Cairo. Egypt. November 7-8, 2022

MENAPS 2022

MIDDLE EAST AND NORTH AFRICA PERFORATING SYMPOSIUM

Innovation of Double Casings Charge to Overcome Annuli pressure Build Up

Presented By
Hassan Al Lawati
PDO

شركة تنمية نفط عمان
Petroleum Development Oman

DynaEnergetics

RAY INTERNATIONAL OIL & GAS

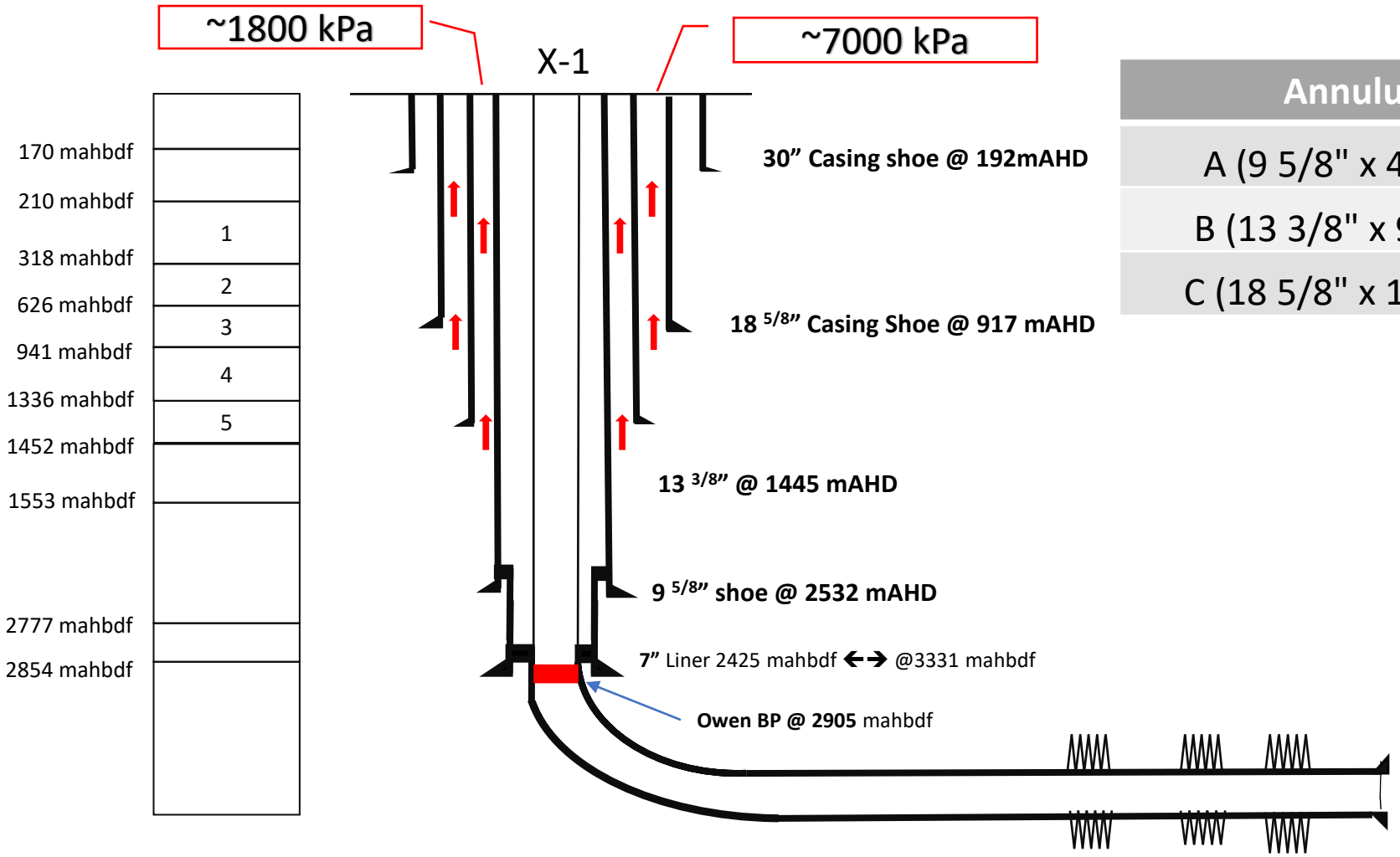
MARJAN PETROLEUM

MENAPS-14-22 AUTHORS: Hassan Al Lawati (PDO), Mohammed Al Taiwani (RAY international), Hamood Al Riyami (Marjaan Petroleum), Henaey Ibrahim (Dynaenergetics),

