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METHOD FOR COMPLETING AND SERVICING A WELL

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METHOD FOR COMPLETING AND SERVICING A WELL

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The present invention is directed to a method for completing and servicing a well. More particularly, the invention is concerned with a method for testing a well without pulling the pipe from the well. In its more specific aspects, the invention is concerned with a method for testing a well drilled through a plurality of productive intervals without pulling the pipe from the well.

The present invention may be briefly described as a method for completing and servicing a well drilled in the earth to penetrate a plurality of productive intervals and having a casing arranged therein penetrated in a selected of said intervals to provide first perforations. In the present invention a tubing string is lowered in the well having a retrievable pressure recorder arranged therein until the lower end of the tubing is position for production at least through the first perforations in the casing. The annular space between the tubing and casing is closed such that pressure is exerted in the tubing and on the pressure recorder. The pressure recorder is retrieved from the well while the tubing is maintained in position whereby the productivity of a selected interval is indicated by the pressure recorded on the pressure recorder. Production is obtained from the well from the selected interval as indicated by the pressure. If pressure is shown by the pressure recorder, then the well is produced until production becomes uneconomical. If no or insufficient pressure is shown by the pressure recorder for commercial production of well fluids then the first perforations are sealed by introducing cement through the tubing into the first perforations to seal same. Thereafter the casing is reperforated to provide second perforations in one of the intervals and the pressure recorder is lowered again in the well and pressure exerted therein from the second perforations. The pressure recorder is again retrieved to determine whether or not production may be had from the second perforations and production is obtained through the second perforations as indicated by the pressure.

In accordance with the present invention, the casing may be reperforated in an interval vertically displaced from the perforated and sealed interval or the casing may be reperforated in the perforated and sealed interval or to perforate more of the productive interval in the same zone which was originally perforated.

The tubing string is lowered in the well casing to position its lower end above the plurality of intervals or it is lowered to position its lower end above the perforated interval. The tubing string may be lowered to position its lower end above the perforated interval and then the tubing is raised after sealing the perforated interval and before reperforating the casing to position its lower end above an interval vertically displaced from the perforated and sealed interval.

The present invention is quite advantageous in that it eliminates unnecessary raising and lowering of the pipe, known in the industry as round trips. In other words, a round trip is the running in of a well pipe in the well and then pulling same out of the well for replacement of a tool or a section of pipe. In the present invention during completion operations in oil and/or gas wells and the like after the production casing is set, drill stem tests are usually made to evaluate the producing zone. Not infrequently it is necessary to repair a primary cement job, which is cement set around the casing in the well bore, or to perforate more of a productive interval than originally perforated or to reperforate the same interval or to fracture or to acidize a productive interval. Sometimes a combination of any or all of these operations is required which would mean running the pipe in the well and pulling same out of the well many times. Present methods of drill stem testing do not provide a means of cementing and reperforating with the formation testing tool in the well. Thus, it is necessary to pull the formation test tool and then conduct the cementing operation, repull the cementing tools and then reperforate the cemented casing. It will be apparent that considerable rig time is consumed during the numerous round trips of the pipe.

In accordance with the present invention, round trips of pipe are eliminated and wells are completed and serviced while formations are tested selectively without removing the tubing string from the well. Thus the invention is quite advantageous and useful in reducing the amount of time consumed in testing and completing wells and thus allowing the wells to be completed and serviced more cheaply than heretofore. Also, by maintaining the tubing in the well, improved results are obtained in that there is less damage to producing formations than that caused by pulling pipe, tubing, and tools from the well using a fluid foreign to formation fluids inside of the casing to control formation pressure.

The present invention may be further illustrated by reference to the drawing in which:

Figs. 1 to 7 represent a sequential stepwise mode of practicing the invention, and
Figs. 4a, 4b, and 5a illustrate a modified mode of practicing the invention taken in conjunction with Figs. 1 to 7.

Referring now to Figs. 1 to 7, in which identical numerals will be employed to designate identical parts, numeral 11 designates a well bore drilled from the earth's surface, not shown, to penetrate a plurality of productive formations 12 and 13 separated by non-productive formation 14. Formations 12 and 13 may be sands, strata, zones, or intervals in a productive formation while non-productive formation 14 may be a non-productive interval, stratum or zone in a productive or non-productive formation.

