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Unlocking Well Potential and Improving Well Accessibility using Electricline Cleaner and Miller at Offshore Field Pertamina Hulu Mahakam

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Abstract. Mahakam field was experiencing gas production decline in some offshore wells. Previous interventions done in the past indicated the high probability of scale and sand which had reduced the production flow path, it had also prevented perforation gun from reaching the target depth in order to perform additional perforation to increase well potential.

Considering existing perforated reservoirs in the wells were still productive, Pertamina Hulu Mahakam (PHM) preferred to use well clean out method without invading/damaging open reservoirs. The additional cost of lost or deferred production was always unwanted. The deployment of traditional rig or coiled tubing unit to help restoring production came with considerable cost due to the equipment and personnel requirements. Consequently, PHM continually looked for new techniques to reduce this challenge. Milling on wireline, where applicable, was one solution since it could be performed in rig-less environment.

The delivery of wireline deployed milling services had been provided by conveying a specially designed milling tool which had its own built in control, power and drive section. The bit design could be customized to make the tool fit for specific application.

For a milling tool to operate properly on wireline, there were 2 physical principles that were needed to be dealt with; weight on bit (WOB) and anti-torque. To address this, wireline tractor was used.

This system fit perfectly with the context of mature field; simple, cost-effective, safe and easy to handle.

Keyword: Scale Removal, Well Intervention, Electricline Miller

1 Introduction

The Mahakam area is part of the Kutai Basin, located in Kalimantan, Indonesia, on the eastern coast of the island of Borneo. It is a very old petroleum province, where production started one century ago. However, the swampy coastal plain and the adjacent offshore area remained untouched until they were opened to the industry in the late 1960s new cycle of oil and gas discoveries took place thereafter, utilizing seismic technology to locate structural closures. Production from these fields began. A to decline in the early 1980s.

Previous interventions done in the past indicated the high probability of scale and sand which had reduced the production flow path, it had also prevented perforation gun from reaching the target depth in order to perform additional perforation to increase well potential.
It was often the case that the entire inside diameter (ID) of the tubing was not completely plugged with sand. Rather, wells often contained sand bridges, pockets of sand that accumulate around the ID variations in the wellbore. Sand bridges could reduce or stop well production, but easier and faster to clean because the volume of sand was smaller compared to when the tubing was completely plugged.
Due to the uncertainty of downhole conditions, two types of electric line clean out tool (electric line cleaner and miller) were mobilized. The miller was planned for running in order to disintegrate or break the hard and compacted debris which requires mechanical agitation/milling before cleaning by electric line cleaner. The miller tool was run in combination with an electric line tractor to apply weight-on-bit as needed and to counter any reactive torque. It was also completed with accessories like pressure-compensated swivels, casing collar locator (CCL) and an electronic release device.

2 Methodology

2.1 The Electric Line Tractor

The electric line tractor (shown in Figure 1) is an electric-over-hydraulic tool operated via a wireline cable. The wireline transmits power to the tractor's electric motor that drives a hydraulic pump and moves the tool string forward. When hydraulically activated, multiple wheel arms extend from the tractor body to push multiple, circumferentially opposed, hydraulically-driven wheels with constant force against the tubing wall. The arms/wheels engage the tubing wall and adapt to the changing internal diameter of the pipe as it moves along. A passive and immediate fail-safe system ensures that the wheels retract under abnormal conditions.
During different phases of the intervention, the tractor conveys the milling tool, driving the tool string through highly deviated or horizontal sections of the cased well bore without the use of drill pipe, threaded tubing or coiled tubing. The tractor also provides Weight-on-Bit (WOB) during the milling operation and as a reactive torque counter.

