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MENAPS 2022

MIDDLE EAST AND NORTH AFRICA PERFORATING SYMPOSIUM

Through Tubing Perforation: Challenges and Solutions

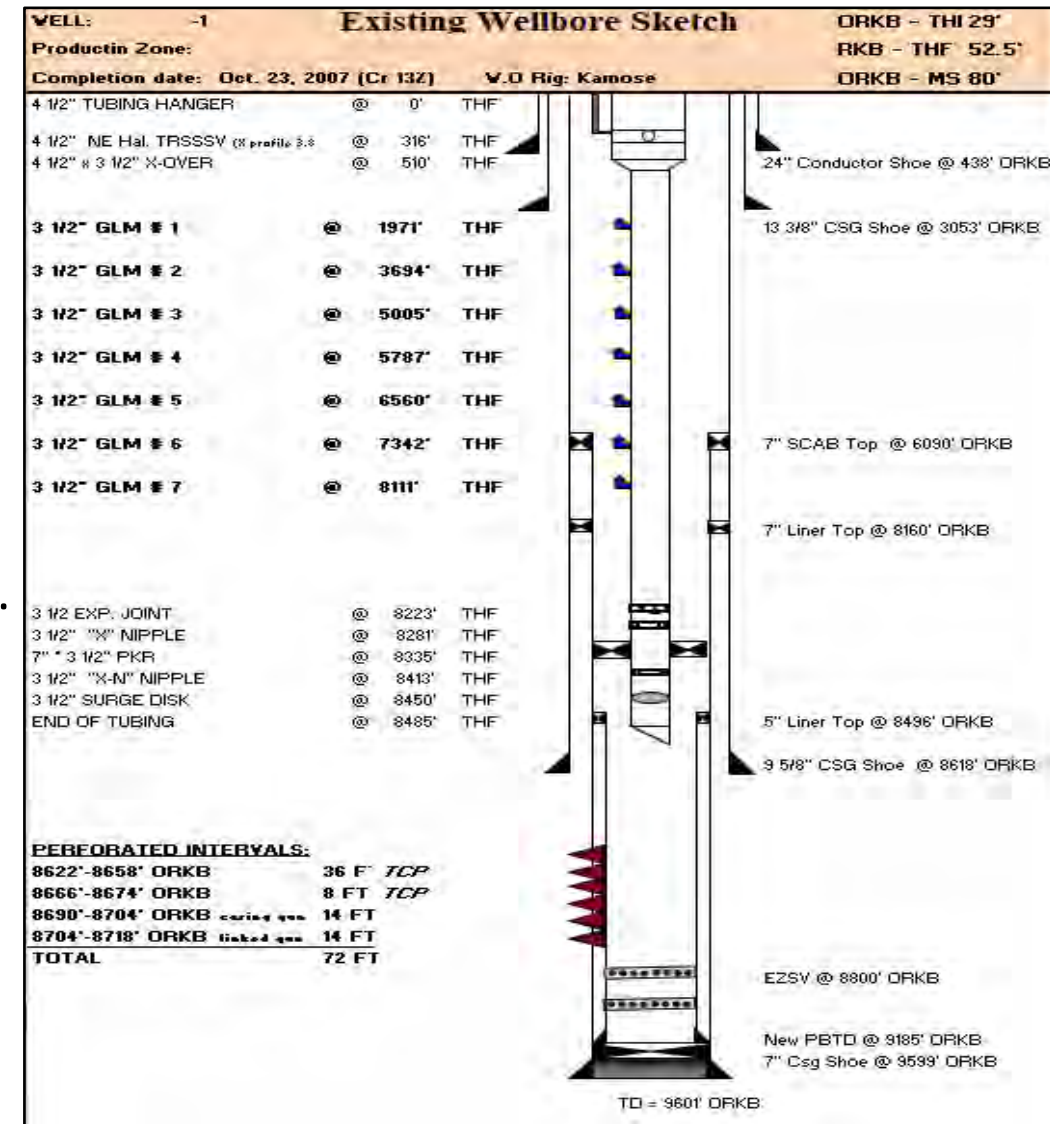


Agenda

- 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 1/2" X 3 1/2" gas lift tubing (Cr-13%).
- Min. ID -3 1/2" 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.



