



Learning from Experience: Completing a Subsea Dual ESP Well, second time round.

Solan Field, West of Shetland

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Run Down

- 1. Background
- 2. ESP Life Cycle
- 3. Historical wells experiences P1 and P2
- 4. New Well planning P3
- 5. P3 Execution
- 6. P3 Learnings
- 7. Conclusions



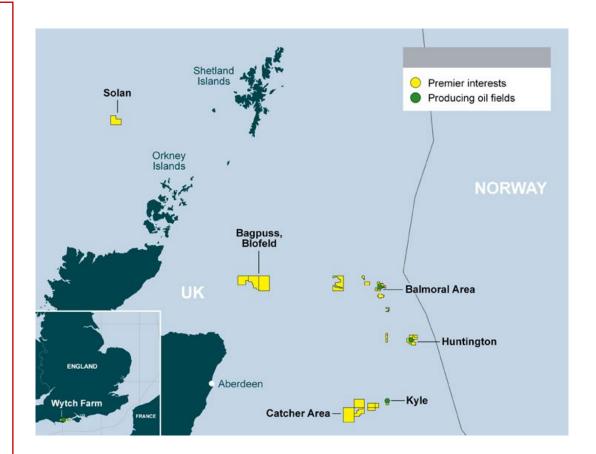
Harbour Energy

- This project was completed under Premier Oil, installation concluded in July 2020
- Harbour Energy plc completed merger with Premier Oil (and Chrysaor) in March 2021



Solan Field

Solan lies in Block 205/26a of the UK continental shelf. It is 96 kilometres North West of the Orkney Islands and 135 kilometres 135 kilometres west of Shetland. The Solan field lies in a water depth of 135m.





Solan Field



Solan comprises three producing wells and two injector wells tied back to a normally unmanned conventional steel platform. Oil is produced into a 300,000-barrel subsea storage tank and offloaded via shuttle tanker. First oil was achieved from Solan in April 2016.



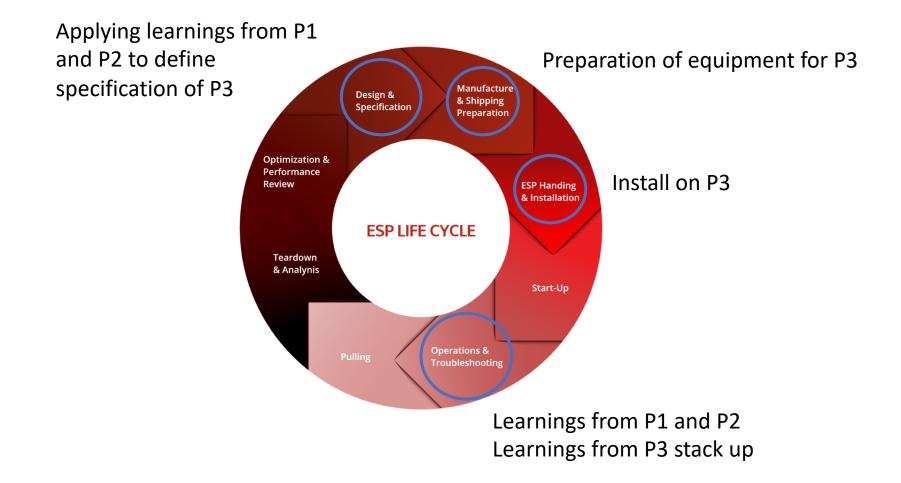
Transocean Leader

The Transocean Leader is a harsh-environment Semi-Submersible and was used for the campaign. It's drilling performance was excellent. It had the correct subsea capabilities. The rig had ESP running and handling experience.





