

MIDDLE EAST AND NORTH AFRICA PERFORATING SYMPOSIUM

Through Tubing Perforation: Challenges and Solutions

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Agenda

- Introduction/ Overview.
- Challenges and Solution.
- Gun Data and Simulation.
- Underbalance and Job Execution.
- Results and Recommendation.
- Case #2.
- Acknowledgement.
- Q & A.



Introduction

- Well-1 was drilled and completed in Jun 1979 as double production liners (5" & 7") with 20,000 BFPD & traces WC.
- Last workover was in Nov 2007 with 1800 BFPD and 50% WC (perforate 44 ft using TCP).
- The well was completed as 4 ½" X 3 ½" gas lift tubing (Cr-13%).
- Min. ID -3 ½" XN Nipple (ID 2.635").
- Max. deviation angle 31° at 3800' ORKB.
- Deviation at perforation depth 15°.
- Planned to add 28 ft below existing intervals.

VELL: -1	Ex	istin	g Wellt	oore Ske	etch ORKB - THI 29'
Productin Zone:					RKB - THF 52.5
Completion date: Oct. 23, 2	007 (C	r 13Z)	V.O Rig	: Kamose	ORKB - MS 80*
4 1/2" TUBING HANGER	0	0.	THE		
4 1/2" NE Hal. TRSSSV (X profile 3.4 4 1/2" x 3 1/2" X-OVER	0	316' 510'			24" Conductor Shoe @ 438' DR
3 1/2" GLM # 1	0	1971'	THE	-	13 3/6" CSG Shoe @ 3053' ORK
3 1/2" GLM # 2	•	3694'	THE	1 1	
3 1/2" GLM # 3		5005'	THE	-	
3 1/2" GLM # 4	•	5787	THE	- 👝 🖓	
3 1/2" GLM # 5		6560'	THE		
3 1/2" GLM # 6	•	7342'	THE		7" SCAB Top @ 6090' ORKB
3 1/2" GLM # 7	0	8111.	THF	•	
3 1/2 EXP. JOINT 3 1/2" "X" NIPPLE 7" * 3 1/2" PKR	@	8223' 8281' 8335'	THF THF THF		7" Liner Top @ 8160' OFKB
3 1/2" "X-N" NIPPLE	@	8413'	THE		
3 1/2" SURGE DISK END OF TUBING	0	8450' 8485'	THE		5" Liner Top @ 8496' ORKB
			-		9 5/8" CSG Shoe @ 8618' ORKI
PERFORATED INTERVALS: 8622'-8658' ORKB 8666'-8674' ORKB 8690'-8704' ORKB caring and	8 FT 14 FT			T	
8704'-8718' ORKB linked and TOTAL	14 FT 72 FT			-	E237 @ 0000 UHKB
					New PBTD @ 9185' DRKB 7" Csg Shoe @ 9599' DRKB
				-	601' ORKB



RD

ohm.m

2000

hale (ND)

2.95

-0.15 0.2

RHOB

g/cm3

NPHI

ft3/ft3

Sand 1

1.95

100 0.45

GR

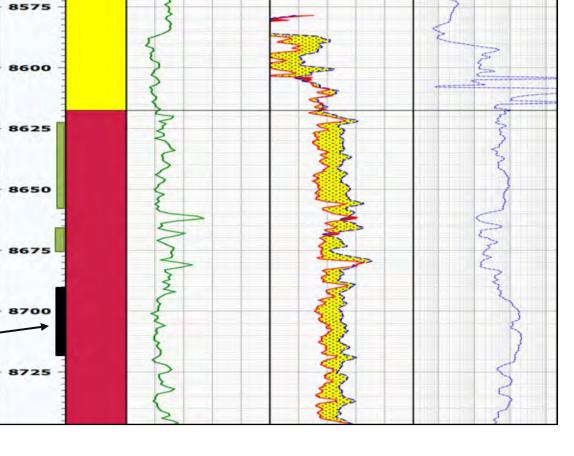
qAPI

Overview

Reservoir data:

Formation Reservoir UCS	Sandstone 7000 PSI	8600	5
Porosity	15%		
Reservoir pressure Reservoir Temp.	2660 PSI 240º F	8625	3
Productivity Index (PI)	around 15 BFPD/PSI	8650	-
Wellbore fluid Deviation at perforation depth	Oil & Water 15°	8675	Wan
	New Interval	8700	
	Need to be added	8725 -	2

Required: Add 28 ft in double casing (5" & 7" liners)



uly_ZONATION

MD (ft)

1:200



Challenge

- The well is double casing (5" & 7" liners),
- Completion string is a gas lift,
- Limited to min. ID is 2.635" (3 ½" XN Nipple),
- Add 28 ft without pulling completion string,
- Maximize efficiency of perforation tunnels (Big EH, deep penetration).