Figure 1 – Electric line Tractor

2.2 The Electric Line Cleaner

The Electric Line cleaner (shown in Figure 2) for liquid environments uses vacuum flow as the main force in the bailing of debris. The system consists of a basic rotational unit (BRU) that includes electronics, pressure compensator and electric motor sections. Once the tool is powered via wireline, the BRU drives a pump which creates the vacuum flow to circulate through the tool, dragging sand through the intake holes into the trap bailers where the debris is deposited.

Figure 2 – Electric line Cleaner

2.3 The Electric Line Miller

The electric line miller (shown in Figure 3) has an electric motor with an interchangeable gear box that varies in torque and speed (RPMs) dependent on the material to mill. The miller tool must be run with either the e-line tractor or a hydraulic stroking tool to provide the required WOB for milling and to counter the reactive torque against the mill bit rotation.

Figure 3 – Electric line Miller

3 Result and Discussion

3.1 Case History 1 (PK-2K)

3.1.1 Background, Objectives and Challenges

PK-2K had around 0.2 MMscfd production rate. In order to get additional gas rate from this well, new additional perforation on reservoir F165 (4919 – 4921 mBRT) was proposed. Unfortunately, the reservoir was covered by sediment. During well intervention, a 3.5" Gauge cutter to check TOS, where it stopped at 4860 mBRT. A 2.3" slickline pump bailer was run to bail sediment; it recovered 4 liters of soft sediment in 2 runs. Total recovery was 12 liters. Sand cleaning was required to re-gain access until 4925 mBRT for additional perforations. Detail well data shown in Figure 4.

Challenges:

- Depleted reservoirs
  Coiled tubing operation was avoided (subject to reservoir damage)
- High pulling weight history
- Target of interest at 4921 mBRT (deeper compared to other Peciko field wells)

