Maximizing Brown Field Production In High Artificial Lift Failures Frequency Environment As A Result Of Wells Harsh Conditions

Mahmoud Sayed
Senior Specialist Production Technology

GPC WORKSHOP 2023
"Go to Green-Sustain Oil Gain"

Agenda

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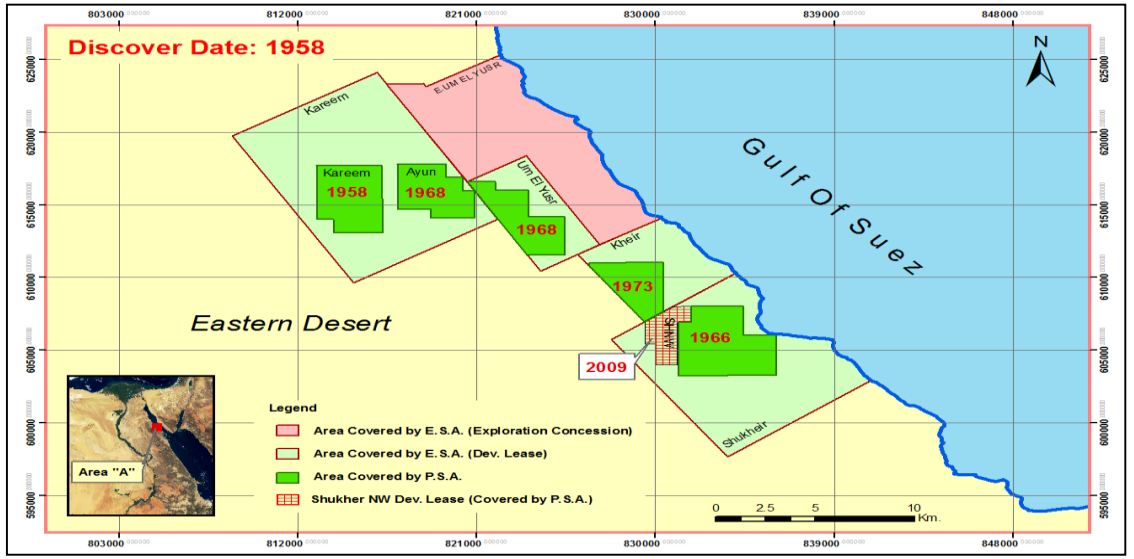
Introduction: AREA-A Wells
Nature & Challenges

Field Overview

Location	350 Sq. Km, Eastern Desert
Operators	KEE, 70% WI, 30% WI for PETROGAS.
Running wells	59
Producing Res.	HF (50%), Yusr (21%), Kareem (12%) & others(17%)



AREA-A Reservoir Parameters:

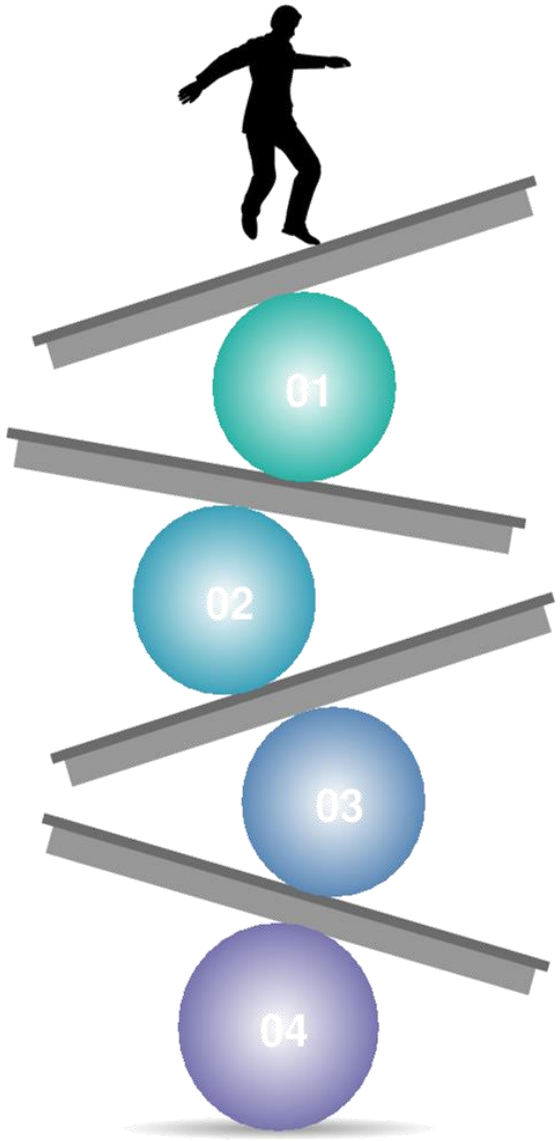
- Very Low Pressures down to 100 PSI; with average pressure in HF with 150 PSI, and 500 PSI in Yusr reservoirs; Average depths is 700 Mt. for HF reservoir and 1100 Mt. for Yusr reservoirs.
- Very High Conductivity of PI 20 BBD/PSI; with maximum production of 1800 BBL/Day in HF reservoir.
- Average Associated gas with oil is 100 KSCFD.

