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The World First Commercial Wireline Retrievable ESP (WRESP) installation in Oman



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**The World First Commercial
Wireline Retrievable ESP (WRESP)
installation in PDO - Oman**



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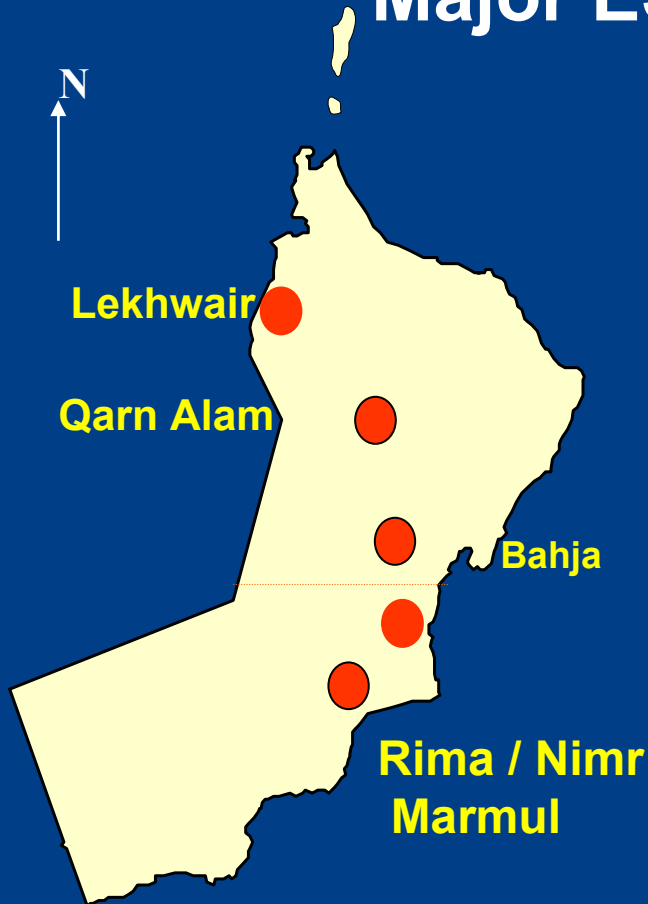


Oman is located.....



ESP DIMENSION:

Major ESP Lifted Fields & Background



SULTANATE OF OMAN

- Multilateral, Horizontal & Vertical wells
- Gravel pack wells, barefoot wells, cased hole wells
- Pumps range m³/d (b/d) Production m³/d (b/d)

600 -to 3444 (3775 to 21660)	1000 to 2500 (6290 to 15725)
200 to 2400 (1260 to 15096)	350 to 1700 (2200 to 10694)
40 to 1400 (250 to 8800)	25 to 1000 (160 to 6290)
- Reservoir pressure: 65 to 168 bar
- Pb pressure: 5 to 145 bar (some fields produce below Pb, hence high GOR)
- Typical PiP: 52 to 104 bar
- Typical PdP: 112 to 196 bar
- Avg PI: 0.025 to 1.0 m³/d/kPa (matrix)
(some reservoirs are producing from fractures)
- GOR: 0.6 to 100 m³/m³
- API: 15 to 40
- Pump setting depth: 900 m to 1450 m
- Pump Set angle: vertical & tangent



ESP DIMENSION: Why Wire Line Deployment?

- 700 ESPs on operation, and expected to double in 5 years business plan
 - lift a $\frac{1}{4}$ of company's net oil production
 - lift $\sim \frac{1}{2}$ of Company's Gross production. ($\sim 96\%$ water cut). Impose substantial design & operation challenges
- 21% of company's unscheduled oil deferment (downtime loss oil) is from ESP
 - Wait on Hoist can be up to 30 days for the low oil producer wells
 - Average work over duration and ESP commission is around 7 days. (5+2)
- Extensive Electrical network to power ESP across PDO, impose Power Quality challenges. Effect downhole motors.
- Some ESP failures reason:
 - 15% due to solids / sand / scales (pump & intakes: blockage, wear & erosion)
 - 20% to 30% due to motor & seal
 - 25% corrosion (effect pump internals / external & tubings)
 - $\sim 5\%$ of ESP failures due to High GOR: Cause gas-lock (if not considered in the design)
- Company's cumulative average Run Life is ~ 2.5 years
 - Average of 170 to 200 ESPs are failing each year, need to be replaced by work- over Hoist.
 - Need 3 to 4 Hoists on full-time basis
 - Add lift cost & increase oil deferment



WHAT ARE THE BENEFITS TO PDO?

