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(54) **A METHOD FOR PULLING A CASING AND A WELL INTERVENTION TOOLSTRING THEREFOR**

VERFAHREN ZUM ZIEHEN EINES FUTTERROHRES UND WERKZEUGSTRANG FÜR
BOHRLOCHINTERVENTION DAFÜR

PROCÉDÉ DE TIRAGE D'UN TUBAGE ET CHAÎNE D'OUTILS D'INTERVENTION DE PUITS
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Description**Introduction**

[0001] The present invention relates to a plug and abandon operation with a pulling out of a casing from the well. The perforate, wash and cementing operation of the invention utilises in an embodiment the applicant's so-called Barricade system, a single trip system to perforate a casing wall, wash the casing annulus, and circulate in cement to the annulus to establish a cement barrier across a geological formation, here the Shetland Group formation. In an embodiment the invention's operation makes use of

[0002] A 24,45 cm (9-5/8") "Stronghold Barricade System" - or more generalized, an annulus wash tool (40) also used for annulus cementing.

[0003] A 24,45 cm (9-5/8") "SAMURAI MF Cutter" - or more generally a casing cutter tool (20) which has a through bore which may also be cemented through.

[0004] A 24,45 cm (9-5/8") "Spearhead Plug" - a spear and plug tool which is enabled to hang off drill pipe string below, or more generalized, a spear tool (10) which has a main through bore which may be circulated through the main bore.

[0005] According to regulations for abandoning a petroleum well, a dual barrier is required. In an example, illustrated in the left column of Fig. A1, B1, and C1, Please also see Fig. A2, B2, and C2, 77,42 m (254ft) of perforations will be made and a 182,88 m (600ft) cased hole cement plug will be placed within a 24,45 cm (9-5/8") casing. This is for a well called BC-07, and other depths may be relevant for other wells, but the example illustrates the problem to be solved.

[0006] The geological formation to be plugged in the example is the Shetland formation between depths: 2.082,09 m - 2.876,10 m (6,831ft - 9,436ft) BHR MD at 31° inclination.

[0007] The top of the completion packer is at 2.651,78 m (8,700ft) BHR MD.

[0008] The planned perforation depth is 2.446,63 m - 2.524,05 m (8,027ft - 8,281ft) BHR MD (77,42 m) (254ft) with a further 105,46 m (346ft) internal cased hole plug covering 2.341,17 m - 2.446,63 m (7,681ft - 8,027ft) MD to ensure the combined plug (182,88 m) (600ft) covers the parts of the Shetland Group formation that needs be plug cemented.

[0009] In an embodiment of the invention a wireline set plug is set at 2.614,57 m (8,578ft) BHR to allow a sump to drop the TCP BHA into.

[0010] Drill string to be used is 12,7 cm (5") NC50 drill pipe to surface.

[0011] WO 2020/256563 A1 relates to a casing retrieval drill pipe string conveyed tool string assembly for a well comprising one or more casings, said tool string assembly comprising:

- a casing spear tool arranged for engaging an inner wall of said casing and lifting part of said casing out when severed; -
- a casing cutter tool arranged for cutting and severing said casing at a casing cutting target depth (CCTD) - a casing perforation punching tool arranged for perforating said casing,
- wash tool arranged for washing said casing's annulus through perforations made by said punching tool.

[0012] WO 2015/105427 A2 relates to a method for pulling casing pipes/liner in a petroleum well, comprising the steps of: a) perforating an actual section of said casing pipe in said well by means of a perforating gun, and then b) washing, by means of a washing tool in at least one casing pipe annulus outside the perforated section of said casing pipe for removing debris material, particles, cement or other bonding substances which otherwise hold said casing pipe section stuck, c) cutting, by means of a cutting tool said casing pipe within or below the perforated section for releasing it from the deeper residing, remaining portion of said casing pipe in said well, d) pulling said released, washed-out section of said casing pipe out of said well.

Brief summary of the invention

[0013] The invention is defined in the attached set of claims.

Brief Figure Captions

[0014] The invention is illustrated in the attached Drawing Figures. The Figures have been drawn in three corresponding series A1 - A11, B1 - B11, and C1 - C11, which differ in the following aspects:

- whether a spear tool (10) is in the original toolstring, please see Fig. A1 - A11,
- whether the spear tool (10) is not in the initial tool string but inserted after the cut has been made, please see Fig. B1 - B11, and

- further whether the whether the spear tool (10) is a through bore spear plug tool (10'), and is not in the initial tool string but inserted after the cut has been made, please see Fig. C1 - C11.

Figs. A1, B1, and C1 illustrate the toolstring run into a well to above a rathole above a bridge plug, and fires a perforation gun to perforate a desired interval of a casing to be cemented. To the left is a depth indicator column for the exemplary well referred to in the Appendix, with a sandstone formation drawn in.

Figs. A2, B2, and C2 illustrate a wash tool (40) washing the annulus of the perforated casing section. The wash fluid is run through the through bore (spear tool (10), cutter tool (20), swivel (30), and out radially from the wash tool (40).

Figs. A3, B3, and C3 illustrate a situation after the wash tool (40) has cemented the washed out annulus and the main bore and formed a rock to rock cement plug. Now we may wait on the cement to harden and set in order to pressure test the formed cement plug from above. The wash tool is not capable of dressing and tagging the cement plug so we conduct a pressure test from above.

Figs. A4, B4, and C4 illustrate the employment of cutter tool (20) knives making a rotational cut through the casing to form a severed-off casing section above the cut to be pulled out of hole eventually.

Figs. A5, B5, and C5 illustrate pulling up the cutter tool (20), the swivel (30) and the wash tool (40) to above the cut, and start preparing for test pulling of the severed-off casing section.

Fig. A6 merely illustrates that it is not required to pull up and insert a spear tool (10) because it is already in the toolstring.

Fig. B6 and C6 illustrate pulling up and inserting a spear tool (10) and a spear plug tool (10') respectively.

Fig. A7 illustrates that it is not required to run the spear tool (10) down to the top of the casing, it was in place in Fig. A5 already.

Fig. B7 and C7 illustrate that the newly inserted spear tool (10) and spear plug tool (10') are run into hole, respectively, to the top of the severed-off casing, and with the cutter tool (20), swivel (30) and wash tool (40) in place below, well off the cut.

Fig. A8, B8, and C8 illustrate the common feature that the spear tool (10) in Figs. A8 and B8, and the spear plug tool (10') in Fig. C8, are set and used to conduct a test pull to check whether the severed-off casing section is free to pull.

Fig. A9, Fig. B9, and Fig. C9 illustrate that the spear tool (10) or spear plug tool (10') are laid out, the cutter tool (20), swivel (30) and wash tool (40) are laid out. Those would otherwise interfere with the coming pull-out process of the severed-off casing section.

Fig. A10, B10, and C10 show insertion of a spear tool (10) or spear plug tool (10'), respectively, and running it down to the top of the severed-off casing.

Fig. A11, B11, and C11 show pulling out of the severed-off casing section, and further operations such as sidetracking or permanent abandonment of the well may be conducted.

Embodiments of the invention

[0015] The invention provides a well intervention toolstring as defined in claim 13.

[0016] The through bore spear plug tool (10, 10') is arranged for engaging and pulling on casing pipe, in this case a casing pipe section having been severed at a desired depth, as illustrated in Figs. A4, B4, C4.

[0017] In an embodiment the through bore spear plug tool (10, 10') is a drill-pipe conveyed spear tool (10) with slips setting in a casing pipe, please see Figs. A1 to A11. In that embodiment the through bore spear plug tool (10, 10') may be in the original drill pipe string, a casing spear (10).

[0018] In an embodiment the through bore spear plug tool (10, 10') is not in the original tool string first run into the well, please see Figs. B1 - B11. but inserted after the cut has been made, please see Fig. B6.

[0019] In another embodiment the through bore spear plug tool (10, 10') is in the form of a casing hanger running tool.

[0020] In yet another embodiment the through bore spear plug tool (10, 10') is in the form of a spear plug tool (10') with

capacity for holding the remaining toolstring of cutter tool (20), swivel (30) and swab cup wash tool (40) below the spear. Such a spear plug tool (10') which has a packer may be used for, in addition to pulling on the severed-off casing section, also to be set under pressure via the drill pipe string, the pressure now directed upwardly from below, also via the cut, in order to create a piston effect from below on the severed-off casing section.

Fourth ball seat

[0021] In an embodiment of the invention the through bore cutter tool (20) has a fourth ball seat (22) arranged for receiving a fourth ball (22B) arranged for building up pressure in the through bore cutter tool (20) in order to extend knives (24), please see Figs. A4, B4, and C4. The reason for naming it the fourth ball seat (22) is that there are three ball seats arranged below, one in the perforation gun (50), and two in the swab cup wash tool (40), which are utilized before the cutter tool ball seat.

Wash tool

[0022] In an embodiment of the invention the swab cup wash tool (40) further has a bypass line (44) across the wash tool (40) swab cups (46).

[0023] The wash tool (40) is arranged for washing the perforated annulus.

[0024] The wash tool (40) is arranged for subsequently cementing the perforated casing annulus, cement passing back in through the perforations and passing through the bypass line (44) to cement the casing main bore, as described in Sverre Bakken's patent EP3036395 on a combined annulus wash and cementing method.

Third and second ball seats

[0025] In an embodiment of the invention there is a second and third ball seat (42, 43) below the swab cup wash tool (40). The second and third ball seat (42, 43) are arranged for receiving a second and third ball (42B, 43B). The second ball seat (42) may be sheared out at a predetermined pressure after the annulus washing procedure, and the third ball seat (43) is sheared out after the cementing circulation procedure for cementing the annulus of the perforated casing, and also for cementing the main bore below the washing tool during the pump and pull operation. Details of the washing and cementing procedures are given in the below appendix.

First ball seat

[0026] In an embodiment of the invention the well intervention, the toolstring further comprises a first ball seat (52) in a firing head (53) and an automatic gun release AGR (54) for the perforation gun (50). A first ball (52B) is dropped to the first ball seat (52), landed, and pressure is set to trigger the firing head (53) which sets off all the guns (50) in common, and activates the automatic gun release (54) to drop the guns into the below rathole above the wireline set plug or other basis for the cementing operation.

Spear plug embodiment

[0027] In an embodiment shown in Figs C1 - C11, the through bore spear (10) is a spear plug tool (10') which comprises a packer and further comprises a switchable ball valve having a bore of relatively large diameter to allow circulation through.

The method of the invention

[0028] The method provides a method for pulling a casing as illustrated in Figs. A1, B1, C1 to A11, B11, C11. The method comprises the steps of:

- assembling the toolstring of the invention as illustrated in Fig. A1. In an embodiment of the invention the toolstring is assembled except for the through bore spear plug tool (10, 10') as illustrated in Figs. B1 and C1, but introduces it in the step of Fig. B6 and C6.
- run the toolstring into hole and place the perforation gun (50) at a predetermined perforation depth, as illustrated in Figs. A1, B1, and C1,
- perforate the casing using the perforation gun (50), wherein the result is illustrated in Figs. A2, B2, and C2 between u. perf. And L. perf. One may in an embodiment use other perforation tools (50) than a gun, such as a perforation tool

which makes one by one perforation, which just takes longer time than a single-firing long gun, but otherwise provides a perforated section of the casing.

- subsequently, wash the perforated casing annulus using the swab cup wash tool (40), please see Figs. A2, B2, and C2, and
- circulate in cement into the washed-out casing annulus and the casing bore preferably using the swab cup wash tool (40), please see Fig. A2, B2, and C2, with the resulting plug illustrated in Figs. A3, B3, and C3. In an embodiment it would be possible to place cement in the main bore and squeeze it into the washed-out casing annulus, but circulating it in using the wash tool better fills the washed-out annulus. The well is now cemented rock-to-rock with the perforated casing as a steel reinforcement in the cement plug, please see Fig. A3, B3, C3.
- After cementing, pull up and wait on cement as illustrated in Fig. A3, B3, C3, and pressure test the cement plug formed.
- Subsequently, pull up the toolstring with the cutter tool knives to the desired shallower depth, and cut the casing at the shallower depth using said casing cutter tool (20). The pulling out operation may involve several thousand feet as shown in the illustrations A3, B3, C3 to A4, B4, C4.

[0029] (In case said spear tool (10) was not inserted in the toolstring initially, such as in Fig. A1 to A5, after the cutting, pull up and insert said spear tool (10) into the toolstring as illustrated in Fig. B6 and A6) (In case the spear tool (10) already was inserted in the toolstring, such as in Figs. A1 to A5, it is not necessary to pull up and insert the spear tool (10), and then the steps of Fig. A6 and A7 have been indicated by "X" as not required, and we may proceed to the test pulling of Fig. A8.)

[0030] Test pull the severed-off casing section using said spear tool (10) as illustrated in Fig. A8, B8, and C8.

[0031] If the test pulling is successful, pull up and remove the spear tool (10), the cutter tool (20) and the swab cup wash tool (40).

[0032] (If the test pulling is not successful, if using a spear plug (10') as in Fig. C8, pressure up on the drill pipe string to add piston pressure force from below on the severed-off casing section, and try also to wash out the annulus via the cut. If still not successful in test pulling, pull up and reinsert the cutter tool and make a shallower cut and repeat the test pulling, until successful test pull.)

[0033] Then reinsert spear tool (10), run it into the well and engage with the severed-off casing section, please see Figs. A10, B10, and C10, and pull said severed casing out of hole, as illustrated in Fig. A11, B11, and C11.