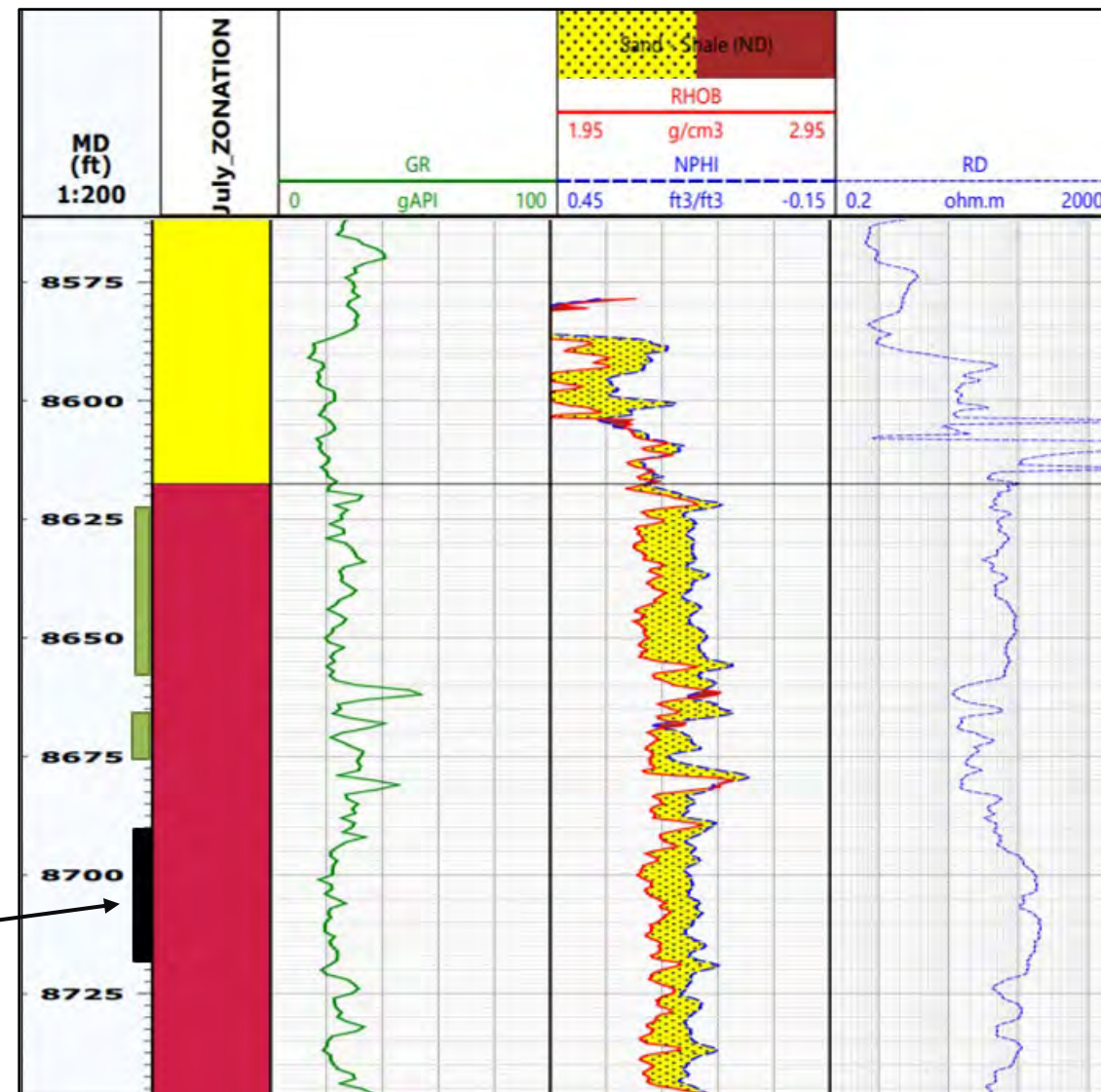
Overview

Reservoir data:

Formation	Sandstone
Reservoir UCS	7000 PSI
Porosity	15%
Reservoir pressure	2660 PSI
Reservoir Temp.	240° F
Productivity Index (PI)	around 15 BFPD/PSI
Wellbore fluid	Oil & Water
Deviation at perforation depth	15°

New Interval
Need to be added

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



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

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.

