Welltec®

Magna Range Plug Milling SIT

Chrysaor A03 & A05

Test Location	Welltec UK
Test Date(s)	11/03/19 – 14/03/19
Test objective	Mill Magna Range Plugs
Welltec®	Titan Swivel 218 WMS 314 Well Stroker 318 XR WT 4ws 318 WM (59:1 GB) Wellpro Mill bits
Author	James Walker Field Engineer Welltec®
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File Name	Chrysaor A03 and A05 Magna Range Plug Milling SIT
Rev	Revision 1

Contents

1. Chrysaor Magna Range Plug Milling

1.1 Purpose

Chrysaor have approached Welltec to see if they can help remove 2 Magna Range bridge plugs – 1 set within well A03; the other in well A05 – part of Chrysaor's Armada Platform (North-Sea).

1.2 Participants

1.2.1 Welltec®

Andy Jessiman	Senior Account Manager
David Buchan	Field Engineer
James Walker	Field Engineer

1.2.2 Chrysaor

Jamie Fraser	Well-Intervention Engineer

1.3 Test Objectives

In order to successfully remove both bridge plugs Welltec proposed to use their Well Miller (WM) BHA in order to free the plugs from the tubing. Two different mill bit sizes (4.1"x2.0" and 4.1"x2.5") were used, 1 for each plug, due to the differences in plug dimensions. These were each fitted to the bottom of Welltec's Well Miller tool using a custom-made x-over (Figure 3).

For well A03, a Halliburton JRC Magna Range bridge plug is to be removed. The proposal for removing this plug is to mill through the upper slips whilst removing the ratchet mechanism on the plug core (using a 4.1"x 2.0" Wellpro mill bit - Figure 2), before rigging up a slickline pulling tool and spang-jar assembly to pull the plug to surface.

For well A05, an Owen Oil Tools Magna range bridge plug is to be pushed to bottom. Although there is no requirement for this plug to be pulled to surface, the proposed method is similar to the one outlined for the Halliburton plug - mill through the upper slips whilst removing the ratchet mechanism on the plug core (using a 4.1"x2.5" mill bit - Figure 1), which should allow the plug mechanism to collapse, this time enabling the plug to be free to be pushed to the bottom of the well.

Figure 1 - 4.1"x2.5" Mill Bit

Figure 2 - 4.1"x2.0" Mill Bit

Figure 3 - Custom x-over

1.3.1 Objective #1: Mill Slips (Halliburton Magna Range Plug – Well A03)

To free the Halliburton Magna range plug and allow it to be pulled to surface, the upper slips first have to be removed. The slips are highlighted in yellow in **Error! Reference source not found.**, along with the respective dimensions. Using a core mill bit to remove these slips should allow the plug mechanism to retract from the tubing wall and thus be pulled free using a slickline pulling tool and spang-jar.