Introduction: AREA-A Wells

Challenges and Harsh Conditions

Sever Sand Production

- Due to Depletion, shallow depths, and high conductivity; severe sand production encountered with non uniform sand sorting;



High Conductivity Reservoirs

- Estimated PI of SHNW area about 10 BBD/PSI; however, of the depletion encountered, the reservoir AOF could be 1900 BBL/Day
- Difficulties of running ESP at these levels of very low reservoir pressure with associated high GOR and severe sand production; which require another new techniques of Artificial lifting methods to produce such high rates

Depletion

- Average reservoir pressure in AREA A fields is relatively very low down to 100 PSI
- Due to Depletion; increase the need to run as deep as possible near to perforations or below perforations; thus, increase of pump sticking troubles due to sand production

Old/Loose Integrity Wells

- AREA-A Fields is old fields since 1950's; thus, led to lose integrity CSG and obsolete CSG Weights; thus, requires special equipment specifications (i.e., 7", 20 IB/Ft. Packers)

Challenges Mitigations Techniques

AREA-A Sand Production Solutions Scenarios

SCENARIO 1

Stand Alone Sand Screens

- *Performed Sieve Analysis.*
- *Sorting Coefficient was poor to select any of current market screens*
- *Most Suitable screen size is 12-20 Mesh size*

Results

- Many wells showed pump sticking due to passing sand
- Many wells showed screen plugging.

SCENARIO 2

Gravel Pack & Frack Pack

- *Performed required geomechanically studies.*
- *Found Gravel Pack will induce additional pressure drop from 100 to 300 PSI whilst average area reservoir pressure is only 150 PSI*
- *Costly operations compared with other solutions.*
- *Difficulties to comply with current loose wells integrity*

Results

- Excluded the solution

SCENARIO 3

Optimize Wells Draw Down and Keep Pump shallower

- *Keeping Pump shallower than the formations*
- *Optimize SRP Parameters to minimize draw down and control sand Production*

Results

- Productivity of wells affected by 20 to 50%
- Gas Lock troubles increased
- Successful solution in one of severest sand producers (SK-01)

SCENARIO 4

High Clearance Pumps; and larger ball and seat sizes

- *AREA-A Wells started with -0.003 Plunger Clearance, then increased gradually to -0.005, and ended finally with -0.007 plunger clearance*
- *Another Approach extended to -0.009 & -0.011 Plunger clearance; installed in wells;*

1. *W-Elkhaleg-1X: However, placing pump to the perforations; the pump efficiently handled the sand*
2. *Kareem-15: However heavy sandy oil production, the well showed stabilized flow with -0.011 pump clearance*

Results

- As result of shallow depths; lower oil slippage encountered even if clearance was -0.030 (+/- 50 BBL) Excellent results in problematic wells i.e W-Elkhaleg-1 & K-15

SCENARIO 5

PCP Pumps

- *Successful sand handling solution and KEE had success story in two wells (Ahmed-02 & Yusr-38)*
- *PCP Can't be standardized as permanent solution since its design is critical due to the following:*
  - *Depletion; since PCP requires certain designed head above pump*
  - *High GOR*
  - *Sand Settling Velocity is not suitable for low productivity wells*

Results

- Excellent results in well Ahmed-02; and acceptable results in wells Yusr-38

Challenges Mitigation Techniques

AREA-A Sand Production Solutions “High Clearance Pumps”

Kuwait Energy

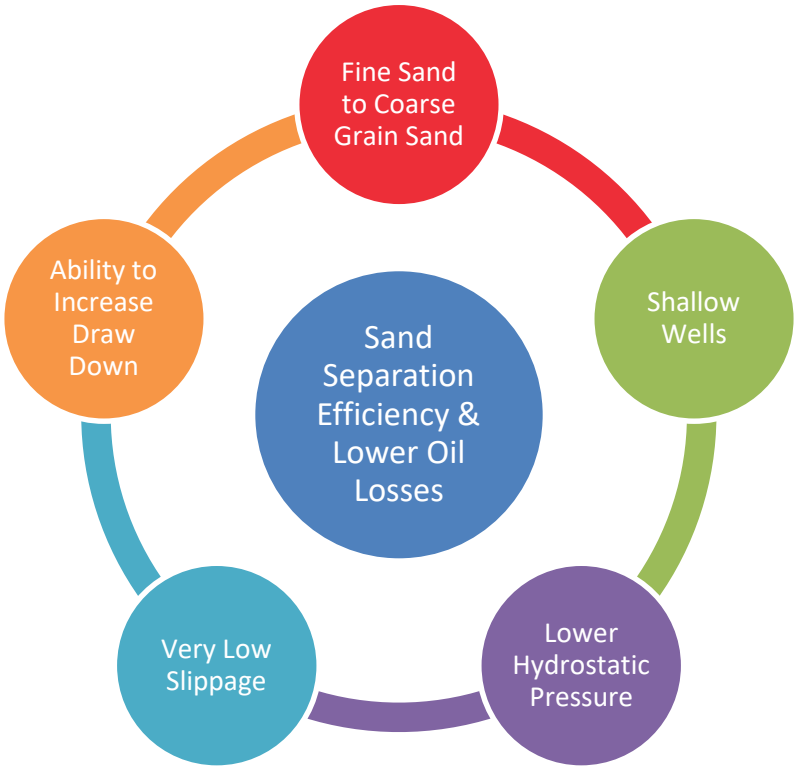
High Clearance Pump Technique:

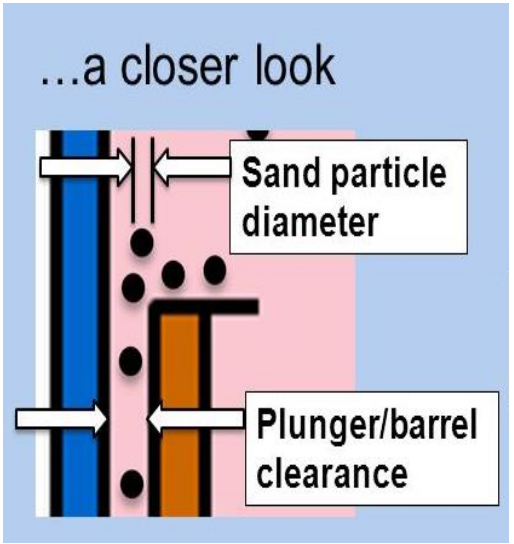
Increase clearance between Plunger and barrel from current standard value of -0.003 & -0.005 to higher value of -0.009 or more up to -0.011

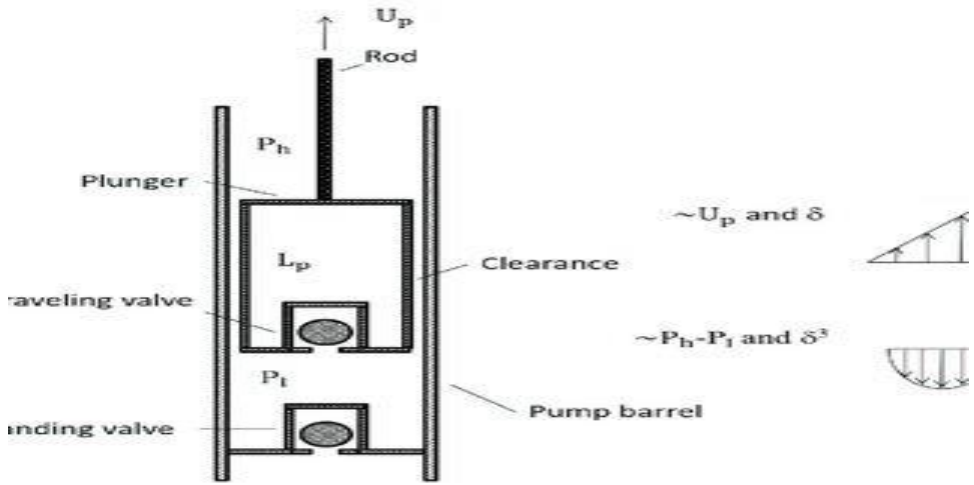
Increase Clearance reduces risk of Plunger sticking with barrel; but cause production drop due to increase slippage

Technique Applications Basis

- AREA-A Wells Produces from relevant shallow depths 700 to 1200 Mt.; which induces hydrostatic pressure of average of 1500 PSI
- AREA-A Wells running with excessive high parameters and large bore size pumps which compensate any production drop due oil slippage







Challenges Mitigation Techniques

AREA-A Sand Production Solutions “High Clearance Pumps”

Oil Slippage Calculations Basis

Viscosity in Centipoise, at temperature (°F) and API gravity

API GRAVITY	60°	70°	80°	90°	100°	120°	140°	160°	180°	200°	220°	240°	260°	280°	300°
14	5000	3000	2000	1000	750	300	190	80	52	33	24	17	12	9	8
19.8	350	250	180	140	100	60	40	27	19	14	11	8.7	6.8	5.8	5
26.8	49	38	29	23	19	13	9.5	7	5.8	4.5	3.7	3.2	2.8	2.4	2.1
31.1	12.5	10	8.8	7.4	6.5	5	4.1	3.3	2.8	2.4	2.1	1.9	1.6	1.5	1.3
34.6	7.8	6.4	5.5	4.5	4	3.3	2.6	2.1	1.8	1.6	1.4	1.3	1.1	1	0.9
44	3.3	3	2.7	2.4	2.2	1,9	1.7	1.4	1.3	1.2	1.1	0.9	N/A	N/A	N/A