Outline

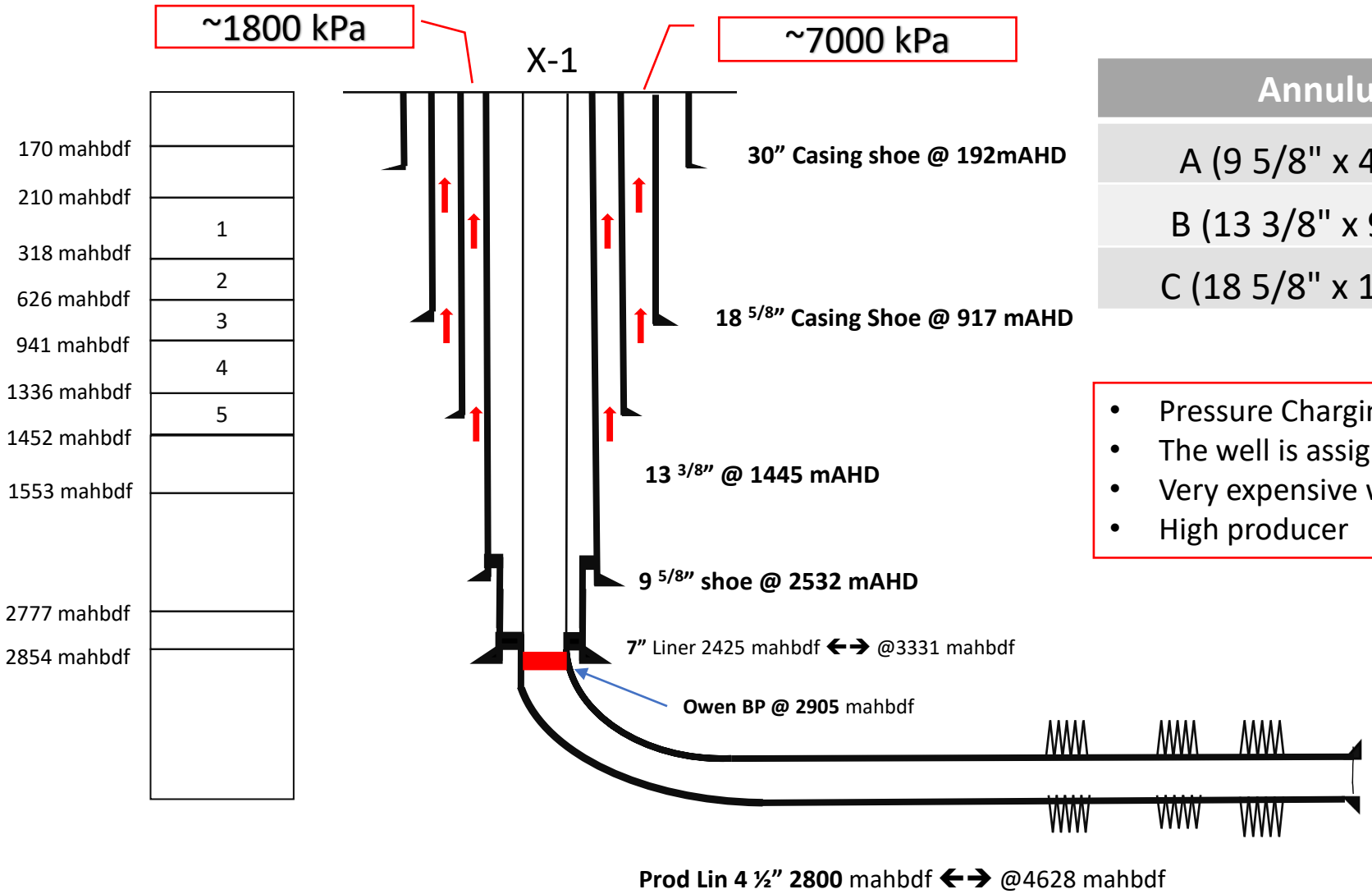
- Problem statement
- Identifying pressure source
- Repair option
- Job Preparation and requirement
- Results
- Conclusion

Problem statement



Annulus	MAASP
A (9 5/8" x 4 1/2")	19900
B (13 3/8" x 9 5/8")	6500
C (18 5/8" x 13 3/8")	3000

Problem statement



Annulus	MAASP
A (9 5/8" x 4 1/2")	19900
B (13 3/8" x 9 5/8")	6500
C (18 5/8" x 13 3/8")	3000

- Pressure Charging from both C annulus is higher than MAASP
- The well is assigned AC9, which requires immediate action
- Very expensive well
- High producer