A casing 15 is cemented in the well bore 11 with a primary cement job 16 and a tubing string 17 is run into the well casing 15 provided adjacent its lower end with packer 18 in inoperative position. Arranged in the lower end of the tubing 17 is a pressure recorder device 19 which is provided with a sealing means 20 to allow a seal between the interior wall of the tubing 17 and the interior wall of the pressure recorder 19. The pressure recorder 19 is a suitable wire line pressure recorder, such as described in U. S. Patent 2,189,919, issued Feb. 13, 1940, in the name of Thomas V. Moore. Other pressure recording instruments available in the industry may be used such as illustrated on page 2720 of the 1952—53 Composite Catalog of Oil Field & Pipeline Equipment.

A valve, such as 21, is arranged in the tubing 17. This valve may be a valve or closure member as described in patent application Serial No. 554,215 filed December 20, 1955, for James E. Willingham, Jr. The closure member is operated by manipulation of the tubing by rotation and setting down weight thereon. The packer 18 is described in Baker Oil Tools, Inc.
bulletin No. 316 printed in the United States of America and may be set by right hand rotation of the tubular string 17 to position the upper packer slips on the tubing head 16. The packer being in the packed position, the inner surface of the well casing 15. Subsequent application of weight, resulting from lowering the tubing string 17 to be supported by the packer slip contact with the well casing 15, causes deformation of the rubber packing element to form a seal in the annulus between the tubing and well casing 15.

The example shown in Fig. 1 is in the running in position, the pressure recorder device being arranged in the tubing at the well head. In Fig. 2 the packer 18 is in operative position to close the annulus A between the tubing 17 and the casing 15. The lower open end 22 of the tubing 17 is arranged immediately above the productive interval 13 in which perforations generally indicated by the numeral 23 had previously been formed such as by lowering a gun perforator through the casing 15 and firing same.

After the pressure recorder has been removed as shown in Fig. 3, cement is flowed down the tubing 17 into the casing 15, the packer 18 being collapsed to allow circulation down the tubing 17 and up the annulus A. Cement, such as cement slurry 27, is deposited in the casing and in the perforations 23 to seal the perforations and to form the plugs or buttons 28 therein. Thereafter the excess cement slurry 27 is removed from the casing 15 by adding the washing liquid, such as water, mud, and the like, down the annulus A and casing 15 adjacent the interval 12. The perforator is operated or fired to form perforations 30 through the casing and into the interval 12 and to allow production therefrom.

Thereafter the gun perforator 29 is withdrawn on wire line 26 as shown in Fig. 5 and the pressure recorder device is lowered over the tubing interval 16 and again positioned in the tubing 17 as shown in Fig. 7. The sequence of operations, as indicated in Figs. 2 to 6, inclusive, may then be repeated until a commercial productive interval is located. Thus, in Figs. 2 and 7, the pressure differential from the intervals 13 and 12 is increased in operation may be increased on the recorder device 19 with the flow of fluids. This pressure differential into the well bore may be obtained by swabbing, circulation, or by reducing the hydrostatic column of fluid in the well to cause flow into the well bore.

In accordance with the present invention, it is possible to arrange the lower open end 22 of the tubing 17 initially above the intervals 12, 13, and 14 and to conduct operations, such as illustrated in Figs. 4 to 5, without raising the tubing string 17. Referencing now to Figs. 4a, 4b, and 5a, the tubing 17 is initially arranged in the well casing 15 as illustrated in Figs. 5, 6, and 7, and it is desired to cement off the perforations 23. To conduct such operations with tubing 22 in the position as shown in Figs. 4a, 4b, and 5a, a tubular extension member, such as 35, is lowered on wire line 26 through the tubing 17 until it extends from the lower open end of the tubing 22 into the region of the casing 15 adjacent the perforations 23. The tubular extension member 35 has a fishing head 36 and packing 37 and is designed to be supported, anchored and/or sealed in a landing nipple, such as 38, as illustrated at page 4063 of the Composite Catalog mentioned supra. As shown in Fig. 4a, the packer 18 is in the collapsed position and a cement slurry is introduced down the tubing 17 and deposited as a body 27 adjacent the perforations 23 to form plugs or buttons 28 therein. The cement slurry employed in Figs. 4 and 4a may suitably be a modified cement, such as described in the Salathiel Patent No. 2,582,459. Other modified cements may suitably be employed.