Perforating

[0034] In an embodiment of the invention, after running into hole and placing the perforation gun (50) at the predetermined perforation depth,

- perforate the casing by landing a first ball (52B) in said first ball seat (52), pressure up to trigger firing head (53) to fire the guns (50) and perforate the casing, please see Figs. 1A, 1B, and 1C, and
- let an automatic gun release (54) drop the used perforation guns (50).

Washing

[0035] In an embodiment of the invention, wash the perforated casing section annulus by

- landing a second ball (42B) in said second ball seat (42), please see Fig. A2, B2, C2,
- circulate wash fluid into said perforated casing annulus while running said swab cup wash tool (40) along said perforated casing section and circulating out debris from the perforated casing annulus.
- After having washed out the casing annulus, place said swab cup wash tool (40) in blank casing,
- shear out the second ball seat (42) and circulate debris in said toolstring annulus out of hole.

[0036] Due to the fact that the second ball seat has been sheared out, we may pump wash fluid through the wash tool axially, and back up through the bypass line (40) across the swab cups, and thus circulate out the debris.

Cementing

[0037] In an embodiment the method for pulling a casing further comprising

- circulate in cement into annulus by

- land a third ball in said third ball seat (43) below said wash tool (40). This will close the main bore below the swab cups.
- Preferably, one should test the integrity of the swab cups in a blank casing section before continuing.
- While running said swab cup wash tool (40) along said perforated casing section, circulate in spacer/primer fluid into said perforated, washed casing annulus.
- Run said swab cup wash tool (40) along said perforated casing annulus, from bottom to top, and circulate cement into said primed perforated casing annulus while pulling up, and
- while pulling up, also cementing further into the casing bore using swab cup wash tool bypass (44)
- pull up to above the top of cement, and shear said third ball seat (43), please see Figs. A3, B3, C3, and circulate out remaining cement from the toolstring annulus, i.e. within the casing above the cement plug formed.

Wait on cement

[0038] In an embodiment of the invention, one shall now wait on cement, i.e. until the cement plug has set and hardened sufficiently to conduct a pressure test, increase the pressure in the casing to pressure test the formed cement plug. We are now at the stage of Fig. A3, B3, and C3, and before the cutting in Fig. A4, B4, C4. If the pressure test, which tests sealing from above, is OK, we are sure that the plug, which is of more than 76, 20 m (250ft) length in the example, has sealed from rock to rock across and along the perforated section, and forms one permanent fluid barrier.

Cut casing

[0039] In an embodiment of the invention, the method further comprises to cut the casing by

- pulling up the toolstring with the cutter tool (20) to the predetermined cut depth,
- land a fourth ball (22B) in said fourth ball seat (22) in said cutter tool (20),
- pressure up in the drill pipe string to extend the knives (22) of the cutter tool (20),
- rotate the drill pipe string with the cutter tool (20) and make a circumferential cut in the casing at the predetermined cut depth, please see Figs. A4, B4, and C4, while
- the swivel (30) allows the swab cup wash tool (40) below to be non-rotating,
- release the pressure in the drill pipe string (22) and deactivate the cutter tool's (20) knives (24).

[0040] Now the cut-off casing section, the severed casing section, should be tested for whether it is possible to pull out and lay out of hole.

Test pull

[0041] According to an embodiment of the invention the method further comprises to test pull said severed-off casing section by

- pull up said cutter tool (20) to well clear above said cut,
- activate and set slips of said spear tool (10, 10') in the severed-off casing section, please see Fig. A8, B8, and C8.
- test pull said severed-off casing section to determine whether it is free.

[0042] There are two possible situations before the test pull can take place:

- either we initially have a spear tool (10) in the toolstring as in Fig. A1 to A5 whereby, with which we may proceed directly to the situation in Fig. A8, (we have indicated that the actions of the crossed-out Fig. A6 and A7 wherein we otherwise would have to insert a spear tool (10) and running it into hole is not required),
- or we have no spear tool (10, 10') initially in the toolstring and have to insert a spear tool (10, 10') and running it into hole in order to conduct a test pulling, please see Figs. B6 and B7, and C6 and C7.

If no spear tool initially

[0043] Thus, in an embodiment of the invention, in case said spear tool (10, 10') was not inserted in the toolstring initially, after the cutting, pull up and insert said spear tool (10, 10') into the toolstring above the cutter tool (20), please see Fig. B6 and C6, and run in said spear tool (10, 10') into the well and engage with said severed-off casing section, please see Fig.

B7, B8, and C7, C8, and test pull the severed-off casing section using said spear tool (10, 10'). Please see Fig. B8 and C8.

Test pull not yet OK

- 5 **[0044]** In case the test pull is not OK, and the severed-off casing section is stuck, we still have the cutter tool in the well, and may repeat the cutting process with cutting higher up and test pulling until free.

Test pull OK

- 10 **[0045]** In case the test pull is OK, we may now pull out the severed-off casing section. But at the surface the drill pipe string with the spear tool (10, 10'), the cutter tool (20), the swivel (30) and the swab cup wash tool (40) will usually be in the way of the process of removing the severed-off casing section and lay it out; in an embodiment of the invention we have to remove the spear tool (10, 10'), the cutter tool (20), the swivel (30) and the swab cup wash tool (40) before pulling the severed-off casing section out of hole.

- 15 **[0046]** In the embodiment we pull out said severed-out casing section by

- pulling up and laying out said spear tool (10, 10'), said casing cutter tool (20), said swivel (30) and said swab cup wash tool (40), please see Fig. A9, B9, and C9. Now the casing cutter tool and swivel and wash tool will not interfere with the casing when laying casing out,
- 20 - reinsert said spear tool (10, 10'), please see Fig. A10, B10, and C10, and
- run in hole said spear tool (10, 10') to engage and hold said severed-off casing section,
- pull out of hole said severed-off casing section,
- release and remove said insert spear tool (10),
- lay out said severed off casing section.

25 **[0047]** Please see Fig. A11, B11, and C11.

[0048] In an embodiment of the invention, if the top of the casing is a casing hanger, engaging said spear tool (10, 10') in the casing hanger, please see Fig. A8, B8, C8, of said severed-off casing, before pulling it out.

[0049] This concludes the embodiments of the method and the severed-off casing section has been laid out of the well.

Appendix: Example of a planned operation on a well.

[0050] The invention is in this appendix lined out with details of the below planned operation on a well. The present invention relates to a plug and abandon operation with a pulling out of a casing from the well. The Perforate, Wash and Cementing operation utilises the applicant's so-called Barricade system, a single trip system to perforate a casing wall, wash the casing annulus, and circulate in cement to the annulus to establish a cement barrier across a geological formation, here the Shetland Group formation.

[0051] Some of the essential tools used in the operation according to the invention are:

40 24, 45 cm (9-5/8") "Stronghold Barricade System" - an annulus wash tool (40) also used for annulus cementing

24,45 cm (9-5/8") "SAMURAI MF Cutter" - a casing cutter tool (20)

45 24,45 cm (9-5/8") "Spearhead Plug" - a spear and plug tool (10, 10' which is enabled to hang off drill pipe string below.

[0052] According to regulations for abandoning a petroleum well, a dual barrier is required, therefore 77, 42 m (254ft) of perforations will be made and a 182, 88 m (600ft) cased hole cement plug will be placed within the 24,45 m (9-5/8") casing.

[0053] Pump and pull rates are based on 4,57 m (15ft) stroke of the HWO Unit.

[0054] BHR Height used has been 8,38 m (27.5ft).

- Shetland formation depths: 2.082,09 m - 2.876, 09 m (6,831ft - 9,436ft) BHR MD at 31° inclination.
- Top of completion packer is at 2.651,78 m (8,700ft) BHR MD.

55 **[0055]** Planned perforation depth will be 2.446,63 m - 2.524,05 m (8,027ft - 8,281ft) BHR MD (77,42 m) (254ft) with a further 105,46 m (346ft) internal cased hole plug covering 2.341.17 m - 2.446,63 m (7,681ft - 8,027ft) MD to ensure the combined plug (182,88 m) (600ft) covers the Shetland Group formation.

[0056] A wireline set plug may be set at 2.614,57 m (8,578ft) BHR to allow a sump to drop the TCP BHA into.

[0057] Drill string to be used will be 12,7 cm (5") NC50 drill pipe to surface.

Pre-Job Planning

[0058] As part of the pre-job planning at a minimum the following should be carried out to ensure flawless execution.
[0059] Fluids to be sent out pre-mixed where possible.

- Ensure all drill pipe is drifted to minimum 5,72 cm (2 1/4") to ensure no restrictions for the 4,45 cm (1.75") swab cup wash tool (40)'s ball.
- Confirm ability to pump at a minimum 1.383, 19 L/min (8.7bbl/min) using Altus Pump and surface setup.
- Confirm max allowable rotation of the unit for use during bottoms up.
- Ensure suitable pit plan is in place for cementing/spacer operations.
- Confirm spacer has been sent out pre-mixed.
- Ensure cementing volumes and all fluid weights are confirmed with cementer to ensure suitable chemicals are available and can be prepared and pumped efficiently.

Planned Wash fluid is 1.246,19 kg/m³ (10.4ppg)

Planned Spacer fluid is 1.246,19 kg/m³ (10.4ppg)

Planned cement fluid is 1.917,22 kg/m³ (16ppg)

- Ensure permits are prepared and plan to be in place for shifts when TCP operations may occur.
- Ensure Archer crew are aware of the barrier policy on the Brent Charlie.
- Firing head and cementing calculations to be finalized offshore based on latest information.
- Ensure surface lines are tested to 310,26 bar (4,500psi) for Archer TCP operations.
- Plan to ensure spacer and cementing operations do not fall across shift change.
- Connections to be made as efficiently as possible, if shift change occurs over washing procedure remain static and continue to circulate - do not stay static without circulation.
- Check and confirm pipe tally and space-out.
- Check and confirm availability of 12,7 cm (5") drill pipe on the Brent Charlie to utilize above the swab cup wash tool (40).
- Confirm swivel assembly to be used during washing and for Pump + Pull operations
- If using King Swivel, ensure a suitable plan for handling the swivel/joint has been assessed.
- Ensure ATEX Zone 1 Tablet is charged for washing operations.
- Confirm if new monitoring system on the HWO unit can be used to record washing data.

Embodiments of the invention

[0060] Below is described embodiments of the invention. The invention is in one aspect a method as defined by claim 1.

[0061] The invention is, in another aspect, a toolstring, as defined by claim 13, arranged for conducting the method. We describe the entire operation beginning with preparations and ending with the situation wherein all sections of the severed-off casing section have been laid-out on deck. The below description of embodiments of the invention is based on the inventor's "Archer Oiltools' Shell BC07 Operation Procedure" for conducting the entire perforate-wash-cement operation for plugging the well in the Shetland Formation before cutting the casing at a shallower depth and pulling out the severed-off casing section. The method may be employed for other wells in the same Shetland Formation, of course adapted to the local relevant depths, but may also be employed in other similar wells wherein the well shall be subject to casing perforation, washing and cementing before cutting the casing at a shallower depth and pulling out the casing. During the procedure the bottom-hole assembly generally comprises a casing perforation gun (which is dropped automatically after perforating), a casing annulus wash and cementing tool, a casing cutter tool, and a spear tool, possibly a combined spear and plug tool is applied, although the spear and plug tool is in some embodiments inserted into the toolstring after the cutter tool has been employed. The scope of protection of the current invention is defined by the appended claims.

Operation Procedure with comments

[0062] Below is described the exemplary operation procedure in minute detail.

RIH Run in Hole

[0063]

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1. Hold TBT. Ensure everyone is aware of the upcoming operation. Ensure everyone is aware of the restrictions/- dangers of handling explosives.

2. Make a PA announcement and barrier off relevant areas prior to rig up Tubing conveyed perforation (TCP) guns (50).

3. M/U tubing conveyed perforation (TCP) BHA as per Archer engineer instructions. Install TCP safety clamp to tubing conveyed perforation (TCP) guns (50) and lift up using 7-5/8" single joint elevators on the WellGear winch and set in the slips in the rotary. Safety clamp remains on until being removed before running through the rotary.

Note: Auto-slips can be used for running the Tubing conveyed perforation (TCP) guns (50) - this eliminates the use of hand slips.

Note: Additional crossovers have been sent out to allow make up to 1 x joint to be able to lower the complete gun string to the lower deck to aid space out.

Note: Confirm ability to utilize winch. Gun string length has been reduced, new winch has better lifting capability.

4. Utilizing the required crossovers and a joint of drill-pipe, lower the top of the gun string to the lower window for better space-out.

5. P/U the wash tool (40) System assembly using the WellGear winch, secure bottom of BHA when moving towards the rotary. Check functionality of the swivel, rotation by hand.

6. M/U tubing conveyed perforation (TCP) gun (50) firing head system to the bottom of the wash tool (40) assembly.

Note: Only Archer personnel to be on the floor when making up the Pressure Activated Firing Head to the tubing conveyed perforation (TCP) gun (50) string.

Note: 3,35 m (11ft) spacer has been loaded out therefore firing head needs to be made up with the top of spacer gun at lower window slips.

7. Grab the upper pup joint of the swab wash tool (40) System in the upper clamp and M/U swab cup wash tool (40) System to tubing conveyed perforation (TCP) (50) string using chain tongs.

Note: Ensure that the swab cup wash tool (40) system is supported so as to not resting on the swab cups.

8. Lower the swab cup wash tool (40) system through rotary and suspend in slips

- Run slowly through BOP / WH or any other restrictions.

