

Perforating Strategy Enhancement for Fracturing Deep Exploration and Gas Wells With Very Tight Formations in Oman

MENAPS 16-07

NOV 13TH, 2016

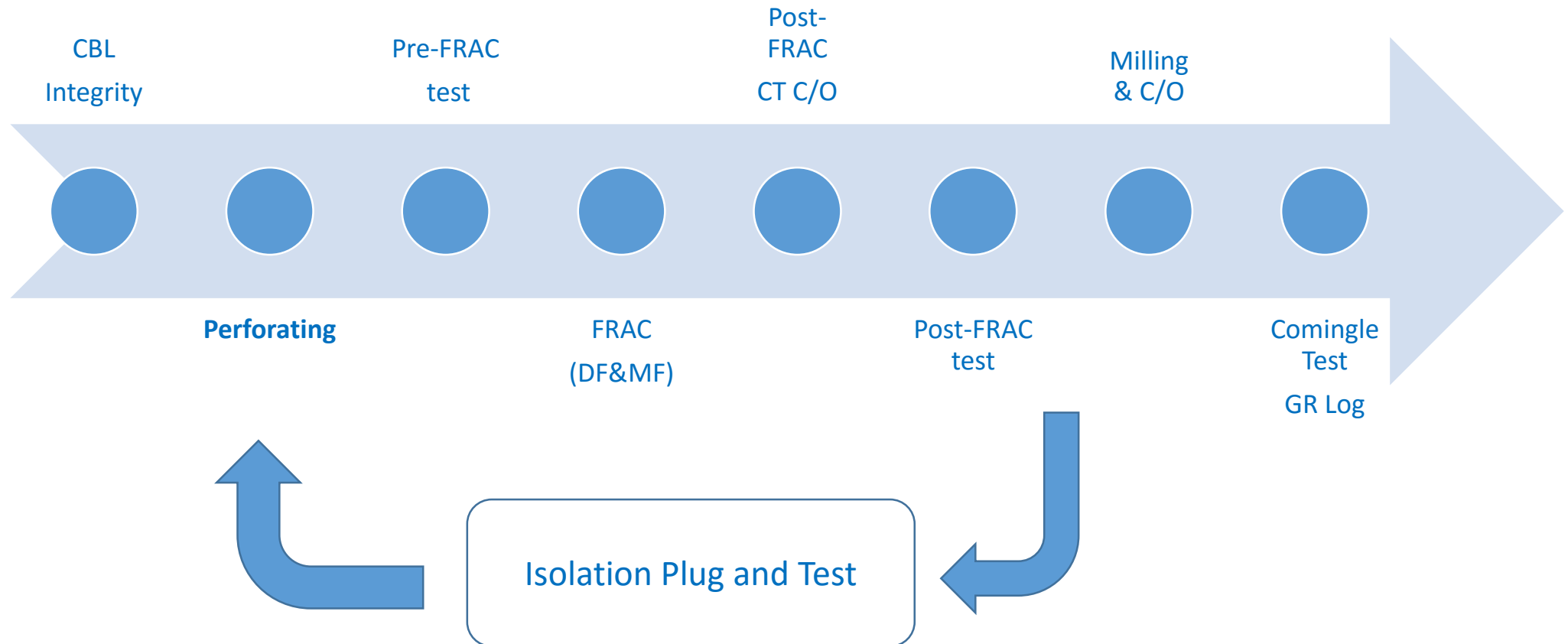
AUTHORS: Alvaro Javier Nunez, Petroleum Development Oman
Mathieu Molenaar, Petroleum Development Oman

AGENDA

- Background
- Challenge
- Solution
- Case Exploration Well_A
- Case Exploration Well_B
- Conclusion

BACKGROUND

FRAC operations in Exploration wells



- Each FRAC stage can go up to 5-7 days
- Wells can have several stages
- **FRAC fleet charges more expensive than drilling Rigs**