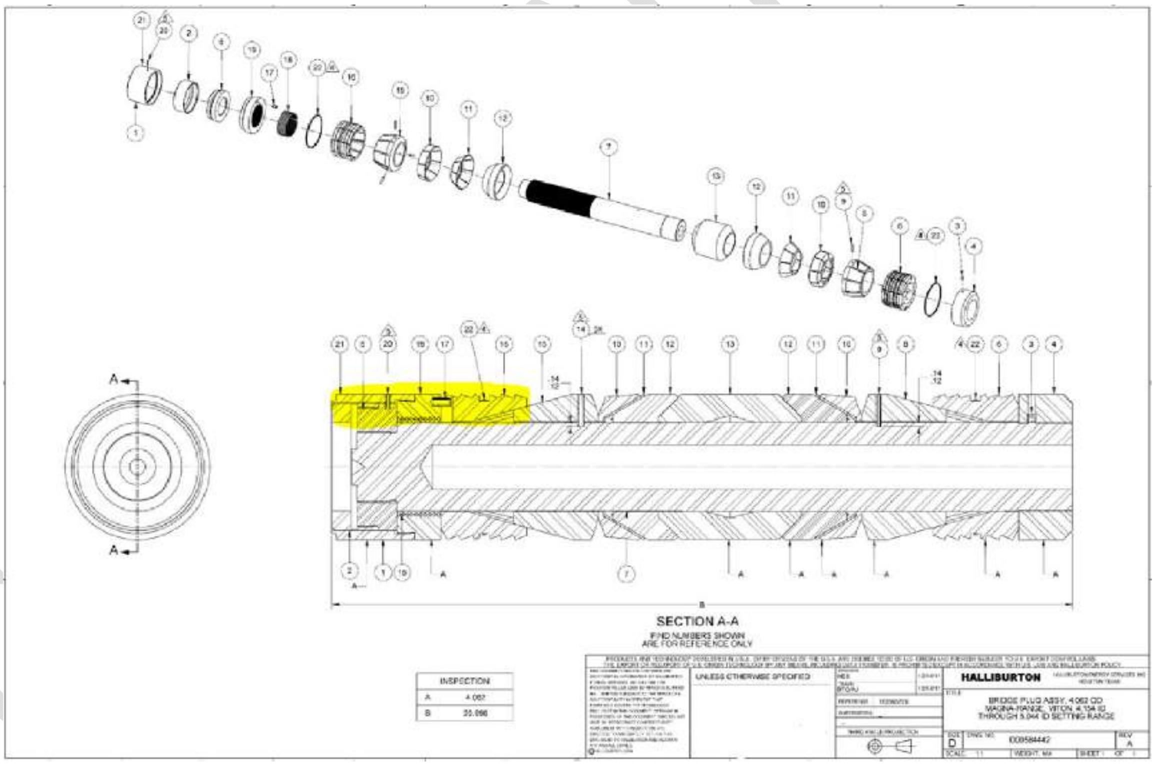


Figure 4 - Halliburton Magna Range plug

1.3.2 Objective #2: Mill Slips (Owen Oil Tools Magna Range Plug – Well A05)

To free the Owen Oil Tools Magna range plug and allow it to fall to the bottom of the well, again the upper slips first have to be removed. The slips are highlighted in yellow in **Error! Reference source not found.**. Again, using a core mill bit to remove these slips should allow the plug mechanism to retract from the tubing wall and thus fall to the bottom. Should the plug not move following the milling operation, slickline will again rig up and attempt to pull the plug to surface (same as Objective #1).

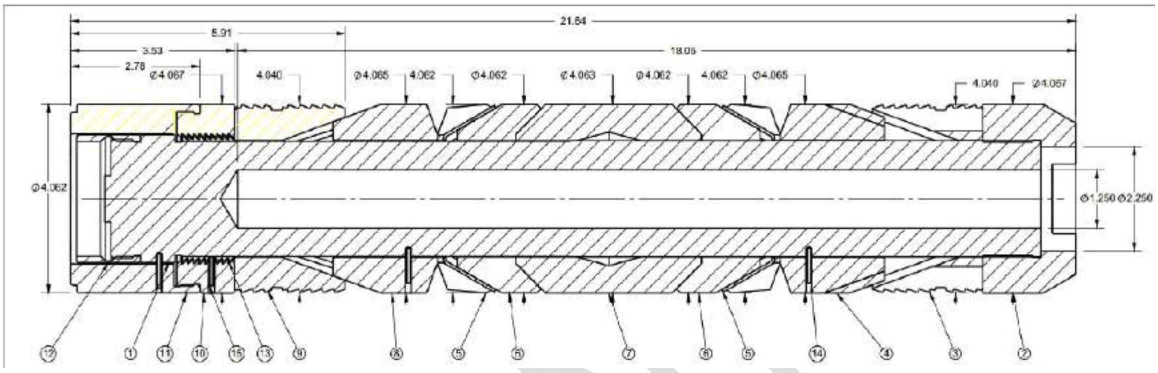


Figure 5 - Owen Magna Range Plug

1.4 Test Setup

1.4.1 Welltec TestTrac

The test was setup within Welltec UK's yard using the TestTrac facility shown in Figure 6. The TestTrac has been developed specifically to test and verify Welltec's specialist downhole mechanical tools by better simulating downhole conditions, including temperature, pressure and deviation. Equipment configurations can therefore be optimised prior to actual operations in the field. A plan of the layout, and legend, can be seen in Figure 7 and Figure 8.