9. P/U Archer cutter tool (20) Multifunction Cutter BHA and remove protector (if applicable)

10. Confirm knife location downhole to space-out correctly for avoiding casing couplings

11. M/U cutter tool (20) to the swab cup wash tool's (40) Pup Joint

12. RIH to tag the pre-set wireline (or "E-line") bridge plug and pull back to space out in order to allow about 98,76 m (324ft) (sump/rathole for dropping the gun)

- Plan to break circulation every 457,20 m (1,500ft), maximum 48,26 bar (700psi)
- Max tag should be 2.267,96 kg (5klbs)
- Max RIH speed limited to 10s per 4,57 m (15ft) stroke.
- Run slowly through BOP / WH or any other restrictions.

13. M/U topside swivel assembly and line up to pump down the string, slowly break circulation to confirm open flow path through the string.

- Maximum pump pressure limited to 48,26 bar (700psi)

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- TCP engineer to be on the floor when circulating

Activate tubing conveyed perforation (TCP) guns (50)

[0064]

14. Break out swivel assembly and insert 2,54 cm (1") steel ball, the first ball (52B) for activating Tubing conveyed perforation (TCP) guns (50). Allow to fall while making up swivel assembly. The first ball (52B) will eventually land in ball seat (52) and prepare for pressure triggering the firing head of the perforation guns (50).

15. Test surface lines to 310,26 bar (4,500psi).

Note: Ensure the string is isolated from this pressure as test pressure will activate Tubing conveyed perforation (TCP) guns (50).

16. Space out to ensure that the perforation guns (50) are on depth.

17. Hold TBT prior to line test/ tubing conveyed perforation (TCP) guns (50) activation

Note: Ensure all barriers are in place, make PA announcement to ensure rig personnel are made aware explosives are about to be activated.

Note: Discuss best way of dealing with gun gas, or gas from the annulus.

18. Close annular bag and rig up shot detection system.

Note: Shot detection system is not Ex rated and needs a permit.

19. Pressure up the drill string to 137,90 - 172,37 bar (2,000 - 2,500psi) to activate tubing conveyed perforation (TCP) gun (50) firing head.

Note: Activation pressure to be confirmed offshore.

- The tubing conveyed perforation (TCP) gun (50) string will disconnect on activation of the firing head.
- Circulation is regained through the string after the automatic gun release (AGR) has dropped the tubing conveyed perforation (TCP) guns (50).

20. Carry out 15min flow check.

Note: Be aware of any gun gas to surface.

21. Open annular bag.

22. Circulate the well over to 1.246,19 kg/m³ (10.4ppg) washing fluid.

Note: Be aware of any gun gas to surface.

Note: Be aware and prepared for any gas to surface.

Washing Sequence

[0065]

23. Check if rig monitoring system for recording flow rate and pump pressure is running.

24. Carry out circulation "fingerprint" and record below.

Circulation rate (gpm/bpm)	Circulation pressure (bar/psi)
252gpm/ 6bpm	
294gpm/ 7bpm	
33gpm/ 8bpm	
378gpm/ 9bpm	
420gpm/ 10bpm	

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25. Stop pumping and break out swivel and insert the second ball (42B), which is a 3,49 cm (1.375") OD Steel Ball.

26. M/U swivel.

27. Circulate the second ball (42B), the 3,49 cm (1.375") ball, to the second ball seat (42) below the swab cup wash tool at maximum 158,99 l/min (1bbl/min). Now the swab cup wash tool (40) main bore is closed and the swab cups may be pressure tested against blank casing.

Note: Max running speed across perforations is 18s per 4,57 m (15ft) stroke.

28. P/U into blank casing and confirm swab cup integrity to 68,95 bar (1,000psi).

29. Hold 20,68 bar (300psi) on the string and slowly RIH the swab cup wash tool (40) to locate top of perforations indicated by pressure bleed off. We may now assume that the fluid enters into the perforations.

30. Continue to RIH a further 0,61 m (2ft) to place the swab cup wash tool (40) swab cups in perforations.

31. Now we start washing. Start pumping to circulate out to the annulus between the swab cup wash tool (40) swab cups and increase rate to a maximum loss free rate aiming for a minimum 1.383,19 L/min (8.7bbl/min) aiming for 1.907,85 L/min (12bbl/min).

- Maximum pump rate for 24,45 cm (9 5/8") swab cup wash tool (40) is 2.225,82 L/min/2.225,82 lpm (14bbl/min / 588gpm).

- Maximum pressure allowed is 75% of 3,49 cm (1.375") ball seat shear rating, 155,13 bar (2,250psi).

- A loss free rate is crucial to ensure we have full control of the fluids and lifting debris to surface. This also ensures we have a stable well for when we carry out cementing operations.

Check circulation rate and circulation pressure.

32. Move the swab cup wash tool (40) and wash downwardly: Once stable rate has been achieved wash downwards at 0,3048 m/min (1ft/min) monitoring for blank sections from TCP BHA. Ensure connections are made quickly and efficiently.

Note: Archer engineer to record parameters in excel sheet on Archer Tablet.

Note: Archer TCP engineer to provide blank section sheet.

Note: Monitor debris returns over the shale shakers.

Note: Reduce the pumping rate across TCP blank sections.

Note: The swab cup wash tool (40) of the BHA is built to Option 2 with 0,5364 m (1.76ft) between internal cups to ensure blank casing sections are straddled.

33. At bottom of perforations continue to pump a string volume while stationary.

34. Switch off pumps and - pull up to top of perforations and repeat the wash down pass while monitoring for a decrease in washing pressure. We now reach the bottom perforations. The washing procedure is now finished and we prepare for primer and cementing of the washed-out casing annulus. But first we must circulate out the washed-out debris from the tool annulus.

35. RIH the swab cup wash tool (40) into blank casing below perforated zone and verify swab cup wash tool (40) swab cups pressure integrity to 68,95 bar (1,000psi) and continue to pressure up to 206,84 bar (3,000psi) shearing out the second ball seat (42) 3,49 cm (1.375") ball seat and regain circulation through the bottom of the swab cup wash tool (40).

Note: If long delays due to weather are expected discuss with town whether shearing the second ball seat (42) with the second ball (42B) 3,49 cm (1.375") ball is correct option.

Note: We are now circulating through the bottom of the swab cup wash tool (40) and up through the concentric bypass line (44) (bypassing the swab cups and wash section) of the swab cup wash tool (40) and up the DP annulus in the casing, also called the "DP x casing annulus".

Theoretical shear value		bar/psi
Actual shear value		bar/psi

36. In order to circulate out the washed-out debris, circulate min 1 x B/U at max allowable rate rotating the string above the swivel (40) above the swab cup wash tool (40) at max allowable rpm continuing to monitor debris returns over shakers. The swab cup wash tool (40) is not rotated.

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Note: Max allowable rpm on the rotary unit is 50 - 80RPM.

Note: Confirm maximum RPM with WellGear.

37. P/U to straddle bottom of perforations with the swab cup wash tool (40) swab cups and drop and circulate a third ball (43B), a 3,49 cm (1.75") ball to the third ball seat (43) which is arranged below the swab cup wash tool (40), at maximum 158,99 L/min (1bbl/min). This third ball (43B), when landed, closes the central bore of the swab cup wash tool (40) to re-enable circulation out to the perforated casing annulus.

38. RIH to blank casing and verify integrity to 68,95 bar (1,000psi) to verify swab cup wash tool (40) integrity. When OK, spacer circulation may commence.

Pump & Pull Spacer fluid

[0066]

39. Hold TBT. Ensure all personnel are aware of roles and responsibilities; ensure communication between Derrickman/pumpman for transferring fluids from pits to the cement unit are clear.

Note: Ensure radios are working correctly

40. Displace full string to contain spacer.

Note: Ensure volumes in/out are confirmed when pumping. Previous lesson learned has seen pumps jacking off showing incorrect volumes pumped.

41. Carry out the pump and pull across perforations as per the displacement plan above. Pumping at 476,96 L/min (3bbl/min) and pulling at 1min per 4,57 m (15ft) stroke.

Note: Due to spacer and wellbore fluid being same weight, closing of the annular bag on the string at connections can be eliminated as no U-tubing is expected.

Note: Optional for new crews is to practice closing the annular bag during cementing is to prevent/reduce u-tubing of cement out of the string when making/break connections.

Note: This can and should be used as preparation for carrying out Pump & Pull with cement if there are several new people involved in the operation. Everyone should be fully aware of what is required, if in doubt STOP.

Pump & Pull Cement

[0067]

42. Hold TBT for cementing operations. Have a review to capture any lessons learned or improvements from the preceding spacer section. Ensure all communications are clear. Discuss the Archer displacement plan.

43. RIH to straddle the bottom of perforations.

Note: Ensure Cementer is aware of the plan and does not start to fill the tanks while displacing down the string.

44. Pump the following volumes down the string as per displacement plan of the appendix below.

- 15.421,77 l (97bbl) Cement slurry
- 2.066,83 l (13bbl) Spacer
- 6.836,46 l (43bbl) of wash fluid

This will displace 10bbl of cement out of the wash tool (40) while stationary prior to starting Pump + Pull operations. Cement will be circulated into the perforated casing annulus and rise above the upper swab cups and back into the toolstring annulus and the upper bypass line (44) port. Pulling up while pumping will now also guide cement down through the bypass and cement the main bore of the casing below the lower bypass port. 45. Start picking up to carry out Pump and Pull operations as per cement calculation parameters. Pumping at 476,96 l/min (3bbl/min) and pulling at 1min per 4,57 m (15ft) stroke.

Note: Monitor maximum volume pumped allowed as per displacement plan.

46. At the top of the perforations continue to P/U into blank casing and shear out the third ball seat (43) with the third ball (43B), the 4,45 cm (1.75") ball seat pinned to 206,84 bar 3,000psi.

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Theoretical shear value		bar/psi
Actual shear value		bar/psi

47. Continue to pump cement as a balanced plug as per displacement plan for the remaining internal cement plug in the main bore. Pumping at 1bpm.

TTOC at approximately 2.341,17 m (7,681ft).

48. POOH (Pull up) until clear above worst-case top of cement TOC at 2.167,74 m (7,112ft).

49. Carry out minimum 1.2 x string volume B/U circulation at minimum 1.383,19 L/min (8.7bbl/min).

Note: If a sponge ball is to be pumped recommended to only pump 1 sponge ball as pumping 2 could lead to the tool being partially plugged. The toolstring should now be free of cement and spacer fluid.

50. POOH, i.e. pull up the toolstring and position the cutter tool (20) knives at cutting depth 983,59 m (3,227ft) where the cut shall be made.

51. Wait on cement WOC and pressure test the formed cement plug formed with the above perforation, washing, and cementing procedure, the so-called "Shetland plug".

Note: Shell to advise timings and parameters

52. Drop a fourth ball (22B), a 6,35 cm (2 1/2") activation ball for a ball seat (22) of a flow controller valve of the cutter tool (20) and record parameters without pumps

RPM	60	100
Torque (ft-lbs)		
Up-Weight		
Down-Weight		
FRW		

53. Chase the activation ball (22B) to land in the seat (22) of the cutter tool (20) with maximum 1.5bpm

54. Watch for pressure build up to indicate that the fourth ball (22B) has landed in seat (22). Increase pressure to shear a pin which activates the longitudinal movement of a piston and piston rod controlled by a flow controller, activating the knife assembly of the cutter tool (20), and watch for pressure drop

Note: If the initial shear is not observed when the maximum expected shear pressure (quoted pressure +25%) has been reached, it is recommended to adopt a staged increase in the application of pressure in order to obtain this shear.

Note: The following procedure should be followed if this occurs

Note: Pressure up to 30% above shear value and hold for one minute.

Note: If no shear observed, bleed off and pressure up to 40% psi and hold for one minute. Repeat this step a maximum of 3 times.

Note: If after applying 40% 3 times no shear has been observed, bleed off and pressure right up until shear is obtained. This would only be done after consultation with Archer Representative. Maximum pressure 334,74 bar (5000 psi)

55. Record flow parameters

Circulation rate (GPM/bpm)	Circulation pressure (bar/psi)
420GPM / 10BPM	
504GPM/12BPM	
588GPM/14BPM	

56. Stop pumps. Increase flow until torque increase is observed

57. Increase pressure to achieve a cutting pressure drop of 59,98 - 79,98 bar (870-1,160psi) in 2mins until stable pressure is witnessed

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Flow Rate		gpm/bar
SPP		psi

Note: If pressure and flow rate deviated from table below, pressure should be used as reference.

	SPP	Estimated flow @ cut pressure	Estimated flow after drop
Upper Nozzle 3.200"	1,160psi	225gpm	572gpm
Upper Nozzle 3.225"		380gpm	880gpm

58. Using the cutter tool (20), cut the casing at 983,59 m (3,227ft) BHR MD according to Archer rep. An increase in torque may be observed during the cutting process. Subject to centralisation, the torque may become erratic as the cut proceeds.

Note: Typical time to cut can be 2-5 minutes. Cutting time is calculated from when cutting pressure is reached. Variations in cutting time are not unusual.

Note: If pressure and flow rate deviated from table above, pressure should be used as reference.

Note: When pressure drop is observed, re-increase flow rate back to cutting pressure and continue to cut for 2mins to ensure clean cut

59. When the cutter tool's (20) knife arms reach their pre-set diameter a pressure drop, due to the end position of the cutter tool's flow regulator, will be observed and the pre-determined knife opening is reached. Immediately increase pump rate to chase the required cutting pressure. A reduction in torque is expected.

Note: Cutting a casing which is in compression can reduce the visibility of the reduction in torque and surface pressure drop.

60. Maintain cutting pressure and continue cutting for a short duration (2 min). The knife arms will continue to the maximum knife sweep. To ensure a clean cut.