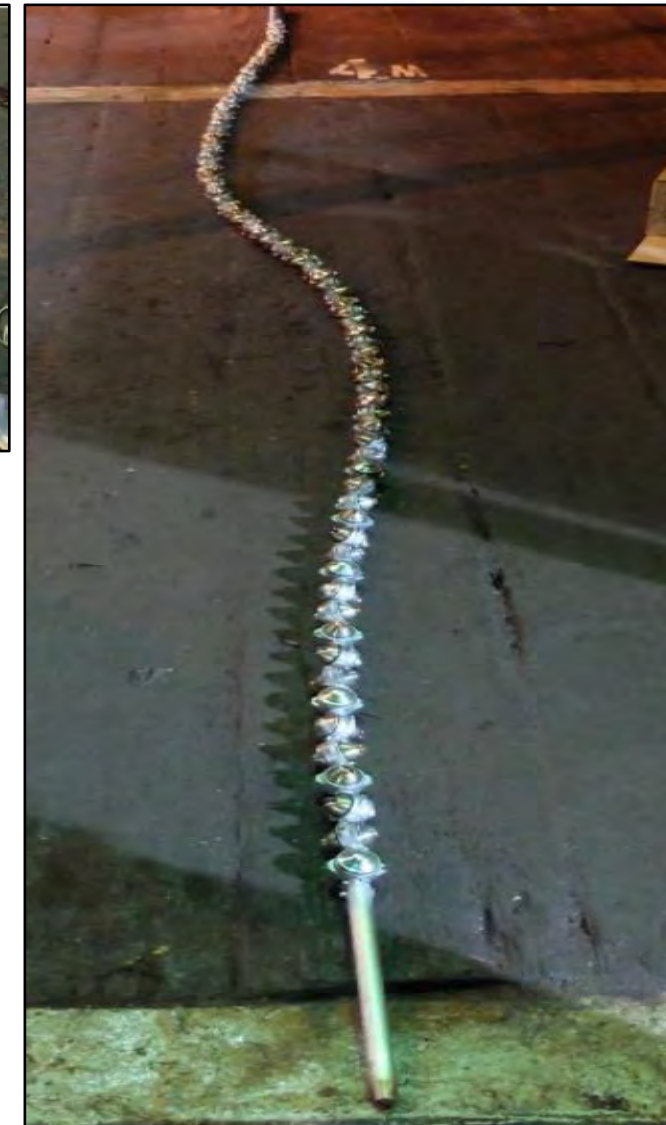
Cased Gun

- 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:

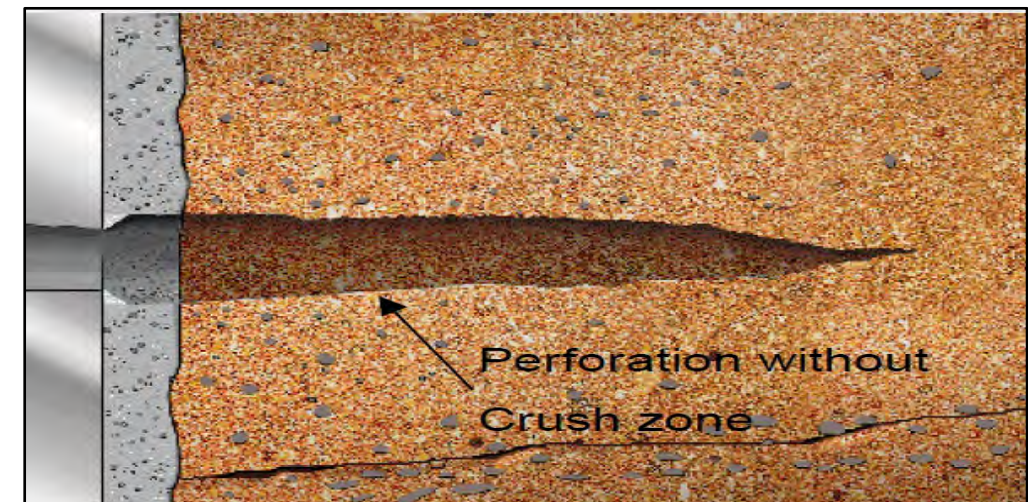
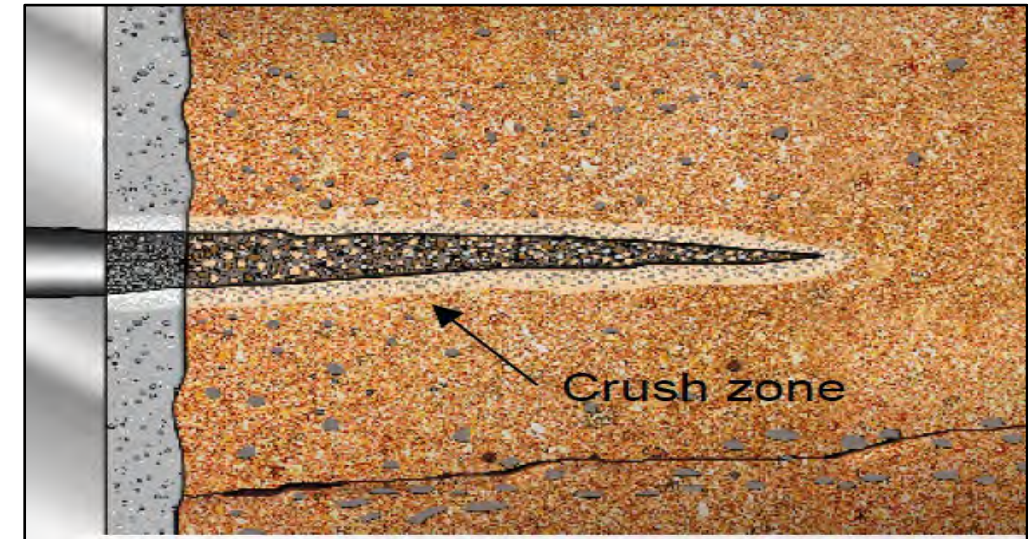