Prior to the test taking place, 2 pup-joints were mobilised to Welltec UK's yard. Each joint had 1 of the plugs set inside them, and could be attached via a threaded x-over to the bottom of the TestTrac tubing. Once fitted to the TestTrac the assembly was filled with water to simulate well-fluid conditions and also to help cool the mill bit.

The wireline cable used was a 1N32 PTZ. 1000ft in length giving a conductor resistance of 3Ω.

Figure 6 - TestTrac Facility

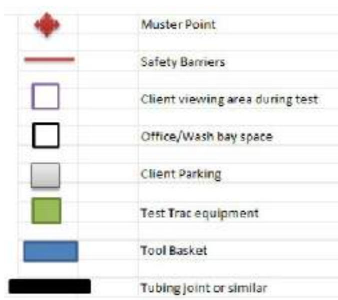


Figure 7 - Test Facility Legend

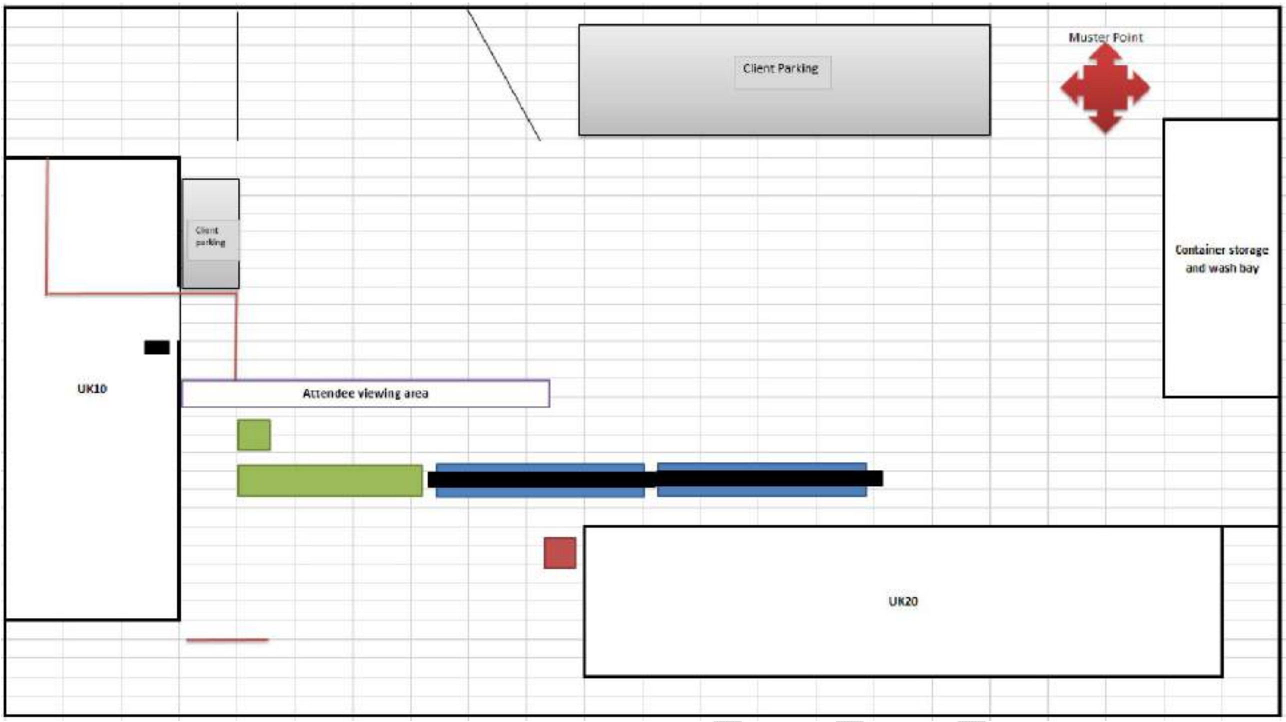


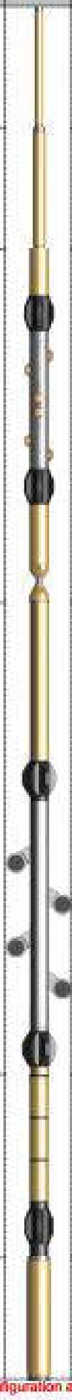
Figure 8 - Layout of Test Facility

1.4.2 Welltec BHA

The tool string used for this test can be seen in Figure 9 and Figure 10 and consisted of:

- Titan Swivel
- 218 WMS SRO (Surface Read Out)
- 314 WS SRO 33K (This is for stroking up if the TS becomes stuck)
- 318 4 Wheel Section WT
- 318 WM (with a 59:1 gearbox)
- Wellpro Mill Bits (4.1"x2.0" for Halliburton Plug; 4.1"x2.5" for Owen Oil Tools Plug)

Figure 9 - Tools use for SIT

	Max OD		Item Length	Acc. Length	Weight in air	Provider
Total	5.35 in			15.09 m	890.112 lbs	
Welltec Cable Head Cone Type II	1.437 in		0.31 m	15.09 m	2.204 lbs	Welltec
Welltec 218 WMS SRO ES24099 Connection housing, 7Kpsi	2.125 in		0.62 m	14.77 m	9.038 lbs	Welltec
Welltec WS 314 DC SRO Body OD: 3.268" ES44125 Length with arm in: 4.32 m Length with arm out: 5.08 m Standoffs: 2 x 4.5" Bottom connector WS XS	5.35 in		4.31 m	14.15 m	277.561 lbs	Welltec