BACKGROUND

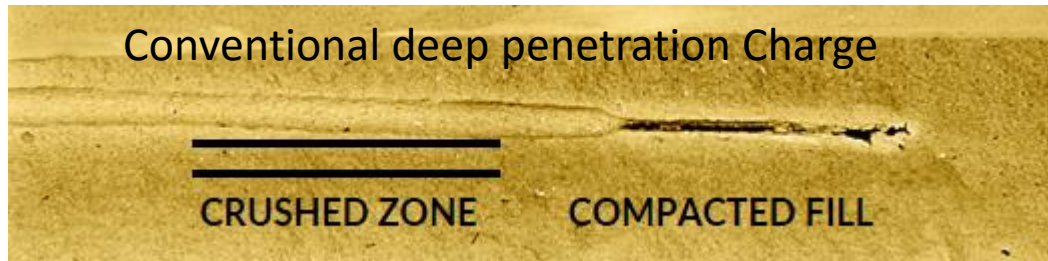
FRAC set up



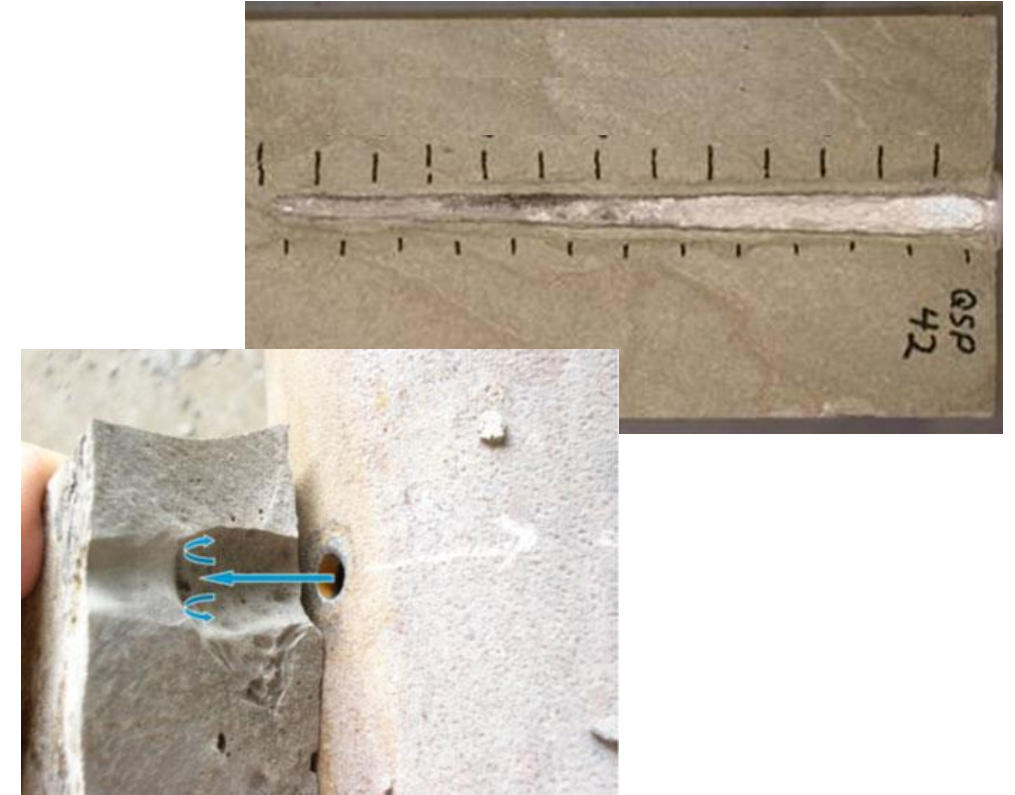
CHALLENGE

- Optimize activities – LEAN (i.e. perforating)
- Perforations are needed to connect the formation to initiate and propagate the FRAC
- Deep penetration charges (e-line) have been historically unsuccessful
- Abrasive Jet (AJ) perforations have been used to reduce the perforating skin to be able to break down
- Accuracy on depth for perforations to avoid fracture barrier (formations)
- **AJ is a complex and lengthy operation (36-48 hrs/stage) that requires Coil Tubing, Sand Management System (SMS), specialized perforator BHA, correlating devices, pumping and mixing equipment and a substantial quantity of fluids and sand per interval.**

SOLUTION



Reactive Liner Charge



AJ perforation

Reactive liner is an innovative (e-line) perforating technology that delivers cleaned tunnels and enhanced perforations removing the skin and facilitating fracturing and stimulation applications by reducing the break down pressures.