ESP Life Cycle





P1 and P2 Experiences

- Two Dual Y-Tool ESP installations occurred in 2016
- Ended up running a single ESP in P1 due to issues

Problems:

- Major slack in MLE Cables (2 ft)
- Discharge Pressure Line too short for ESP assembly
- Systems were out of alignment during install
- Issues with Pump Sub



P1 and P2 Experiences

- The ESP wouldn't pass through the GE HXT (Helix)
 - 11 days spent trying
 - Testing Y-Tool on drill pipe, it rotated 60° through the Helix
- Detaching Pump Support Block Spear
- ESP Bypass Clamps failed
 - Clamp sheared and was riding against Y-Tool

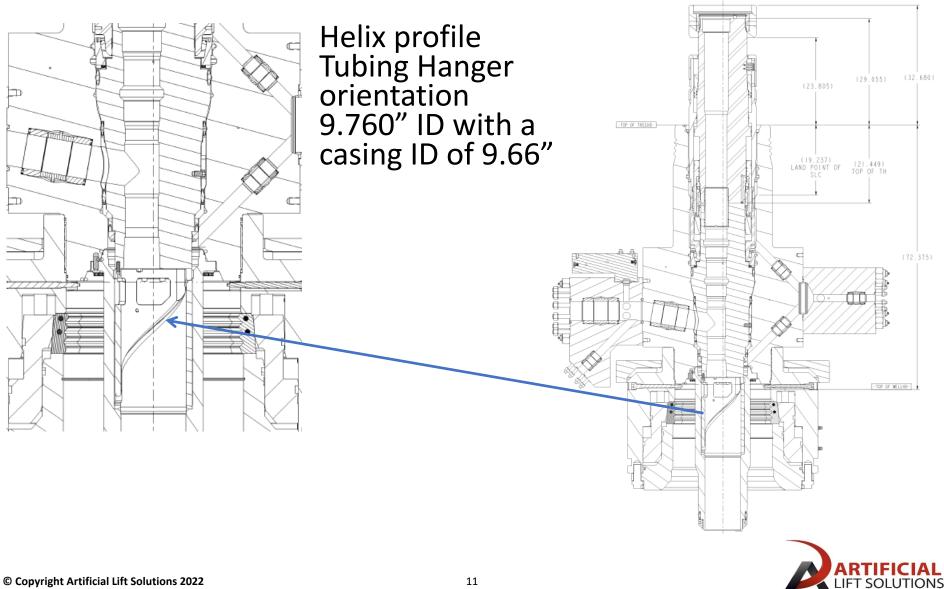








P1 and P2 Experiences



Suspected Causes

- Was the ESP too rigid for the casing?
 - Not enough flex to make it through the well profile
- Was the Bypass Clamp design optimal?
 - Bolts shearing
 - Bolts backing out
 - Large OD
- Was the MLE too heavy to manipulate?
 - Too heavy to pull tension on by hand when RIH
 - Too difficult to move when installing Bypass Clamps



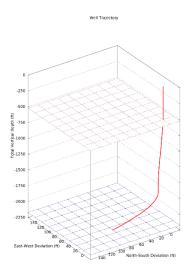
Suspected Causes

- The systems being out of alignment?
 - Did this make the ESP oversized?
- Well Geometry optimal?
 - There was a Dog Leg in the profile
- Did the lower pump being in the riser for 18 hours contribute to issues?
 - Did the waves hitting the riser cause vibrations which backed out the clamp bolts?



P3 Plan

- It was a new drill well designed for an ESP
 - 1200ft tangent for ESP
 - DLS very low
 - Low inclination
- ESP needed to have:
 - high, variable rate
 - be capable of dealing with fine sands, H2S and CO2
 - Cable that was manageable
- Automatic / controlled Bleed off of Annulus





P3 Plan

- The ESP completion design had to be optimised
 - Distance between ESPs increased
 - Y-Tool designs minimal in size
 - Bypass clamp had to be more robust
 - MLE had to be more manageable
- ESP Quality had to be ensured
- Assurance was required for passing through the Helix
- Summer installation best option for weather