Solution

- The perforation will be performed using through tubing technique,
- Available solutions are exposed gun & cased gun,
- Simulation performed showed estimated penetration for:
- > 2 1/8" Exposed gun is 17.33"
- ➢ 2" Cased gun is 9.51"

Based on that, select exposed gun for perforation

WENAPS 2022

Exposed Gun Vs. Cased Gun

Exposed Gun

- **Pros** Expendable gun,
 - More explosive weight,
 - Deep penetration & big EH,
 - Recommended in double casing wells.

- **Cons** Assembled at wellsite & take time,
 - Max recommended length per run is 24 ft. (more runs),
 - Limited running in speed,
 - Difficult in high deviation, and scaled wells,
 - Difficult to confirm 100% firing or partial misfire.

Cased Gun

- Retrievable gun,
- Max length based on lubricator length,
- Quick assembled at workshop or wellsite,
- Recommended in single casing wells,
- Confirm 100% firing efficiency.
- Less charge wt. than exposed gun,
- Shallow penetration, and less EH than casing guns,





Gun Data & Simulation

 The following table illustrates specs & the simulation data for both guns:

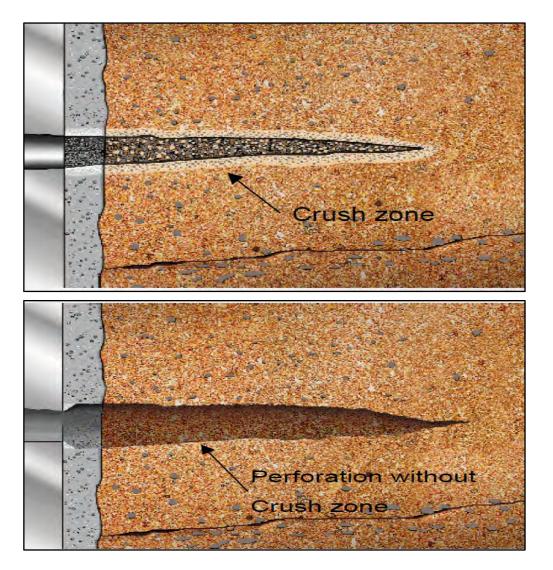
	Cased Gun	Exposed Gun	
Gun OD Size, inch	2"	2 1/8"	
Powder HMX, gm	6.5 gm	13 gm	
Phasing, degree	60	60	
Shot Density	6.0	6.0	
Damaging Diameter, in	8"		
Inner EH Diameter, in	0.20''	0.26"	
Total Penetration, in	9.51"	17.33"	
Form. Penetration, in	7.31"	15.13"	





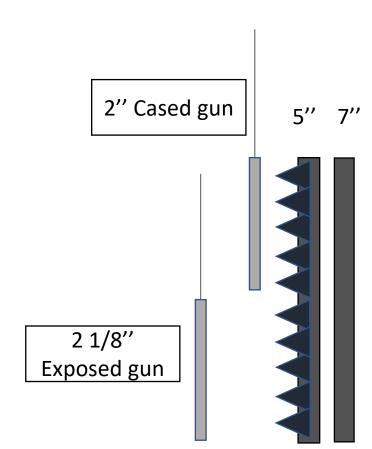
Underbalance

- One of GL completion advantage is to perforate the well while the well on production (flowing underbalance),
- Most of perforations in GUPCO are performed using underbalance technique,
- How to perform?
- \checkmark RIH while the well is SI,
- ✓ Perform correlation pass,
- ✓ Stop below intervals, open the well on production using GL till get sample on the surface,
- ✓ Wait 15 -30 minutes for stabilizing downhole condition,
- ✓ Perform shooting pass correlation then fire the gun,
- ✓ POOH 50 -100 ft above perforation and wait 10 minutes,
- ✓ SI the well and POOH, check the gun on surface.
- This technique helps in cleaning perforation tunnels, and improving well performance.



Job Execution

- The perforation was designed to be on 2 runs of 2 1/8" exposed gun,
- The 1st run was RIH successfully with 2 1/8" exposed gun and got fired indications (100 lb drop in tension, Volt & Amp. Pattern),
- The 2nd run with exposed gun (Length of gun is 14 ft), the gun had several slacks at different GL mandrels, and failed to pass across GLM#6 after several trials for 3 hours, so the decision was taken to POOH and check the gun (no visible deformation or damage noticed),
- After 12 days skid back on the well to perforate the top interval; The 3rd run with 2" cased gun (HMX 6.5 gm, 6SPF, 60 Phasing) to perforate top 14 ft and got fired indications (30 lb drop in tension, Volt & Amp. Pattern),
- Flowing underbalance is 200/ 250 psi.







Result

• The shown table illustrates well test data before and after the perforation job.