3.1.2 Well Data

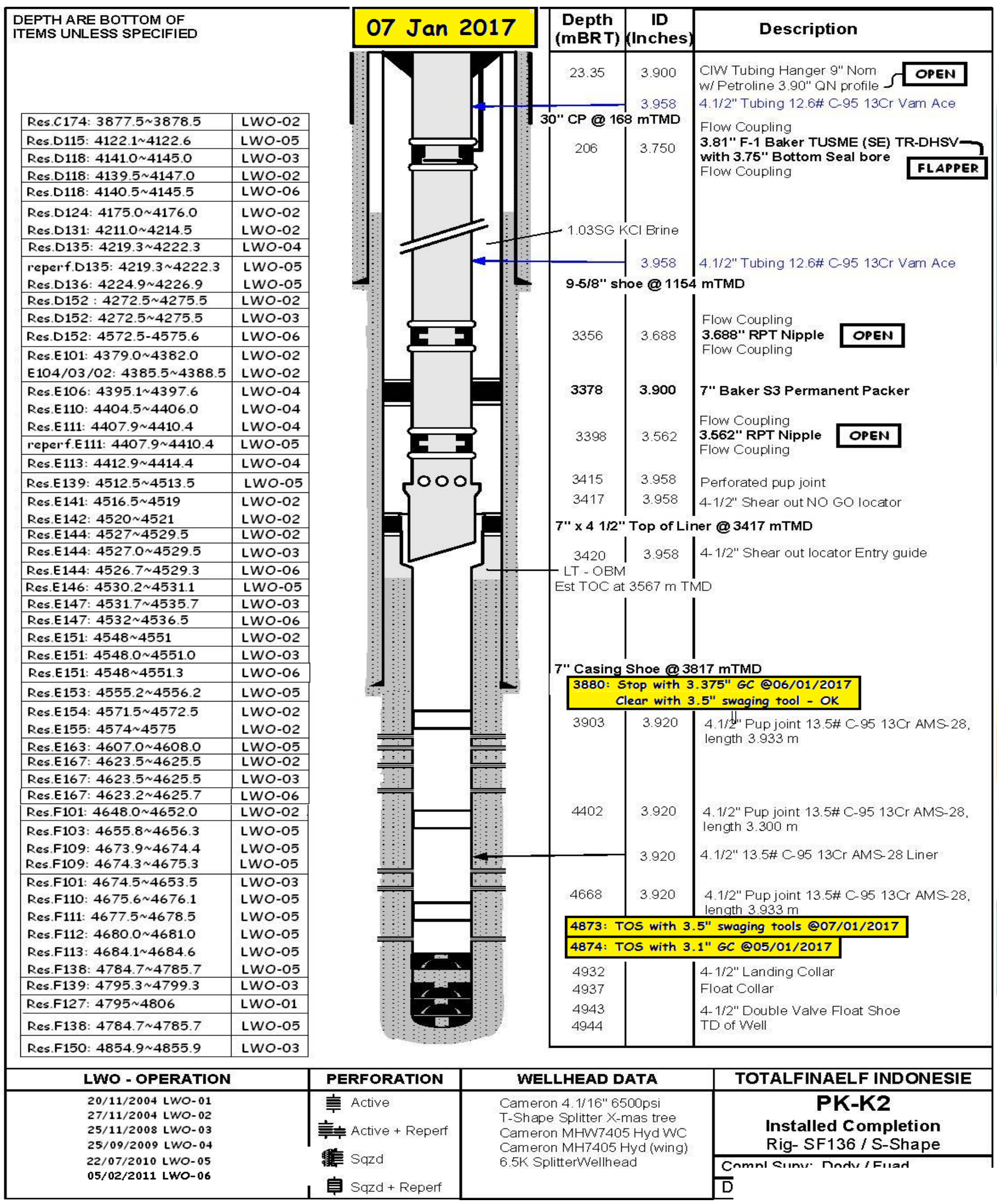


Figure 4 – PK-2K well diagram

Well Status	:	Flowing 0.2 MMscfd
WHSIP	:	1200 psi, based on record on 22 Jan 2017
Ann #A/B/C	:	0/0/0 bar, MAWOP:138/69/17 bar
Wellhead Connection	:	4-1/2"; 6.5K psi with BX-155
Minimum Restriction	:	3.562" RPT landing Nipple at 3398 mBRT
Maximum Deviation	:	52.16^{o} at 870 mBRT
Well Temperature	:	146 ^{o}C
Fluid Level	:	4208 mBRT
Future Perforation Plan	:	Shown in Table 1

Table 1. Future perforation plan

Reservoir Name	Fuid	Top Perf (mTMD)	Bottom Perf (mTMD)	Perf Length (m)	PHI AB (%)	Deq Min	Deq Max
C173	GAS	3868.6	3869.9	1	0	0.2	0.4
C173A	GAS	3874.7	3875.7	1	0	0.2	0.4
E162	GAS	4604.9	4605.9	1	0	0.37	0.5
E164	GAS	4611.2	4612.2	1	9.58	0.2	0.44
F101	GAS	4649	4650.5	1.5	11.29	0.24	1
F107	GAS	4664.8	4665.8	1	0	0.8	1
F165	**GAS**	**4949**	**4912**	**2**	**14.5**	**1**	**1.32**
F165 *covered by sediment*							

3.1.3 The Solution

Potential solution of this long interval sediment cleaning:

- **Coiled Tubing sediment washing**
  PROS: Proven technology
  CONS: Costly and high potential to cause reservoir damage
- **Slickline Bailing**
  PROS: Cost effective and proven technology
  CONS: Time consuming and low success ratio
- **Electricline/Wireline**
  PROS:
  - No circulation needed (eliminate potential well loss and formation damage)
  - No additional fluid/chemical injection
  - Job duration shorter compared to slickline and coiled tubing
  - No shortfall for high producer adjacent wells
  - Logistic friendly (less complex, no heavy lifting involved)
  - Cost effective compared to Coiled Tubing operation

CONS: First pilot project

Considering all the pros and cons potential solution of this long interval sediment cleaning, then electricline/wireline option was chosen.