P3 Plan

- Premier Oil contracted the services of Artificial Lift Solutions
- The ESP contract was awarded to Baker Hughes
 - Multiple services award
- Engenya were contracted for Design Analysis
- A stack up trial was planned



Quality Plan

- Collaboration was required in creating a robust Quality Control Plan that included sub suppliers
- The ESP quality plan included:
 - Full ESP parts and build inspection
 - SIT performed at factory
 - Full parts and build inspection at sub suppliers
 - Full FAT of Auto Y-Tools
- Additional qualification testing of new bypass clamp design



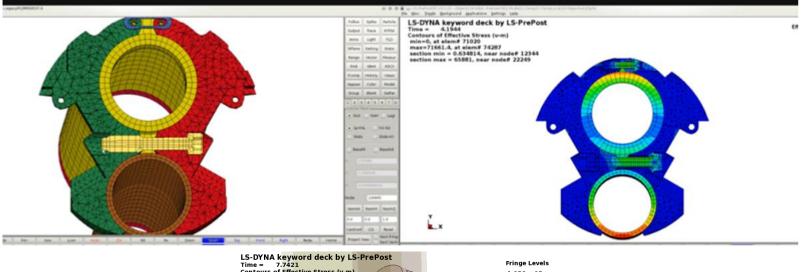
Bypass Clamp Design

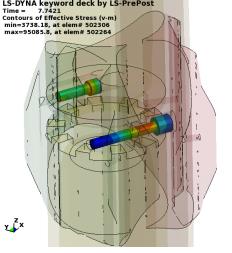
- The Bypass Clamp redesign was a high priority due to issues faced previously
- RMSpumptools created a new design
- Robust two bolt clamp was created no hinge.
- Reduced OD (9.563" to 9.504")
- Nord-Lock Washers
- Ran Qualification testing
 - Shock Loading
 - Vibration Testing

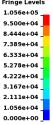


Bypass Clamp Design

• Engenya Design Analysis was run

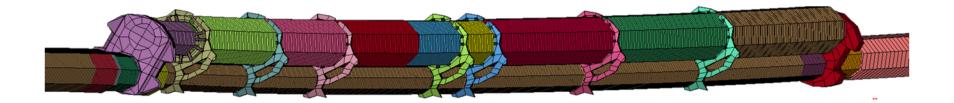








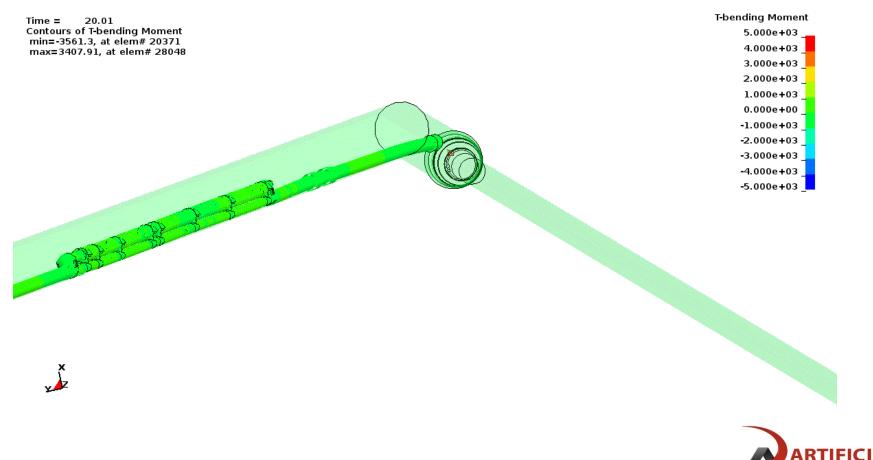
• Engenya created a full model and conducted FEA of the system at all stages of installation