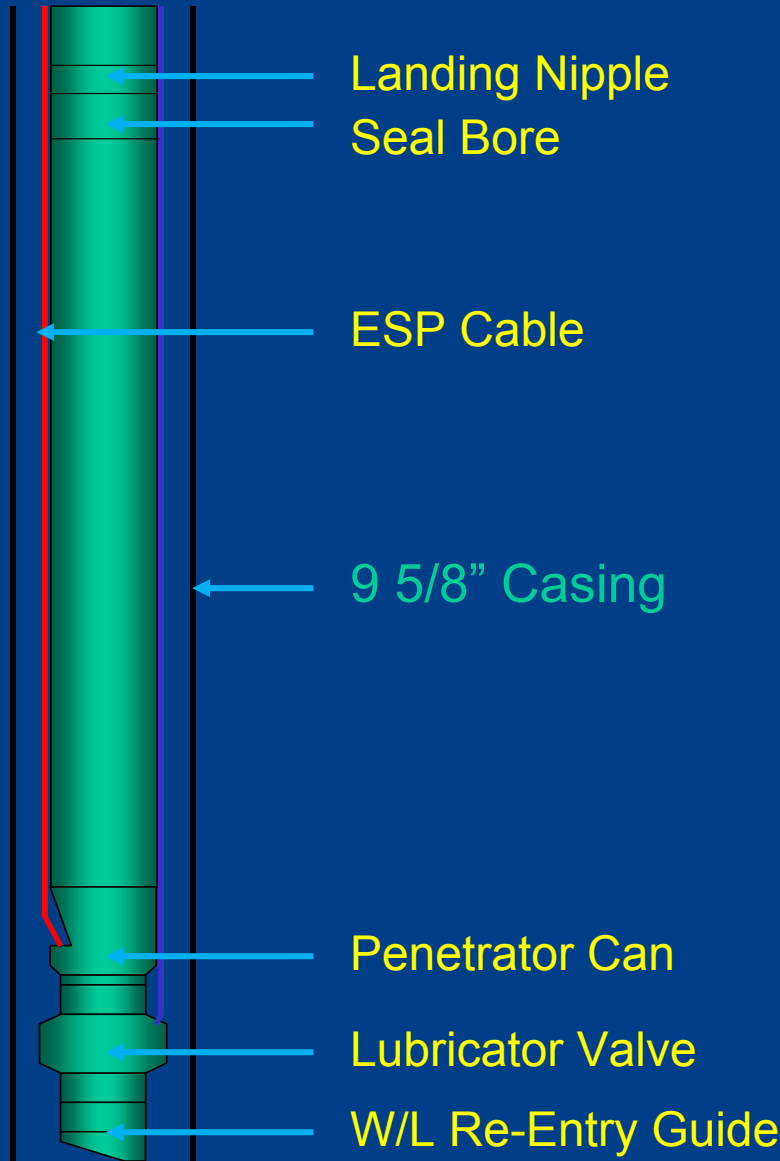
- Quick, safer & cost effective replacement of failed system:
 - Free Hoist to work on other WRM (Well & Reservoir Management) activities
 - No formation impairment, save acid wash job / re-stimulation
 - Reduction of oil deferment
 - Safer well intervention, less exposure (fewer heavy equipments & people)
 - Minimizing overall life-cycle cost of ESP (reducing Opex)
- Provide flexibility of servicing ESP (i.e. clean & service pump, seal & motor) resulting in:
 - Increased cumulative run-life. (can address 35 to 45 % failure modes in PDO; i.e. pump, intake, motor & seal)
 - Minimize oil deferment. (increase ESP reliability & increase ESP uptime)
 - Decrease number of ESP failures (decrease work-over frequency)
- Easy & cost effective replacement of sub-optimal system
 - Can optimise the existing working system to cater for change of reservoir deliverability or pump wear
- Allow temporary deployment:
 - Sacrificial systems: to clean wells of transient solids and debris (drilling, perfs,etc) resulting in fewer premature failures.
 - Test systems: to measure the well productivity and facilitate optimal design of the 'primary systems'
- Through-bore accessibility to the reservoir (1 11/16th tool string for logging, re-perforation, zonal control) when ESP pulled for maintenance or replacement by WL. (9 5/8" casing; 7" WRESP kit)



