

SPECIFICATION

Retrievable Bridge Plug Tool and Method for Plugging off a Well Casing Therewith

The invention relates to a packer-type bridge plug which is retrievable from a well casing.

In the production of oil and gas there are various downhole operations which may require temporarily plugging off the well casing at a given point, or at more than one point. Examples of such operations are cementing of the annulus between the borehole and the well casing, hydraulic fracturing of a producing zone, or treating the zone with chemicals to consolidate loose sand.

The tools now available for plugging the well casing are not entirely satisfactory in that they are difficult to use and costly to maintain. For example, one of the commercially available plugging tools has an extremely complex structure which includes many parts. The complexity of the structure and the large number of parts makes it relatively easy to overlook a defective part during reconditioning of the tool between operations. This same tool is also built with a substantial number of O-ring seals which adds to the problem of fluid leakage in a downhole tool.

The packer-type bridge plug of this invention is particularly useful for temporarily plugging off a well casing. Following performance of a downhole operation, the bridge plug can be retrieved from the well casing and reconditioned for further use.

The present invention resides in a bridge plug tool capable of plugging off a well casing and thereafter being retrievable from the well casing, the tool comprising:

- an elongate mandrel 10 having a shoulder member 10a, and first and second threaded segments, spaced from each other;
- the mandrel being enclosed by upper components which include a coupling means 11, 12, 13, a cone member 16, packing elements 19, 20, 21 positioned between the coupling means and the cone member, a packing sleeve 23 secured to the coupling means, and a compression sleeve 26 positioned between the packing sleeve 23 and the mandrel 10;
- the mandrel being enclosed by lower components which include a set of lock members 32 engagable with the first threaded segment 29 on the mandrel, a set of control members 31 engagable with the second threaded segment 30 on the mandrel, and retainer means 35, 39 for retaining the lock members and the control members in place on the tool; and
- a set of slip members 36 mounted on the retainer means and adapted to slidably engage the cone member during downward movement of the cone.

More specifically, the tool of the present invention comprises an elongate mandrel, which is enclosed by a group of upper and lower components to make up the complete tool. On the mandrel itself is an integral shoulder member and two separate thread segments.

The upper component group includes a coupling means, a cone member, and packing elements positioned between the coupling means and the cone member. In addition, the upper part of the tool has a packing sleeve which fastens into the coupling means, and a compression sleeve positioned between the packing sleeve and the mandrel. The lower components enclosing the mandrel include a set of lock members, a set of control members, and a retainer means for the lock members and control members. One of the thread segments on the mandrel is adapted to engage the lock members during one phase of the tool operation. During another phase of the tool operation, a second thread segment on the mandrel is adapted to engage the control members.

A set of slip members are mounted on the retainer means. These slip members are adapted to slide upwardly on the cone as the cone moves downwardly. Also mounted on the retainer means is a set of drag blocks. As the tool is lowered into the well casing, the drag blocks are adapted to push outwardly and drag against the inside of the well casing.

90 Description of the Drawings

Figure 1 is a two-part elevation view, partly in section, illustrating the bridge plug tool as it appears, both during run in and retrieval from the well casing.

Figure 2 is a two-part elevation view, partly in section, showing the bridge plug tool during its set position in the well casing.

In the drawing the letter T generally indicates the tool of this invention which is adapted to be lowered into a well casing 22 and which is made up of an elongate mandrel 10, which is enclosed by upper and lower components. Part of the upper component structure is defined by a coupling means which includes a top coupling 11, a center coupling 12, and a lower coupling 13. The top coupling 11 is threaded onto the top end of center coupling 12 and the lower coupling 13 is threaded to the bottom end of the center coupling 12.

The center coupling 12 has at least one vent opening 14 therein. In actual practice more than one vent opening may be used which communicates with a space 15 defined between the center coupling 12 and mandrel 10. Near the center of the tool, the mandrel is enclosed by a cone 16. A group of four lenthwise slots 17 are machined into the outside surface of the cone 16.