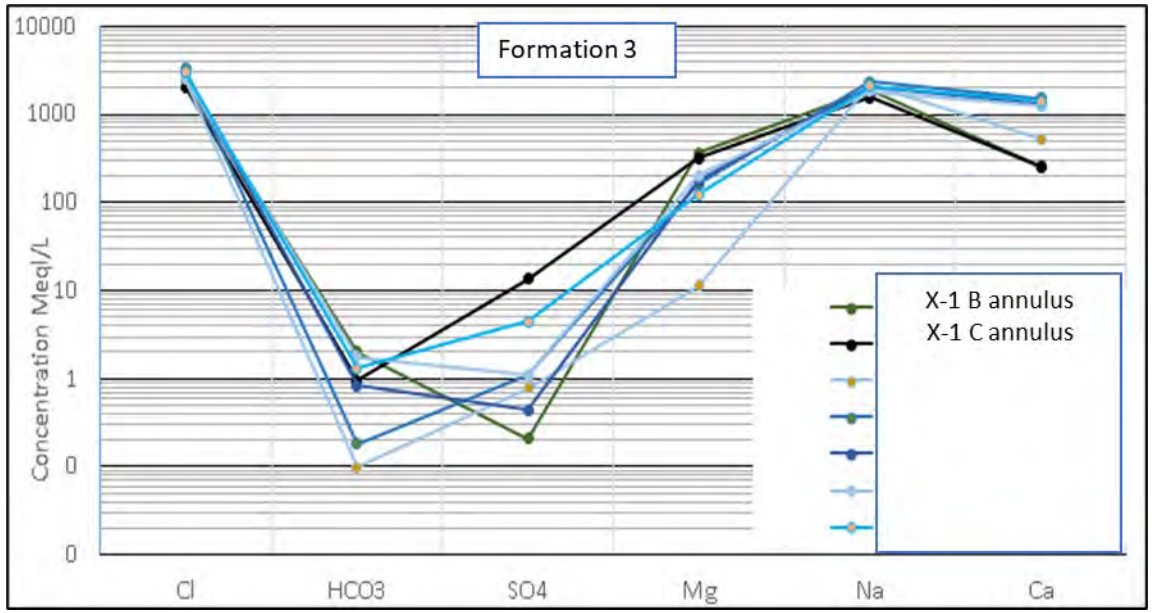
Identifying Pressure Source

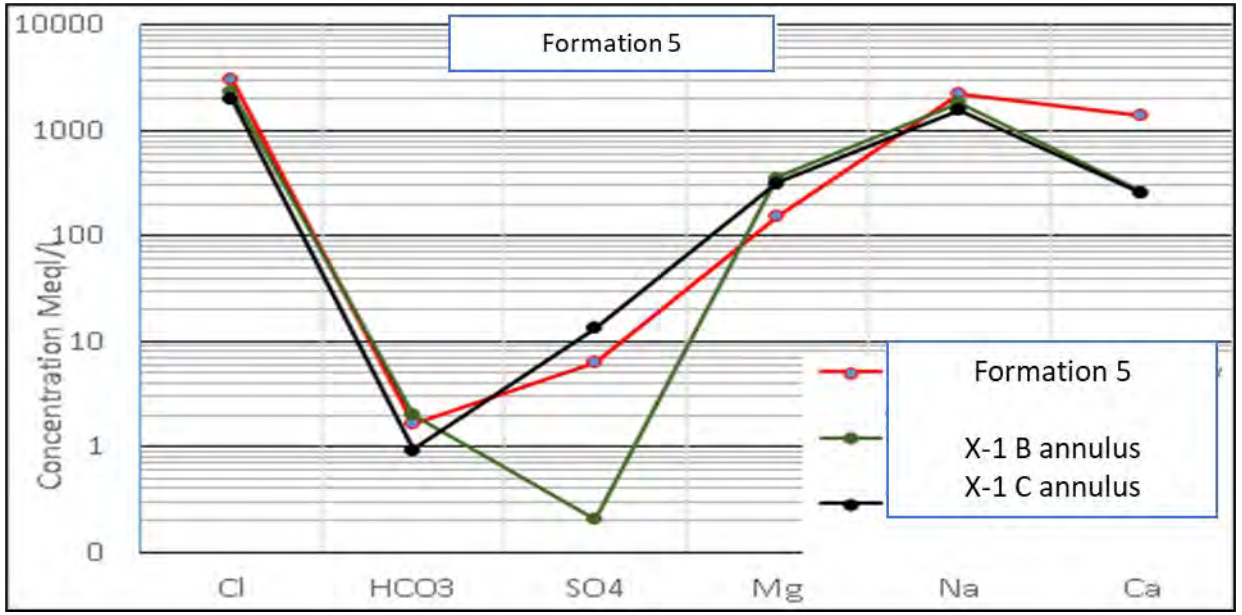
- In order To identify the pressure source, the following investigation/logs were required:
  - Fingerprinting analysis
  - Corrosion log
  - Temperature log
  - SNL & A.I

Identifying Pressure Source

- In order To identify the pressure source, the following investigation/logs were required:
  - Fingerprinting analysis
  - Corrosion log
  - Temperature log
  - SNL & A.I

No Exact match was found with either Shuaiba or Natih Fluid





Identifying Pressure Source

- In order To identify the pressure source, the following investigation/logs were required:
  - Fingerprinting analysis
  - Corrosion log
  - Temperature log
  - SNL & A.I

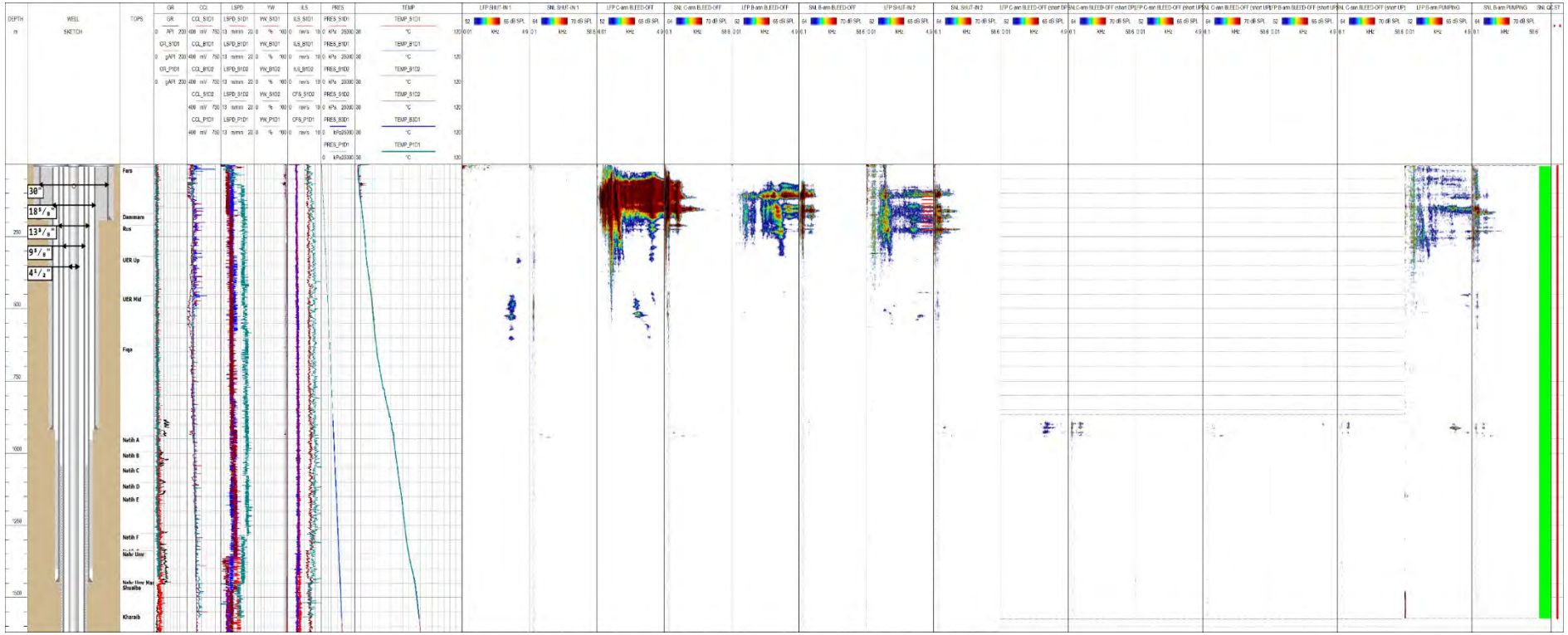
All Strings were in good integrity condition with no metal loss