Welltec WT 318 XR Top connec. F9RP WK/tandem top Body OD: 3.15" ES44121 4 wheel sections Max reach: 9.941" Wheel size: 3.374" Standoffs: 2 x 4.5"	4.5 in		6.8 m	9.83 m	428.137 lbs	Welltec
Welltec WM 318 Top con. F8RP tandem top Body OD: 3.15" ES44123 Gear Box OD: 3.15" Standoffs: 1 x 4.5"	4.5 in		2.42 m	3.03 m	148.172 lbs	Welltec
WellPro Well pro	4.1 in		0.6 m	0.6 m	25 lbs	WellPro

The drawing is a guideline only and actual configuration and lengths may vary and should be checked onsite

Figure 10 - Welltec BHA

1.4.3 WS – Well Stroker

The Well Stroker (Figure 11) used for this milling trial is designed to apply up to 33,000lbs axial force up/down hole using a bi-directional hydraulic ram. The reason for including this as part of Welltec's BHA is to be able to pull the tool-string free should it get stuck during milling operations, rather than relying on the wireline winch. This particular WS also comes with SRO capabilities (surface read out), meaning it can send data to surface allowing the FE to determine the stoker piston's position and the force being applied.

Figure 11 -Well Stroker

1.4.4 WT – Well Tractor

The Well Tractor® (Figure 12) is an electric/hydraulic based tool-conveyer, designed to push intervention tools into horizontal wells whilst pulling the wireline cable behind it. The power sent from surface is controlled by Welltec's own control panel, which powers the tractor's electric motor and drives two hydraulic systems. The first hydraulic system rotates the wheels, making the tool move forward; whilst the second system extends the wheel arms, and pushes the wheels out to grip the tubing wall.