Plunger Diameter, inches	D	2.250
Plunger seal Length, inches	L	48
Fluid Level from Surface, feet		1,500
Specific Gravity of Fluid		1.00

(Enter these four data items,
then read slippage below by
choosing viscosity and clearance.)
(If needed, a viscosity conversion chart is below)

Slippage in Barrels per Day

Clearance inches C	Viscosity in Centipoise μ 1	2	4	8	16	32	64	128	256	512	1028
0.001	0.73	0.36	0.18	0.09	0.05	0.02	0.01	0.01	0.00	0.00	0.00
0.002	2.09	1.05	0.52	0.26	0.13	0.07	0.03	0.02	0.01	0.00	0.00
0.003	3.87	1.94	0.97	0.48	0.24	0.12	0.06	0.03	0.02	0.01	0.00
0.004	6.00	3.00	1.50	0.75	0.38	0.19	0.09	0.05	0.02	0.01	0.01
0.005	8.42	4.21	2.11	1.05	0.53	0.26	0.13	0.07	0.03	0.02	0.01
0.006	11.11	5.56	2.78	1.39	0.69	0.35	0.17	0.09	0.04	0.02	0.01
0.007	14.05	7.02	3.51	1.76	0.88	0.44	0.22	0.11	0.05	0.03	0.01
0.008	17.21	8.60	4.30	2.15	1.08	0.54	0.27	0.13	0.07	0.03	0.02
0.009	20.58	10.29	5.15	2.57	1.29	0.64	0.32	0.16	0.08	0.04	0.02
0.010	24.16	12.08	6.04	3.02	1.51	0.75	0.38	0.19	0.09	0.05	0.02
0.011	27.92	13.96	6.98	3.49	1.75	0.87	0.44	0.22	0.11	0.05	0.03
0.012	31.87	15.94	7.97	3.98	1.99	1.00	0.50	0.25	0.12	0.06	0.03
0.013	35.99	18.00	9.00	4.50	2.25	1.12	0.56	0.28	0.14	0.07	0.04
0.014	40.29	20.14	10.07	5.04	2.52	1.26	0.63	0.31	0.16	0.08	0.04
0.015	44.74	22.37	11.19	5.59	2.80	1.40	0.70	0.35	0.17	0.09	0.04
0.016	49.35	24.68	12.34	6.17	3.08	1.54	0.77	0.39	0.19	0.10	0.05
0.017	54.12	27.06	13.53	6.76	3.38	1.69	0.85	0.42	0.21	0.11	0.05
0.018	59.03	29.51	14.76	7.38	3.69	1.84	0.92	0.46	0.23	0.12	0.06
0.019	64.08	32.04	16.02	8.01	4.01	2.00	1.00	0.50	0.25	0.13	0.06
0.020	69.28	34.64	17.32	8.66	4.33	2.16	1.08	0.54	0.27	0.14	0.07
0.021	74.61	37.31	18.65	9.33	4.66	2.33	1.17	0.58	0.29	0.15	0.07
0.022	80.08	40.04	20.02	10.01	5.00	2.50	1.25	0.63	0.31	0.16	0.08
0.023	85.68	42.84	21.42	10.71	5.35	2.68	1.34	0.67	0.33	0.17	0.08
0.024	91.40	45.70	22.85	11.43	5.71	2.86	1.43	0.71	0.36	0.18	0.09

Estimating the oil viscosity from the below table: It was concluded that AREA wells viscosity is about 5 to 13 CP

Challenges Mitigation Techniques

Depleted High Conductivity Reservoirs “Sucker Rod Over Sized Pumps”

3.25’’ OTP Pump

Non-Conventional oversized pump; able to produces rates from 500 BFPD to 1900 BFPD; in Shallow depths (700 Mt. up to 1100 Mt.), in depleted wells of 150 PSI reservoir pressure.

Normally 3.25” DHP is designed to be run inside 4.5” TBG; but due to non availability of this TBG size in AREA-A Inventory, an innovative idea to run this type of pumps inside 3.5” EUE TBG; which is On-Off Tool

Sucker Rod Pump On-Off Tool; is a designed tool to connect rod string with down hole pump plunger

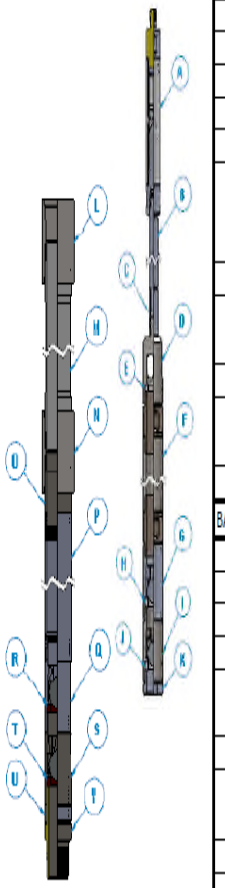
Running Procedures “Idea” of the OTP Pump inside 3.5” EUE TBG