After the buttons or plugs 28 have been formed in the perforations 23, the wires or plugs 28 are conveyed to the tubing 17 through the tubing 17 and thence through the tubing 17 to the wellhead. Thereafter, as shown in Fig. 5a, the packer 18 is expanded to seal off the annulus A and a plug perforator 29. The cement slurry employed in Figs. 4 and 4a may be conducted without moving the tubing after the running in operation. While it is possible to place the tubing in the well and then run the recorder device on a wire line as shown in Fig. 6, instead of running it into the well when the tubing is run in, as shown in Fig. 1, the operation as described with respect to Fig. 1 eliminates one wire line running operation and, therefore, is to be preferred.

Thus, in accordance with the present invention, a new method is provided for testing selected intervals in an oil and/or gas well without requiring round trips. This method involves running the tubing with the valve closed, as described in Fig. 1, to a depth just above the perforated interval to be tested. The packer is set and the valve is opened to allow the test to be made. After the test has been made the pressure recorder device is retrieved on a wire line. The packer 18 is lowered on wire line 26 so that it may be extended over the tubing string from the well head and into the tubing interval 16 and 17. Thereafter the tubing 17 is collapsed on the tubing interval 16 and 17 and the packer 18 is lowered on wire line 26 in the tubing interval 16 and 17. Thereafter the tubing 17 is lowered through the tubing interval 16 and 17. The packer is set and the tubing 17 is collapsed on the tubing interval 16 and 17 and the packer 18 is lowered on wire line 26 in the tubing interval 16 and 17. The packer 18 is lowered on wire line 26 in the tubing interval 16 and 17.
A method for completing and servicing a well drilled in the earth to penetrate a plurality of productive intervals and having a casing arranged therein perforated in one of said intervals, said casing containing a hydrostatic column of well fluids sufficient to prevent flow into the perforated casing and in which round trips of tubing are avoided, which comprises lowering a tubing string in said well casing having a retrievable pressure recorder arranged therein until the lower end of the tubing is positioned for production from at least said perforated interval, the passageway through the tubing being closed at a level above the pressure recorder, whereby the tubing is free of said well fluids, closing the annular space between the tubing and casing and opening the passageway through the tubing, adjusting the pressure in the well such that pressure from said perforated interval is exerted in said tubing and on said pressure recorder, retrieving said pressure recorder while maintaining the tubing in position whereby the productivity of said perforated interval is indicated by the pressure recorded on said pressure recorder, and then obtaining production from said perforated interval as indicated by the pressure on said pressure recorder.

A method for completing and servicing a well drilled in the earth to penetrate a plurality of productive intervals and having a casing arranged therein perforated in a selected of said intervals to provide first perforations, said casing containing a hydrostatic column of well fluids sufficient to prevent flow into the perforated casing and in which round trips of tubing are avoided, which comprises lowering a tubing string in said well casing having a retrievable pressure recorder arranged therein until the lower end of the tubing is positioned for production at least through said first perforations, the passageway through the tubing being closed at a level above the pressure recorder, whereby the tubing is free of said well fluids, closing the annular space between the tubing and casing and opening the passageway through the tubing, adjusting the pressure in the well such that pressure is exerted in said tubing and on said pressure recorder, retrieving said pressure recorder while maintaining the tubing in position whereby the productivity of said selected interval is indicated by the pressure recorded on said pressure recorder, retrieving said pressure recorder while maintaining the tubing in position whereby the productivity of said selected interval is indicated by the pressure recorded on said pressure recorder, reperforating the casing to provide second perforations in one of said intervals, arranging the pressure recorder in the lower end of the tubing, exerting pressure in said tubing and on said pressure recorder through the second perforations, again retrieving said pressure recorder from the tubing whereby productivity is indicated by the pressure recorded on said pressure recorder, and then obtaining production through the second perforations.

A method in accordance with claim 8 in which the casing is reperforated in the perforated and sealed interval.

A method in accordance with claim 8 in which the tubing string is lowered in the casing to position its lower end above the plurality of intervals.

A method in accordance with claim 8 in which the tubing string is lowered to position its lower end above the perforated interval and the tubing is raised, after sealing the perforated interval and before reperforating the casing, to position its lower end above an interval vertically displaced from the perforated and sealed interval.

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