61. Stop circulation, bleed of pressure and stop rotation.

Note: Bleed off pressure thru the standpipe to prevent hydraulic locking

62. P/U pick up string weight and POOH to bit depth 906,17 m (2,973ft) BHR MD, which is 77,42 m (254") above the cut made at 983,59 m (3,227").

Note: Knives are now retracted into the pockets.

Note: Do not seat knives inside the cut as it may damage the hinge pin holes.

Note: Due to potential washout of the nozzle assembly, cutter tool (20) shall not be used for excessive circulation. If the spear tool (10) was not inserted in the original toolstring, now the spear tool (10) shall be inserted into the toolstring. The reason for not having inserted the spear tool (10) before now is twofold: Firstly, if the spear tool (10) is in the embodiment of a spearhead spear plug tool (10') it has drag blocks and thus cannot rotate with the cutter tool. Secondly, the activation ball, the fourth ball (22) for the cutter tool (20) may be larger than the bore of the spearhead spear plug tool (10').

63. P/U the spear tool (10) assembly and remove the Safety Clamp from the spear tool (10) Running Tool. In case of using a spear plug tool (10'), Make sure the ball valve of the spear plug tool (10') is open.

64. M/U the spear tool (10) assembly to the drill pipe set in the slips

65. Remove inner bushing and lower the spear tool (10) through the rotary

66. M/U to NC50 drill pipe and RIH to engage the spear tool (10) in the casing hanger of the severed-off casing section.

Note: While running into hole, run the spear tool (10) slowly through BOP/WH and any other restrictions

Note: Do not set the slips on the DP when spear tool (10) is in BOP/WH.

67. Record up/down weights and DP stretch

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PUW		lbs
SOW		lbs
DP Stretch		ft

68. Start circulating and condition mud in order to clean the spear tool (10) and the internal casing wall of the setting area. In case of using a spear plug tool (10'), start circulating and condition mud in order to clean the lips, drag blocks of the spear plug tool (10') and the internal casing wall of the setting area. Depending on the well condition, circulate for 10 min. with maximum rate.

Note: Full attention paid to pump pressure and weights during entire operation

Note: Reciprocate the spear tool (10), while circulating, 6 ft. above and below, either side of the setting area. Note that reciprocation of pipe while circulating will increase amount of fluid bypassing the spear tool (10) and circulation rate may have to be decreased

Note: Stop circulation before proceeding with setting sequence.

Note: Confirm recorded weights after circulation

69. Make sure to space out in a manner so that you have some room to work with during setting, ideally 9, 14 m (30ft) above RKB.

Note: should be to place mid-joint of single across BOP's to prevent connection being immediately below or at blind shear rams of the BOP when the spear tool (10) is set.

70. Move DP down to 6ft above desired setting depth and pick up to neutral weight.

71. Activate the slips of the spear tool (10). In case of using a spear plug tool (10'), Establish right hand RH rotation at 15-20RPM. Confirm stationary wind-up torque by rotating the drill pipe string slowly until break-over torque of the spear tool (10) is reached & weight is confirmed, minimum 10 turns. This will activate the slips and the packer of the spear plug tool (10'). Record number of turn to achieve free rotation torque (FRT), and weight(FRW):

RPM		
FRT		Ft-lbs
FRW		lb
Number Turns for FRT		

72. Set the slips of the spear tool (10). In case of using a spear plug tool (10'), move the string down at approximately 1ft/s in order to engage and set the slips of the spear plug tool (10'). When the spear plug tool (10') starts to take weight, stop rotation, release torque and set down minimum 19.958,09 kg (44klbs) below slack off weight (SOW), holding weight 2mins

73. Pick up, in order to have 9.979,05 kg (22klbs) tension on the spear tool (10), compared to Pick up weight (PUW)

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Top Plug at		ft
Mid-element at		ft

74. Release torque in the string and verify that the spear tool (10) is set according to Archer rep. Now the spear tool (10) is ready to pull the casing.

75. Pull the severed-off casing section according to Archer rep

Note: Pull in steps, each step until stable weight.

Note: Max hook load while pulling: 318.022,68 kg (701,120lbs) + Block weight

Note: Evaluate to circulate while pulling

76. If the severed-off casing section is not free, follow the below steps:

Step 1: Work the toolstring up and down

Step 2: Apply fluid pressure while pulling, max 129,97 bar (1,885psi) in 19,99 bar (290psi) steps (reduce max pull to 294.381,45 kg (649klbs) + block weight when applying 129,97 bar (1,885psi), because the fluid pressure will create extra tension in DP)

Step 3: Keep pressure / tension for a while to allow for possible movement of the severed-off casing section, max 30 minutes. If still no free severed - off casing section, we still have the cutter tool (20) available in the well but cannot cut without laying out the spear tool (10). See below.

77. If the severed-off casing section is free and possible to move, release the spear tool (10), because we will now lay out the cutter tool (20) and the swab cup wash tool (40) before pulling out the severed-off casing:

78. Slack off to have 2.267,96 kg (5klbs) above free rotation weight (FRW).

79. Release the spear tool (10). In case of using a spear plug tool (10'), still with 2.267,96 kg (5klbs) above the free rotation weight (FRW), start RH rotation at 15-20 RPM, in order to release spear plug tool (10').

80. In case of using a spear plug tool (10'), when spear plug tool (10) is free, pull the string slowly as you rotate another 10 turns. Then stop rotation gently as you continue pulling the string another 304,8 - 365,76 cm (10-12 ft).

81. In case of using a spear plug tool (10'), if no indication that spear plug tool (10) has released after 20 turns, increase over pull in steps towards pick up weight. Once spear plug tool (10) releases pull the string slowly as you rotate another 10 turns. Then stop rotation gently as you continue pulling the string another 304,8 - 365,76 cm (10-12 ft).

NOTE: Make sure that while operating spear tool (10), the TD must at all times be positioned so that spear tool (10) can be released and DP made up/broken with the Iron Rough Neck

82. Stop pulling and wait 10 minutes to allow elements to fully retract.

83. If possible, run spear tool (10) in-hole to below setting depth, to ensure that spear tool (10) is retrieved and free.

84. POOH and lay out the spear tool (10) assembly. We shall now get rid of the cutter tool and wash tool before pulling the severed-off casing section.

85. POOH and lay out the Archer cutter tool (20) and swab cup wash tool (40). The reason for having kept the cutter tool (20) in the work-string until now is due to the fact that if the severed-off casing section remained stuck and impossible to pull, we could now make a new cut and try to pull the new, shorter severed-off casing section in order to proceed.

86. P/U the spear tool (10) assembly and M/U to NC50 drill pipe. RIH to engage the casing hanger of the severed-off casing section.

Note: Run the spear tool (10) slowly through BOP/WH and any other restrictions

Note: Do not set the slips on the DP when spear tool (10) is in BOP/WH.

87. Repeat steps 67-76 for setting the spear tool (10) in the severed-off casing section, now without the cutter tool (20) and swab cup wash tool (40), and to determine that the severed-off casing section is free.

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88. Apply overpull to lift casing and break circulation to wash old mud from behind the casing

89. POOH Pull the casing hanger out of hole and lay out the casing hanger

90. Release the spear tool (10) as per steps **78-82**. L/O Spear tool (10) assembly

91. L/O lay out the severed-off casing section using casing handling equipment.

5 **[0068]** The severed-off casing has now been removed from the well, subsequent to the well having been plugged.

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Appendix: Cementing and Pump + Pull Calculation

Archer**STRONGHOLD BARRICADE - Pump and Pull calculations**

Insert data in yellow panes

Date: 14/01/2021

Customer: Shell UK

Rig: Brent Charlie

Well: BC07

Project No: 21-393339

Cement & Spacer Volume

	Cap (bbl/ft)	Length (ft)	Volume (bbl)
Casing1	0.07321	346	26.00
Casing2			0.00
Perforated intervall (OH ID)	0.2186	254	56.00
Added Excess Cement			10.00
Under-displaced Cement			5.00
Added Excess Spacer			10.00
Tail Spacer			10.00
Total cement volume			97.00

Additional information:

ODES to BHR	27.50	ft
BP set at	8550	ODES
	8577.50	BHR
Length guns LIH	266.65	ft
Top of Guns LIH	8310.85	ft
Bottom Shot	8280.85	ft
Top Shot	8026.85	ft
Casings		
9-5/8" 47# L80 - 8.681" ID		
Drill pipe		
5" NC50	0.0169bbl/ft	

Insert data in yellow panes

Total DP	Cap (bbl/ft)	Length (ft)	Volume (bbl)
DP1 - 5" (at surface)	0.0169	8280.85	139.95
Total			140.00

Volume of pipe pulled OOH while pumping & pulling.	Cap (bbl/ft)	Length (ft)	Volume (bbl)
Casing	0.0169	346	5.85
Perforations	0.0169	254	4.29
Total			10.14

P&P in Casing		
Pump rate	42	(GPM)
Pulling Speed HWO Unit	52.42	s/15ft Stroke

P&P in Perforated intervall		
Pump rate	126	(GPM)
Pulling Speed HWO Unit	61.07	s/15ft Stroke

Job Information		
Volume pr stroke	0.0210	bbl/stroke
Top Cement Plug	7680.85	ft
Top Perforation	8026.85	ft
Bottom Perforation	8280.85	ft

Displacement plan	Total Volume: (bbl)	Strokes:
Displace cement with Tail Spacer	10.00	476
Displace cement to Tool	43.00	2048
Displace Excess cement out of Tool	53.00	2524
Displace while pump and pull (perforations)	104.71	4986
Displace while pump and pull (above perforations)	124.86	5946
Total (End displacement)	124.86	5946
Cement left in pipe	5.00	

Total Cement Needed	
97.0 bbl	
Total Spacer needed: (Surface line included)	
219.0 bbl	

Appendix: Fluid Displacement Plan

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Pumping speeds slowed down to compensate for time to move jack

HWU's Fastest pulling speed with weight of string is 1min per 457,2 m (15ft) stroke which includes jack movement time

All Depths reference BHR - Basket Handrail Depth which is ODES + 838,2 cm (27.5ft)

[0069]

TTOC - 2.341,05 m (7,681ft)	Total Cement Volume - 15.421, 77 l (97bbl)
Top Perforation - 2.446,63 m (8,027ft)	Total Spacer Volume - 34.818,22 l (219bbl)
Bottom Perforation -2.523,93 m (8,281ft)	String volume - 22.735,18 l (143bbl) (including line volume)
Top of Gun assy - 2.533,19 m (8,311ft)	Cement unit Line Volume - 476,96 l (3bbl)
Top of Bridge plug - 2.614,57 m (8,578ft)	Rig pump Line Volume - 476,96 l (3bbl)

1. With wash tool (40) at the bottom of the perforated section. Circulation ports 30,48 cm (1ft) above bottom shot at 2.523,74 m (**8,280ft**). Pump 24.325,05 l (**153bbl**) of Spacer @ 7.5 BPM using the Altus pump.

- This will displace full string to spacer and pump 10 bbls out of the wash tool (40) .
- This will fill lines with Spacer
- Reduce pump rate to **3bpm** on final 1.172,40 l (**10bbls**) in preparation for pump and pull.

2. Begin pump and pull through perforated section Pumping at **3bpm** and pulling at **60s per 457,2 cm (15ft) stroke** (HWU's fastest pulling speed + jack movement time = 1min per 15ft stroke)

- Monitor return volumes for volume control
- When tool reaches top perforation, Circulation ports 30,48 cm (1ft) below top perf @ 2.446,93 m (**8,028ft**) (Total volume of Spacer pumped should be **205bbl** (52bbl pumped into perforations).

3. After Spacer pump and pull is complete RIH to position circulation ports 1ft above bottom shot at 2.534,74 m (**8,280ft**).

4. Pressure test surface lines to 241,32 bar (**3,500psi**) from cement unit to HWU.

5. Pump 15.421,77 l (**97bbl**) of cement at **4bpm**.

- Set cement unit pressure limiter to 103,42 bar (**1,500psi**) (ball seat shear pressure 206,84 bar (3,000psi)).

6. Pump 1.550,17 l (**13bbl**) of spacer @ **3 bpm**.

- In the string there will be 5.246,58 l (**33bbl**) spacer+ 15.421,77 l (**97bbl**) cement + 1.589,87 l (**10bbl**) spacer + 476,96 l (**3bbl**) spacer/cement line Volume (Total Volume 22.735,18 l (**143bbl**))

7. Switch line up to pump from Altus Unit

- Make sure flow meter reading zero

8. With swab cup wash tool (40) stationary, pump 6.836,45 l (**43bbl**) of Jetting Fluid @ **3bpm**

- **1.589,87 l (10bbl)** of cement will be displaced out of the swab cup wash tool (40)

Note: Monitor displacement closely from this point

9. Begin Pump and pull through perforated section displacing with Jetting Fluid Pumping @ **3bpm** and pulling at **60s**

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per 457,2 cm (15ft) stroke (HWU's fastest pulling speed + jack movement time = 1min per 457,2 cm (15ft) stroke)

- When breaking connection close annular ram to prevent u-tubing
- When tool reaches top perforation Circulation ports at 2.446.93 m **(8,028ft)**. Total volume of Jetting fluid pumped by Altus Pump should be 15.103,79 l **(95bbl)**
- Maximum fluid to be pumped during first stage pump + pull is 8.267,34 l **(52bbl)**

10. Continue picking up into blank casing above top shot and shear out ball seat at +/-3,000psi

11. After shearing ball seat adjust pump rate to **1bpm** and pump a further 3.179,75 l **(20bbl)** of jetting fluid with the swab cup wash tool (40) in stationary position to place the balance plug.