1. Since Plunger size is 3.25” which couldn’t be run inside 3.5” EUE TBG “2.99” ID”; the barrel is connected to TBG and ran separately with the TBG String, and the plunger is left inside the barrel while RIH

2. The Plunger is being run with bottom part of the On-Off Tool; and to be ready for attachment with top part of the On-Off Tool

3. Top Part of On-Off Tool is being run with sucker rod string

4. Once Sucker Rod String being run inside the TBG; Slacking the top part of On-Off Tool on the bottom part with slight rotation till fully connected



DEAL MACHINE #: 2129189

ITEM	PART NUMBER	UNIT	MATERIAL
PLUNGER ASSEMBLY			
A	160QX-BM	PC	4140 LOW ALLOY STEEL
B	651F26X	FT	1045 CARBON STEEL
C	PR54X1	PC	CLASS T
D	S33R1	PC	316 STAINLESS STEEL
E	11RC	PC	TUNGSTEN CARBIDE
F	102RQ4-7-M	PC	BASE: 1026 CARBON STEEL PINS: MONEL 400 SPRAY HARDNESS: 58 HRC MINIMUM
G	S39R-QS	PC	316 STAINLESS STEEL
H	12RCTC	PC	BALL: TITANIUM CARBIDE SEAT: TUNGSTEN CARBIDE
I	1000306218	PC	316 STAINLESS STEEL
J	12RCTC	PC	BALL: TITANIUM CARBIDE SEAT: TUNGSTEN CARBIDE
K	S98R-C	PC	316 STAINLESS STEEL
BARREL ASSEMBLY			
L	24-TBGC0030EL8	PC	L80 TUBING
M	1000304335	PC	304 STAINLESS STEEL
N	24-TBGC0030EL8	PC	L80 TUBING
O	S43QR	PC	316 STAINLESS STEEL
P	B18R25N	PC	443 ADMIRALTY BRASS
Q	S37T-CQS	PC	316 STAINLESS STEEL
R	12TCTC	PC	BALL: TITANIUM CARBIDE SEAT: TUNGSTEN CARBIDE
S	1000306214	PC	316 STAINLESS STEEL
T	12TCTC	PC	BALL: TITANIUM CARBIDE SEAT: TUNGSTEN CARBIDE
U	S95T-S	PC	316 STAINLESS STEEL
V	S43QR-1	PC	316 STAINLESS STEEL

Challenges Mitigation Techniques

Depleted High Conductivity Reservoirs “Sucker Rod Over Sized Pumps”

OTP Pumps Pros

High Rates
Ability to run depleted high conductivity reservoirs in AREA-A with abnormal rate up to 1900 BFPD in well S-Kheir-03

Large Size Pump in Small TBG Size
On-Off Tool enable to run the pump in lower common tubing string “3.5 inches” instead of 4.5” TBG size

Pulling String Dry
On-Off Tool allow pulling the TBG string as dry string instead of pulling wet string

Durability
Large & heavy weight TV & SV Balls; gives high durability against gas locking, and sand production troubles, Increase pump durability in harsh conditions

OTP Pumps Cons

TBG Pulling
Requires pulling TBG string; if pump malfunction for any reason compared to conventional tubing and Rod pumps in Conventional Pumps could retrieve SV & Plunger in TBG Pumps or Whole Pump in case rod pumps utilized

TBG Punch
Requires additional slick line TBG Punch operations prior pulling TBG string to avoid pulling string in wet conditions

Availability in Market
Since this type of pump is not common in market; it requires extended lead time

On-Off Tool Durability
On-Off Tool is greatly affected by well condition i.e., fluid pound, gas pound, an could be released if optimum conditions was not achieved

Challenges Mitigation Techniques

Placing More Than One Pump in Same Completion”