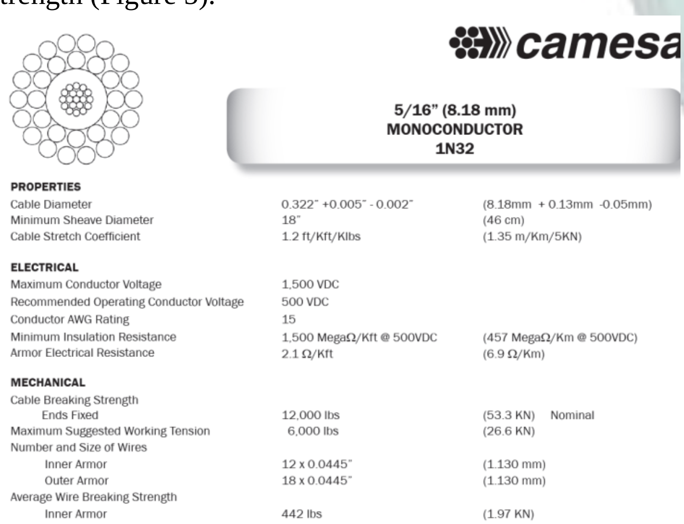
3.1.4 Job Procedure

PK-2K sediment cleaning using electricline procedure

1. Rig up E-line PCE and test as per procedure
2. RIH Well Cleaner with speed 30-50 m/min, while performing correlation to the cleaning depth
   Note:
   - Reduced speed when passing restrictions
   - Stopped every 500 m to check pick up weight
   - Continuously recorded the pickup weight
3. Rig up E-line PCE and test as per procedure
4. RIH Well Cleaner with speed 30-50 m/min, while performing correlation to the cleaning depth
5. Activate Well Cleaner
   Note:
   - Maximum penetration speed 6 ft/min
   - Regular pick up tension every 1m progress
   - Performed long sweep to 4870 mBRT every 5 meters' progress
6. POOH Well Cleaner to surface once bailer sections are full and Re-RIH until target depth
   Note:
   - Proceeded with scale milling when found hard sediment/cement during cleaning

Electricline cable selection

From tension simulation using 5/19" cable with breaking strength of 12,000 lbs and working tension 7,200 lbs (60%) breaking strength (Figure 5).


camesa

5/16" (8.18 mm)
MONOCONDUCTOR
1N32

PROPERTIES		
Cable Diameter	0.322" +0.005" - 0.002"	(8.18mm + 0.13mm -0.05mm)
Minimum Sheave Diameter	18"	(46 cm)
Cable Stretch Coefficient	1.2 ft/Kft/Klbs	(1.35 m/Km/5KN)
ELECTRICAL		
Maximum Conductor Voltage	1,500 VDC	
Recommended Operating Conductor Voltage	500 VDC	
Conductor AWG Rating	15	
Minimum Insulation Resistance	1,500 MegaΩ/Kft @ 500VDC	(457 MegaΩ/Km @ 500VDC)
Armor Electrical Resistance	2.1 Ω/Kft	(6.9 Ω/Km)
MECHANICAL		
Cable Breaking Strength		
Ends Fixed	12,000 lbs	(53.3 KN) Nominal
Maximum Suggested Working Tension	6,000 lbs	(26.6 KN)
Number and Size of Wires		
Inner Armor	12 x 0.0445"	(1.130 mm)
Outer Armor	18 x 0.0445"	(1.130 mm)
Average Wire Breaking Strength		
Inner Armor	442 lbs	(1.97 KN)
Outer Armor	442 lbs	(1.97 KN)

Figure 5 – Electricline cable selection

3.1.5 Job Execution

Even though there was suspect of debris bridging, the amount of debris in the well was expected to be substantial. Low recovery efficiency by slickline led the operator to search for alternative solutions. It was decided to mobilize electric line cleaner. Electric line Miller was also mobilized as contingency plan if hard/compact debris was found. During slickline Gauge cutter (tubing clear) run, it was found that the top of sand is 20 m shallower than previous intervention, and this had increased the clean out interval from 30 to 60 meters.