	Cased Gun	Exposed Gun
Gun OD Size, inch	2"	2 1/8"
Powder HMX, gm	6.5 gm	13 gm
Phasing, degree	60	60
Shot Density	6.0	6.0
Damaging Diameter, in	8"	
Inner EH Diameter, in	0.20"	0.26"
Total Penetration, in	9.51"	17.33"
Form. Penetration, in	7.31"	15.13"



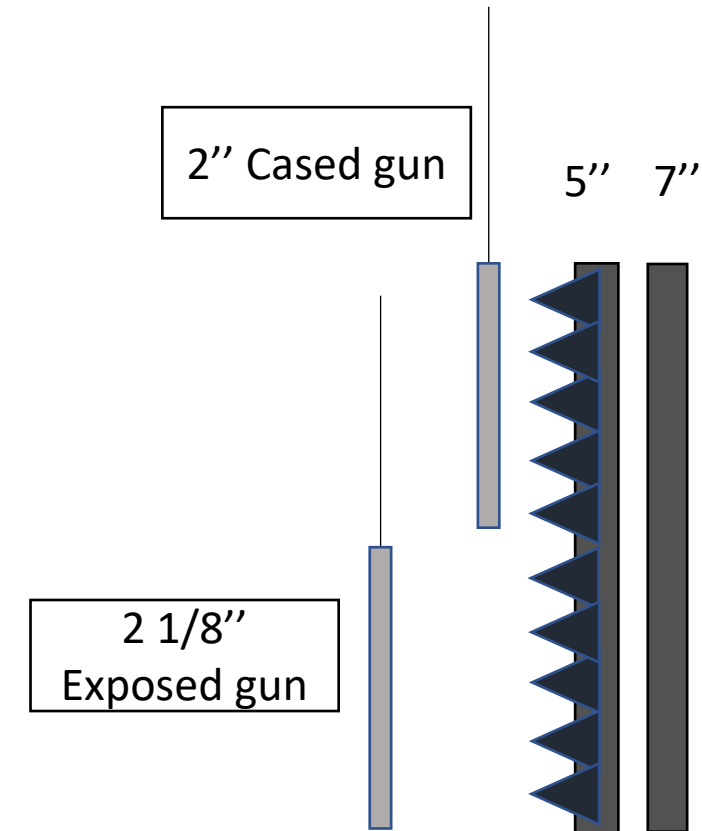
Underbalance

- 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?**
 - ✓ 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