Placing More than Pump Sizes in Same Completion

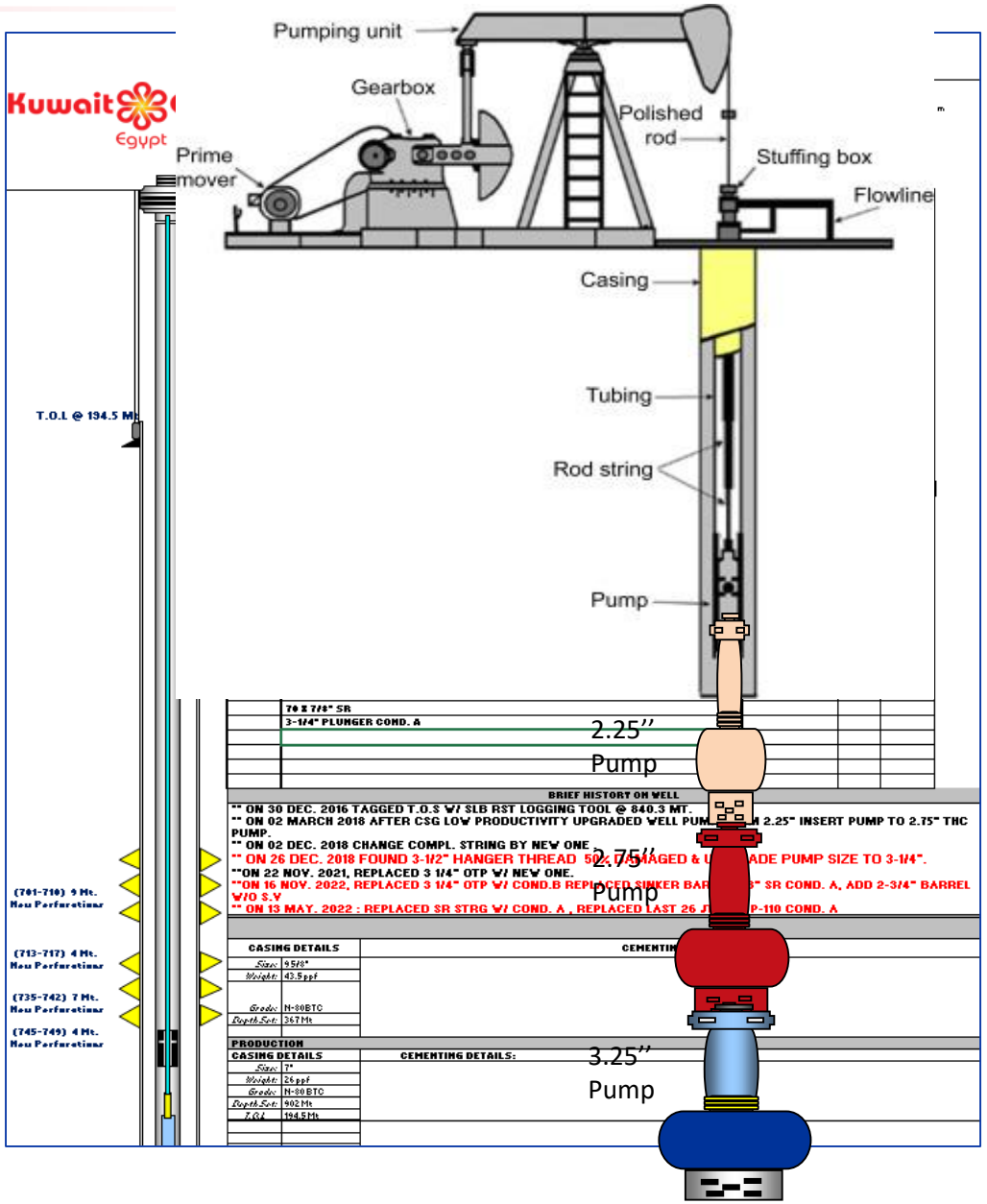
As result of Harsh Conditions “Sand, & Corrosion” which requires back up option to produce the well instantaneous once the pump failed due to the following reasons

1. Well Productivity is sufficiently high; and might affect the area production
2. TBG Leak just above the bottom pump
3. Sucker Rod TBG Pump barrel corrosion or erosion; and rig is not available

Methodology

In case completed the well with TBG Pump i.e. 2.75”, placing pump seating nipple two joints above the TBG Pump to provide a back up option in case pump failed for any reason

In Key important wells; which is running with 3.25” OTP Pumps; completed with two contingent plans; hence the well is running with 3.25” OTP Pumps, with 2.75” TBG Pump barrel on joint above the OTP Pump, then 2.25” Pump Seating nipple placed two joints above the 2.75” TBG Pump.



Challenges Mitigation Techniques

Depleted High Conductivity Reservoirs “Sucker Rod Over Sized Pumps”

Our Standard Wells Troubleshooting Methods

Down Hole Problems

- High Water Cut
- H2S and Corrosive gases Production
- Severe Sand Production
  - Paraffine and Wax
  - Depletion
  - Gas Production
- High-Rate Wells Production Challenge
- Valve rod parted troubles

- Resources Consumption
- Production Drop
- Cost and Time Consumption

Solutions

- Use of J-55 TBG Grade instead of P-110
- Use of Brass Ni-Cr Alloy instead of St. Steel and Chrome plated pumps
- High Clearance Pumps/ Sand Trap / Shallower TBG Strings.
- Optimize Running Parameters
- Poor Boy Gas Anchor/ Run Pump Below Perforations, & Double Valves.
- Utilize Unconventional large size pumps (3.25” Pumps)
- Utilize Collet Type Bushing.
- Utilize TBG Screens in selective cases