A gauge ring 18 is threaded over the top end of cone 16. A group of three packing elements, a top element 19, center element 20, and bottom element 21, are sandwiched between the bottom edge of lower coupling 13 and the top edge of gauge ring 18. The packing elements are made of a rubber composition, with the top and bottom elements having the same resiliency and the center element having a softer or more resilient structure. The center element is made of a softer structure to enable the packing elements to

compress sufficiently to form a good seal against the inside surface of the well casing 22 when the tool is put into its set position.

The packing elements 19, 20, and 21 are held in place on the tool by a packing sleeve 23. The top end of sleeve 23 is threaded into the lower coupling 13 so that the sleeve remains fixed at the top end. The lower end of the packing sleeve 23 is slidable lengthwise within a space 24 defined between cone 16 and mandrel 10. In Figure 2 the tool is shown as it appears when in the set position. In this position the packing sleeve moves downwardly to seat against an inside shoulder 25 on cone 16. A compression sleeve 26 is positioned between the packing sleeve 23 and mandrel 10. The top end of sleeve 26 is defined by a head portion, similar to a piston head. An O-ring 27 in the head portion forms a seal with the inside wall of the center coupling 12.

Near the top end of mandrel 10 is an integral shoulder member 10a. A needle bearing assembly 28 is positioned between the mandrel shoulder and an inside shoulder 12a on coupling 12. The purpose of the bearing 28 is to prevent excessive wear between the underside of the mandrel shoulder 10a and the inside shoulder 12a on coupling 12 during rotational movement of the mandrel. Mandrel 10 also includes two integral but separate threaded segments located at the lower part of the mandrel. The first segment 29 is a left-hand male thread and the second thread segment 30 is a right-hand male thread positioned below the left-hand thread 29.

One of the lower components of the bridge plug tool is a set of four control members 31, only one of which is shown in the drawing. During the running-in step, that is, when the tool is being lowered into the well casing 22, the right-hand male thread 30 engages a corresponding female thread on the control members 31. Another part of the lower component structure is provided by a set of four lock members 32, only two of which are shown in the drawing. When the tool is out into the set position in the well casing, the left-hand male thread 29 on the mandrel is adapted to engage the corresponding female threads 33 on each of the lock members 32. During the running-in of the tool, as illustrated in Figure 1, the threads 29 are disengaged from the threads 33 on the lock members. The lock members 32 are held against the mandrel 10 by a pair of garter springs 34. A housing 35, which encloses and retains the lock members 32, is another part of the lower component structure.

A set of four slip members 36 provides means for gripping the inside of the well casing 22. Only one of the slip members is shown in the drawing. The bottom end of each slip member is secured to the lock member housing 35 by a link connector 37 which allows each of the slip members to slide up and down in the longitudinal slot 17 on the outside surface of cone 16.

The lower component structure also includes a drag block housing 38 and a retainer collar 39.

The drag block housing 38 is threadably secured to the threaded bottom end of the lock member housing 35 while collar 39 is threadably secured to the bottom end of the drag block housing. The combined structure of the housings 35 and 38 and collar 39 provide a means for retaining the lock members 32 and control members 31 in position on the mandrel 10. A coil spring 40 is fitted between the collar 39 and each control member 31 to hold the control member in contact with mandrel 10.

A set of four drag blocks 41 provides means for centering the tool in the well casing 22. Only one of the drag blocks is shown in the drawing. These blocks, which are always in contact with the casing wall during raising and lowering of the tool also provide a means for resisting downward movement of the tool while it is in the set position (as shown in Figure 2). The drag blocks 41 are held in place on housing 38 by an upper retainer ring 42 and a lower retainer ring 43. A pair of coil springs 44 and 45 are fitted between each drag block and the housing 38. These springs provide a biasing force to push the drag blocks outwardly against the well casing 22.