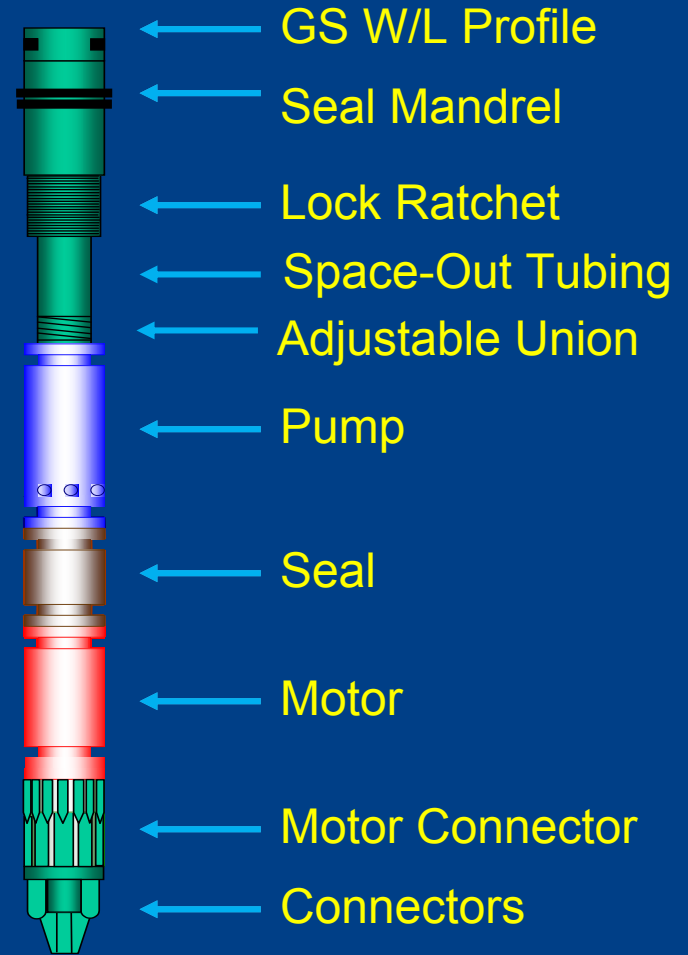
ESP Shuttle™ System Design



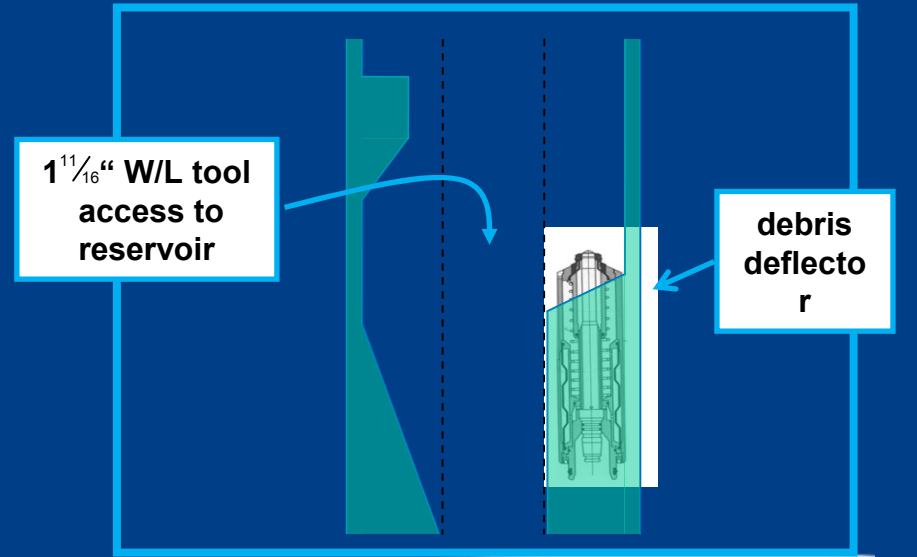
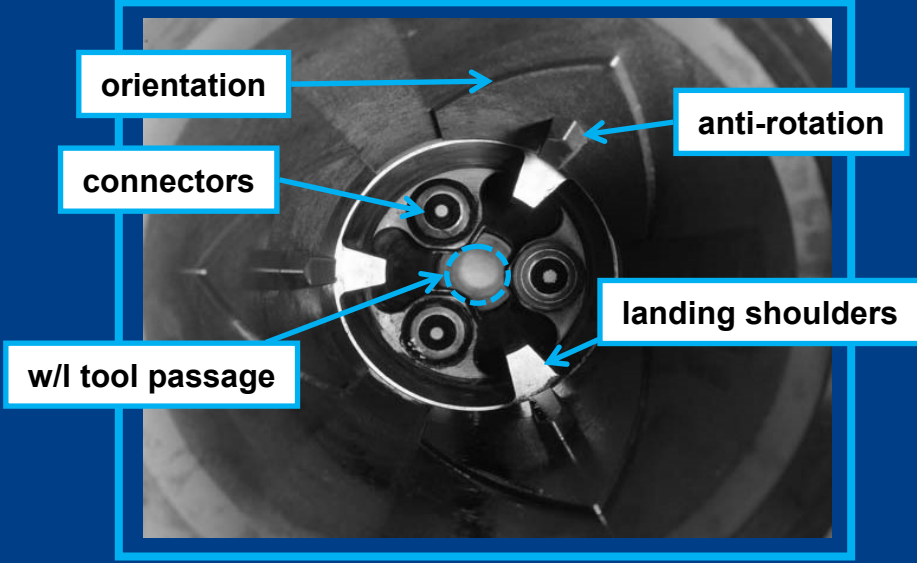
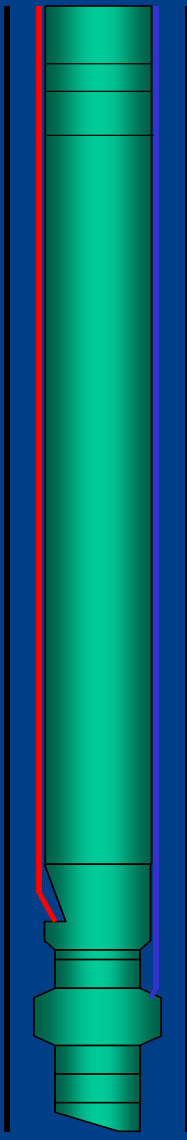
Permanent Components