String Type	Pipe Installation	OD	Weight	Corroded Interval		Av. Metal Loss	Max. Metal loss	Level of Corrosion	Corrosion Status
				Top	Bottom				
		(in)	lb/ft	mbdf	mbdf	%	%		
Completion string	2011	4.5	11.6	8.8	2585.1	0	0	None	Pass
Production Liner	2011	7	29	2428.8	2585.1	0	0	None	Pass
Production Casing	2011	9.625	53.5	9.1	2533.1	0	0	None	Pass
Intermediate Casing	2011	13.375	72	8.9	1444.6	0	0	None	Pass

Identifying Pressure Source

- In order To identify the pressure source, the following investigation/logs were required:
  - Fingerprinting analysis
  - Corrosion log
  - Temperature log
  - SNL & A.I

Noise was captured across Natih



Repair Options

Available repair options

1- Conventional perforation and cement squeeze
- wasn't done across two annuli
- Requires applying pressure against formation (risk of formation fracture)
- In case of patchy cement is behind the casing the effectiveness of the job is compromised

2- Local expander (new Technology)
- Used for single annulus repair (not applicable)

3- Perf, wash & cement (PWC) (new Technology)
- Cement placed without squeezing (no risk of formation fracture)
- Proper annuli wash to remove cement patches

Repair Options

PWC technique:

1. Perforating the casing or liner.
2. Washing the perforated annulus.
3. Placing spacer fluid in the casing and annulus.
4. Placing barrier material in the casing and annulus

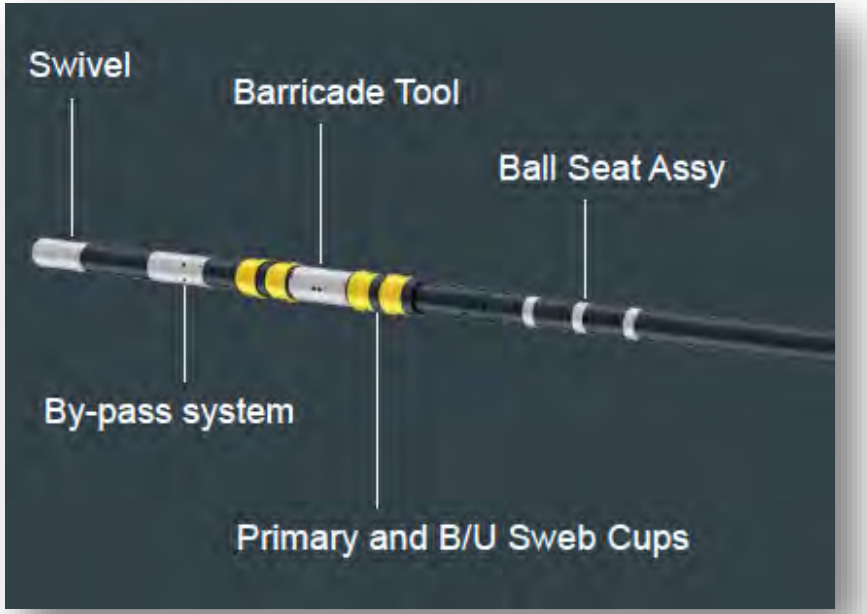
Probability of success:

The technology was tried in 4 wells

- succeeded in 3 (single annulus repair)
- failed in 1

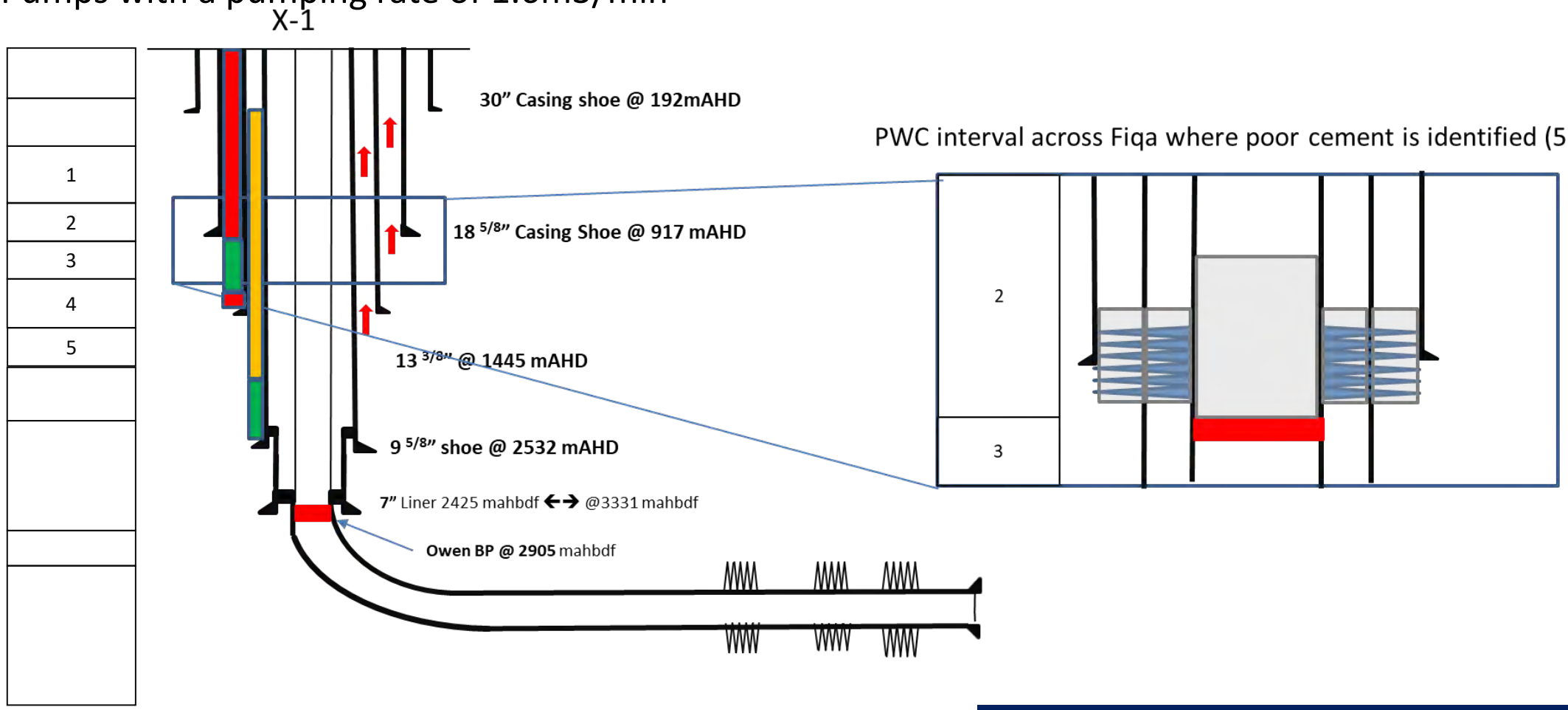
Job Requirements:

- Poor or no cement across both annuli in against Natural barrier
- Guns with EHD of 0.5” across both casings (SM95s 9 5/8” #53.5 & 13 3/8” L80 #72) without penetrating the third casing & 12spf shot density (no Gun was available in country with this specification)
- Pumps with a pumping rate of 1.6m3/min



Job Preparation and requirement

- Poor or no cement across both annuli in against Natural barrier
- Guns with EHD of 0.5” across both casings without penetrating the third casing (no Gun was available in country with this specification)
- Pumps with a pumping rate of 1.6m3/min



Job Preparation and requirement

- Poor or no cement across both annuli in against Natural barrier
- Guns with EHD of 0.5” across both casings without penetrating the third casing (no Gun was available in country with this specification)
- Pumps with a pumping rate of 1.6m3/min

Two vendors were approached to conduct the job.
Vendor A has shared simulations on available commercial guns.

Vendor A simulation cases:

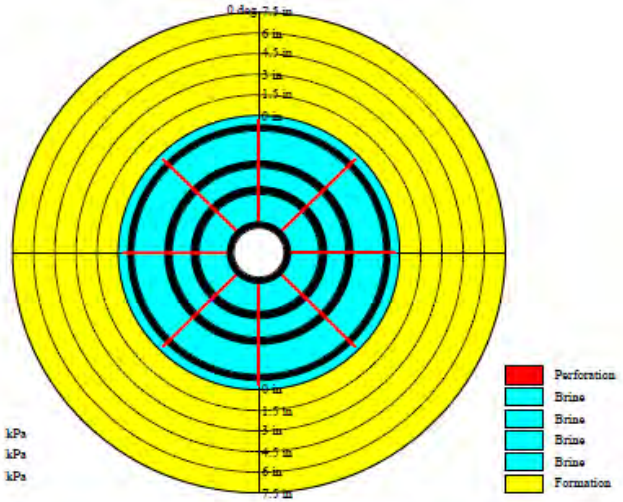
#	Name	Chg Wt (g)	Gun OD (in)	API Pen (in)	API EH (in)	Comment
1	4-1/2" HSD, PowerFlow 4621, RDX	19.0	4.5	5.90	0.83	Based on RP43 5th Ed
2	7" HSD, PowerFlow 4621, RDX	19.0	7	5.90	0.83	Based on RP43 5th Ed
3	7" HSD, PowerFlow 5008, RDX	30.0	7	5.80	0.98	RP43 C-33M
4	7" HSD, HyperJet 4505, RDX	38.8	7	37.00	0.57	Based on RP43 5th Ed
5	4-1/2" HSD, HyperJet 4505, RDX	38.8	4.5	37.00	0.57	RP43 C-33M

Job Preparation and requirement

Perforating System #1

4-1/2" HSD, PowerFlow 4621, RDX, 19.0 g,OD 4.5 in

135/45° Phasing, 12.00 spf



Rock Type: Sandstone
Rock UCS: 44147 kPa
Vertical Stress: 18096 kPa
Pore Pressure: 8086 kPa

Angle (deg)	Clearance (in)	Total Pen ^ (in)	Form Pen ^ (in)	Form Dia (in)	Csg EH Dia (in)	Perf Tunnel Area (in2)	Perf Tunnel Volume (in3)
0	2.02	5.36	0.00	0.00	0.37/0.14/0.08	0.00	0.00
45	2.02	5.36	0.00	0.00	0.37/0.14/0.08	0.00	0.00
90	2.02	5.36	0.00	0.00	0.37/0.14/0.08	0.00	0.00
135	2.02	5.36	0.00	0.00	0.37/0.14/0.08	0.00	0.00
180	2.02	5.36	0.00	0.00	0.37/0.14/0.08	0.00	0.00
225	2.02	5.36	0.00	0.00	0.37/0.14/0.08	0.00	0.00
270	2.02	5.36	0.00	0.00	0.37/0.14/0.08	0.00	0.00
315	2.02	5.36	0.00	0.00	0.37/0.14/0.08	0.00	0.00
Average	2.02	5.36	0.00	0.00	0.37/0.14/0.08	0.00	0.00