The invention can be illustrated by describing a typical operation in which the bridge plug tool is used to temporarily plug off a well casing. The mandrel 10 is normally connected to a transition piece at its upper end which, in turn, is connected to a J-slot bypass, a retrieving head and a tubing string. The tubing string, retrieving head, bypass and transition piece are not shown in the drawing. The bridge plug tool is lowered into the well casing 22 until it reaches the point where the casing is to be plugged off.

During this running-in step it is critical that the mandrel 10 not be allowed to move either up or down within the tool structure. If the mandrel were allowed to shift during the running-in step, it would assume a position in which the slips and the packing elements could not be actuated to engage the inside of the well casing.

To prevent any longitudinal shifting of the mandrel, the mandrel is put in a locked position during the running-in step, as illustrated in Figure 1. When the mandrel is in such locked position, the threads 30 are in engagement with the corresponding threads on the control members 31. Also, the shoulder 10a at the top of the mandrel is positioned between the top coupling 11 and the bearing assembly 28. When the tool reaches the desired point for plugging off the casing, the tool is put into a neutral or unengaged position. This is done by rotating the mandrel clockwise until the threads 30 move down far enough to disengage from the corresponding threads on the control members 31. Following this step, the operator on the rig floor applies a weight on the tubing string to force the mandrel downwardly until the threads 29 engage the threads 33 on the lock members 32, by a ratcheting action.

As the mandrel 10 moves downwardly, the lower coupling 13 pushes down on the packing

elements 19, 20 and 21 which, in turn, force the cone 16 to move downwardly. As the cone 16 moves downwardly, the slip members 36 ride upwardly in the slots 17 on the cone 16 to force the slip members outwardly into gripping engagement with the inner surface of the well casing 22. When the slip members bite into the casing wall they prevent further downward movement of the cone. The packing elements are compressed between the lower coupling and the cone where they are expanded transversely to sealingly engage against the inner casing wall. When the slips and the packing elements are engaged with casing wall the tool is in its set position, as illustrated in Figure 2.

The tool of this invention is also provided with a compression sleeve 26 for applying a positive downward force against the cone 16. This downward force prevents the slip members 36 from releasing and unloading the packing elements 19, 20 and 21, when the tool is in the set position. Thus, when the bridge plug tool is in the run-in position, the lower end of the compression sleeve 26 is positioned above the inside shoulder 25 on cone 16. However, in the set position, the head portion at the top of compression sleeve 26 moves down only slightly within the space 15, which is defined between the center coupling 12 and lower coupling 13.

The function of compression sleeve 26 is to utilize the bottom hole fluid pressure as a reserve force to prevent the cone 16 from moving upwardly and casing the slip members 36 to expand outwardly against the casing. To explain further, the fluid below the packing elements (bottom hole fluid) pushes up against the lower packing element 21. When the fluid pushes against the packing element, it is forced through a restricted space defined between cone 16 and the mandrel 10, and between the compression sleeve 26 and the mandrel. When the upwardly moving fluid reaches the top of the compression sleeve, it pushes down on the top face of the compression sleeve head to force the lower end of the compression sleeve downwardly against shoulder 25 on cone 16. The vent opening 14 in the center coupling 12 provides an outlet for the fluid which becomes trapped on the space 15 below the head of sleeve 26 as the compression sleeve moves downwardly.

After the bridge plug tool has been set, to plug off the casing, the tubing string (not shown) is disconnected from the mandrel so that the desired downhole operation can be performed. When the job is finished, the tubing string is lowered into the casing until the retrieving head engages the J-slot bypass (not shown). Rotation of the mandrel 10 in a clockwise direction causes the mandrel to move upwardly and disengage the left-hand threads 29 from the corresponding left-hand threads 33 on the lock members 32. When the mandrel has moved far enough upwardly, the right-hand threads 30 will engage the corresponding right-hand threads of the control members 31. This puts the mandrel back into its

locked position so that it is secured against any longitudinal shift. Upward movement of the mandrel also allows the slip members 36 to slide downwardly on the cone 16 and disengage or release from the well casing 22. At the same time, the packing elements 19, 20 and 21, release from the well casing so that the tool can be either retrieved from the casing, or re-set at another point in the casing. During retrieval, the tool is once again in the position illustrated in Figure 1.