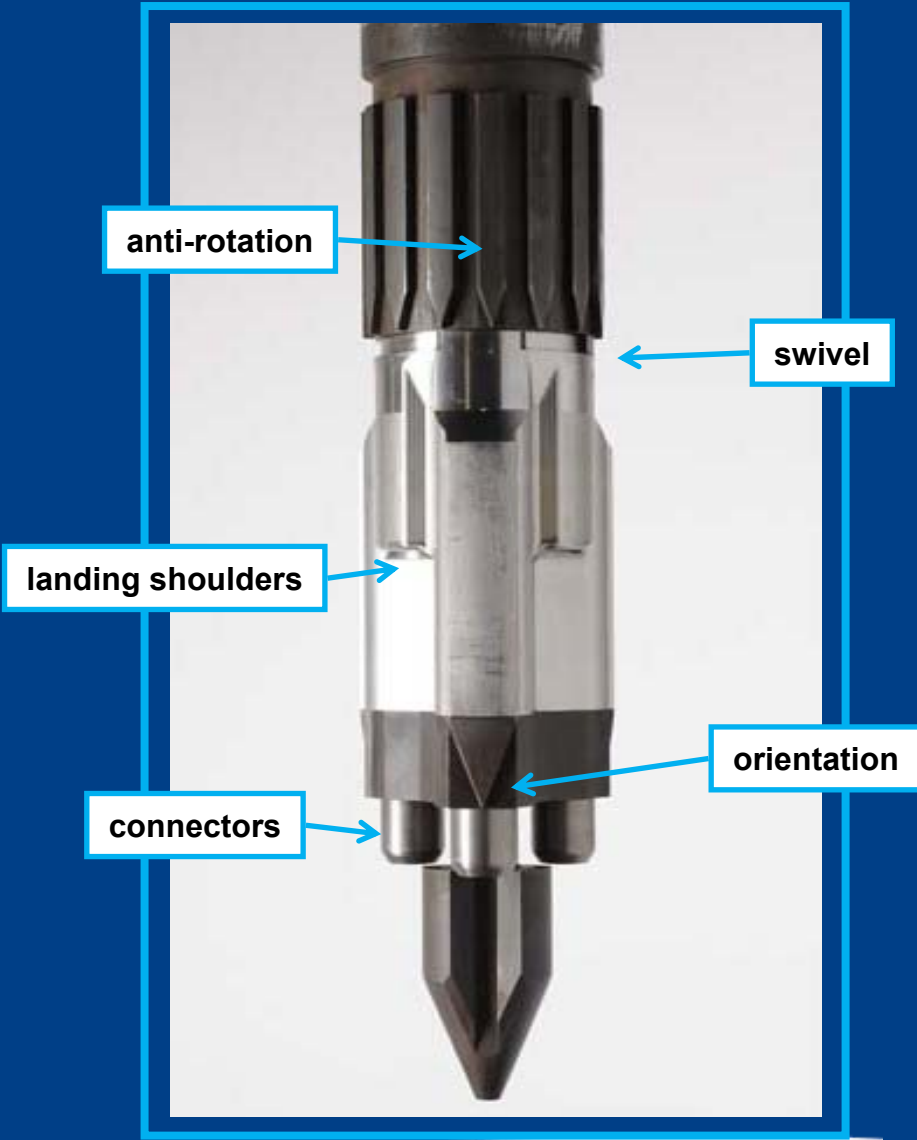
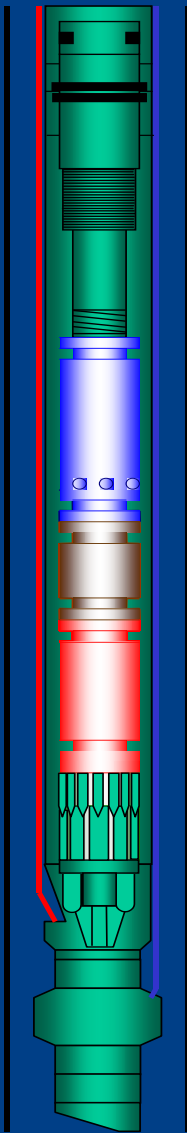
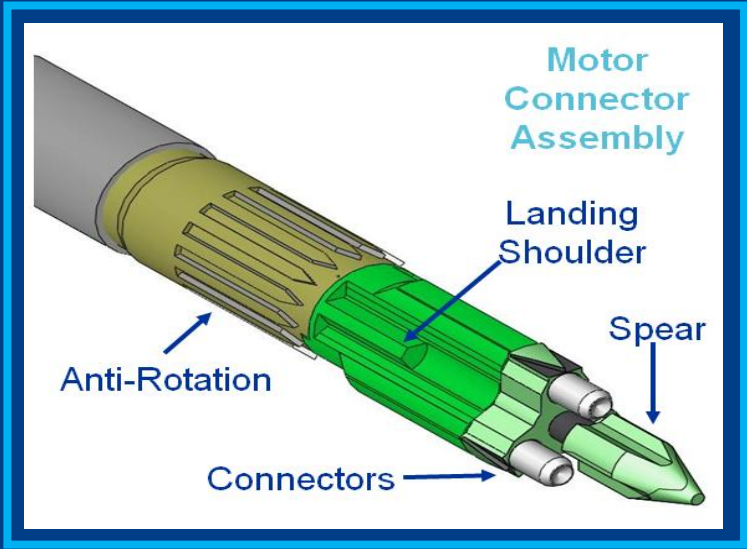
Retrievable Components