- Lessons Learned
- Technology Solutions Dependence

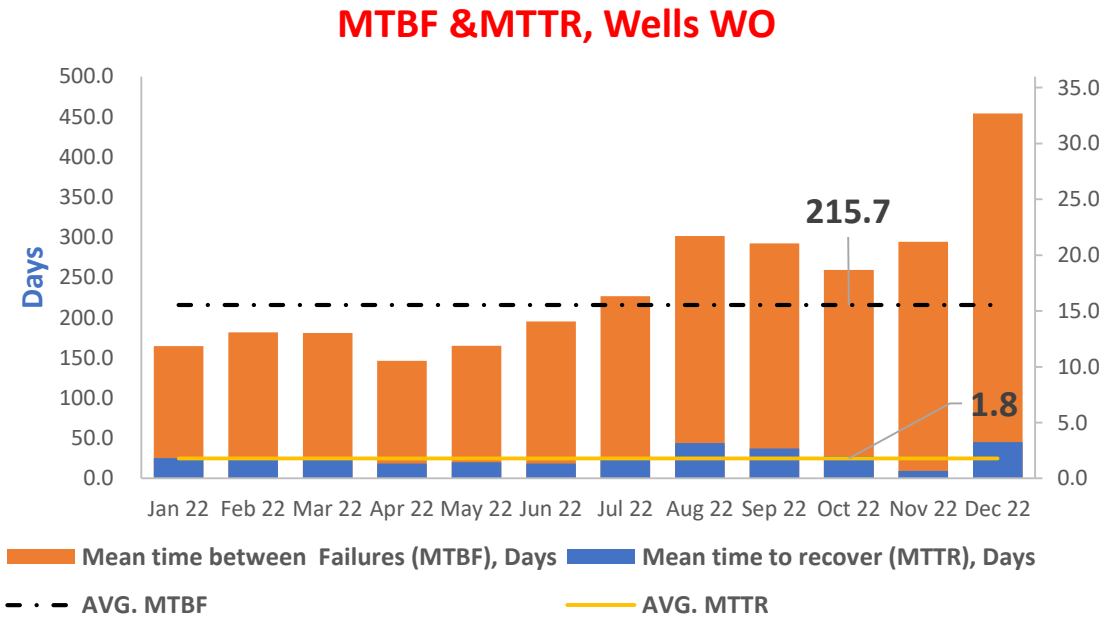
Results & Observations

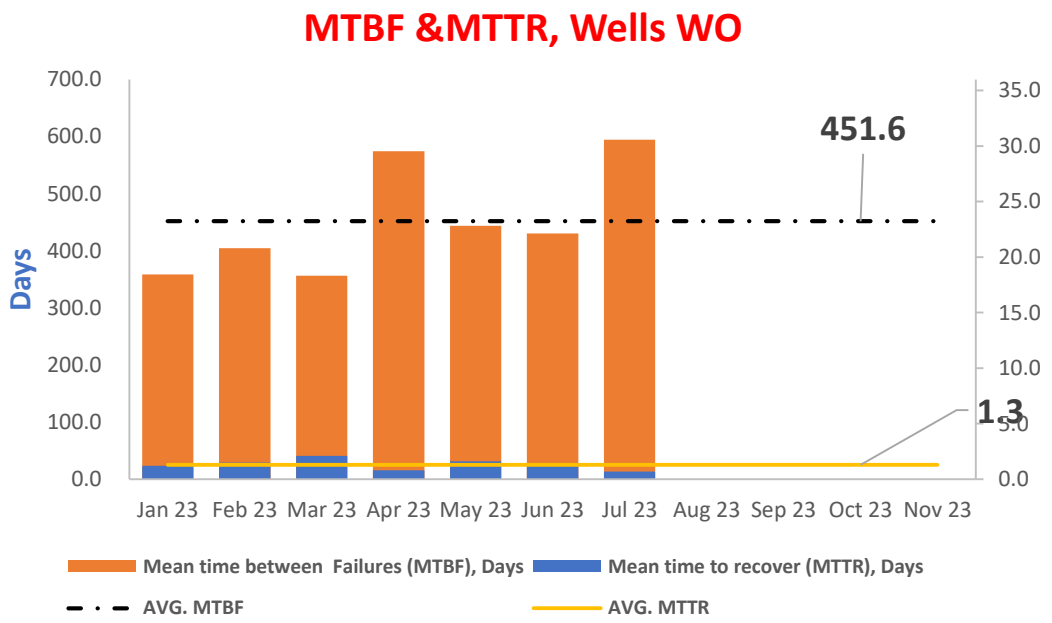
- TBG Leak Failures rate reduced; but still need enhancement
  - Pump Corrosion troubles has been eliminated (H2S. Co2, & W.C. environment)
  - Sand Troubles Failures enhanced
  - Gas Troubles Failures enhanced
- Produce wells in AA with High Production rate up to 1900 BFPD
- Almost Valve Rod Troubles eliminated

- Optimized use of resources
- Decrease NPT
- Cost and Time Saving

Results and Conclusion

Mean Time Between Failures (MTBF) & Mean Time to Recover (MTTR)