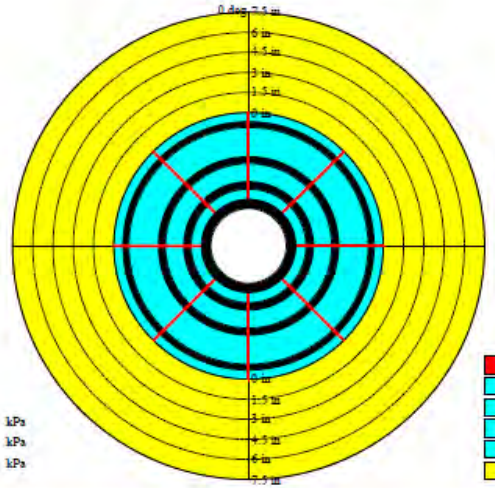
AOF (cm2/m) 26.83/3.83/1.16 at 12.00 spf

API: Pen 5.90 in, EH Dia 0.83 in, Based on RP43 5th Ed
^ Concrete-based Model

Perforating System #2

7" HSD, PowerFlow 4621, RDX, 19.0 g,OD 7 in

135/45° Phasing, 12.00 spf



Rock Type: Sandstone
Rock UCS: 44147 kPa
Vertical Stress: 18096 kPa
Pore Pressure: 8086 kPa

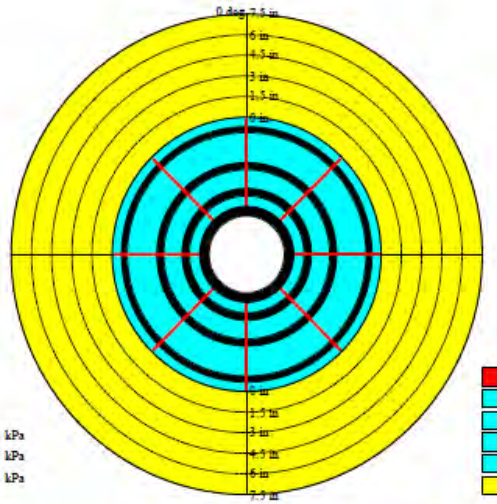
Angle (deg)	Clearance (in)	Total Pen ^ (in)	Form Pen ^ (in)	Form Dia (in)	Csg EH Dia (in)	Perf Tunnel Area (in2)	Perf Tunnel Volume (in3)
0	0.77	5.70	0.00	0.00	0.84/0.32/0.17	0.00	0.00
45	0.77	5.70	0.00	0.00	0.84/0.32/0.17	0.00	0.00
90	0.77	5.70	0.00	0.00	0.84/0.32/0.17	0.00	0.00
135	0.77	5.70	0.00	0.00	0.84/0.32/0.17	0.00	0.00
180	0.77	5.70	0.00	0.00	0.84/0.32/0.17	0.00	0.00
225	0.77	5.70	0.00	0.00	0.84/0.32/0.17	0.00	0.00
270	0.77	5.70	0.00	0.00	0.84/0.32/0.17	0.00	0.00
315	0.77	5.70	0.00	0.00	0.84/0.32/0.17	0.00	0.00
Average	0.77	5.70	0.00	0.00	0.84/0.32/0.17	0.00	0.00

AOF (cm2/m) 40.40/20.05/6.07 at 12.00 spf

Perforating System #3

7" HSD, PowerFlow 5008, RDX, 30.0 g,OD 7 in

135/45° Phasing, 12.00 spf



Rock Type: Sandstone
Rock UCS: 44147 kPa
Vertical Stress: 18096 kPa
Pore Pressure: 8086 kPa

Angle (deg)	Clearance (in)	Total Pen ^ (in)	Form Pen ^ (in)	Form Dia (in)	Csg EH Dia (in)	Perf Tunnel Area (in2)	Perf Tunnel Volume (in3)
0	0.77	5.54	0.00	0.00	0.99/0.37/0.20	0.00	0.00
45	0.77	5.54	0.00	0.00	0.99/0.37/0.20	0.00	0.00
90	0.77	5.54	0.00	0.00	0.99/0.37/0.20	0.00	0.00
135	0.77	5.54	0.00	0.00	0.99/0.37/0.20	0.00	0.00
180	0.77	5.54	0.00	0.00	0.99/0.37/0.20	0.00	0.00
225	0.77	5.54	0.00	0.00	0.99/0.37/0.20	0.00	0.00
270	0.77	5.54	0.00	0.00	0.99/0.37/0.20	0.00	0.00
315	0.77	5.54	0.00	0.00	0.99/0.37/0.20	0.00	0.00
Average	0.77	5.54	0.00	0.00	0.99/0.37/0.20	0.00	0.00