'Permanent' Components



Retrievable Components



WRESP CONCEPT (PRE-INSTALLATION Diagram)

Well-A		Sidetrack:	Hole 1	Beit Start Date:	22/5/2007	RDL:	TBF	ODF to TBF:	5.70 m	Petroleum Development Oman	
Well ID:	1673	Sidetrack Top AHD:	0.00 m	Beit End Date:	8/6/2007	ODF Elev:	172.93 m	RDL Elev:	167.23 m	WH Connection: 4-1/16" Hand Tight	
Field:	Rima	Sidetrack Bot AHD:	1,019.30 m	Beit Type:	Workover	Horizontal?	D	Remarks: WH: OA65, OB66, C61, D64			
Well Type:	Development Oil Producer	Sidetrack Reason:	Main wellbore	Well Profile Type: Kill String		Warning: <no data>		Current RDL: Top Bottom Flange			
Spud Date:	28/9/1985	Sidetrack PB AHD:	964.30 m								

Well Status

Casing details	Top/Btm	Liner details	Top/Btm	Completion Items	Top	Well sketch	Top	Mech Item/MWL	Item/HUD	Perf Intervals	
CSG 3.5/8 40# NT55HE LTC R3	-0.30 m			- FMC TC-B-ECC THGR 11" X 5k	-0.57 m						
				- TBG 4.1/2 12.75# J55/EU R2	-0.29 m						
13-3/8" csg, 81.1Kg/m, K55, STC	0.13 m										
FLTCOL133/8STC 81-101 K55 - Cel	676.87 m										
13-3/8" csg shoe, 81.1Kg/m, STC	700.49 m/701.07 m										
				- XN L/N 3.813 4.1/2 EUBXP 12.75#	824.35 m						
				- XD 4.1/2" 12.75#EUB X 3.1/2" 9.2	836.87 m						
				- ESP DISCHARGE HD (3.5" EU)	837.12 m						
				- TE 7000, (53 STAGES) ESP	837.27 m						
				- TE 7000, (53 STAGES) ESP	842.70 m						
				- INTAKE TR5 RS ESP	848.13 m						
				- ESP SEAL 2BP/2L - TR5, AFLA	848.51 m						
				- 250 HP MOTOR, ESP	851.46 m						
				- DSS TR-5 SENSOR, ESP	860.45 m						
				- ESP BULLNOSE	861.41 m						
				- PKR194-60FBT 95/8 75/8LTC	900.61 m						
				- 7-5/8" gravelpack extension	901.59 m						
				- 7-5/8" gravelpack port sub	902.73 m						
				- 7-5/8" gravelpack sealbore	903.38 m						
					903.90 m						
				- Teltale (W/S) 7" LTC	907.36 m						
				- JNT EXPANSION 2" 7" 23# LTC	913.35 m						
				- CSG 7" 23# K-55 LTC R3	915.63 m						
				- W/S 7" LTC 34.23Kg/m R3 S316	927.68 m						
				- BULL P/LG 7 8 RND/LTC NOSE 2	963.55 m						
								363.55 m	HUD -Cement - 0 kPa		
								364.30 m	Cement plug - 0 kPa		



WRESP INSTALLATION OPERATION : WELL

Test Well Candidate Selection

- sub-hydrostatic well with ESP history (good quality design data)
- 9 5/8" casing to pump setting depth (854 m TBF)
- moderate inclination (< 5 deg)
- low free gas volume fraction (FGVF) at intake (< 20 %)
- low cost intervention environment
- moderate production rate and high water cut (minimal deferment)

Well-A

- Pump TE5500 (35+53 stages)
- Seal TR5 2BP/2L
- Motor TR5 1900V, 50A 156HP
- Cable AWG#2 Flat
- Weight ~3900 lbs
- Length ~78 ft



WRESP INSTALLATION OPERATION : Scope of Work

The pilot test of the ESP Shuttle comprised of two phases.