• Note: Full analysis was done on P1 as hindsight

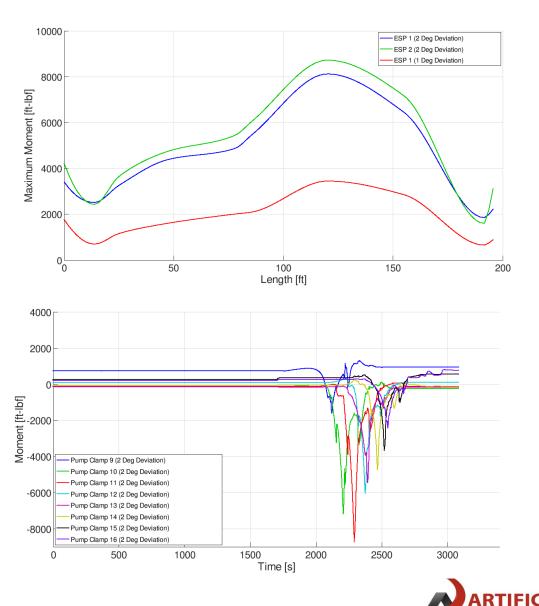


 Please note, this is a generic ESP assembly – not manufacturer specific - to demonstrate the movement.



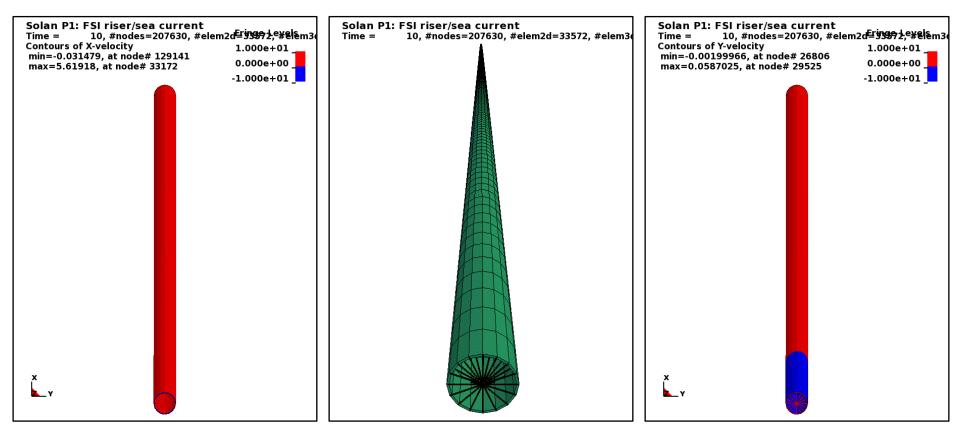
Maximum Moment
 v ESP Length

 Moment on ESP Clamps



LIFT SOLUTIONS

 Other / Vessel or Riser Movement / Vortex induced Vibration?





ESP Completion Design

- Distance between Lower Y-Tool and Upper Pump Support block increased from 67ft to 530ft
- Pump Sub length increased to allow flexibility in the system
- Deflection force decreased to an 1/8 of previous levels