AOF (cm2/m) 93.92/27.16/8.16 at 12.00 spf

API: Pen 5.80 in, EH Dia 0.98 in, RP43 C-33M
^ Concrete-based Model

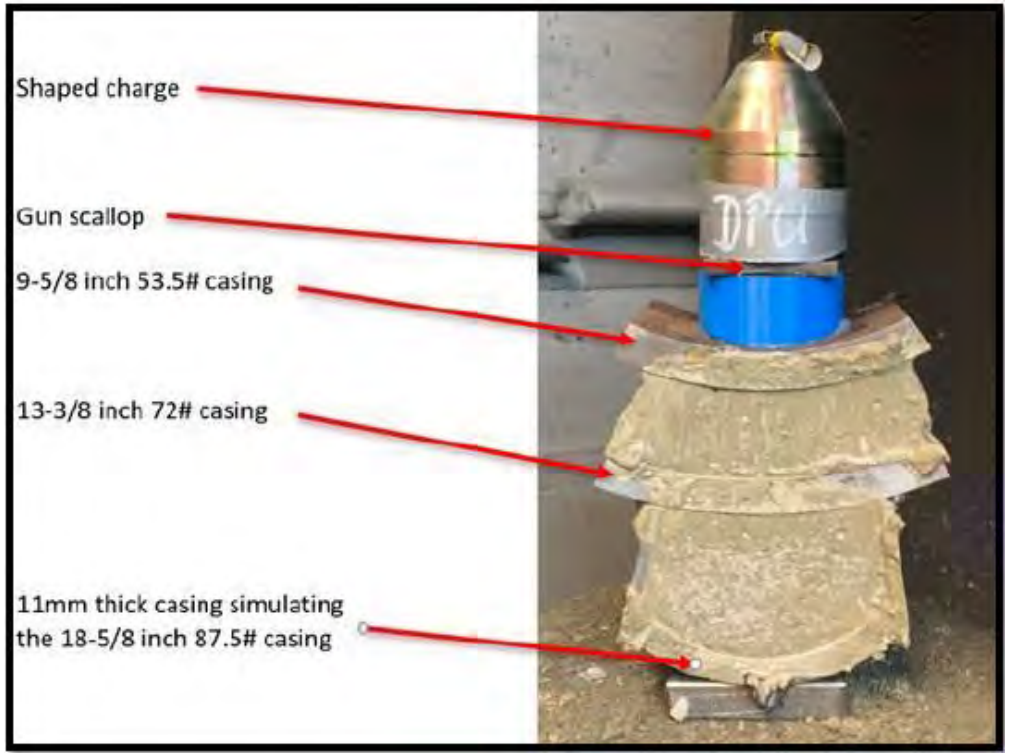
Job Preparation and requirement

Vendor B have highlighted that they have manufactured guns with this specification on order basis but wasn't tested across two casings.

We have requested them to carry a gun test for assurance

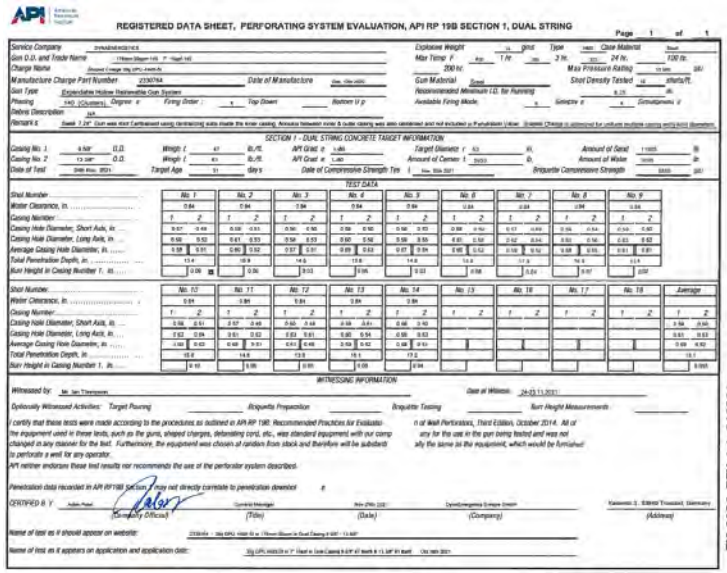
	EHD in 9-5/8" casing	EHD in 13-3/8" casing	Indentation depth 18-5/8" casing
Test 1 39g DPU	0.61 inch	0.50 inch	0.08 inch
Test 2 39g DPU	0.61 inch	0.50 inch	0.10 inch

Gun Size/Type & Shot Density	7" HSD, 12 SPF, 39g DPU, HMX



Job Preparation and requirement

- 39g DPU is a specially engineered shaped for multiple casing applications.
- 39g DPU is the result of many finite element simulations and casing configurations shots, and it offers nearly constant entry hole across two casing string.