▪ Pilot Test Phase 1 (initial installation by Hoist)



- Running the tubing & permanent completion components to 'shallow depth'
- Running & setting the ESP system on wireline.
- The electrical integrity of the system could then be checked frequently while running in hole.

NB: In the unlikely event of a total system failure, the system will require retrieval of the tubing and permanent components also in much the same way as a standard ESP.

- Only when full electrical integrity was confirmed would the complete system run to pump setting depth.
- The ESP would be produced for a period of approximately one month before Phase 2.

▪ Pilot Test Phase 2 (retrieval and re-deployment by WL)



Approximately one month after the initial installation

- The well would be revisited without rig or hoist.
- The ESP would be retrieved on wireline, serviced and re-run on wireline.
- The ESP would then be put back on production.



WRESP INSTALLATION OPERATION : Hoist Preparation

1. All the material was sent to MB completion shop (Fahud, in the desert) and all the concerned members inspected the material and X overs for the operation.
2. All the assemblies were pre assembled and tested at MB completion Fahud prior to lowering.
3. 7" VAMFJL were planned to be run for the clearance issue.
4. Lifting subs were arranged for the handling of 7" VAMFJL casing.
5. Enough solid cable clamps were at site prior to start operation.
6. Lateral learning from the last trial were discussed and plan was modified accordingly.
7. Penetrator assemblies was tested to 5000 psi prior to shipment to Oman.



WRESP INSTALLATION OPERATION : Hoist Steps

1. Pre-Installation

- Check all equipment; Pre-MU in MB Fahud
- N/D Xmas Tree, N/U BOPs & Test
- POH existing ESP completion
- Perform clean out
- Casing Integrity test
- MB Wireline perform new WL Seasoning
- Change Wellhead: WHB2958F, mod TBG HGR / TH Adaptor, WHD75

2. Installation

- M/U Lower assy: WEG, DHG, DDV, Flow sub, Penetrator Can
- RIH 7" csg space-out
- Wireline drift run
- M/U & RIH Retrievable component: ESP Pump
- RIH ESP Pump assy & Lock Ratchet assy on WL
- Run 7" csg to surface
- Perform electrical test
- Wireline drift run to top of ESP
- Land Hanger, test
- Final electrical test
- ND BOP, NU & Test Xmas Tree

3. Commissioning

- Electrical test whole system
- Pump test



WRESP INSTALLATION OPERATION : Hoist Summary



1. Conducted tool box talk for the job with all the crew member and contractors.
2. Measurement of all the assemblies at site was done.
3. Made dummy runs for 5/16" braided Wireline for seasoning.
4. Made arrangement to run ESP cable, DDV control line and Safeway cable from the mast simultaneously.
5. R/I DDV and Safeway gauge and tested the completion to 21000 kpa.
6. R/I Penetrator assembly and space for lock ratchet assembly as per the length of motor assembly.
7. R/I 5 singles of 7" VAMFJL and R/U MB Wire Line.
8. P/U ESP motor assembly and lock ratchet assembly and ran with 7" GS tool.
9. Tried to Jar down the assembly but could not. Shear down the GS tool and R/I with Wire line assembly for Pull test.
10. During the pull test found ESP assembly is free.
11. Later on after the pull out found dogs were not sheared.



WRESP INSTALLATION OPERATION : Hoist Detail

- The permanent components of the WRESP shuttle system were made up and ran successfully
- The DDV (Downhole Deployment Valve) and PDG (pressure sensors) were pressure tested positive
- The electrical integrity of the system was tested fine {although it was observed that the measurements vary at different time of testing, which can be probably be explained due to extreme hot desert temperatures}
- The retrievable components of the WRESP system were made up and ran successfully – several attempts were made on Wire Line with sprang / Liner jars but no jarring could be achieved - the jars are needed to first shear pins in the Lock Ratchet Assembly to open dogs and lock the ESP in place and then subsequently to shear pins to release the GS running tool
- The lock down function of the Lock Ratchet Assembly is only needed to prevent high horsepower ESP system from jumping up on start-up
- The installation of WRESP system in well Rima-36 was successfully completed on 8th July
- The ESP descended, aligned and connected perfectly with good electrical integrity.