- Total Volume of Jetting Fluid pumped with Altus pump should be 18.283,54 l **(115bbl)**.
- Planned TOC at 2.321,97 m **(7,681ft)**
- Worst case TOC 2.167,74 m **(7,112ft)** (Based on 27,94 cm (11") Open hole and all excess above TTOC = 569ft)

12. POOH with ventilated string to place bottom of string @ 2.164,08 m **(7,100ft)**.

13. Circulate string Clean

- Insert Qty 1 sponge ball
- Max Circulation rate 10bpm.
- Max rotation 60rpm.
- Recommended to only pump 1 x sponge ball as 2 may risk blockage of the tool.

14. Continue to cutting sequence

Appendix: BHA Bottomhole assembly

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Archer				TCP STRING DIAGRAM (All lengths in feet "ft")								
CLIENT Shell UK		RIG Brent Charlie		WELL BC07	FIELD Brents	JOB No. 21-393339	REV. 0	RUN 1	DATE Draft	ENGINEER GENERIC		
Outer Diam. (ft)	Inner Diam. (in)	Length (ft)	MD (ft) (top tool)	Length (ft)	BHA Assembly	Top Thread (Box)	Bottom Thread (Pin)	Description		Serial Number		
TBC	TBC	10.000	7950.820	10.00		NC50	NC50	Archer Supply 10ft Pup Joint				
6.500	2.250	5.850	7960.820	5.85		NC50	NC50	9-5/8" Archer Supply Spiral Blade Stabilizer				
6.375	2.250	10.890	7966.670	10.89		NC50	NC50	SAMURAI MF Cutter (dressed for 9-5/8" 47# L80 Casing)				
6.500	2.250	5.850	7977.560	5.85		NC50	NC50	9-5/8" Archer Supply Spiral Blade Stabilizer				
TBC	TBC	31.40	7983.410	10.00		NC50	NC50	Archer Supply 10ft Pup Joint				
9.50	2.81		7993.410	6.12		NC50	NC50	9-5/8" Archer Supply String Mill				
6.50	2.35		7999.530	3.12		NC50	NC50	9-5/8" NC50 Stronghold Swivel				
8.94	2.35		8002.65	3.62		NC50	N/A	9 5/8" Barricade Tool Top tool - Mid Cups				
8.94	2.35		8006.27									
8.94	2.35		8006.27	3.46		N/A	N/A	9 5/8" Barricade Tool Mid Cups - Bottom Tool				
8.94	2.35		8009.73									
4.57	1.50		8009.73	0.75		SA	SA	Choke Sub c/w 1.75" Ball Seat				
4.57	1.14		8010.48	0.75		SA	SA	Choke Sub c/w 1.375" Ball Seat				
4.57	1.14		8011.23	3.58		SA	2 7/8 EUE	Ball Seat catcher				
3.67	N/A	0.44	8014.81	0.44		2 7/8 EUE	2 7/8 EUE	2-7/8" EUE coupling				
3.10	N/A	1.31	8013.08	1.31		2 7/8 EUE	2 7/8 EUE	Burst disc sub. (1.5in2 flow area after burst)				
3.67	N/A	0.44	8010.59	0.44		2 7/8 EUE	2 7/8 EUE	2-7/8" EUE coupling				
3.10	N/A	0.31	8014.50	0.31		2 7/8 EUE	2 7/8 EUE	Ball drop isolation sub (1" Drop Ball)				
3.67	N/A	0.44	8014.39	0.44		2 7/8 EUE	2 7/8 EUE	2-7/8" EUE coupling				
3.10	N/A	3.80	8011.03	3.80		2 7/8 EUE	2 7/8 EUE	4ft 2-7/8" EUE Pup Joint				
3.67	N/A	0.44	8014.81	0.44		2 7/8 EUE	2 7/8 EUE	2-7/8" EUE coupling				
3.67	N/A	0.21	8014.83	0.21		2 7/8 EUE	N/A	Absolut Pressure Firing Head c/w Automatic Gun Release				
3.67	N/A	0.21	8015.04	0.21		N/A	SA	Shear point when guns dropped				
7.00	N/A	11.29	8015.25	11.29		SA	SA	7", 11ft, Safety spacer				
7.00	N/A	42.48	8026.54	21.24		Top Shot	SA	7", 21ft 12spf gun loaded 12spf				
7.00	N/A	21.24	8047.78	21.24		SA	SA	7", 21ft 12spf gun loaded 12spf				
7.00	N/A	21.24	8069.02	21.24		SA	SA	7", 21ft 12spf gun loaded 12spf				
7.00	N/A	21.24	8090.26	21.24		SA	SA	7", 21ft 12spf gun loaded 12spf				
7.00	N/A	21.24	8111.50	21.24		SA	SA	7", 21ft 12spf gun loaded 12spf				
7.00	N/A	21.24	8132.74	21.24		SA	SA	7", 21ft 12spf gun loaded 12spf				
7.00	N/A	21.24	8153.98	21.24		SA	SA	7", 21ft 12spf gun loaded 12spf				
7.00	N/A	21.24	8175.22	21.24		SA	SA	7", 21ft 12spf gun loaded 12spf				
7.00	N/A	21.24	8196.46	21.24		SA	SA	7", 21ft 12spf gun loaded 12spf				
7.00	N/A	21.24	8217.70	21.24		SA	SA	7", 21ft 12spf gun loaded 12spf				
7.00	N/A	21.24	8238.94	21.24		SA	SA	7", 21ft 12spf gun loaded 12spf				
7.00	N/A	21.52	8260.18	20.67		SA	N/A	7", 21ft 12spf gun loaded 12spf				
7.00	N/A		8280.85	0.85		Bottom Shot	N/A	bottom shot to end of bull nose.				
			8281.70					Bottom BHA				
8026.54	= Top Shot										Casing Size: 9 5/8"	PSTD (RMD): TBC
8280.85	= Bottom Shot										Liner Size: N/A	Firing Head Depth (ft/VD): TBC
8281.70	= Bottom of TCP string										Minimum ID Completion: N/A	BHP: TBC
338.04	= Total length of Archer BHA										Top 7" PBR (m): N/A	BHT: TBC
266.66	=TCP String LIH										Pick up height (m): N/A	Firing Head Op Press : TBC
Company Rep					☐ Tick	Top an bottom shot verified					☐ Tick	
					☐ Tick	Clearance from bullnose to clean out depth verified					☐ Tick	

Claims

1. A method for pulling a casing, comprising the steps of:

- assembling a toolstring, from top to bottom, of
- a drill pipe string,
- a spear tool (10, 10')
- a space-out drill pipe string above a cutter tool (20)
- a through bore cutter tool (20),
- a swivel (30) below the cutter tool (20),
- a swab cup wash tool (40),
- a perforation gun (50),
- run in hole and place the perforation gun (50) at a predetermined perforation depth,
- perforate the casing using the perforation gun (50),
- wash the perforated casing annulus using the swab cup wash tool (40),
- circulate in cement into the washed casing annulus and the casing bore using the swab cup wash tool (40),
- wait on cement and pressure test the cement plug so formed,
- pull up and cut the casing at a shallower depth using said casing cutter tool (20),
- test pull the severed-off casing section using said spear tool (10),
- if test pull successful, pull up and remove said spear tool (10), said cutter tool (20) and said wash tool (40),
- reinsert said spear tool (10) and run in to engage the severed-off casing section, and pull said severed casing section out of hole.

2. The method according to claim 1,

- wherein said spear tool (10, 10') is a spear plug tool (10'), said spear plug tool also used for pressure testing and generating below pressure for pulling.

3. The method according to any of the preceding claims,

- wherein said perforation gun (50) comprises a first ball seat (52) in a firing head (53) and an automatic gun release AGR (54) for the perforation gun (50) comprising the further steps of:

- perforate said casing by
 - land a first ball (52B) in said first ball seat (52), pressure up to actuate said firing head (52) to perforate the casing,
 - let said automatic gun release (50) drop said firing gun (50).

4. The method according to any of the preceding claims,

- wash the perforated casing section annulus by
 - landing a second ball (42B) in a second ball seat (42) arranged below said swab cup wash tool (40),
 - circulate wash fluid into said perforated casing annulus while running said wash tool (40) along said perforated casing section and circulating out debris from the perforated casing annulus,
 - place said wash tool (40) in blank casing,
 - shear out the second ball seat (42) and circulate debris out of hole.

5. The method according to claim 4 further comprising

- circulate in cement into annulus by
 - landing a third ball (43B) in said third ball seat (43) below said wash tool (40),
 - while running said wash tool (40) along said perforated casing section, circulate spacer/primer fluid into said perforated, washed casing annulus,
 - run said wash tool (10) along said perforated casing annulus and circulate cement into said primed perforated casing annulus while pulling up, and
 - while pulling up, also cementing further into the casing bore using a wash tool bypass line (44),
 - pull up, shear said third ball seat (43), and circulate out remaining cement.

6. The method according to claim 5, further comprising waiting on cement to set, and pressure testing the formed cement

plug.

7. The method according to any of the preceding claims, further comprising cut the casing by

- 5 - pulling up the toolstring with the cutter tool (20) to a predetermined cut depth,
- land a fourth ball (22B) in said fourth ball seat (22) in said cutter tool (20),
- pressure up to extend knives (24) of the cutter tool (20),
- rotate the drill pipe string with the cutter tool (20) and make a circumferential cut in the casing at the predetermined cut depth, while
- 10 - the swivel (30) allows the wash tool (40) below to be non-rotating,
- release the pressure and deactivate the cutter tool's (20) knives (24).

8. The method according to any of the preceding claims, further comprising test pull said severed-off casing section by

- 15 - pull up said cutter tool (20) to well clear above said cut
- activate and set slips of said spear tool (10) in the severed-off casing section
- test pull said severed-off casing section to determine whether it is free.

9. The method according to any of the preceding claims,

- 20 - pull out said severed-out casing section by
- pulling up and lay out said spear tool (10, 10'), said casing cutter tool (20), said swivel (30) and said wash tool (40),
- 25 - insert said spear tool (10, 10'), and
- run in hole said spear tool (10) to engage and hold said severed-off casing section,
- pull out of hole said severed-off casing section,
- release and remove said insert spear tool (10),
- lay out said severed off casing section.
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10. The method of claim 9, wherein engaging said spear tool (10, 10') in a casing hanger of said severed-off casing.

11. The method according to claim 10,

- 35 - in case said spear tool (10) was not inserted in the toolstring initially, after the cutting, pull up and insert said spear tool (10) into toolstring above said cutter tool (20) and test pull the severed-off casing section using said spear tool (10).

12. The method according to claim 10, said spear tool (10, 10') being a spear plug tool (10'), setting a packer against said severed-off casing, setting pressure below said spear plug tool (10') while pulling, in order to increase the upward force on said severed-off casing.

13. A well intervention toolstring comprising from top to bottom:

- 45 - a drill pipe string,
- a spear tool (10, 10'),
- a space-out drill pipe,
- a through bore cutter tool (20),
- a swivel (30) below the cutter tool (20),
- 50 - a swab cup wash tool (40),
- a perforation gun (50).

14. The well intervention toolstring according to claim 13,

- 55 - wherein said spear tool (10, 10') is a spear plug tool (10'), such as a spear plug tool (10') which comprises a packer, and has hang-off capacity.

15. The well intervention toolstring according to any of claims 13 - 14, wherein the through bore cutter tool (20) has a fourth

ball seat (22) arranged for receiving a fourth ball (22B) arranged for building up pressure in the cutter tool (20) in order to extend knives (24).

5 16. The well intervention toolstring according to any of the preceding claims 13-15, wherein the swab cup wash tool (40) further has a bypass line (44) across the wash tool (40) swab cups (46),- said wash tool arranged for washing the perforated annulus,

10 - said wash tool further arranged for subsequently cementing the perforated casing annulus, cement passing back in through the perforations and passing through the bypass line (44) to cement the casing main bore.

17. The well intervention toolstring according to any of the preceding claims 13

- 16, further comprising

15 - a second and third ball seat (42, 43) arranged for receiving a second and third ball (42B, 43B) below the swab cup wash tool (40).

18. The well intervention toolstring according to any of the preceding claims 13-17 and the method for pulling a casing according to any of claims 1-12, wherein

20 - the through bore spear (10, 10') is a spear plug tool (10') and further comprises a switchable ball valve.

Patentansprüche

25 1. Verfahren zum Ziehen eines Futterrohrs, umfassend die Schritte:

- Zusammenbauen einer Werkzeugkette von oben nach unten aus

- einem Bohrrhrstrang,

30 - einem Speerwerkzeug (10, 10')

- einem Beabstandungs-Bohrrohrstrang über einem Schneidwerkzeug (20)

- einem Durchgangsbohrungs-Schneidwerkzeug (20),

- einem Drehgelenk (30) unterhalb des Schneidwerkzeugs (20),

- einem Tupferbecher-Waschwerkzeug (40),

35 - einer Perforationskanone (50),

- Einfahren in ein Bohrloch und Platzieren der Perforationskanone (50) in einer vorbestimmten Perforationstiefe,

- Perforieren des Futterrohrs mit der Perforationspistole (50),

- Waschen des perforierten Futterrohringraums unter Verwendung des Tupferbecher-Waschwerkzeugs (40),

- Einzirkulieren von Zement in den gewaschenen Futterrohringraum und die Futterrohrbohrung unter Verwendung des Tupferbecher-Waschwerkzeugs (40),

40 - Warten auf den Zement und Druckprüfen des so ausgebildeten Zementpfropfens,

- Heraufziehen und Schneiden des Futterrohrs in einer geringeren Tiefe unter Verwendung des Futterrohrschneidwerkzeugs (20),

- Prüfziehen des abgetrennten Futterrohrabschnitts unter Verwendung des Speerwerkzeugs (10),

45 - falls das Prüfziehen erfolgreich ist, Heraufziehen und Entfernen des Speerwerkzeugs (10), des Schneidwerkzeugs (20) und des Waschwerkzeugs (40),

- erneutes Einsetzen des Speerwerkzeugs (10) und Einfahren, um den abgetrennten Futterrohrabschnitt in Eingriff zu nehmen und Herausziehen des getrennten Futterrohrabschnitts aus dem Bohrloch.