CASE 1

Exploration Well_A

WELL_A: Two FRAC stages, 4.5" monobore, ~5200mts

- Stage 1
 - ✓ 24 meters to be perforated.
 - ✓ 48 AJ stations at 3.3BPM,
 - ✓ 40# gel with 1.0 lb/gal 100 mesh Silica
 - ✓ 8min/station
 - ✓ **6.4** hours pumping AJ fluid

- Stage 2
 - ✓ 44 meters to be perforated.
 - ✓ 72 AJ stations at 3.3BPM,
 - ✓ 40# gel with 1.0 lb/gal 100 mesh Silica
 - ✓ 8min/station
 - ✓ **9.6** hours pumping AJ fluid

Tool OD (in.)	Tool ID (in.)	Tool Diagram	Length (m)	Description	Connection (Make-Up Torque)
2.88	1.38		0.50	External Slip Type Connector f/ 2.00" O.D. Coil	2-3/8" PAC Pin Dn (2,300 Ft/Lbs)
2.88	1.00		0.43	Dual Back Pressure Valve	2-3/8" PAC Box Up (2,300 Ft/Lbs) x 2-3/8" PAC Pin Dn (2,300 Ft/Lbs)
2.88	0.69		0.68	Hydraulic Disconnect	2-3/8" PAC Box Up (2,300 Ft/Lbs) x 2-3/8" PAC Pin Dn (2,300 Ft/Lbs)
3.06	1.00		0.99	Spiral Abrasive Perforator w/ (6) Ports 1ft long @ 60°	2-3/8" PAC Box Up (2,300 Ft/Lbs) x 2-3/8" PAC Pin Dn (2,300 Ft/Lbs)
2.88	0.50		0.16	Ball Seat Wash Nozzle	2-3/8" PAC Box Up (2,300 Ft/Lbs)

AJ perforator BHA on 2" CT

RESULTS

Exploration Well_A

WELL_A: Two FRAC stages, 4.5" monobore, ~5200mts

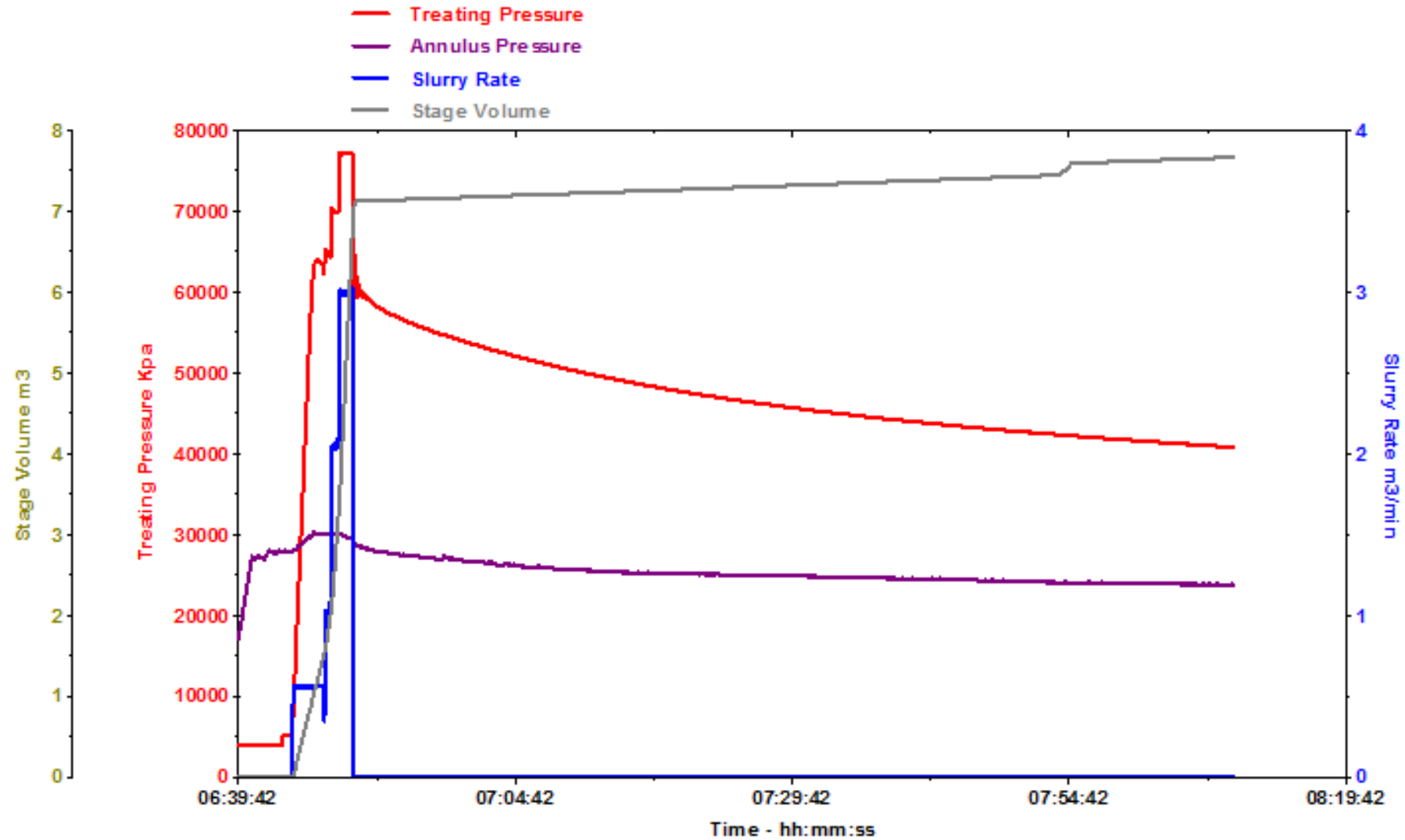
- Stage 1
 - ✓ 18mts (of 24m AJ) perforated in two runs
 - ✓ 9.5 mts per run
 - ✓ 2 7/8", 6SPF, Reactive liner Charges
 - ✓ 9 hours (RIH, Perforate and POOH)
 - ✓ **Formation successfully broke down and Fractured**