WRESP INSTALLATION OPERATION : Wire Line

Pilot Test Program Phase 2 (rigless replacement)

Retrieval and Redeployment : Scope Of Work

- Stop ESP
- Rig Up WL & Working Platform
- Rig Up WL unit
- Retrieve ESP on wireline
- Lay down Lock Ratchet Assembly and ESP
- Pick up and service ESP
- Re-install ESP on wireline
- Start ESP system



WRESP INSTALLATION OPERATION : Wire Line

Phase 2 - Retrieval and Redeployment

- *Phase 2 of the ESP Shuttle Pilot Test program was completed successfully on 14th August 2009. The ESP system (pump, seal and motor) was retrieved on wireline, disassembled, inspected, reassembled, serviced and then redeployed on wireline. The ESP was then started at 16:25 on 14th August.*
- The wireline drift run was completed to expected HUD at top of Lock Ratchet Assembly
- The 5" GS tool was run on wireline and latched into the Lock Ratchet Assembly. The ESP was unseated with 5000lbs upward pull and POOH.
- The ESP system was retrieved to surface and found to be in excellent condition.
- The Motor and Motor connector were pulled back for inspection and found to be in excellent condition. The Motor Connector, Motor and Seal Section were then serviced with clean dielectric oil according to standard ESP service procedures
- Wireline equipment was RU and the ESP string RIH on wireline. At HUD less than 14 jars down were required to release the ESP and electrical integrity was established.
- At 16:25 on 14th August the ESP was re-started with indications (pending well test) at good flow.

Job duration (Net WL operation)

- ✓ Dummy WL run (drift run): 3 hours
- ✓ Pull ESP, clean the pump, change LRA, re-run ESP: Duration 5 hours



OPERATIONAL LEARNING / CHALLENGES - Hoist / WL

1. Wireline Running

- Jars used was not appropriate for setting & locking Pump assembly
- NPT related to Wireline run was 64 hrs {2.6 days}
- Jar BHA for ESP needs to redesigned

2. Lock Ratchet

- Jarring action failed to lock the Pump assembly using Lock Ratchet
- Set ESP pump but without locking in the Landing Nipple
- POOH Pump 3 times with 7" GS pulling during pull test
- Pins for Lock Ratchet mandrel were not sheared by jarring actions
- GS tool pins design to shear at higher force were sheared
- When all pins were removed it took several jarring to release Jar off Pump

3. Hook Up

- Pump test was successful; flowed to Crude Oil tank for 1 hr to proof pump
- Flow line hook-up will take few days due to height of new well head
- Sensor gauges also required civil work & team already visited location
- Hook up member should be part of every special well completion project



PDO WIDE DEPLOYMENT STRATEGY: Pilot trials

- Plan to install 4 WRESP systems in South & North Clusters (9 5/8" & 7" csg size) as a pilot test.
 - 1st Trial in South, Well-A. (WG Pump)
 - 2nd Trial in North (Well-B). Deployment preparation is on going. In the Hoist sequence for mid May-2010 (WG Pump)
 - 3rd & 4th trial (North & South) in Q2 & Q3-2010 (Centrilift Pumps)
- Objectives of Pilot Trial
 - Enhance / follow the development of the completion configuration (gas handlers, solids handlers, improve downhole sensors, increase through-bore access size to reservoir)
 - Establish in-house WL deployment capability, competence (PEs & CIW)
 - Improve WL deployment tools configuration (jars)
 - Possible test the weight (pull) limit of WL. This impact the length of the retrievable component of the system
 - Test other vendors' ESP
- Formulate PDO wide strategy
 - PDO WL dedicated team (include key stake holders: PE; Ops)
 - Establish the selection criteria for ESP wells eligible to be converted to WL deployment method. [work closely with Asset Teams]
 - Target some 20 to 30% of ESP population.
 - Contractual aspect
- Time line (current estimate):
 - Assessment of the technology & benefits of 4 wells pilot : yr 2009 to 2010
 - Roll on deployment: yr 2011 onward



OVERALL TECHNOLOGY CHALLENGES

- Further development of the system is needed to tackle current technical limitations for WRM (Well & Reservoir Management) requirements.
 - To handle gas (fit with gas separators, gas handlers) & solids production (fit with check valves, ADV)
 - To have retrievable down-hole gauges, to ensure continuous data acquisition.
- The system completion design need to be improved:
 - To allow the integrity pressure test of outer casing (casing next to producing csg/tubing) to be in line with company's integrity failure policy. To avoid Hoist intervention.
 - To enable the usage of the conventional wellhead to eliminate additional cost to the technology.
 - To ensure retrieval is managed in case of sand production. (improve clearance?)
 - Handling of 7" lubricator for full ESP compl assy (78ft) is an issue in case of DDV (Downhole Deployment Valve) failure.
- Commercial side of the technology need to meet company's overall economic cut-off.
- ESP WL deployment philosophy is a completely new concept to PDO and world wide industry at large. Hence a dedicated WL team is required to pursue the company wide implementation of this technology.
- Flexibility of ESP contract is needed to cater WL deployment operational philosophy, such as preventive maintenance of ESP, etc, in order to fully realised the benefits.