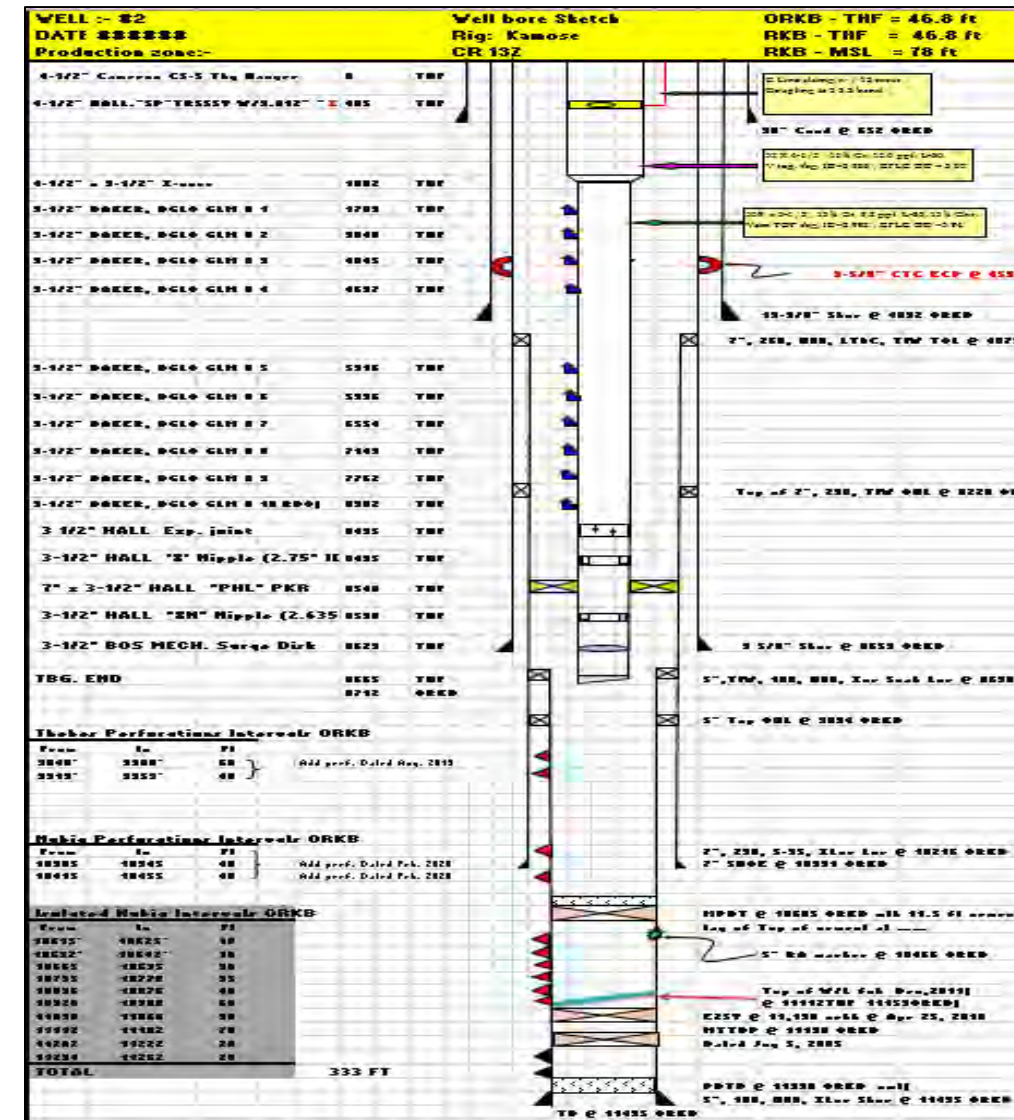
- We should use a reliable bottom nose (sufficient length & OD as a guide of the gun),
- Used in non scaled wells,
- Used in vertical, and semi vertical wells.



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 1/2" X 3 1/2" gas lift tubing (Cr-13%),
- Isolate existing intervals in 5" in June 2019,
- Min. ID -3 1/2" 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).