- Stage 2
 - ✓ 25mts (of 44m AJ) perforated in 4 runs
 - ✓ 2 x 9.5 mts per run & 2 x 3 mts
 - ✓ 2 7/8", 6SPF, Reactive liner Charges
 - ✓ 18 hours (RIH, Perforate and POOH)
 - ✓ **Formation successfully broke down and Fractured**

RESULTS

Exploration Well_A Stage 1

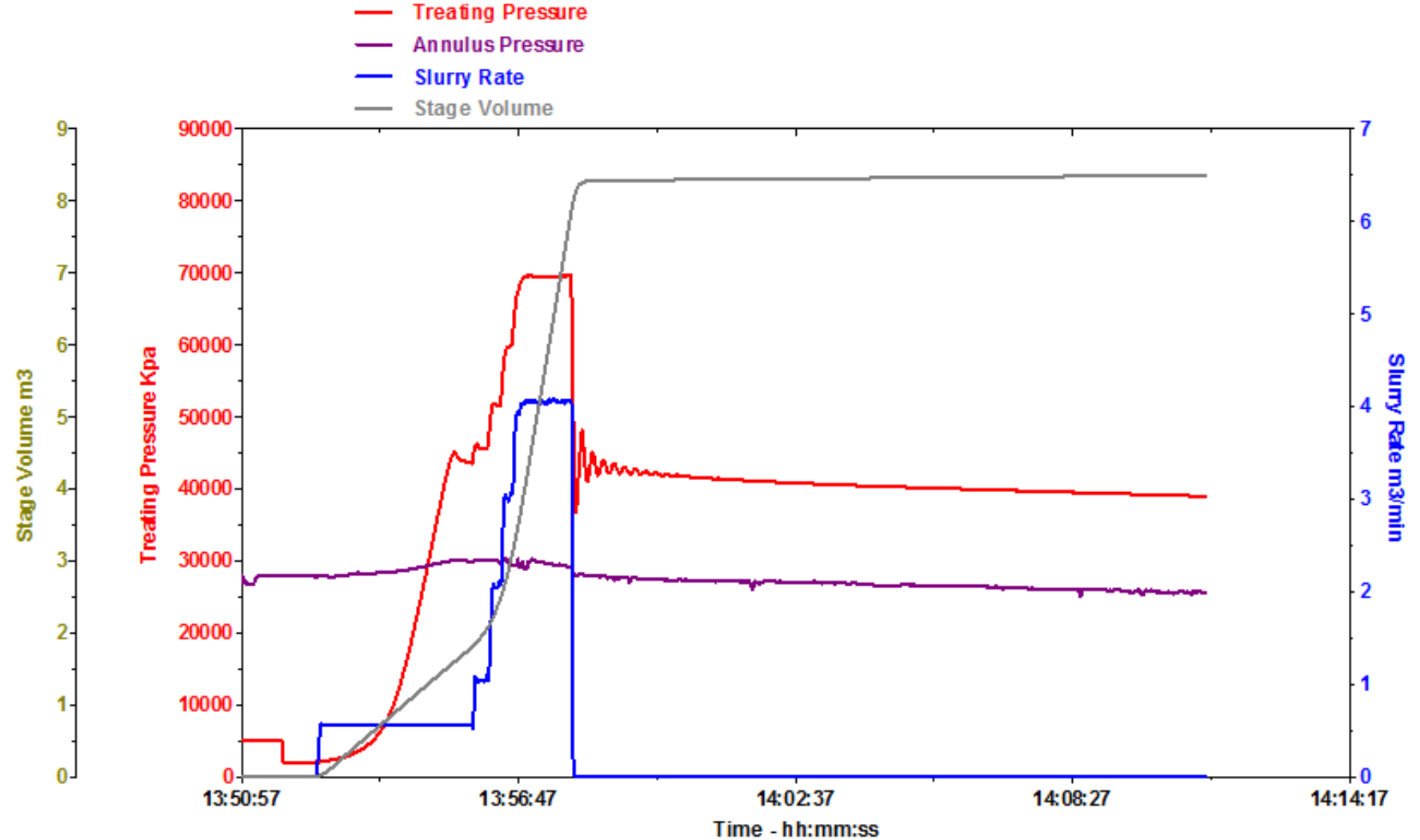
- Break down at 64000Kpa
- Max Pressure 77000Kpa
- Completion tested to 95000Kpa