	Fluid Rate, BFPD	WC, %	Oil Rate, BOPD
Test Before	2900	75	725
After 1 st run	NA	55	NA
Test After	3550	60	1420
	Gain		700

Recommendation

- We should use a reliable bottom nose (sufficient length & OD as a guide of the gun),
- Used in non scaled wells,
- Used in vertical, and semi vertical wells.



Case #2



Introduction

- Well-2 was drilled and completed in Feb. 1994, perf 333 ft in
 5" production liners with 1,900 BFPD & traces WC,
- Last workover was in May 2010 and reperf. 200' in 5" liner,
- The well was completed as 4 ½" X 3 ½" gas lift tubing (Cr-13%),
- Isolate existing intervals in 5" in June 2019,
- Min. ID -3 ½" XN Nipple (ID 2.635") at 8635' ORKB,
- Max. deviation angle 19° at 5600' ORKB.
- Deviation at perforation depth 15°
- Planned to add 40 ft in double casing (5" & 7") &
 40' in one casing (5" liner).

WELL :- #2	Well bore Sketch	ORKB - THF = 46.8 ft
DATE SESSE	Rig: Kamose CR 13Z	RKB - THF = 46.8 ft RKB - MSL = 78 ft
Production zone:-		RKB - MSL = fort
4-3/2" Concres CS-5 Thy Ronger		E Constalants n / 53 menur Delagling at 3.3.5 menu
-1/2" BALL."SP-TRSSST W/3.812" "		38" C Q EST ORED
the second second		52 X 4/2 / 2 / 2 / 2 / 2 / 2 / 2 / 2 / 2 / 2
4-1/2" - 3-1/2" X	1112 TBC	
1-172" BARER, BGLO GLH 8 1	1783 TBP	
1-1/2" BARER, BELS CLH 8 2	2848 TRE	Ven TOT ALL ID-2 ME . STLC DD-0 ME
1-1/2" BARER, BELS CLH 8 1	4845 TRP 🛃 🔺	-
1-1/2" PARES, PGL+ GLH 8 4	4637 YBF	- 3-SAT CTC ECP @ 455
Prove Provente over a construction		13-3/8" Shar @ 4832 OREP
		and the second sec
		7", 268, 888, 176C, TW Tel @ 482
1-1/2" DATES, DELO CLH 8 5	5395 TBP	
1-1/2" DARER, DGLO GLO I I	3335 TRF	
1-1/2" BAEER, BELS GLH # 7	6554 TRP	
	7343 TBP	1
	7752 787	
		T-p -5 2", 230, The +81 @ 1220 +
	8435 THE	
3-1/2" HALL "8" Hipple (2.75" IL	1935 TUP 10-10	
7" # 3-1/2" HALL "PHL" PKR	8548 TUR 🔀 🔀	
3-1/2" HALL "SH" Hipple (2.635	1531 787 2 1	
3-1/2" BOS MECH. Surge Dirk	1123 THE	1 5/8" SL @ 8531 +888
		the state of the second s
		5". The, 488, 888, Xar Sout Los @ \$550
The second second		5" T., +8L @ 1834 +8EF
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44282 39222 28		Baled Jug 5, 2885
19234 19252 28		
	B3 FT	



PHIE_1

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V/V

NPHI 2

gra 1

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0.45

200

Overview

Reservoir data:

neser fon datar		0 Geler 200		0.2 CHMM 2000	-03 OC3 0.4	0.3 00 0
Formation	Limestone	nez			A.	
Reservoir UCS	4892 PSI	Z	-9600		1	~
Porosity	17%	<u> </u>			2	
Permeability	12 mD	100	.9700			
Reservoir pressure	1700 PSI		-9700	14 C		
Reservoir Temp.	280° F	- 14		1. 1. 1. 1.		
Formation fluid	Gas		-9800	124		
Underbalance Pressure	400-500 PSI	nolog	1122			
			-9900		2	
Wellbore fluid	Water (8.7 PPG)	nubia 102	250	3	2	Z
Deviation at perforation depth	15° New Intervals	-	-10000	1		-
	Need to be added				1	4
	Need to be added		10180			×.
Required: - Add 40 ft in double o	casing (5" & 7" liners) &	F				- A
- Add 40 ft in 5" liner.		105				2
		5	-10200		2.2	

PAY FLAG 1

0HMM

RD_1 0HMM 2000

185 ORMM - 2000

levation(TVD)