The tool of this invention has certain features which give it a distinct advantage over many of the tools now used to plug off a casing. One of these features is that the present tool requires very few O-ring seals. The only sealing rings required with the tool of the present invention include O-ring seals 46 and 47, positioned between the mandrel 10 and couplings 11 and 12. Two other O-ring seals, 48 and 49, are positioned between the compression sleeve 26 and coupling 13, and between the packing sleeve 23 and coupling 13. A single O-ring 27, as described earlier, seals the compression sleeve against the inside wall of coupling 12.

The gauge ring 18 provides another improved feature which permits using packing elements of different sizes on the same bridge plug tool. This is done by providing gauge rings of different sizes, each ring being designed to accommodate packing elements of a specific size. The use of interchangeable gauge rings therefore enables the tool to be used in casings of different sizes without the inconvenience of having to assemble a "new" tool each time.

Another mechanical feature is a means for connecting the bridge plug tool, through the tubing string, to a weight indicator (not shown) on the rig floor. The weight indicator allows the operator on the rig floor to determine at all times where the tool is located in the well casing, and whether the tool is in the set position, or the neutral position.

Claims

1. A bridge plug tool capable of plugging off a well casing and thereafter being retrievable from the well casing, the tool comprising:
 - an elongate mandrel (10) having a shoulder member (10a), and first and second threaded segments, spaced from each other;
 - the mandrel being enclosed by upper components which include a coupling means (11, 12, 13), a cone member (16), packing elements (19, 20, 21) positioned between the coupling means and the cone member, a packing sleeve (23) secured to the coupling means, and a compression sleeve (26) positioned between the packing sleeve (23) and the mandrel (10);
 - the mandrel being enclosed by lower components which include a set of lock members (32) engagable with the first threaded segment (29) on the mandrel, a set of control members (31) engageable with the second threaded segment (30) on the mandrel, and retainer means



elements 19, 20 and 21 which, in turn, force the cone 16 to move downwardly. As the cone 16 moves downwardly, the slip members 36 ride upwardly in the slots 17 on the cone 16 to force the slip members outwardly into gripping engagement with the inner surface of the well casing 22. When the slip members bite into the casing wall they prevent further downward movement of the cone. The packing elements are compressed between the lower coupling and the cone where they are expanded transversely to sealingly engage against the inner casing wall. When the slips and the packing elements are engaged with casing wall the tool is in its set position, as illustrated in Figure 2.

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After the bridge plug tool has been set, to plug off the casing, the tubing string (not shown) is disconnected from the mandrel so that the desired downhole operation can be performed. When the job is finished, the tubing string is lowered into the casing until the retrieving head engages the J-slot bypass (not shown). Rotation of the mandrel 10 in a clockwise direction causes the mandrel to move upwardly and disengage the left-hand threads 29 from the corresponding left-hand threads 33 on the lock members 32. When the mandrel has moved far enough upwardly, the right-hand threads 30 will engage the corresponding right-hand threads of the control members 31. This puts the mandrel back into its

locked position so that it is secured against any longitudinal shift. Upward movement of the mandrel also allows the slip members 36 to slide downwardly on the cone 16 and disengage or release from the well casing 22. At the same time, the packing elements 19, 20 and 21, release from the well casing so that the tool can be either retrieved from the casing, or re-set at another point in the casing. During retrieval, the tool is once again in the position illustrated in Figure 1.

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Another mechanical feature is a means for connecting the bridge plug tool, through the tubing string, to a weight indicator (not shown) on the rig floor. The weight indicator allows the operator on the rig floor to determine at all times where the tool is located in the well casing, and whether the tool is in the set position, or the neutral position.