RESULTS

Exploration Well_A Stage 2

- Break down at 45000Kpa
- Max Pressure 70000Kpa
- Completion tested to 95000Kpa




CASE 2

Exploration Well_B

WELL_B: Two FRAC stages, 4.5" monobore, ~5200mts

- Stage 1
 - ✓ 31 meters to be perforated.
 - ✓ 62 AJ stations at 3.3BPM,
 - ✓ 40# gel with 1.0 lb/gal 100 mesh Silica
 - ✓ 8min/station
 - ✓ **8.3** hours pumping AJ fluid

- Stage 2
 - ✓ 28 meters to be perforated.
 - ✓ 56 AJ stations at 3.3BPM,
 - ✓ 40# gel with 1.0 lb/gal 100 mesh Silica
 - ✓ 8min/station
 - ✓ **7.4** hours pumping AJ fluid

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2.88	0.50		0.16	Ball Seat Wash Nozzle	2-3/8" PAC Box Up (2,300 Ft/Lbs)

AJ perforator BHA on 2" CT

RESULTS

Exploration Well_B

WELL_B: Two FRAC stages, 4.5" monobore, ~5200mts

- Stage 1
 - ✓ 26mts (of 31m AJ) perforated in 3 runs
 - ✓ 2x 9.5 mts & 1x7 mts runs
 - ✓ 2 7/8", 6SPF, Reactive liner Charges
 - ✓ 13 hours (RIH, Perforate and POOH)
 - ✓ **Formation did NOT break down**
 - ✓ 31m perforated with AJ as program
 - ✓ **Formation did NOT break down and skip FRAC**

- Stage 2
 - ✓ 23.5mts (of 28m AJ) perforated in 3 runs
 - ✓ 2 x 7.5 mts & 1x8 mts runs
 - ✓ 2 7/8", 6SPF, Reactive liner Charges
 - ✓ 12 hours (RIH, Perforate and POOH)
 - ✓ **Formation successfully broke down and Fractured**