Whenever the electric motor stops, the wheels collapse into the tool body, making the system fail safe.

The Well Tractor® pushes the tool string down hole and is also used as the means for providing weight-on-bit (WOB) for milling operations whilst also providing the Well Miller® with reactive torque.

Figure 12 - Well Tractor

1.4.5 WM – Well Miller

Deployed on e-line, the Well Miller (Figure 13) is a robust and effective tool for removing obstructions with robotic precision across a diverse environment including horizontal wells. The rotation of the mill-bit is generated by an in-built electric motor that creates a rotational force. Custom mill bits have been designed and manufactured for this operation by Wellpro (4.1"x2.0" and 4.1"x2.5" core bits). For this operation a 59:1 gearbox was also used as part of Well Miller, giving an output speed of 55RPM in low speed and 66 RPM in high speed.

Figure 13 - Well Miller

1.5 System Integration Test

1.5.1 Procedure

1. Rig up Welltec tool string as per SOP
    a. Confirm Bit type is correct (4.1"x2.0" Wellpro bit for Halliburton plug in well A03; and 4.1"x2.5" Wellpro bit for Owen Oil Tools plug in Well A05) and fully painted up to monitor depth milled.
2. Continue to carefully RIH until just above the HUD (plug)
3. Pull back to full pickup weight.
    a. Ensure that tool string has moved up hole and is not in contact with HUD during start up as tool may draw excessive current.
4. Switch operational mode and power up both Well Tractor in LOW speed and Well Miller in HIGH speed DO NOT RIH on the wireline winch until an increase in tension has been seen. Ensure the SRO function of the tool string is activated for maximum control while milling.
    a. Pull force of the Well Tractor will be circa 900kgs, as soon as the surface tension and HT increase is observed start the winch to RIH at 2-3m/min until HUD is reached.
    b. If excessive current is seen then switch the Miller to LOW speed.
    c. An increase in current consumption and a drop-in wireline tension will indicate mill bit contact with the obstruction.
    d. Stall out may been observed during the milling stage, if so then first attempt to restart should be in the same location, if this isn't allowing smoot start up then PU the tool string 3ft and restart step.
5. Continue to mill as long as Head Tension and Current data supports that progress is being made
6. Monitor tool current consumption and head tension data to asses milling action on the plug. If no more progress being made then Stop tools following step 7.
7. Keep the wire-line back tension above 200 lbs, shut down the tool string, this will allow the string to slightly pick up from the milled plug and allow a smoother retrieval from the plug.

    a. If tools are stuck Power up the Well Stroker in UP Stroke to pull tools free from plug
8. POOH.
9. Once OOH inspect the mill face for damage and debris, collect if available
    a. Inspect mill bit paint marks and report.
10. Rig down as per SOP being careful as the plug may be retrieved within the mill bit.
11. Inspect mill bit,

1.5.2 Mill through Upper Slips

Once the tools were rigged up inside the TestTrac the pup joint was then connected to the bottom joint of the TestTrac tubing. The WT and WM were then powered up and RIH slowly until the plug was tagged. The operating current was allowed to settle out before increasing WOB. The target current range was between 3.5 – 5A with up to full WOB. This current did fluctuate throughout the milling operation due to the different material sections making up the plugs. A common current signature can be seen in Figure 14. As there was no HT (head-tension) Swivels in the workshop we were unable to accurately determine the specific WOB. It was possible however to achieve full WOB for most of the test. There was also several stalls seen at varying points throughout the milling operations – it was always possible to pull free using either the wireline winch, or the stroker (stroking up). A more detailed narrative for each milling operation is outline in Table 1 and Table 2.