Claims

1. A bridge plug tool capable of plugging off a well casing and thereafter being retrievable from the well casing, the tool comprising:
 - an elongate mandrel (10) having a shoulder member (10a), and first and second threaded segments, spaced from each other;
 - the mandrel being enclosed by upper components which include a coupling means (11, 12, 13), a cone member (16), packing elements (19, 20, 21) positioned between the coupling means and the cone member, a packing sleeve (23) secured to the coupling means, and a compression sleeve (26) positioned between the packing sleeve (23) and the mandrel (10);
 - the mandrel being enclosed by lower components which include a set of lock members (32) engagable with the first threaded segment (29) on the mandrel, a set of control members (31) engageable with the second threaded segment (30) on the mandrel, and retainer means

(35, 39) for retaining the lock members and the control members in place on the tool; and

- 5 a set of slip members (36) mounted on the retainer means and adapted to slidably engage the cone member during downward movement of the cone.

- 10 2. A tool as claimed in claim 1 including a set of drag blocks (41) mounted on the retainer means, and adapted to push outwardly against the inside of the well casing when the tool is lowered into said casing.

- 15 3. A tool as claimed in claim 1 or claim 2 wherein the upper end of the packing sleeve (23) is fastened to the coupling means and the lower end of said sleeve is slidable longitudinally in a space (24) defined between the cone member and the mandrel for compression of the packing elements between the coupling means and the cone member (16).

- 20 4. A tool as claimed in any one of the preceding claims including a bearing means positioned between the mandrel shoulder (10a) and a shoulder (12a) defined on the coupling means.

- 25 5. A tool as claimed in any one of the preceding claims, wherein the compression sleeve (26) is longitudinally slidable in a space between the mandrel (10) and the cone member (16), packing sleeve, and coupling means.

- 30 6. A method for plugging off a well casing with the bridge plug tool of claim 1 comprising the steps of:

- 35 running the tool into the casing to a desired point for plugging off the casing;
positioning the mandrel (10) during the run-in, such that the first threaded segment is disengaged from the lock members and the second threaded segment (30) is fully engaged with the control members (31);

- 40 rotating the mandrel to cause the mandrel to move downwardly and disengage the mandrel from the control members;

- 45 applying a weight on the mandrel from above the tool to cause the mandrel to move further downwardly and engage the first threaded segment (29) on the mandrel with the lock members (32);

forcing a cone member (16) on the tool

- 50 downwardly against said set of slip members (36) to cause the slip members to move outwardly and set against the inside wall of the casing; and
compressing said packing elements (19, 20, 21) between the cone member (16) and said coupling means (11, 12, 13) to cause the
55 coupling means to expand and set against the inside wall of the casing.

7. A method as claimed in claim 6 including the steps of:

- 60 rotating the mandrel to cause the mandrel to move upwardly and disengage the first threaded segment from the lock members and to engage the second threaded segment with the control members;

- 65 causing a sleeve member (23) in the tool to engage the cone member and pull it upwardly; allowing the slip members to slide downwardly on the cone member and thereby release from the casing wall;

- 70 causing the coupling member on the tool to move upwardly by engagement with a shoulder member on the mandrel to retract the packing members and release said packing members from the casing wall; and

- pulling the tool out of the well casing.

- 75 8. A method as claimed in claim 6 including the step of:

- causing a packing sleeve (23) fastened to the coupling member to seat against the cone member and to force the cone member
80 downwardly after the slip members and packing elements are set against the casing wall.

- 85 9. A method as claimed in any one of claims 6 to 8 wherein the first threaded segment on the mandrel engages corresponding threaded means on the lock members by a ratchet action as the mandrel moves downwardly.

10. A bridge plug tool as claimed in claim 1 substantially as hereinbefore described with reference to and as illustrated in the
90 accompanying drawings.

11. A method for plugging off a well casing as claimed in claim 6 substantially as hereinbefore described.

- 95 12. A well casing whenever plugged by a method as claimed in any one of claims 6 to 9, or claim 11.