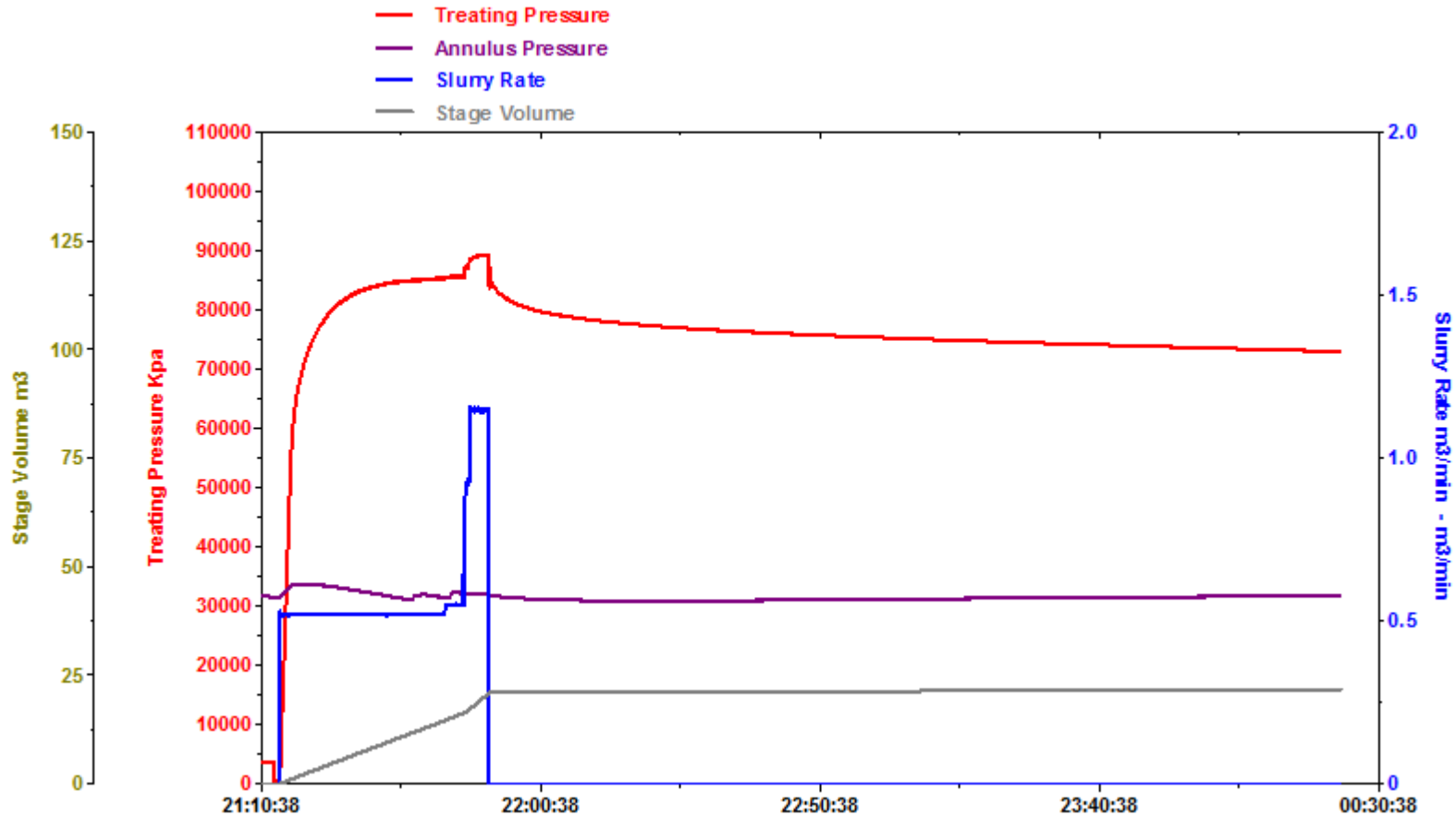
RESULTS

Exploration

Well_B Stage 1

Post reactive liner perfo

- Formation unable to break down
- Completion tested to 95000Kpa



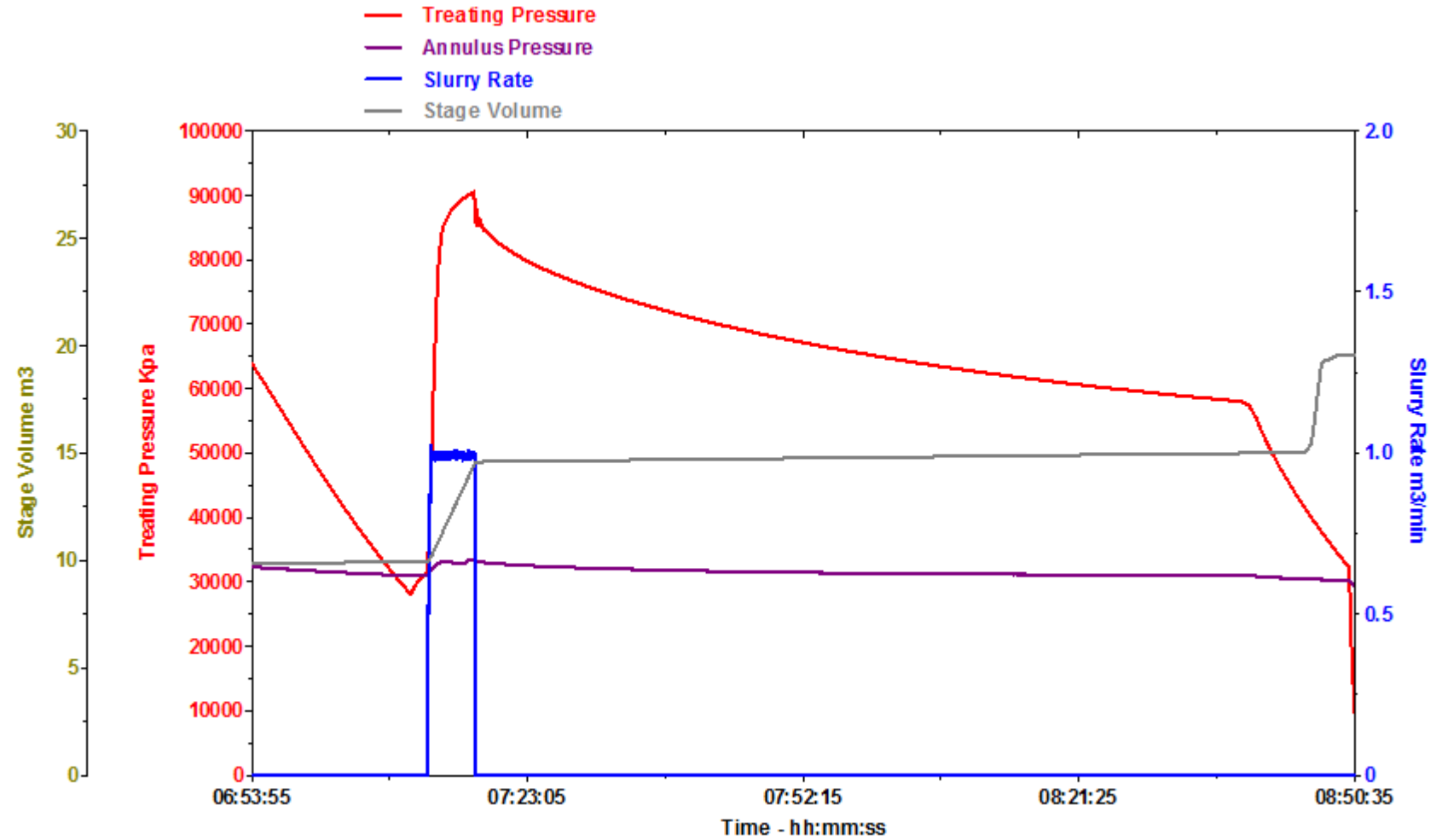
RESULTS

Exploration

Well_B Stage 1

Post AJ perforations

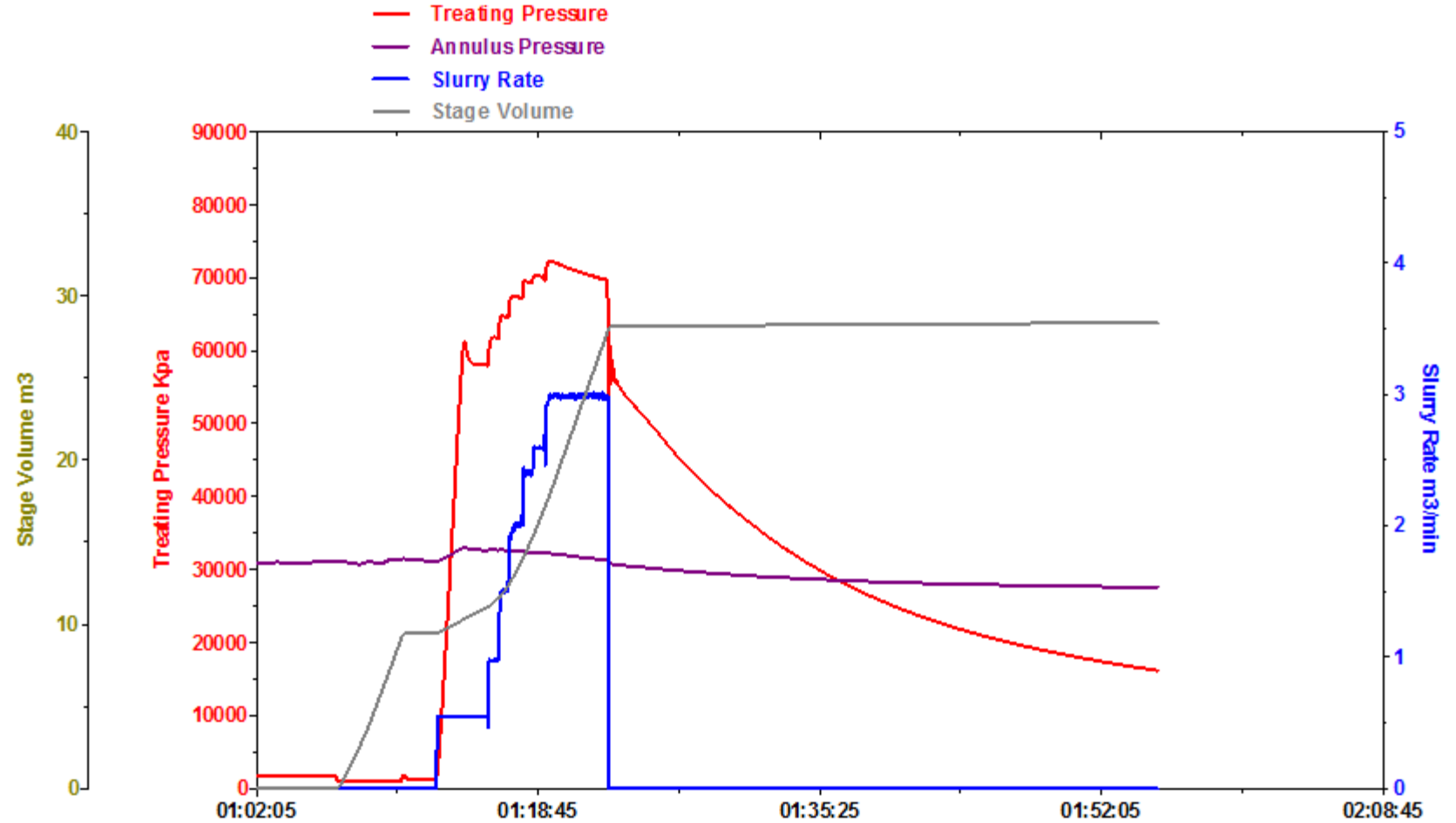
- Formation unable to break down
- Completion tested to 95000Kpa



RESULTS

Exploration Well_B Stage 2

- Break down at 61000Kpa
- Max Pressure 72000Kpa
- Completion tested to 95000Kpa



CONCLUSIONS

- Reactive liner technology has been successfully proved to replace Abrasive Jet perforations which has been the preferred perforating technique, however it can't be generalized and need to be assessed case by case
- Efficiency has been substantially improved from 36-48 Hours (AJ) to 12-15 hours on e-line perforations
- Actual perforating savings costs of 40% have been seen in the stages successfully fractured
- HSE exposure is reduced from complex AJ operations (CTU, SMS, pumping) to e-line operations.
- Depth accuracy is 100% achieved on e-line perforations while AJ is still 3mts off average in best cases
- Shot density is limited on AJ (depending on pumping program) while e-line perforations can go to 20SPM (6SPF)
- Opportunity to execute perforations ahead of frac move minimizing cost impact

MENAPS 2016

Middle East and North Africa Perforating Symposium

MUSCAT, OMAN

QUESTIONS?
THANK YOU!

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