UPPER	PPER COMPLETION PLANNED V2 FIELD: SOLAN PLATFORM: TBC WELL TYPE: DUAL ESP OIL PRODUCER FLUID W1: 12.5PPG MAX DOQLED: 3.0 0.8785					BLOCK: 205/26a WELL: P3 CASING / LINER / TUBING DATA							
PremierOil DESCRIPTION XMAS TREE WELLHEAD TUBING SPOOL TUBING HAAGER		FIRST COMPLETED: WORKOVER DATE: N/A WORKOVER NO.: N/A ANNULUS FLUID: TBC	RTE: 88 FT (AVG SEM) MAX DEVATION: 87 0 882HT SWMe: N/A MINNIMIM: D: 2.982* 0 BYPASS KOP: N/A AN PAY ANQLE: HUD: N/A HUD: N/A REF LDG: MILLER DATA		9.22 30° 20° 13 3/8° 10 3/4° 10 3/4°		GHT 1 0# 3# 2# 5#	SING / LINER / TUBIN SRADE CONN. X52 LEOPARDSD2 X56 LEOPARDSD2 LEOPARDSD2	JNTS TOP MD 530	766 1700 6000 7000 8225 8500 7210	766 1700 5959 6754 7547 7804 6859		
		MAKER TYPE BHOE HOKT BHOE MS700	SZE & PRESSURE 5" PRODUCTION x 2" ANNULUS - 10,000PSI 18-3/4" - 15,000PSI		9 5/8* 5 1/2*	53	.5# 80X	SI 13%CR	8225				
MD	HANGER TVD (ft)	DIAGRAM	DESCRIPTION	ID	4 1/2"	DRFT	.6# 80K DEV (deg)	SI 13%ICR	7230 COMMENTS	8400	7676		
(R) 520	(ft) 520	Diricities and the second s	OF RIDGER TIRING HANDER HOD	(in)	(in)	(in)		DEPTHS DETAILED ARE		Y TABLE (art)		
650	650	•	5^{1} // T is just these for the time of the set 21 for these hander rup cont 5^{1} // T is used in this first respective to the set 21 for the set 2	4.890 4.890 4.890	5.978 5.978 5.978	4767 4767 4767							
		Ϋ́	5 1/2" 17# L80 13%CR VAM21 TLBING	4.893	5.978	4.767							
			5 1/2" 17# L80 138CR VAM21 BOX x PIN PUP JOINT	4.893	5.978	4.767							
			5 1/2" 17# LB0 13%CR VAM21 BOX x PIN FLOW COUPLING	4.893		4.767							
2500	2500		5 1/2" DHSV	4.563									
			S 1/2" TY LEO 13502 YONGY BOX x PPN PLP JOINT	4.895	5.978	4.767							
			s 1/2" tay lao 1380:r vak21 tubing	4.895	5.978	4.767							
7000	6754		TTCC BEHND 10 3/4° CASHG										
			5-1/2" VAM 21, 17# FLOW COUPLING										
			5-1/2" VAM 21, 17# LAND OFF / LOCATOR FOR PACKER CUTTING 5-1/2" VAM 21, 17# L80 1380R PUP JOINT										
			5 1/2" 17# LB0 138CR VAM21 HT BOX x PN PUP JOINT	4.893	5.978	4.767							
7210	6895		10 3/4" DUAL ESP PRODUCTION PACKER (CUT TO RELEASE) - LEAVE ROOM FOR RE-RUNI	3.903	9.455	3.833							
			4 1/2" 12.5# LBO 13%CR VAM21 PUP (8FT MIN FOR PLUG SETTING)	3.958		3.833							