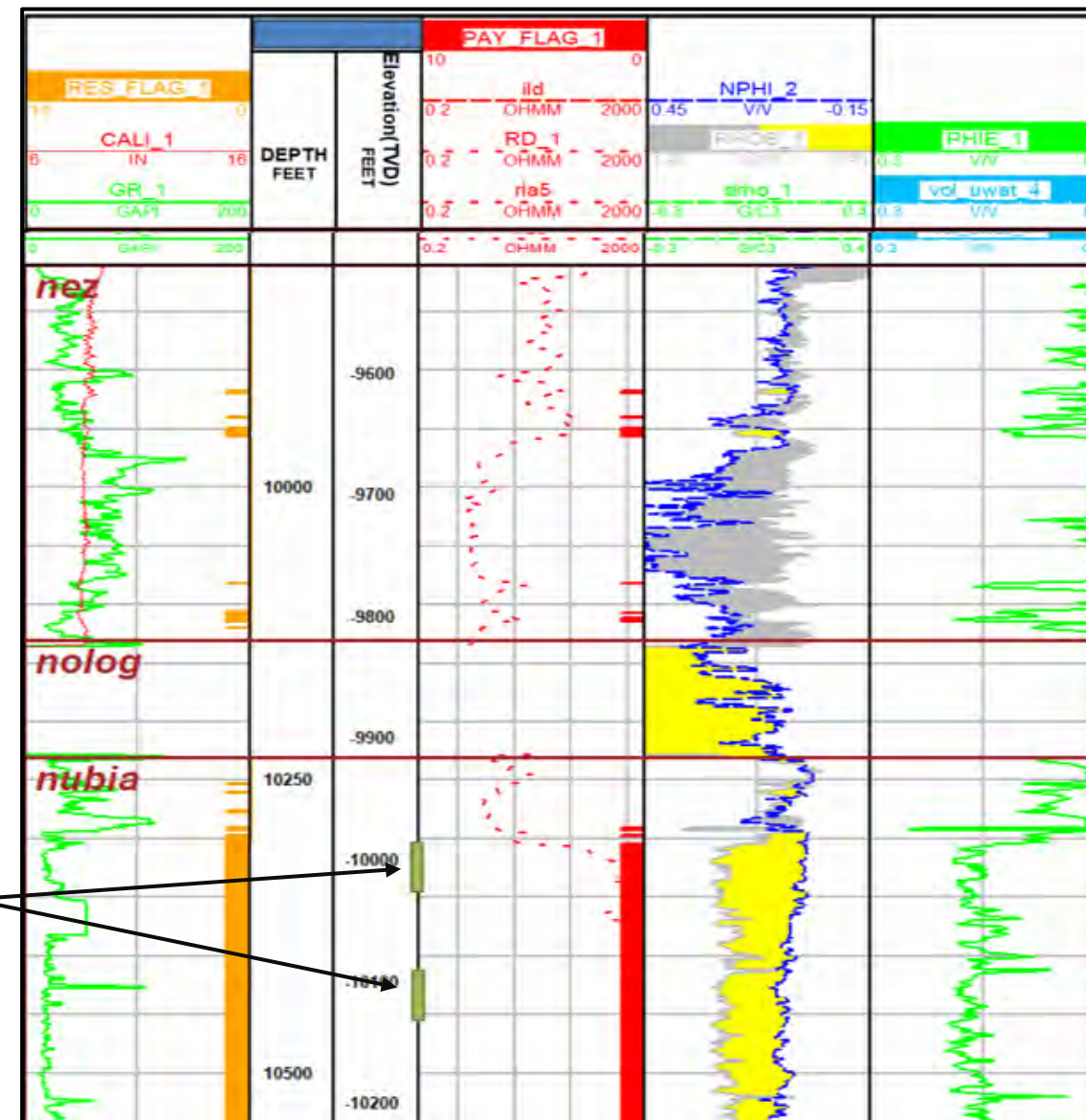
Overview

Reservoir data:

Formation	Limestone
Reservoir UCS	4892 PSI
Porosity	17%
Permeability	12 mD
Reservoir pressure	1700 PSI
Reservoir Temp.	280° F
Formation fluid	Gas
Underbalance Pressure	400-500 PSI