On the first run of electric line cleaner, good recovery was achieved (12.6 liters with 3 bailers) (see Figure 6), the depth progress was 4 meters but on the next 4 runs, the recovery was not very significant (2 liters per run in average). Contaminated sand with pieces of metal (suspected from gun debris) was recovered and there was no depth progress. It was suspected that the Electricline Cleaner tool string was hung up at the same depth due to hard restriction.

Decision to run Electric line Miller with 3.5" tapered scale bit was then made. During milling run, there was effective milling indication at the point where the electric cleaner was hung up on the previous run. Milling was performed for around 3 meters' interval in 4 milling cycles then POOH and prepared for electric line cleaner run.

After the milling, the recovery efficiency of the well cleaner increased significantly, and on the next 5 runs of well cleaner, the average recovery was around 16-17 liters per run. On the last 2 runs, only 1 liter of debris recovered per run. However, the target depth was achieved, and last tag depth was 4934.7 mBRT (initial target depth was 4921 mBRT). Objective was met and access for perforation was regained. Detail runs sequence described below and shown in Table 2.

Table 2. PK-2K Job Log

Run #	Worked Depth (m)	Filter Micron	Chambers	Type of fill	Fill Recovered (liters)
1	4874	100µ	3	Wet sand	12.7
2	4874	100µ	4	Wet sand	2.6
3	4874	100µ	4	Wet sand	2
4	4874	100µ	3	Wet sand	0.3
5	4874	250µ	3	Wet sand	4
6	4874	250µ	3	Wet sand	16.1
7	4876.4	250µ	3	Wet sand	16.1
8	4880.7	250µ	4	Wet sand	16.1
9	4885.5	250µ	4	Wet sand	17.8
10	4889.7	100µ	4	Wet sand	17.8
11	4893.9	100µ	4	Wet sand	17.8
12	4906.4	100µ	4	Wet sand	1
13	4934.7	100µ	4	Wet sand	1

Figure 6 – Recovered debris (PK-K2)

3.2 Case History 2 (PK-14K)

3.2.1 Background, Objectives and Challenges

Last additional perforation was done in January 2017. After perforation, the total gas rate was > 4 MMscfd. From the original 33m perforation proposal, the operation only managed to perforate 8 m due to restriction at depth 3959 mBRT. The production declined to est. 2.5 MMscfd which led to re-evaluation of the possibilities of sand milling. The main objective of this job was to regain access to the bottom of the perforation interval and to limit the deposition of scale which had been growing at the rate of 0.5 m/month (compared with TOS in 2015). The restriction almost fully blocked the access with only a minor flow path open for gas production. Detail well data shown in Figure 7.

Challenges:

- Obstruction profile unknown
  Running MIT (Multi Imaging Tool) was impossible since the smallest gauge cutter could not pass through
- Length of obstruction unknown
  Running IB (Impression Block) got clear mark on the bottom of IB
- Type of obstruction unknown
  Running slickline bailer with no recovery
- Other concern
  Potential stuck from the last intervention and marginal cost