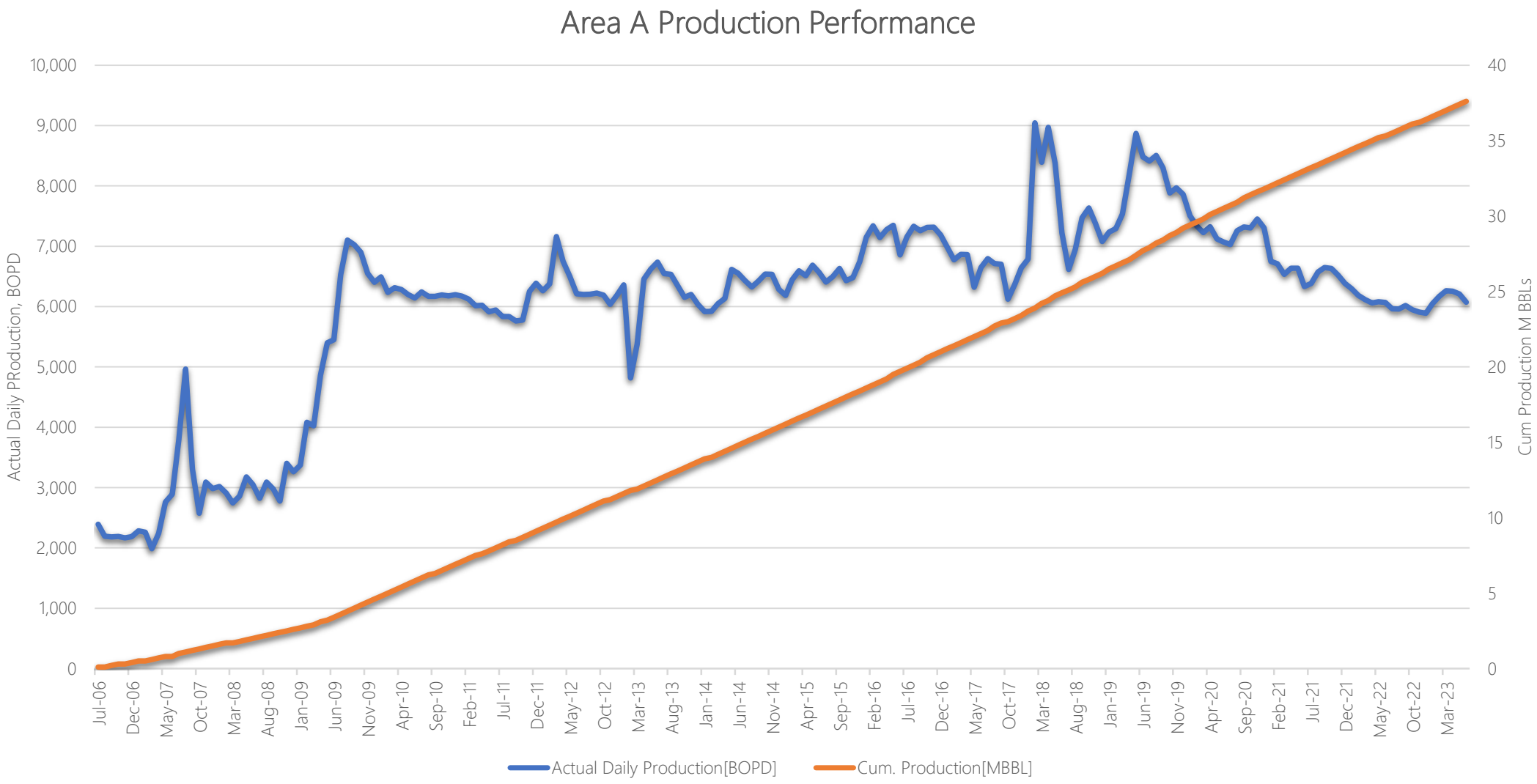


Since Application of the Mitigation Techniques; Observed

1. Enhancement of MTBF from 215 Days in 2022 up to 451 days as an average of first half of 2023
2. Enhancement of MTTR from 1.8 days in 2022 down to 1.3 days as an average of first half of 2023

Results and Conclusion

Production Enhancement



Results and Conclusion

Summary and Recommendations

1- Selection of Optimum method to handle sand production troubles based on Area Experience and challenge all possible solution based on studies, trials, grab data, and execution on all area wells

2- Oversized Sucker Rod Pumps with the On-Off Tool provides affordable method to produce high-rate low pressure reservoir in a depleted gassy, and sandy environment which ESP couldn't handle & not cost effective

3- In Shallow depleted reservoir utilization sucker rod pump with high clearance provide excellent solution rather than costly gravel pack which induces additional pressure drop on such very depleted reservoirs

4- Internal Resources utilization to provide back up options in Key problematic wells is essential which revealed in utilization of more than one pump size in the same well to provide many back up options to return failed wells to production ASAP.

THANK YOU

For Further information Please access the SPE paper: SPE- 216432-MS