			4-1/2" VAM 21, 12.8# FLOW COUPLING	3.958	4.969	2.833							
			4-1/2" SLIDNG SLEEVE or PUNCH?? 4 1/2" 12.6# LB0 138CR VAM21 BOX x PIN SPACE OUT PUP JOINTS	3.951	4.937	3.833							
				3.956		3.833							
7273	6944		4 1/2" 12.6# L80 13%CR VAM21 BOX x PIN HANDUNG PUP JONT (8ft) 4-1/2" ADJUSTABLE STROKE UNKON (24" SET AT MID-STROKE)	3.920	5.450								
			4 1/2" 12.6# LBO 139CR VAM21 BOX x PIN HANDLING PUP JOINT 4 1/2" 12.6# LBO 139CR VAM21 BOX x PIN SPACE OUT PUP JOINT	3.958 3.925									
7308	6967		4 1/2" 12.6# LBO 138CR VANZI BOX x PIN PUP JOINT UPPER ESP AUTO Y-TOOL	3.958	4.937	3.833							
			UPPER BYPASS ESP SYSTEM	2.993	9.500	2.867		LOWER PUMP TO BE IN THE UPPER PUMP ASS	THE 10-3/4" ENBLY	WHILE WA	KING UP		
7473	7074		UPPER PUMP SUPPORT SUB 4 1/2" 12.6# LBO 13%CR VAM21 BOX x PIN PUP JOINT	3.956	4.937	3.833							
7489	7084		4 1/2" FAST SWIVEL / ALLIGNMENT TOOL	3.958		3.833							
8035	7439	ЬЦ	4 1/2" 12.64 LB0 13%CR VAM21 TUBING (S39FT LOWER PUMP BELOW BOP) 4 1/2" 12.64 LB0 13%CR BOX x PIN PUP JONT LOWER SSP AUTO Y-TOOL	3.958		3.833 3.833							
			LOWER BYPASS ESP SYSTEM	2.993	9.500	2.867							
81.85 8210	7546 7553		LOWER PLAY SUB-PORT SUB - ABOVE 10-3/4" x 9-5/8" CROSSIVER BY +/- 25FT 10 3/4" x 9 5/8" CROSSOVER 4 1/2" L244 L05 ISSEC WARD BOX x PM TLBING 4 1/2" L244 L05 ISSEC WARD BOX x PM PERFORMTED PUP JOINT				49	10-3/4" X 9-5/8" X, CALCARENITE AT 8263 8535" WITH 9-5/8" SI	O TO BE CIRC - BOTTOM O	A 50R AB	WE THE NITE AT		
8233	7567		1/2 12.0# LBU 13XCR VAN2T BOX x PIN PERFORATED PUP JOINT 4 1/2" DHCI VALVE C/W 12.6# LBU 13XCR VAN2T BOX x PIN CONNECTIONS (ASPHALTENE)					8535" WITH 9-5/8" SI	IOE AT 8,600F	т			
8289	7604	II K	4 1/2" DHCI WALVE C/W 12.64 LBO 13300R WAR21 BOX x PIN CONNECTIONS (ASPHALTENE) 4 1/2" 12.64 LBO 13300R WAM 21, BOX x PIN PERFORATED PUP JOINT 4 1/2" DHCI WALVE C/W WAR21, 12.84 LBO 13300R (SCALE)										
8795	7623	劉月丁圖	4 1/2" 12.64 LBO 138CR VAM21 TLBING 4 1/2" 12.64 LBO 138CR VAM21 BOX NDECNIG MLE-SHCE LOWER COMFLETON (REFER TO SEPERATE SCHEMATIC)				50						
8395 8400	7673 7676 : PLANNING	REVII REASON: DESIGN	CHANGES WOLL-STOCK REFER TO SEPERATE SCHEMATIC) CHANGES PREPARED BY: KEVIN EDDE CH	ECKED BY	0.000	00000			0010010	DATE: 25/	0/10		