3.2.2 Well Data

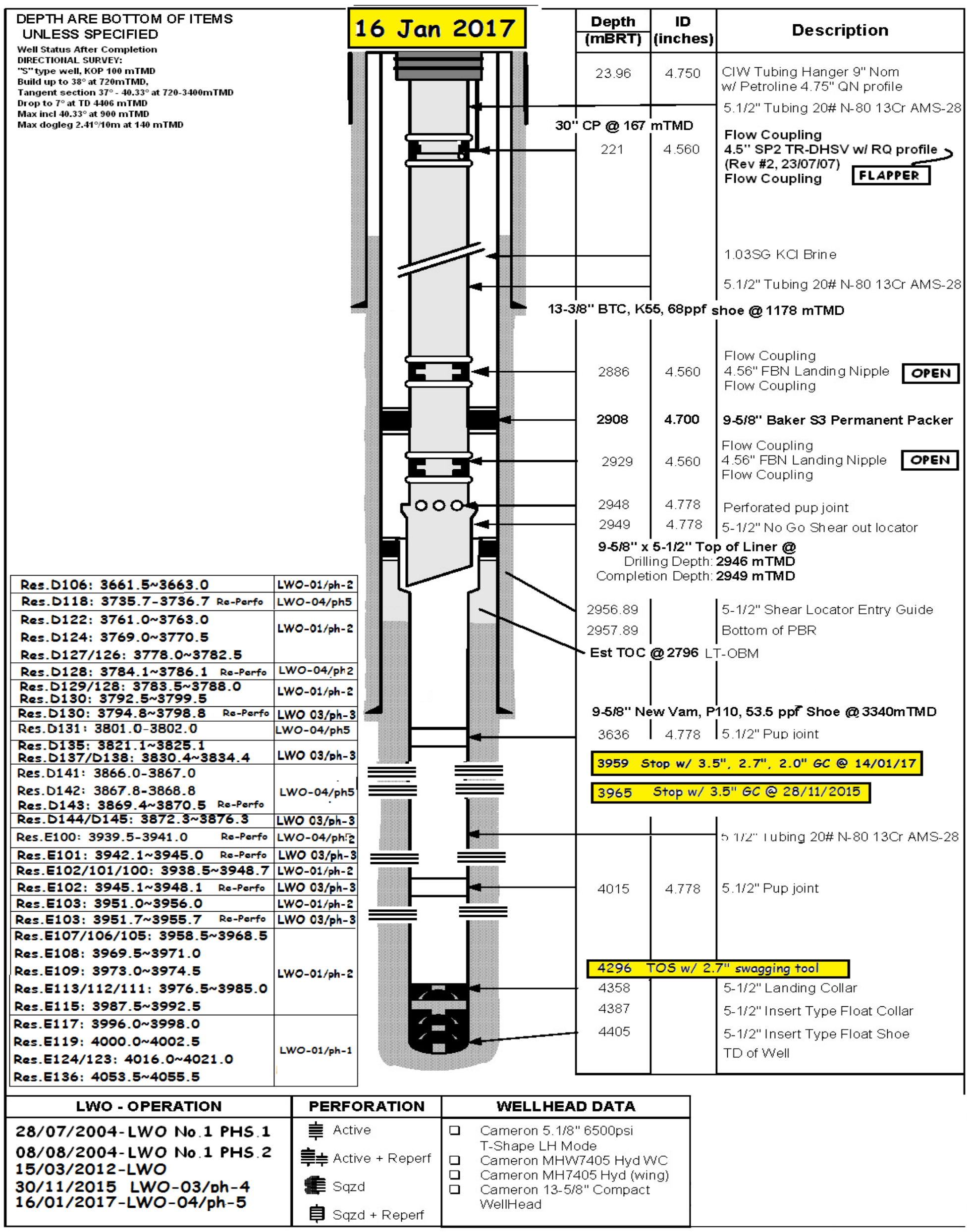


Figure 7 – PK-14K well diagram

3.2.3 The Solution

Potential and preferred solution referred to section 1.3 above. PK-14K decision tree shown in Figure 8 below:

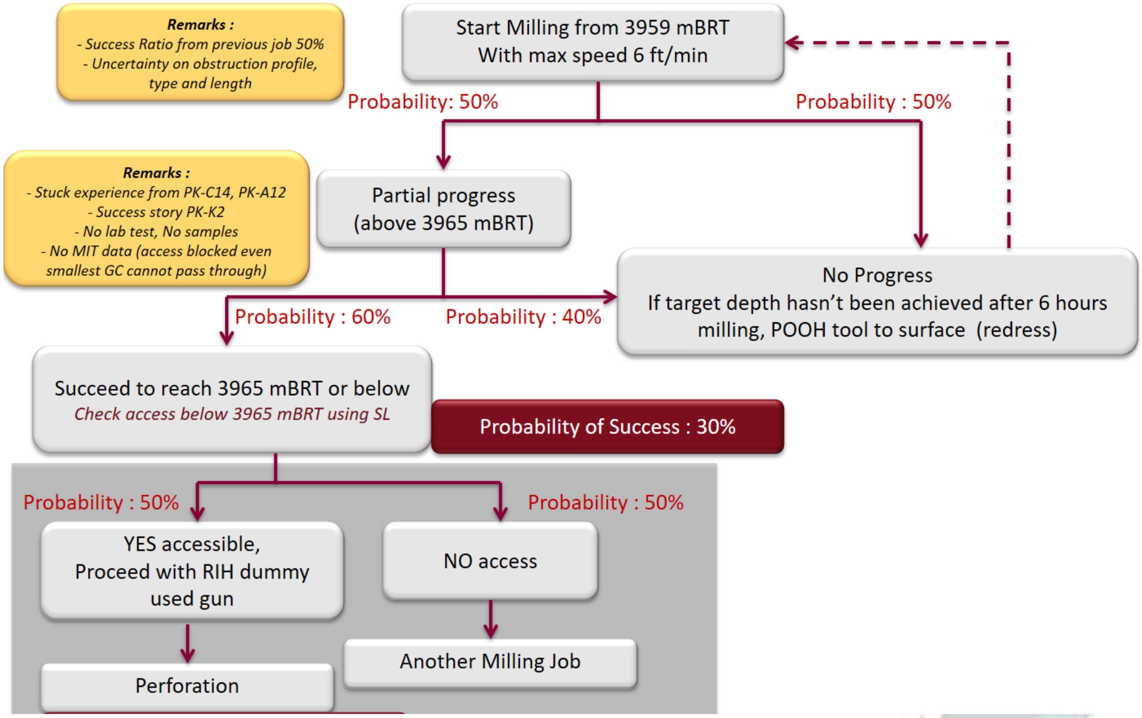


Figure 8 – PK-14K decision tree

3.2.4 Job Execution

Due to the uncertainty of the nature of the scale bridge, 2 types of milling bits were mobilized, namely concave scale bit and tapered scale bit.

The electric line cleaner and electric line miller was run alternately to prevent the tool string buried by the cutting from the milling due to no circulation. Total 4 runs were done for each electric line cleaner and miller; recovered 12.5 liter of scale and 2.5 liter of sand with total depth clean out interval was 339 meters (recovered debris shown in Figure 9).

Figure 9 – Recovered debris (PK-14K)

4 Conclusion

The clean out technology on electric line fit perfectly with the context of mature field; simple, cost-effective, safe and easy to handle. Any field with fluid sensitive reservoirs could apply this technology and re-entered their wellbores as they declined without the risk of losing future production.
Benefits of the electric line cleaner and miller tool include safer operation compared to heavier intervention methods, such as CT, because less and lighter equipment, fewer lifts, and fewer personnel required.
The electric line cleaner and miller tool also demonstrated to the operator that sand or scale bridging does indeed occur, as opposed to the accumulation of full sand columns.

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Nomenclature

BRU	- Basic Rotational Unit
CCL	- Casing Collar Locator
CT	- Coiled Tubing
IB	- Impression Block
ID	- Inside Diameter
mBRT	- Meter Below Rotary Table
MIT	- Multi Imaging Tool
MMscfd	- Million Standard Cubic Feet per Day
PCE	- Pressure Control Equipment
POOH	- Pulling Out of Hole
RPM	- Revolutions Per Minute
TOS	- Top Of Sand
WOB	- Weight On Bit

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