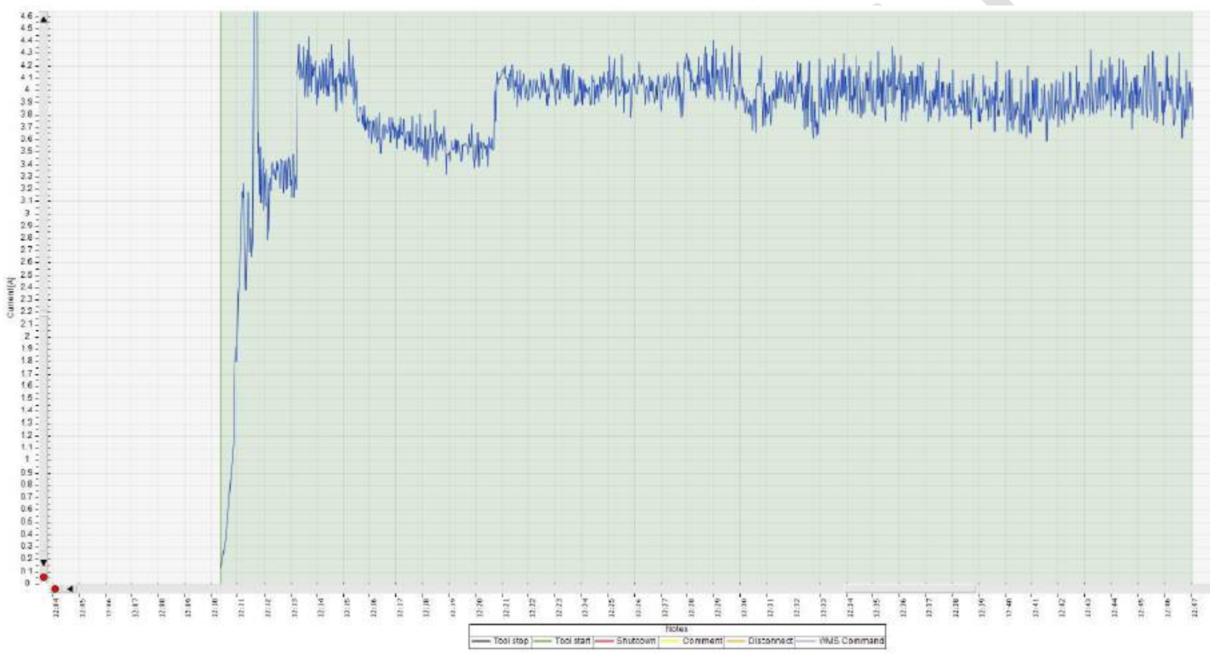


Figure 14 - Typical Milling Current Profile

Milling Owen Oil Tools Magna Range Plug	
Day 1 (12/03/19)	
07:40	Start tools, baseline 3.1A, WM in LS
07:47	Make contact, stall
07:52	Stall again after 30s milling, 3.4-3.9A
07:54	Start, 3-3.4A
08:02	Stall after nudging in
08:08	High current, then drops to baseline
08:10	Move in, 5A
08:11	Stop operation to inspect – snap-ring gone and now over core; wear on inside of mill
09:15	Restart and stall on contact
09:25	Use Stroker to pull free

09:30	Restart and stall again
09:35	Stroke up
09:37	Milling again then stall
09:48	Stroke up
09:52	Switch back to LS milling
10:00	Numerous stalls, Stroker needed to pull free
10:20	Milling 4A, using winch brake to inch in, up to 4.2A
11:35	Break open to inspect – 1cm past where retaining ring was, 13cm total travel
12:10	Restart, 4.2A
12:26	4A sine wave seen, full WOB, potentially spinning
12:55	PU and go back down, baseline 2.8A when over top of plug
13:20	3.5A when milling, stall, Stroker needed
13:30	Re-engaged, 3.5A – breakout to inspect – down to lock-ring retainer
14:05	Restart, current up to 4.4A then drops to 3.7A
14:23	Switch to HS milling – 4.1A
14:51	Another 1cm of progress seems to have been made
15:04	Higher current, now onto slips, full WOB
16:00	PU and go back down to try clearing swarf
16:15	4.5A after retagging
17:00	Stall, stroke up
17:07	Restart milling
17:16	Two stalls after drawing high current for 30s
17:20	4.2A milling again
17:45	Up to 5A
18:00	Stop test – 9" total of milling

