normally open closure means permitting fluid communication therethrough; closing the test valve to entrap a fluid sample in the sampling section between the sub and the valve means; retrieving the sampling section to the earth's surface and relieving excess pressure in said sampling section by operation of the normally closed valve; and closing the normally open closure means in the sub when the sub is brought to the surface and before uncoupling the sampling section from the string of pipe.

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