12 -

DEPTH

RES FLAG 1

CALI_1

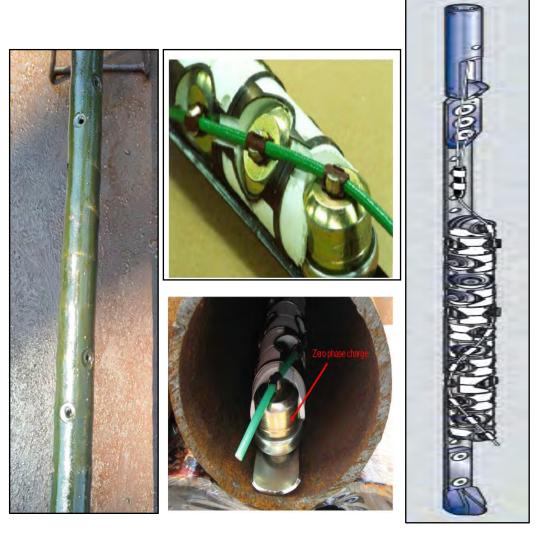
GR 1



Gun Data & Simulation

 The following table illustrates specs & the simulation data for Semi expendable & cased guns:

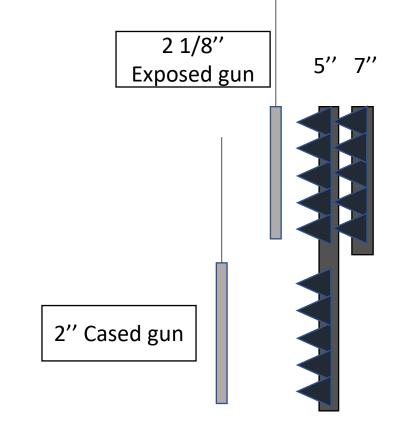
	Cased Gun	Exposed Gun	
Gun OD Size, inch	2"	2 1/8"	
Powder HMX, gm	7.3 gm	14.5 gm	
Phasing, degree	60	45	
Shot Density	6.0	6.0	
Damaging Diameter, in	8.0''		
EH Diameter, in	0.20''/ 0.17''	0.29"/ 0.25"	
Form. Diameter, in	0.39	0.58	
Total Penetration, in	9.35"	13.07"	
Form. Penetration, in	7.24"	10.96"	



Job Execution

- The perforation was designed to be on 4 runs rigless work:
- The 1st & 2nd runs (Length of gun is 20 ft.) were performed successfully with cased guns in 5" liner and got fired indications (90 & 60 lb. drop in tension respectively),
- Next day The 3rd & 4th runs with exposed gun (Length of gun is 20 ft., HMX 14.5 gm, 6SPF, 45 Phasing) were performed successfully and got fired indications (180 & 310 lb. drop in tension respectively),
- Flowing underbalance is 400/500 psi.







Result

 The shown tables illustrates perforation performance & well performance data before and after the perforation job.

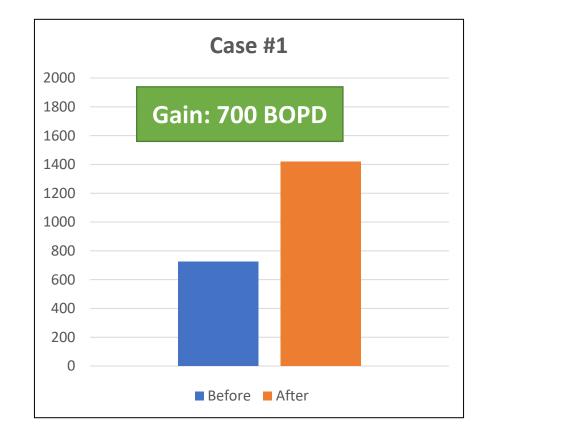
Run	Casing	Tension Drop, Ib	SIWHP After Shooting, PSI
#1 (2" Cased gun)	5"	90	80
#2 (2" Cased gun)	Э	55	120
#3 (2 1/8" Exposed gun)	5" & 7"	180	500
#4 (2 1/8" Exposed gun)		310	940

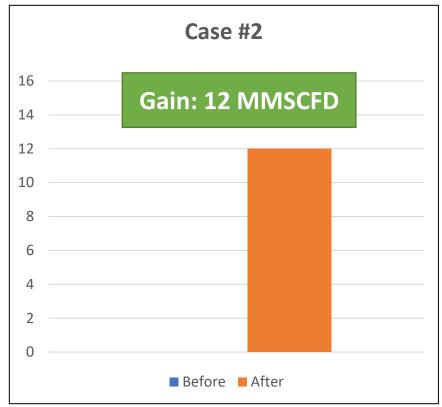
	Fluid Rate, MMSCFD	FWHP, PSI	WC, %	Gas Rate, MMSCFD	
Test Before	Not Producing				
Test After	12 MMSCFD	12			
	12 MMSCFD				



Conclusion

• The exposed gun is a good choice to perforate double casing wells using TT technique.







Acknowledgement

- I would like to express special thanks to Eng. Hanaey for his support.
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- Special thanks to our service companies for their co-operation.



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