Table 1 – Milling Operation – Owen Oil Tools Plug

Milling Halliburton Magna Range Plug	
Day 2 (13/03/19)	
08:00	Start WM, 3.2A when clear of plug – MB rubbing on lower side of tubing; 3.8A when contact made, full WOB
09:00	Current drop to 2.8A
09:01	Back to 3.8A, 1cm of travel
09:40	PU clear and go back down3.2A
10:35	Current up to 6A before stalling
10:38	Stroker required

10:45	Re-engage, current up to 6A so pull back on winch until 4A
10:50	Stall/stroke up
10:58	Re-tag 4A
11:02	Stall/stroke up, breakout tools – 1" wear inside MB, threaded part of core gone, section of core can now be spinned by hand
11:30	Re-engage, stall, stroke up, restart in LS
11:47	Current fluctuating 2.5-4A
11:55	Full WOB, 3.3A
12:41	PU and re-engage in HS, 3.7A
13:22	Stop, PU, re-engage
13:45	Current up to 6A
14:20	Stall/stroke up, re-engage, 4A
14:29	Stall/PU, re-engage, 3.9A
17:00	Stop/PU, re-engage, 3.8A
19:00	Stop/PU, re-engage, 3.4A
21:30	Stop for day
Day 3 (14/03/19)	
08:40	Start milling in HS, baseline when not touching plug 3.4A
08:45	Make contact, 4A
09:30	Stop to inspect – still on slips, slight wear on MB (chamfered inside edge)
09:50	Re-engage in HS
10:00	Current down to 3.5A
10:41	Stall/PU, re-engage, 3.5A
12:00	Stop test – breakout – MB is worn on the inside edge, and approx. 8.5" of the plug has been milled
Swap back to Owen Oil Tools Plug	
Day 3 (14/03/19)	
13:22	Baseline 3.3A, 4.5A when milling, full WOB
14:40	End of test – milled 1" extra (10" total)

Table 2 – Milling Operation – Halliburton Plug

There was a total of 17 hours spent milling on the Halliburton bridge plug – milling away 8.5" of the plug (Figure 18); and 10 hours spent milling the Owen Oil Tools bridge plug – milling away 10" of the plug (from the core to the underside of the slips - Figure 16). Throughout each of the 2 milling operations the pup-joints were removed from the TestTrac several times to inspect the wear on the mill bits (Figure 15 and Figure 17), and also check the milling progress.

Figure 16 - Milling of Owen Oil Tool Plug

Figure 18 - Milling of Halliburton Plug

Figure 15 - Mill bit following milling of Owen Oil Tools Magna Plug

Figure 17 - Mill bit following milling of Halliburton Magna Plug

2. Conclusion

Following milling operations on both plugs neither of them have come free. Despite successfully milling a significant portion of each plug, neither plugs' mechanisms relaxed enough to be pulled free or to drop to the bottom of the TestTrac. A spang-jar and slickline pulling tool were used by hand to try and manipulate the Owen Oil Tools Magna range plug from the tubing, with around 1" worth of movement seen, however, following this the test had to be ended due to time constraints.

2.1 Recommendations

For the operation Welltec recommends the following should the test be continued in future:

1: Continue milling, with the possibility of using different mill bits or with current design.

2: Consider a Magnet Run to retrieve potential loose material.

3: After milling, conduct a test where more force can be applied than the jarring tool assembly – possibility of running Well Stroker.

Welltec and Chrysaor to discuss contingency options following this SIT.

Prepared by	Date
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