Crossflow May HIT Your Back!

By Cheryl Perng (Murphy Oil Corp.)
Presentation Outlines

- Well Overview
- Operational
- Implemented Lesson Learned
- Best Practices
- Conclusion
Well Overview

Well ‘A’ focused on an integrated marginal gas field development located in Sarawak.

- Small platform
- Monobore completion - triple wellhead
- Multi-stacked reservoirs
- New zones were proposed after current zone almost depleted
- Up hole/ bottoms-up completion strategy
- Underbalanced perforation technique is preferred
- Existing perforated zones were not isolated
- Existing perforated zones were not killed to ensure wellbore state undisturbed
- Downhole pressure data was unavailable - pressure estimation from other offset wells
- Equalization shot was planned to equalize/ pressurize the wellbore prior perforating main gun.
Operations

Well A

Plan

EQ shot (2 shots)

Main Gun at SAND G

778 to 2100psi
(K=1300mD)

- EQ shot
- 7 gun runs
- Gross interval: 301m
- Net interval: 25m

750 psi (K=1200mD)

Pressure increased –
50 psi

Pressure increased –
1150 psi

EQ1 depth at SAND G

THP
Before: 500psi
After: 550psi

BHP
Before: 483psi
After: 525psi

Pressure increased –
50 psi

Existing zones

Proposed zones

 Existing Open Perfs
Net Interval: 28.5 metres
Flowrate: 2 MMSCFD
Pavg 750 psi (K=1200mD)

EQ shot did not generate pressure increase as expected.

CROSSFLOW MAY HIT YOUR BACK
In Well B, total of six equalizing shots were sequentially added in selective until full well system pressure per model was achieved before adding gross perforations.

<table>
<thead>
<tr>
<th>Sand</th>
<th>Run Sequence</th>
<th>Perforation design</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>Perf Run #1  EQ#1 (Sel. Bottom)</td>
<td>2 shots</td>
</tr>
<tr>
<td></td>
<td>EQ#2 (Sel. Mid)</td>
<td>4 shots</td>
</tr>
<tr>
<td></td>
<td>EQ#3 (Sel. Top)</td>
<td>4 shots</td>
</tr>
<tr>
<td>C</td>
<td>Perf Run #2  EQ#4 (Sel. Bottom)</td>
<td>4 shots</td>
</tr>
<tr>
<td></td>
<td>EQ#5 (Sel. Mid)</td>
<td>4 shots</td>
</tr>
<tr>
<td></td>
<td>EQ#6 (Sel. Top)</td>
<td>4 shots</td>
</tr>
<tr>
<td>B</td>
<td>Perf Run #3  Main gun</td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>Perf Run #4  Main gun</td>
<td></td>
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**Expected Reservoir Pressure**

<table>
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<tr>
<th></th>
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<th>BHP post EQ</th>
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<tbody>
<tr>
<td>SAND A</td>
<td></td>
<td>EQ 6: 1,020 psi</td>
</tr>
<tr>
<td></td>
<td>943.6 psi (K=653mD)</td>
<td>EQ 5: 966 psi</td>
</tr>
<tr>
<td></td>
<td></td>
<td>EQ 4: 930 psi</td>
</tr>
<tr>
<td></td>
<td>1139.5 psi (K=385mD)</td>
<td>EQ 3: 852 psi</td>
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<td></td>
<td></td>
<td>EQ 2: 796 psi</td>
</tr>
<tr>
<td></td>
<td>1557.0 psi (K=151mD)</td>
<td>EQ 1: 728 psi</td>
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**Current Well Pressure**

- **Flowrate: 0.2 MMSCFD**
  - SAND C: 635psi
  - SAND B: 664psi
  - SAND A: 665psi

**Well B**

**Crossflow**

CROSSFLOW MAY HIT YOUR BACK
Best Practices

Prior perforating,
• To predict estimated influx rate (based on kh) and couple the influx rate with the tool lift calculation.
• Consider installing check valve to temporarily isolate depleted/ almost depleted zones.

IF pressure response for EQ is not as expected;
• Make multiple EQ shots runs to observe sufficient pressure increase before perforating main gun.

Conclusion

• Crossflow can mask pressure response.
• Engineered EQ shot strategy can mitigate risk.
QUESTIONS?
THANK YOU!
Plan vs Actual for Well A

**PLAN**

- Fire EQ shot @1617.31m
- Perforate #1 @1616.0 – 1619.0m
- Perforate #2 @1574.0 – 1579.0m
- Perforate #3 @1435.8 – 1440.8m
- Perforate #4 @1365.0 – 1368.0m
- Perforate #5 @1359.8 – 1362.8m
- Perforate #6 @1342.3 – 1345.0m
- Perforate #7 @1318.0 – 1322.0m

**Expected reservoir pressure = 778-2,100psi SAND A**

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**ACTUAL**

- Fired the EQ shot @1617.31m SITHP = 550 psi.
- Fired gun @1616 – 1619m (SAND A)
- SITHP increased to 1700 psi. Tension dropped from 1550 to 785 lbs
- Toolstring blown up downhole
- Worked on wire
- RU slickline. Jarred and moved fish down to 1,723m

- Lost downhole signal. Lost ERS function.
- Break Weak Point. Max pull = 2850 lbs
- Tool did not move. Pulled to 4650 lbs. Toolstring free. Tension jerking between 1700 - 2800 lbs
- Lost toolstring @ 1500m with 15 metres wire.
- Decided not to perforate shallow sands due to high reservoir pressure from this perforated sand.

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- SITHP before firing was 500 psi
- Expected reservoir pressure = 778-2,100psi SAND A
- Pressure increased from 500-550 psi

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**Crossflow may hit your back**
Operations

Well A

Plan

EQ1 depth at SAND G
(2 shots)

Main Gun at SAND G

- THP
  - Before: 500psi
  - After: 550psi

- BHP
  - Before: 483psi
  - After: 525psi

- Pressure increased – 50 psi
- Pressure increased – 1150 psi

EQ shot did not generate pressure increase as expected.

Existing Open Perfs
Net Interval: 28.5 metres
Flowrate: 2 MMSCFD
$P_{avg}$ 750 psi (K=1200mD)

Existing zones
Proposed zones

2 shots

SAND G

561 shots
AOF x 280 !!!!!!
Implemented Lesson Learned on Well B

In Well B, total of six equalizing shots were sequentially added in selective until full well system pressure per model was achieved before adding gross perforations. Flow test was conducted post 6th EQ to obtain reservoir pressure.

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Expected Reservoir Pressure

- 943.6 psi (K=653mD)
- 1139.5 psi (K=385mD)
- 1557.0 psi (K=151mD)

BHP post EQ

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- EQ 2: 796 psi
- EQ 1: 728 psi

Expected Reservoir Pressure

- 635psi
- 664psi
- 665psi

SAND A
SAND B
SAND C
SAND D
SAND E
SAND F