50 2. Verfahren nach Anspruch 1,

- wobei das Speerwerkzeug (10, 10') ein Speerstopfenwerkzeug (10') ist, das auch zum Druckprüfen und Erzeugen eines Unterdrucks zum Ziehen verwendet wird.

55 3. Verfahren nach einem der vorstehenden Ansprüche,

- wobei die Perforationskanone (50) einen ersten Kugelsitz (52) in einem Zündkopf (53) und einen automatischen Kanonenauslöser AGR (54) für die Perforationskanone (50) umfasst, umfassend die weiteren Schritte:

- Perforieren der Futterrohrs durch
- Landen einer ersten Kugel (52B) in dem ersten Kugelsitz (52), Druckerhöhen, um den Zündkopf (52) zu betätigen, um das Futterrohr zu perforieren,
- Auslösenlassen (50) der automatischen Kanone, Fallenlassen der feuernenden Kanone (50).

4. Verfahren nach einem der vorstehenden Ansprüche,

- Waschen des perforierten Futterrohrabschnittsringraums durch
- Landen einer zweiten Kugel (42B) in einem zweiten Kugelsitz (42), der unterhalb des Tupferbecher-Waschwerkzeugs (40) angeordnet ist,
- Einzirkulieren von Waschfluid in den perforierten Futterrohringraum während eines Entlangfahrens des Waschwerkzeugs (40) an dem perforierten Futterrohrabschnitt und Herauszirkulieren von Ablagerungen aus dem perforierten Futterrohringraum,
- Platzieren des Waschwerkzeugs (40) in einem leeren Futterrohr,
- Herausscheren des zweiten Kugelsitzes (42) und Herauszirkulieren von Ablagerungen aus dem Bohrloch.

5. Verfahren nach Anspruch 4, ferner umfassend:

- Einzirkulieren von Zement in den Ringraum durch
- Landen einer dritten Kugel (43B) in dem dritten Kugelsitz (43) unterhalb des Waschwerkzeugs (40),
- während des Entlangfahrens des Waschwerkzeugs (40) an dem perforierten Futterrohrabschnitt, Einzirkulieren von Beabstandungs-/Primerfluid in den perforierten gewaschenen Futterrohringraum,
- Entlangfahren des Waschwerkzeugs (10) an dem perforierten Futterrohring und Einzirkulieren von Zement in den vorbereiteten perforierten Futterrohringraum, während eines Heraufziehens und
- während des Heraufziehens auch weiteres Zementieren in die Futterrohrbohrung unter Verwendung einer Waschwerkzeugumgehungsleitung (44),
- Heraufziehen, Abscheren des dritten Kugelsitzes (43) und Herauszirkulieren des restlichen Zements.

6. Verfahren nach Anspruch 5, ferner umfassend das Warten auf das Setzen des Zements und Druckprüfen des ausgebildeten Zementpfropfens.

7. Verfahren nach einem der vorstehenden Ansprüche, ferner umfassend das Schneiden des Futterrohrs durch

- Heraufziehen des Werkzeugstrangs mit dem Schneidwerkzeug (20) bis zu einer vorbestimmten Schnitttiefe,
- Landen einer vierten Kugel (22B) in dem vierten Kugelsitz (22) in dem Schneidwerkzeug (20),
- Druckerhöhen, um die Messer (24) des Schneidwerkzeugs (20) auszufahren,
- Drehen des Bohrrohrstrangs mit dem Schneidwerkzeug (20) und Vornehmen eines Umfangsschnitts in dem Futterrohr in der vorbestimmten Schnitttiefe, während
- das Drehgelenk (30) ermöglicht, dass das Waschwerkzeug (40) darunter nicht drehend ist,
- Lösen des Drucks und Deaktivieren der Messer (24) des Schneidwerkzeugs (20).

8. Verfahren nach einem der vorstehenden Ansprüche, ferner umfassend das Prüfziehen des abgetrennten Futterrohrabschnitts durch

- Heraufziehen des Schneidwerkzeugs (20), um deutlich über dem Schnitt zu liegen
- Aktivieren und Setzen von Abfangkeilen des Speerwerkzeugs (10) in dem abgetrennten Futterrohrabschnitt
- Prüfziehen des abgetrennten Futterrohrabschnitts, um zu bestimmen, ob es frei ist.

9. Verfahren nach einem der vorstehenden Ansprüche,

- Herausziehen des abgetrennten Futterrohrabschnitts, durch
- Heraufziehen und Auslegen des Speerwerkzeugs (10, 10'), des Futterrohrschneidwerkzeugs (20), des Drehgelenks (30) und des Waschwerkzeugs (40),
- Einstecken des Speerwerkzeugs (10, 10') und
- Einfahren in das Bohrloch des Speerwerkzeugs (10), um den abgetrennten Futterrohrabschnitt in Eingriff zu nehmen und zu halten,
- Herausziehen aus dem Bohrloch des abgetrennten Futterrohrabschnitts,
- Lösen und Entfernen des Einsteckspeerwerkzeugs (10),

- Auslegen des abgetrennten Futterrohrabschnitts.

10. Verfahren nach Anspruch 9, wobei das Speerwerkzeug (10, 10') in einen Futterrohraufhänger des abgetrennten Futterrohrs eingreift.

11. Verfahren nach Anspruch 10,

- falls das Speerwerkzeug (10) nicht anfangs in den Werkzeugstrang eingesetzt wurde, nach dem Scheiden, Heraufziehen und Einstecken des Speerwerkzeugs (10) in den Werkzeugstrang über dem Schneidwerkzeug (20) und Prüfziehen des abgetrennten Futterrohrabschnitts unter Verwendung des Speerwerkzeugs (10).

12. Verfahren nach Anspruch 10, wobei das Speerwerkzeug (10, 10') ein Speerstopfenwerkzeug (10') ist, das einen Packer gegen das abgetrennte Futterrohr setzt und während des Ziehens einen Druck unterhalb des Speerstopfenwerkzeugs (10') setzt, um die aufwärts gerichtete Kraft auf das abgetrennte Futterrohr zu erhöhen.

13. Bohrungsinterventions-Werkzeugstrang, umfassend, von oben nach unten:

- einen Bohrrrohrstrang,
- ein Speerwerkzeug (10, 10'),
- einen Beabstandungs-Bohrrrohrstrang,
- ein Durchgangsbohrungs-Schneidwerkzeug (20),
- ein Drehgelenk (30) unterhalb des Schneidwerkzeugs (20),
- ein Tupferbecher-Waschwerkzeug (40),
- eine Perforationskanone (50).

14. Bohrungsinterventions-Werkzeugstrang nach Anspruch 13,

- wobei das Speerwerkzeug (10, 10') ein Speerstopfenwerkzeug (10') ist, wie ein Speerstopfenwerkzeug (10'), das einen Packer umfasst und eine Abhängekapazität aufweist.

15. Bohrungsinterventions-Werkzeugstrang nach einem der Ansprüche 13 bis 14, wobei das Durchgangsbohrungs-Schneidwerkzeug (20) einen vierten Kugelsitz (22) aufweist, der zum Aufnehmen einer vierten Kugel (22B) angeordnet ist, die zum Aufbauen von Druck in dem Schneidwerkzeug (20) angeordnet ist, um die Messer (24) auszufahren.

16. Bohrungsinterventions-Werkzeugstrang nach einem der vorstehenden Ansprüche 13 bis 15, wobei das Tupferbecher-Waschwerkzeug (40) ferner eine Umgehungsleitung (44) über die Tupferbecher (46) des Waschwerkzeugs (40) hinweg aufweist, wobei das Waschwerkzeug zum Waschen des perforierten Ringraums angeordnet ist,

- wobei das Waschwerkzeug ferner zum anschließenden Zementieren des perforierten Futterrohrhohlraums angeordnet ist, wobei Zement durch die Perforationen zurück und durch die Umgehungsleitung (44) fließt, um die Futterrohrhohlbohrung zu zementieren.

17. Bohrungsinterventions-Werkzeugstrang nach einem der vorstehenden Ansprüche 13 bis 16, ferner umfassend

- einen zweiten und einen dritten Kugelsitz (42, 43), die zum Aufnehmen einer zweiten und einer dritten Kugel (42B, 43B) unterhalb des Tupferbecher-Waschwerkzeugs (40) angeordnet sind.

18. Bohrungsinterventions-Werkzeugstrang nach einem der vorstehenden Ansprüche 13 bis 17 und das Verfahren zum Ziehen eines Futterrohrs nach einem der Ansprüche 1 bis 12, wobei

- der Durchgangsbohrungsspeer (10, 10') ein Speerstopfenwerkzeug (10') ist und ferner ein schaltbares Kugelventil umfasst.

Revendications

1. Procédé de tirage d'un tubage, comprenant les étapes consistant à :

- assembler un train d'outils, de haut en bas, de
- un train de tiges de forage,
- un outil de harpon (10, 10')
- un train de tiges de forage espacé au-dessus d'un outil de coupe (20)
- un outil de coupe d'alésage traversant (20),
- un pivot (30) en dessous de l'outil de coupe (20),
- un outil de lavage de coupelle de pistonnage (40),
- un pistolet de perforation (50),
- enfoncer dans le trou et placer le pistolet de perforation (50) à une profondeur de perforation prédéterminée,
- perforer le tubage à l'aide du pistolet de perforation (50),
- laver l'anneau de tubage perforé à l'aide de l'outil de lavage de coupelle de pistonnage (40),
- faire circuler du ciment dans l'anneau de tubage lavé et dans l'alésage de tubage à l'aide de l'outil de lavage de coupelle de pistonnage (40),
- attendre la cimentation et faire un test de pression sur le bouchon de ciment ainsi formé,
- faire remonter et couper le tubage à une profondeur plus superficielle à l'aide dudit outil de coupe de tubage (20),
- faire un test de traction sur la section de tubage tronquée à l'aide dudit outil de harpon (10),
- si le test de traction est concluant, tirer vers le haut et retirer l'outil de harpon (10), ledit outil de coupe (20) et ledit outil de lavage (40),
- réinsérer ledit outil de harpon (10) et l'enfoncer pour mettre en prise la section de tubage tronquée et tirer ladite section de tubage tronquée hors du trou.

2. Procédé selon la revendication 1,

- dans lequel ledit outil de harpon (10, 10') est un outil de prise de harpon (10'), ledit outil de prise de harpon est également utilisé pour le test de pression et la génération de pression inférieure pour la traction.

3. Procédé selon l'une quelconque des revendications précédentes,

- dans lequel ledit pistolet de perforation (50) comprend un premier siège de bille (52) dans une tête de tir (53) et un déclencheur automatique de pistolet AGR (54) pour le pistolet de perforation (50) comprenant, en outre, les étapes consistant à :

- perforer ledit tubage en
- disposant une première bille (52B) dans ledit premier siège de bille (52), en appliquant une pression vers le haut pour actionner la tête de tir (52) pour perforer le tubage,
- laissant ledit déclencheur automatique de pistolet (50) lâcher ledit pistolet de tir (50).

4. Procédé selon l'une quelconque des revendications précédentes,

- laver l'anneau de section de tubage perforé en
- disposant une deuxième bille (42B) dans un deuxième siège de bille (42) agencé en dessous dudit outil de lavage de coupelle de pistonnage (40),
- faisant circuler le fluide de lavage dans ledit anneau de tubage perforé tout en enfonçant ledit outil de lavage (40) le long de ladite section de tubage perforé et en faisant circuler les débris hors de l'anneau de tubage perforé,
- plaçant ledit outil de lavage (40) dans le tubage vide,
- cisailant le deuxième siège de bille (42) et en faisant circuler les débris hors du trou.

5. Procédé selon la revendication 4 comprenant en outre

- faire circuler dedans du ciment jusqu'à l'anneau en
- déposant une troisième bille (43B) dans ledit troisième siège de bille (43) en dessous dudit outil de lavage (40),
- tout en enfonçant ledit outil de lavage (40) le long de ladite section de tubage perforée, en faisant circuler le fluide espaceur/d'apprêt dans ledit anneau de tubage perforé et lavé,
- enfonçant ledit outil de lavage (10) le long dudit anneau de tubage perforé et en faisant circuler du ciment dans ledit anneau de tubage perforé apprêté tout en tirant vers le haut, et
- tout en tirant vers le haut, en cimentant également en outre dans le trou de tubage à l'aide d'une conduite de dérivation d'outil de lavage (44),
- tirant vers le haut, en cisailant ledit troisième siège de bille (43) et en faisant circuler du ciment restant.

6. Procédé selon la revendication 5, comprenant en outre l'attente du durcissement du ciment et le test de pression du bouchon de ciment formé.

7. Procédé selon l'une quelconque des revendications précédentes, comprenant en outre la coupe du tubage en

- remontant le train d'outils avec l'outil de coupe (20) jusqu'à une profondeur de coupe prédéterminée,
- disposant une quatrième bille (22B) dans ledit quatrième siège de bille (22) dans ledit outil de coupe (20),
- appliquant une pression vers le haut pour étendre les couteaux (24) de l'outil de coupe (20),
- mettant en rotation le train de tiges de forage à l'aide de l'outil de coupe (20) et en effectuant une coupe circonférentielle dans le tubage à la profondeur de coupe prédéterminée, tandis que
- le pivot (30) permet à l'outil de lavage (40) en dessous de ne pas entrer en rotation,
- relâchant la pression et en désactivant les couteaux (24) de l'outil de coupe (20).