CONCLUSION

- WRESP deployment method has a lot of benefits to PDO that will eventually:
 - Increase ESP uptime
 - Increase ESP run-life
 - Reduce oil deferment
 - Minimize Hoist count, which will decrease life cycle cost
- WRESP technology has to be commercially attractive to tap in the values in typical PDO operational environment
- WRESP technology has to be technical robust to handle PDO well conditions
- The contract approach of the WRESP need to be flexible to ensure the benefits obtained from improved existing conventional ESP contracts is realised
- When proven economic & operational sound, 20 to 30% of ESP population can be equipped with WRESP



THANK YOU

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BACK UP SLIDES



Operational Learning / Challenges

- Equipment 'inspection and make-up day' at Fahud {Completion Workshop} was time well spent
- PCA and MCA should be stored in boxes with lids (out of direct sun-light)
- Control line for DDV should be pre-filled with hydraulic oil 'off-line'
- 6.055" Drift should be modified to increase flow through / bypass
- Congestion on rig floor needs careful management
- Spares needed for adjustable union set screws and lugs
- Fit handling pups to all components to aid handling / prevent thread damage
- Remove sharp edges on Cannon clamps to prevent damage to c/l and i-wire
- Prefer Tubetec clamps to Cannon clamps
- Route control line and i-wire on same side of Penetrator Can and power cable
- Make up PDG to Penetrator Can in Fahud shop (PDG arrived too late)
- Need swivel in Penetrator Can lifting sub to aid handling
- Function test hydraulic oil pump before operation
- Protect PDG control box from damage in direct sunlight
- Hand torque critical connections
- Need protection sleeve for motor connector.
- Review MB jar design, specification, stem configuration etc.



Operational Learning / Challenges (cont'd)

- Field redressing of LRA needs stands to bring to working height
- LRA best wound back with strap wrench
- Pull test not needed for ESPs with low power to weight ratio
- External marking of components (LNA and PCA) would facilitate space out
- One crane with two winches would greatly facilitate retrieval program
- Development of a standard toolkit to facilitate program
- Review choice and design of DDV (e.g. fail close, high reliability ball valve)
- Seal damage on POH can result in toolstring taking overpull
- Method developed for freeing toolstring with excessive overpull
- Daylight requirement limits flexibility of program – source flood lights?



Operational Learning / Challenges- Detail

	Activity step description	Area for Improvement
i	M/U Lower assy: Permanent component	a. Pup join M/U before hand, at the site on the ground using chain tong
		b. Function test hydraulic oil pump before operation
ii	W/L drift line	a. 6.055” Drift should be modified to increase flow through / bypass and reduce weight
iii	M/U & RIH Retrievable component: ESP pump	a. Control line for DDV should be pre-filled with hydraulic oil ‘off-line’
iv	RIH ESP Pump assembly & Lock Ratchet Assembly on WL	a. Correct jars & configuration are needed to appropriate setting & locking Pump assy.
		b. NPT related to WL run was 6 hours at
		c. Jarring to shear GS tool at 65 m depth could be a challenged due to less column weight & lack of fluid.
		d. Jar BHA for lower ESP needs to be re-designed
		e. Jarring action failed to lock the Pump assy using Lock Ratchet
		f. Set ESP pump but without confirmation of locking in the Landing Nipple
		g. POOH ESP 3 times with 7” GS pulling during pull test. NB: Pull test not needed for ESPs with low power to weight ratio
		h. Pins for Lock Ratchet mandrel were not sheared by jarring actions.
		i. GS tool pins design to shear at higher force were sheared
		j. When all pins were removed it took several jarring to release Jar off pump.
v	Rig floor	a. Congestion on rig floor needs careful management



Operational Learning / Challenges-Detail

Equipment (/dressing / servicing / storage / spares / readiness / handling)

	Activity step description	Area for Improvement
i	Spares	a. Spares needed for adjustable union set screws and lugs
ii	Storage	a. Equipment (particularly Penetrator Can assembly and Motor Connector) should be stored in boxes with lids on (out of direct sun-light)
		b. Protect PDG control box from damage in direct sunlight
		c. Need protection sleeve for motor connector.
iii	Handling & Logistic	a. Fit handling pups to Landing Nipple Assembly (and all critical components) to aid handling and prevent irreparable damage to critical threads
		b. Remove all sharp edges on Cannon clamps to prevent damage to control line and i-wire
		c. Route control line and i-wire on same side of Penetrator Can and power cable
		d. Need swivel in Penetrator Can lifting sub to aid handling
		e. External marking of components (LNA and PCA) would facilitate space out measurements



Operational Learning / Challenges-Detail

Equipment (/dressing / servicing / storage / spares / readiness / handling)

	Activity step description	Area for Improvement
iv	ESP Clamps	a. Prefer Tubetec clamps to Cannon clamps
v	Jars (during WL operation)	a. Complete review jar design, fit-for-purpose, specification, operating envelope, stem configuration, centralization with MB
vi	Lock Ratchet Assembly	Field redressing of LRA needs proper supports to bring to working height and strap wrench (possibly handle on base to help rewinding)
vii	Crane (pick-up assy in WL stand-alone retrievable operation)	a. One crane with two winches would greatly facilitate retrieval program
viii	Tool kit for WRESP operations	a. Development of a standard toolkit to facilitate program – do not make assumptions or rely on ‘standard’ tools being available at rig/hoist.