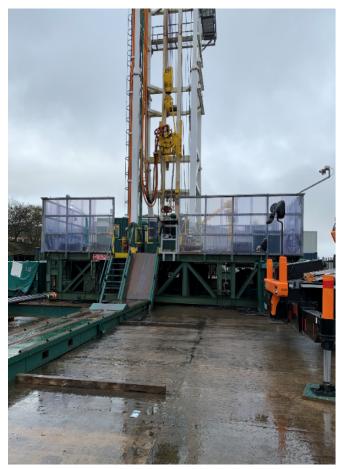
Theory complete!

- At this point we had:
 - ESP equipment selected and in manufacture
 - Bypass Clamp design completed and qualified
 - ESP Bypass system (dual Y-Tool) manufactured
 - Engenya Design Analysis complete
- Everyone was happy with the theory
- Time to put it into practice!



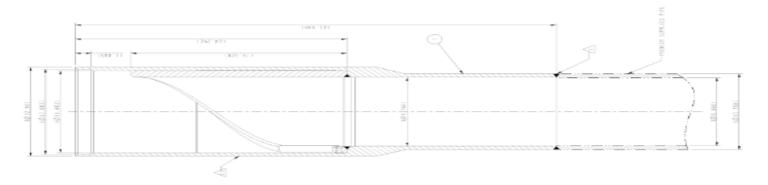
P3 Stack Up Trial

- Conducted at Franks test rig (now Expro) in Aberdeen
- The main purpose was to:
 - Trial alignment
 - Run the ESP through the Helix
 - Install new clamps
 - Test the SCLMA
 - Record lessons/create procedures





Helix Sub





Helix back from Manufacturing





Helix with 10-3/4" pup welded on

Helix in action with pump support block



SCLMA





- SCLMA had 3 lines
- Worked great with back tension spoolers
- Lifts lines out the way for installing clamps
- Shear guillotine with remote
- Reduces manual handling of the MLE's



Stack Up Round-up











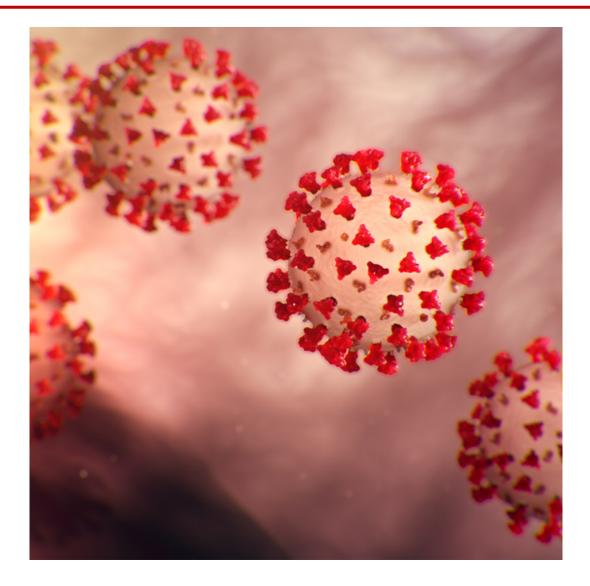


Other Issues during Project

- Pressure limitations on cable system
 - Multi scenario testing (pre drill) flagged a potential issue with certain scenarios causing large differentials
 - This caused issues with the testing and bleed downs required for the completion
 - This was dealt with by both Baker Hughes and RMSpumptools and a sensible solution was reached
- Cable Penetrator Hysteria
 - An 'issue' was flagged by a third party to Harbour Energy about the electrical penetrators
 - Mass panic ensued....
 - The 'issue' was categorically disproven



Spanners in the works.....





Covid Impact

- Remote inspections (videos, live feeds etc) had to be put in place quickly
- ESP string inspection was unable to be witnessed
- ESP shipping preparations were unable to be checked
- ESP installation equipment, including spares and consumables, were unable to be verified
- POB limitations offshore



The Real Deal

- There were some issues encountered...
 - Incident when a BPT joint was damaged, the ESP hung up at surface
 - Lost readings through the subsea umbilical. when the ESP was landed
 - Electrical readings were unable to be taken when landing
 - The MLE was destroyed by abrasion





The Real Deal – take two

- MLE markings didn't tally up perfectly with the ESP
- Run number 2 was a success!
- The well was completed with a Dual ESP as planned



P3 Learnings

- More provisions for electrical testing through Subsea umbilical had to be made to ensure integrity when landing
 - We ironed out a lot of this on Run 2
- Communication must be maintained at ALL times this was the root cause of the BPT incident
- Base all MLE marking on actual measured lengths. Keep markings to a sensible minimum
- Bypass Tubing Lengths should be determined after the ESP design is finalised. Handling and 'stick up' should be planned



Future Workover Considerations

- Consider a POD system?
- Reduce the intermediate tubing?
- If radical changes were to be made:
 - Engenya model would be updated
 - Stack up testing would be carried out
- ESP running Rig availability



General Conclusions

- Don't have a global pandemic during a project...
- Engage help early
- Design for success
- Give the project ample time
- If hindsight is available USE IT!
- If an assurance is available TAKE IT!
- Prepare for the worst full back ups and alternative plans



Collaboration was key!













Questions?



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