8. Procédé selon l'une quelconque des revendications précédentes, comprenant en outre le test de traction de ladite section de tubage tronquée en

- tirant vers le haut ledit outil de coupe (20) pour bien dégager au-dessus de ladite coupe
- activant et définissant des glissements dudit outil de harpon (10) dans la section de tubage tronquée
- faisant un test de traction de ladite section de tubage tronquée pour déterminer si elle est libérée.

9. Procédé selon l'une quelconque des revendications précédentes,

- extraire ladite section de tubage tronquée en
- tirant vers le haut et en plaçant ledit outil de harpon (10, 10'), ledit outil de coupe de tubage (20), ledit pivot (30) et ledit outil de lavage (40),
- insérant ledit outil de harpon (10, 10'), et
- enfonçant dans le trou ledit outil de harpon (10) pour mettre en prise et maintenir ladite section de tubage tronquée,
- extrayant du trou ladite section de tubage tronquée,
- libérant et en retirant ledit outil de harpon d'insert (10),
- plaçant ladite section de tubage tronquée.

10. Procédé selon la revendication 9, dans lequel la mise en prise dudit outil (10, 10') dans un crochet de tubage dudit tubage tronquée.

11. Procédé selon la revendication 10,

- dans le cas où ledit outil de harpon (10) n'a pas été inséré initialement dans le train d'outils, après la coupe, tirer vers le haut et insérer ledit outil de harpon (10) dans le train d'outils au-dessus dudit outil de coupe (20) et faire un test de traction sur la section de tubage tronquée à l'aide dudit outil de harpon (10).

12. Procédé selon la revendication 10, ledit outil de harpon (10, 10') étant un outil de prise de harpon (10'), mettre une garniture d'étanchéité contre ledit tubage tronqué, mettre une pression en dessous dudit outil de prise de harpon (10') tout en tirant, afin d'augmenter la force ascendante sur ledit tubage tronqué.

13. Train d'outils d'intervention sur puits comprenant de haut en bas :

- un train de tiges de forage,
- un outil de harpon (10, 10'),
- un tube de forage à vide,
- un outil de coupe d'alésage traversant (20),
- un pivot (30) en dessous de l'outil de coupe (20),
- un outil de lavage de coupelle de pistonage (40),
- un pistolet de perforation (50).

14. Train d'outils d'intervention sur puits selon la revendication 13,

- dans lequel ledit outil de harpon (10, 10') est un outil de prise de harpon (10'), tel qu'un outil de prise de harpon

(10') qui comprend une garniture d'étanchéité, et qui a une capacité de mise en pendant.

5 **15.** Train d'outils d'intervention sur puits selon l'une quelconque des revendications 13 à 14, dans lequel l'outil de coupe à alésage traversant (20) a un quatrième siège de bille (22) destiné à recevoir une quatrième bille (22B) destinée à créer une pression dans l'outil de coupe (20) afin d'étendre les couteaux (24).

10 **16.** Train d'outils d'intervention sur puits selon l'une quelconque des revendications précédentes 13 à 15, dans lequel l'outil de lavage de coupelle de pistonnage (40) a en outre une conduite de dérivation (44) à travers les coupelles de pistonnage (46) de l'outil de lavage (40), ledit outil de lavage destiné à laver l'anneau perforé,

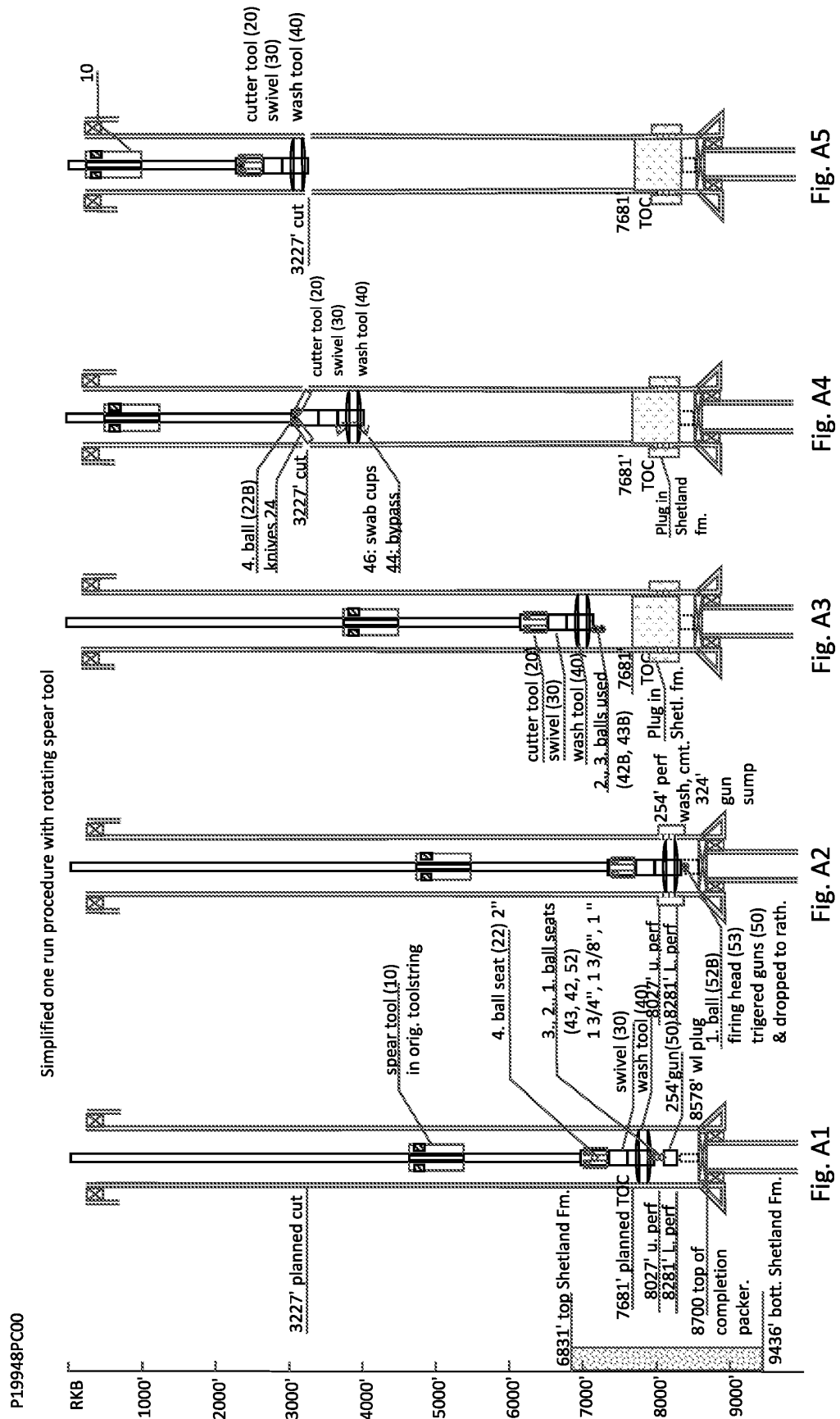
- ledit outil de lavage en outre destiné à cimenter ultérieurement l'anneau de tubage perforé, le ciment repassant à travers les perforations et passant à travers la conduite de dérivation (44) pour cimenter l'alésage principal de tubage.

15 **17.** Train d'outils d'intervention sur puits selon l'une quelconque des revendications précédentes 13 à 16, comprenant en outre

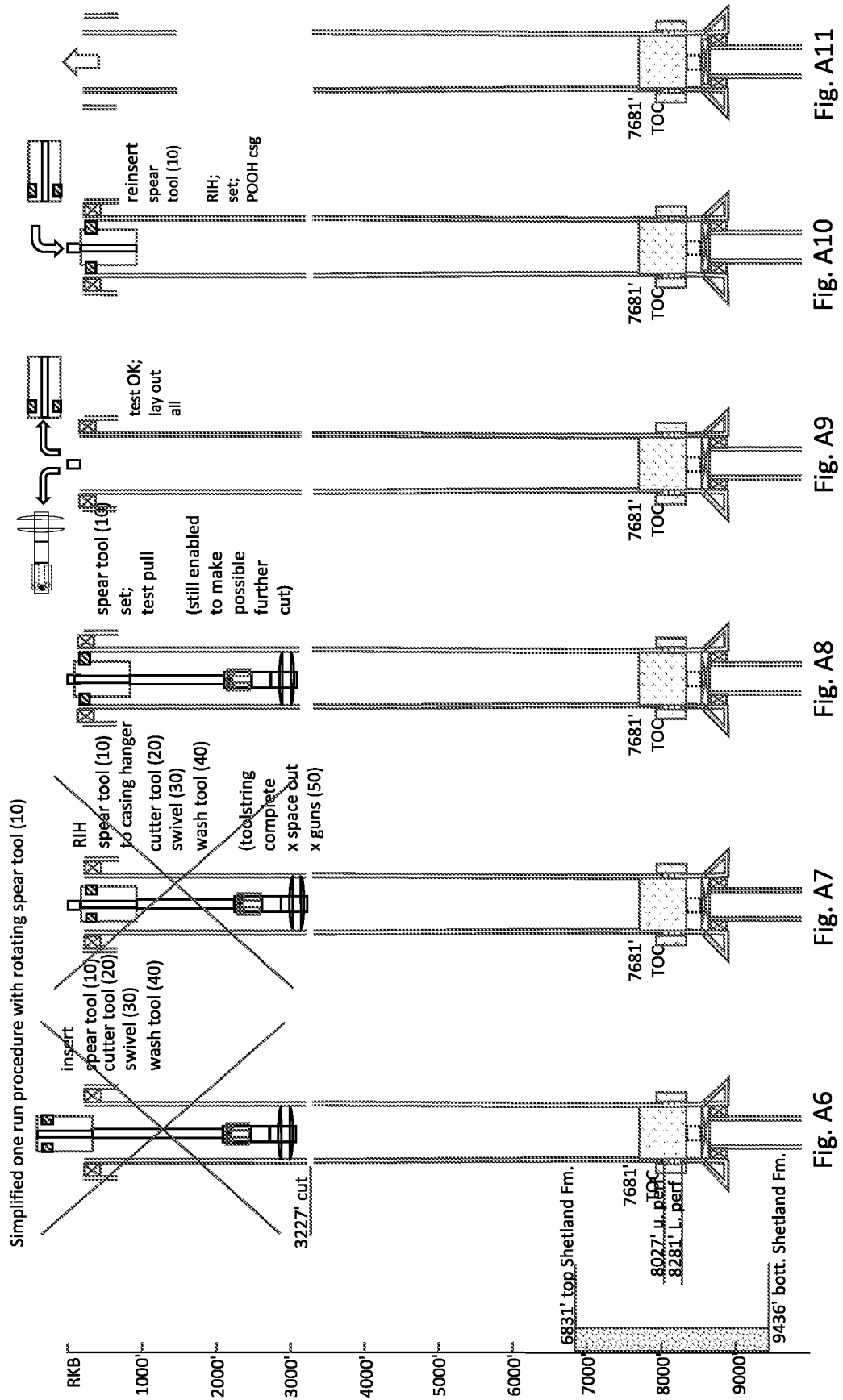
20 - un deuxième et troisième siège de bille (42, 43) destiné à recevoir une deuxième et une troisième bille (42B, 43B) en dessous de l'outil de lavage de coupelle de pistonnage (40).

18. Train d'outils d'intervention sur puits selon l'une quelconque des revendications précédentes 13 à 17 et procédé de tirage d'un tubage selon l'une quelconque des revendications 1 à 12, dans lequel

25 - la harpon à orifice traversant (10, 10') est un outil de prise de harpon (10') et comprend en outre une vanne à bille sphérique commutable.