Wellbore fluid	Water (8.7 PPG)
Deviation at perforation depth	15°

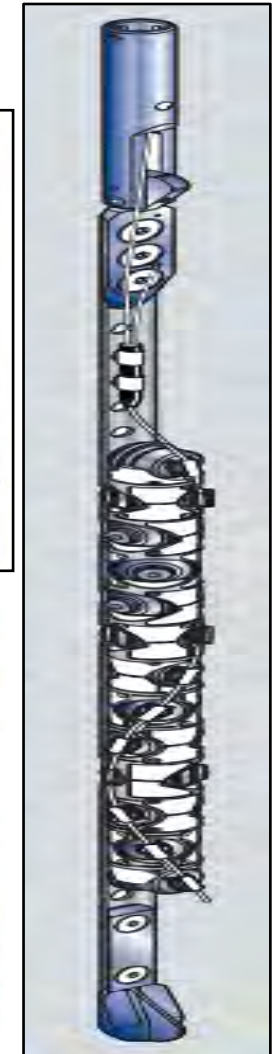
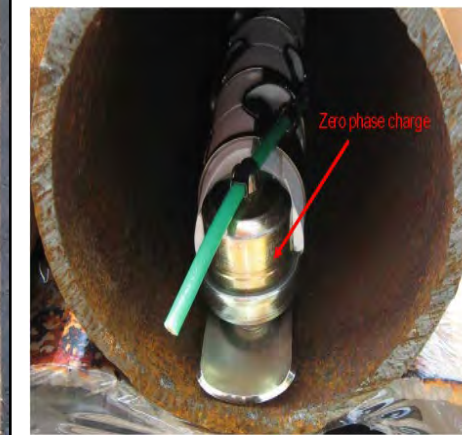
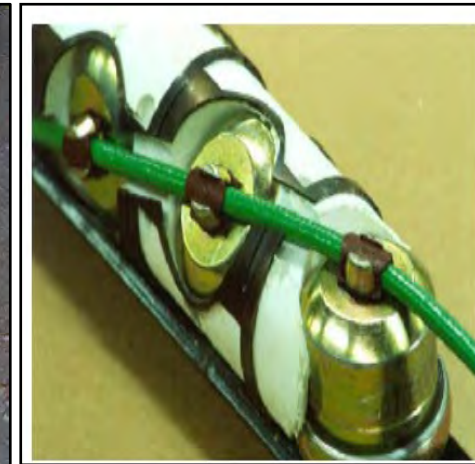
Required: - Add 40 ft in double casing (5" & 7" liners) &
- Add 40 ft in 5" liner.



Gun Data & Simulation

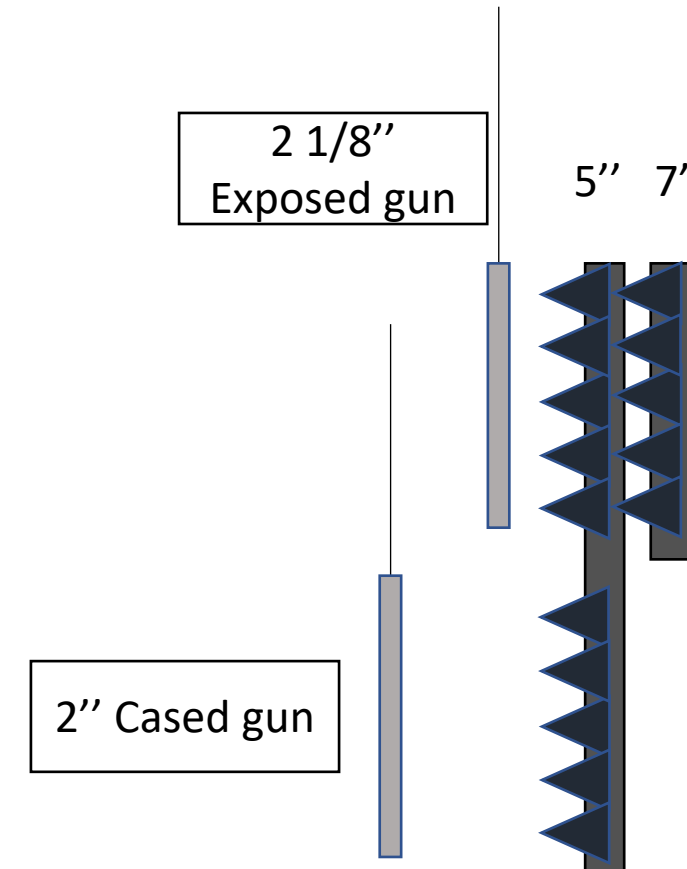
- The following table illustrates specs & the simulation data for Semi expendable & cased guns:

	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

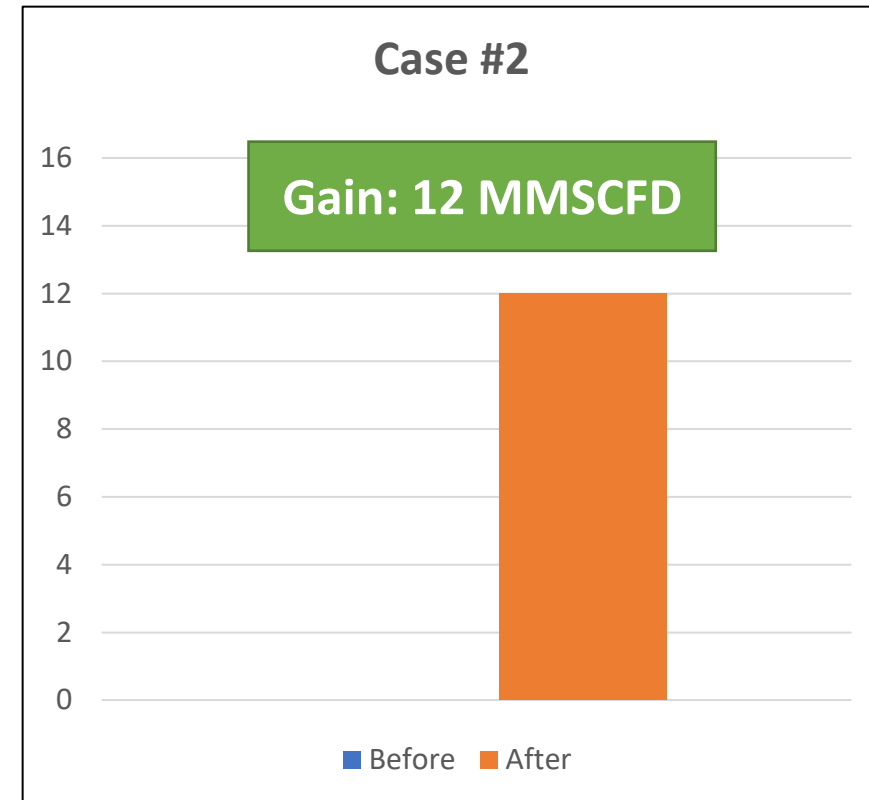
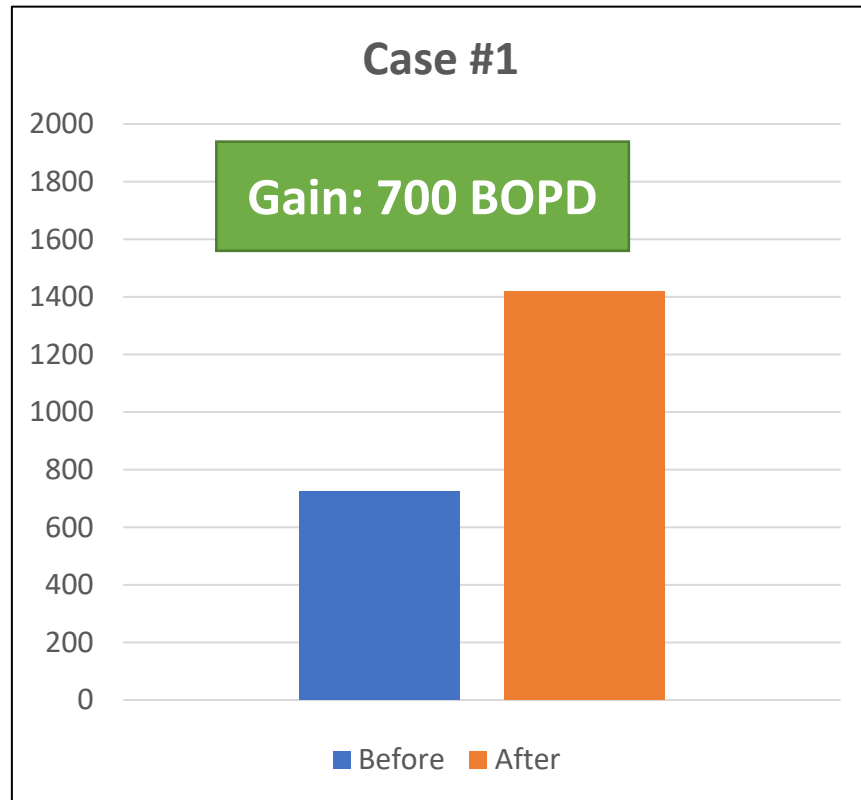
- The shown tables illustrates perforation performace & well performance data before and after the perforation job.

Run	Casing	Tension Drop, lb	SIWHP After Shooting, PSI
#1 (2" Cased gun)	5"	90	80
#2 (2" Cased gun)		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	280	0	12
Gain				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.
- Special thanks to all district engineers for the hard work, efforts and dedication.
- Special thanks to our service companies for their co-operation.



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Q&A