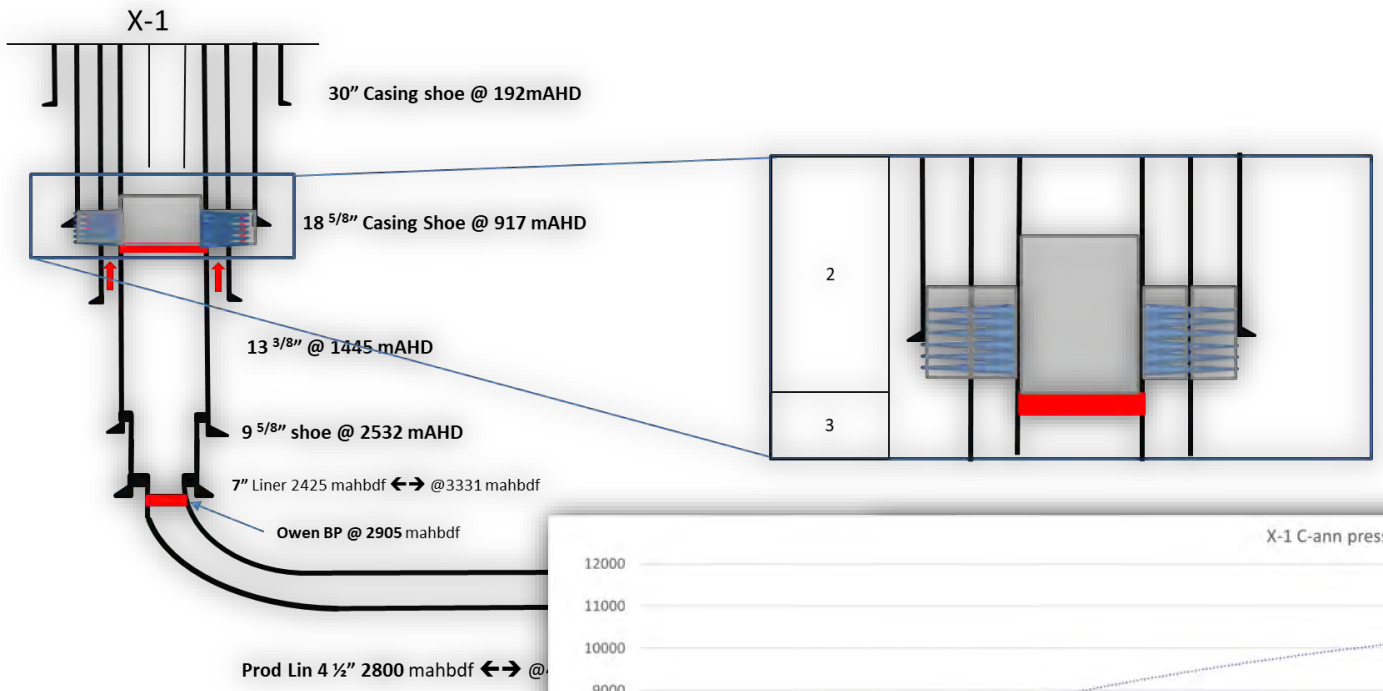


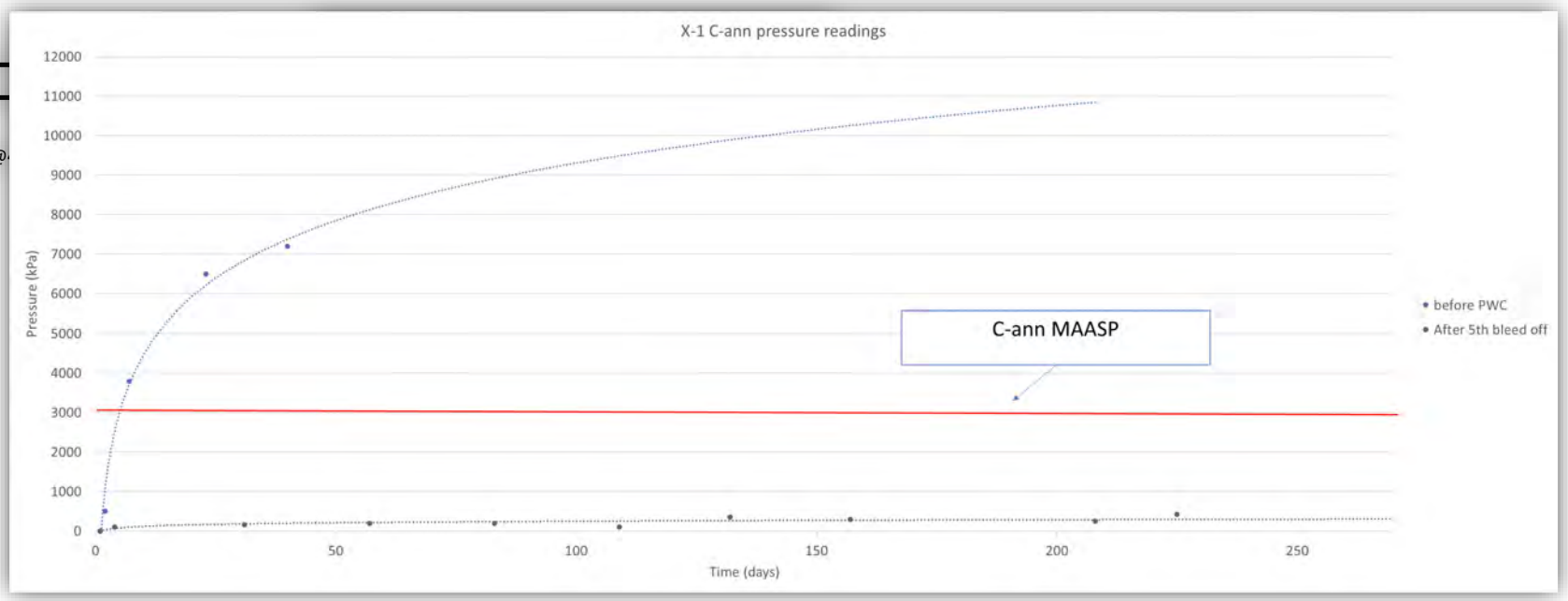
REGISTERED DATA SHEET, PERFORATING SYSTEM EVALUATION, API RP 19B SECTION 1, DUAL STRING

FM-3034 REV_1.1 012821

- The large EHD (≥ 0.50 in across both casings) made the 39g DPU the charge of choice for perf-wash-cement operations across double casing completions.

Results


X-1
30" Casing shoe @ 192mAHD
18 5/8" Casing Shoe @ 917 mAHD
13 3/8" @ 1445 mAHD
9 5/8" shoe @ 2532 mAHD
7" Liner 2425 mahbdf ←→ @3331 mahbdf
Owen BP @ 2905 mahbdf
Prod Lin 4 ½" 2800 mahbdf ←→ @
2
3


X-1 C-ann pressure readings
Pressure (kPa)
12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
0
50
100
150
200
250
Time (days)
C-ann MAASP
before PWC
After 5th bleed off

Cairo. Egypt. November 7-8, 2022

MENAPS 2022

MIDDLE EAST AND NORTH AFRICA PERFORATING SYMPOSIUM

Q&A