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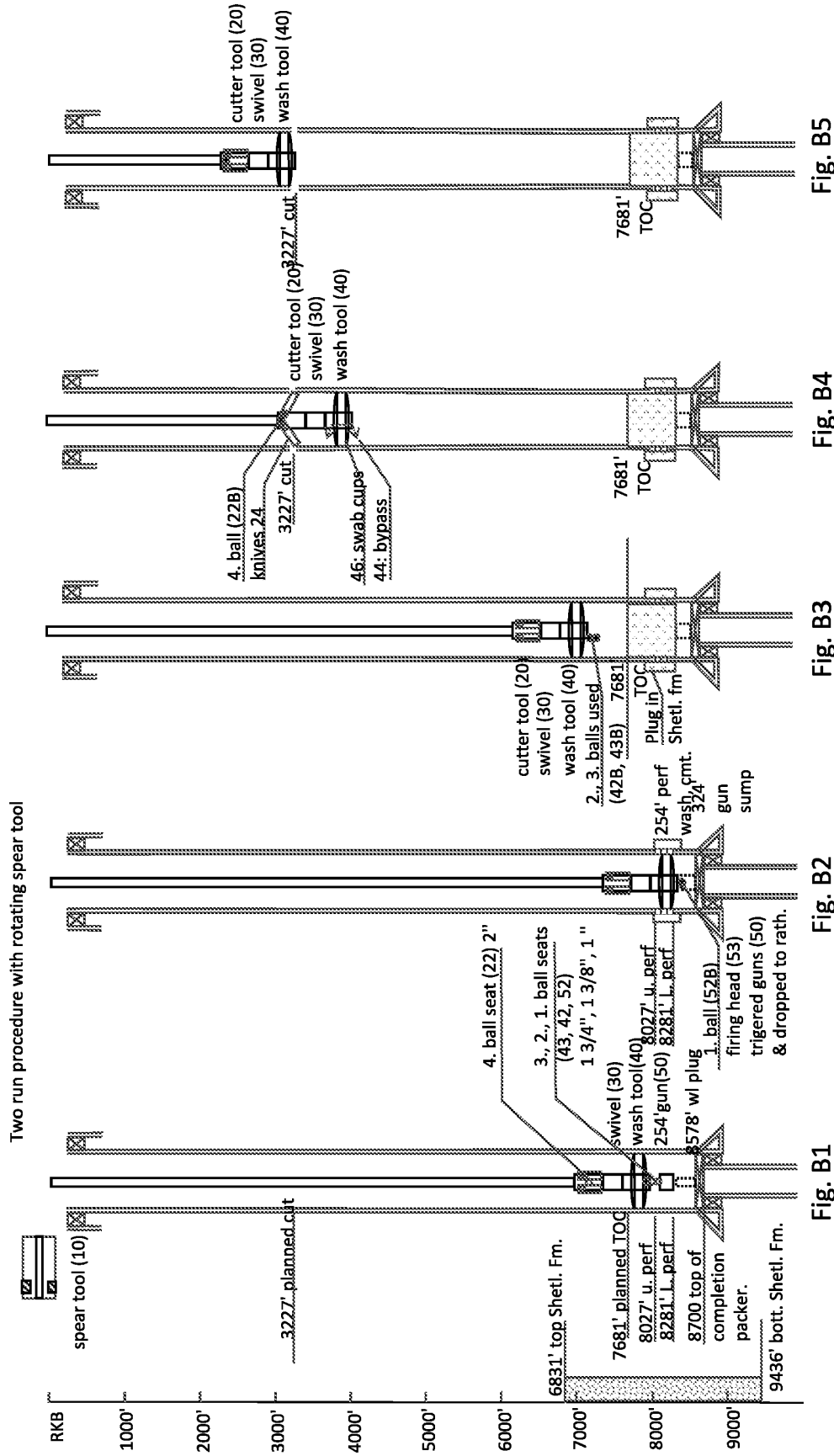


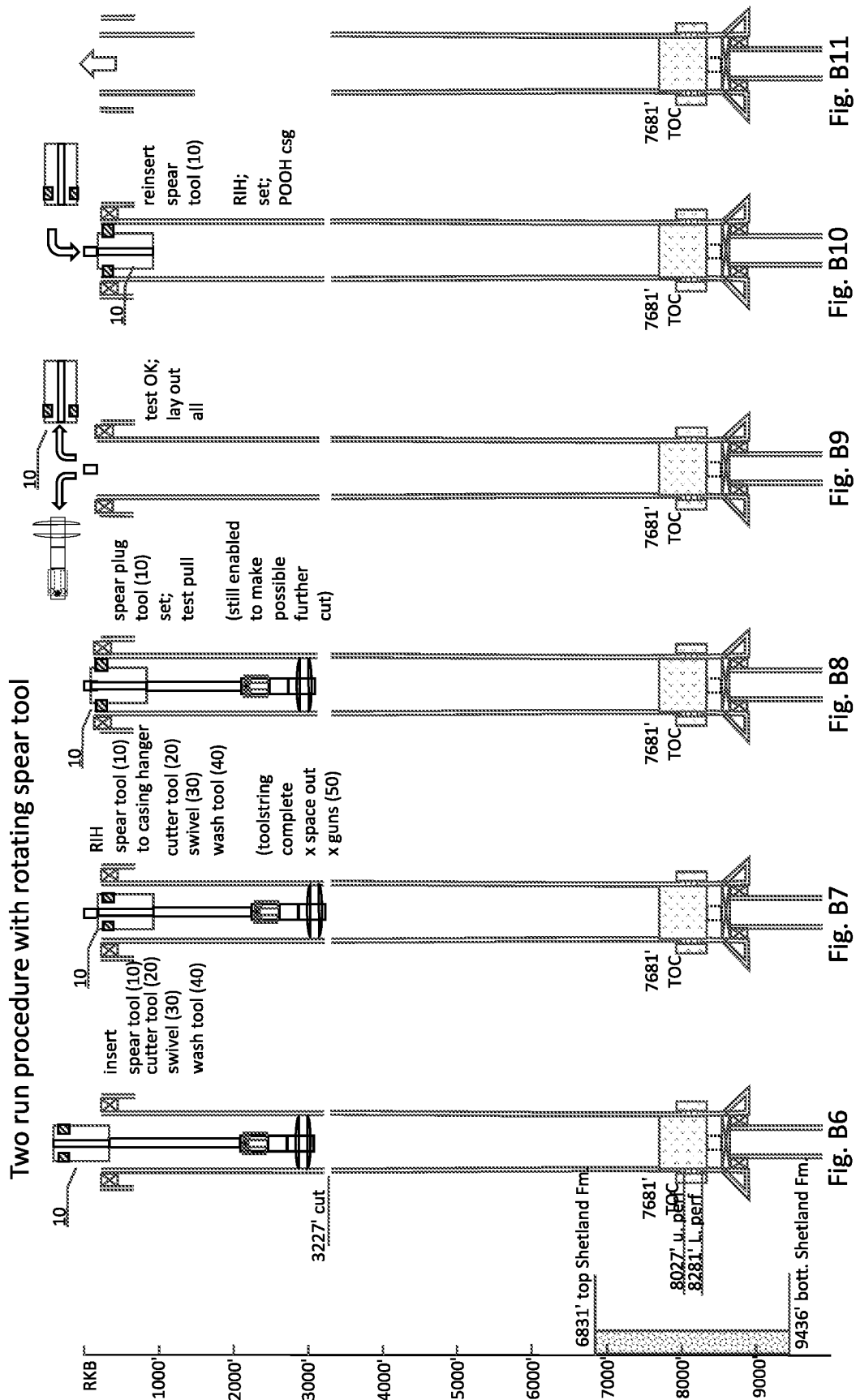
Fig. B5

Fig. B4

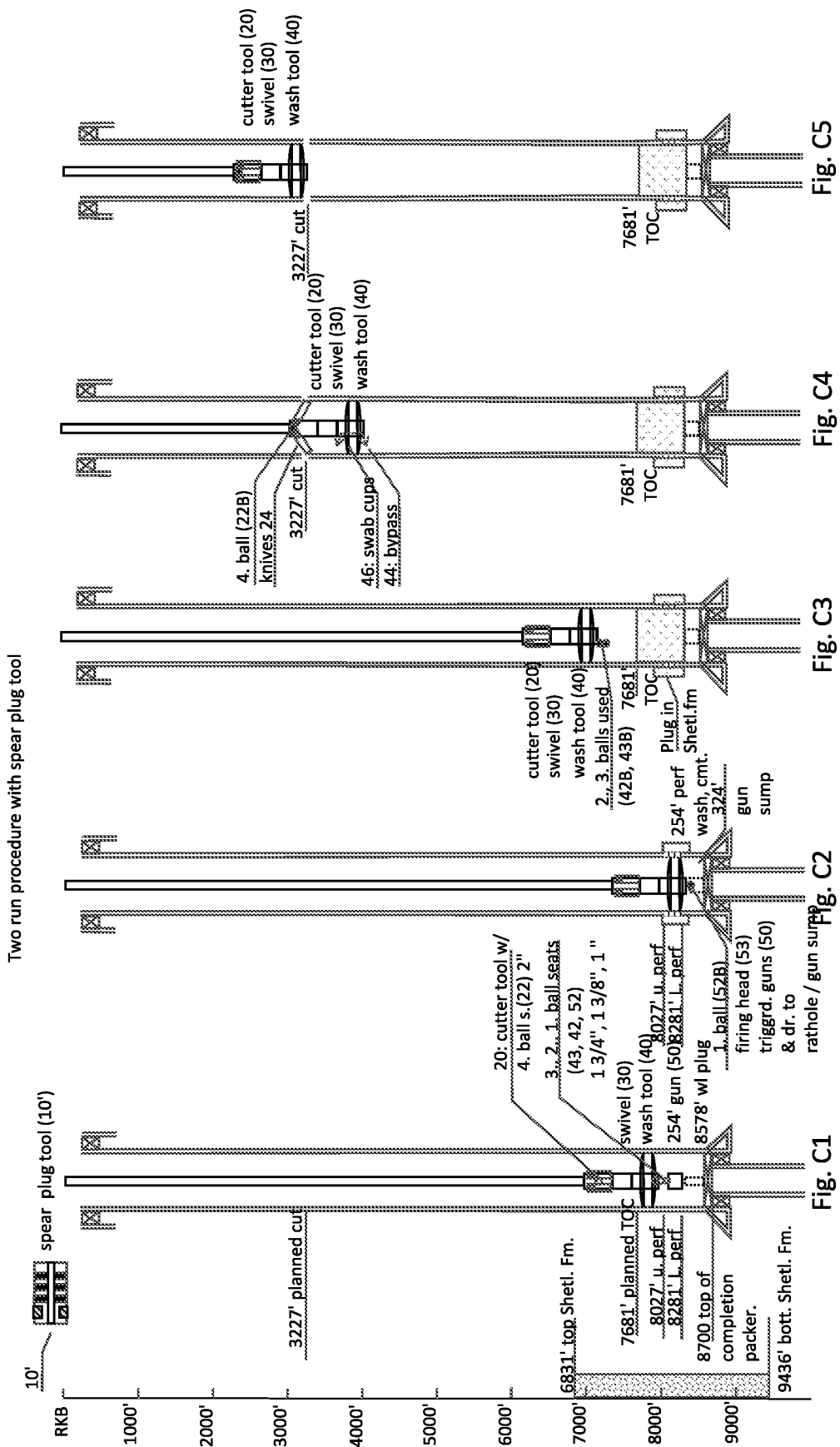
Fig. B3

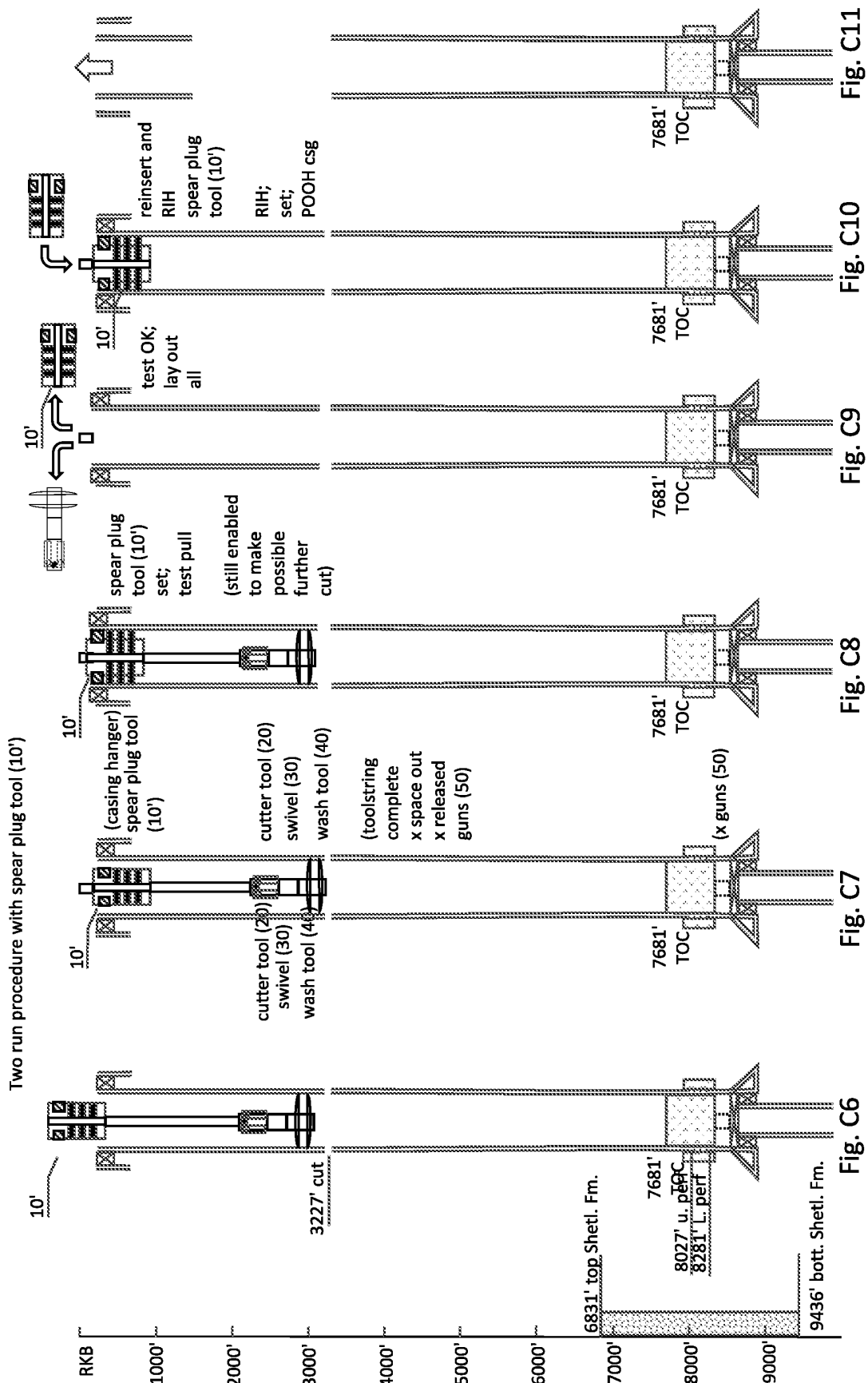
Fig. B2

Fig. B1



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REFERENCES CITED IN THE DESCRIPTION

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