SURVEILLANCE USING PRESSURE GRADIENTS AND PRODUCTION TESTING

Wellbore Gradients and Production Testing

- Wellbore gradient data is one key to gas lift optimization
- Production test data is the other key to optimization
- Gradient and production data gathering guides are given to improve data quality and minimize operations risk
- API RP 11V8 – Gas Lift System Design and Performance Prediction has the detailed recommended practices
MATCH THE PRODUCTION TEST
WHICH LIFT DEPTH?

- RATE = 1448 BFPD (Gross fluid)
- WATER = 24%
- TGLR = 2693 SCF/STB
- IGLR = 2510 SCF/STB
- RES PRESS = 2495 PSIG
- FLOWING WHP = 130 PSIG
PRESSURE GRADIENT SURVEY CHART

JRN 003 PR & TEMP VS TIME
29 JULY 2007

John Martinez – Surveillance with gradient surveys and production testing
Guides to Flowing Gradient Data

1. Obtain measured pressure and temperature
   - validate calculated computer program results
2. Use data to determine
   - point of lift
   - estimate whether gas is passing at more than one point
3. Compare flowing fluid pressure to the calculated gas pressure
   - determine the possibility for a deeper point of lift
4. Use the formation fluid gradient below the point of lift
   - confirm the assumed PVT formation fluid properties
5. Observe temperature reductions to substantiate gas passage points or leaks
Guides to Flowing Gradient Data

- Gradient stop times:
  - MATCH PRESSURE MAX/MIN CYCLE

- Pressure survey applications:
  - GAS ENTRY POINT
  - ADJUST FLUID PROPERTIES

- Temperature survey applications:
  - GAS ENTRY POINT
  - TEMPERATURE TO SET DEEPER VALVES
  - MULTIPHASE FLOW CALCULATIONS

GRADIENT MATCH

C-4 MEAS VS CALC PRESSURE
**Wireline Job Recommendations**

- Run gauge ring
- Use dead weight tester
- Use weight bar to resist up flow
- Use anti-move lock when well has slugging production
- Stop time based on pressure swing
- Stop above and below mandrel
- Stop at 500 ft and 1000 ft for surface temp
- Several stops below inj. point for formation fluid gradient
- Stop in perfs for 30 min
- Stop to total depth for fill and water
- Pull gauges carefully

**Guides to Testing**

- **Hour by hour data tabulation to check for:**
  - Freezing at night
  - Emulsion tendency with cold weather
  - Injection gas loss during hot part of day
  - Fluid rate change due to meter error
  - Input gas greater than total gas
TEST MATCH

PRODUCTION RATE VS INJECTION GAS - WELL C-4

DELIVERY CURVE PRODUCTION RATE VS INJECTION GAS
PERFORMANCE LIST

WELLS GROUPED PER COMPRESSOR

<table>
<thead>
<tr>
<th>WELL</th>
<th>OIL BBL/M</th>
<th>GROSS BBL/M</th>
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<tbody>
<tr>
<td>B04</td>
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COMPRESSOR SUCTION AND DISCHARGE PRESSURE EFFECTS
Optimize Compression Horsepower (BHP)

COMP. BHP/STB VS SEP. PRESS.

WELL 1: Pi = 10, RATE = 3000 STB/D, INJ P = 1100 PSIG
WELL 2: Pi = 1, RATE = 500 STB/D, INJ P = 900 PSIG

<table>
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<tr>
<th>SEPARATOR PRESSURE, PSIG</th>
<th>BRAKE HP PER STB</th>
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<tr>
<td>0</td>
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<td>100</td>
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<td>150</td>
<td>0.09</td>
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<tr>
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</table>

WELL 1
WELL 2
TEST ACCURACY

- HIGH RATES EASY
- STEADY FLOW BEST
- SIZE METERS
- TEST DURATION TO OBTAIN STABLE RATE
- SEPARATOR PURGE TIME
- TEST FLOWLINE PURGE TIME
- SHRINKAGE FACTOR APPLIED
- TEMPERATURE COMPENSATION
- GAS SAMPLES

TEST FREQUENCY

- BASIS FOR FREQUENT TESTING:
  - RAPID RESERVOIR PRESSURE LOSS
  - WATER BREAKTHROUGH
  - LIFT GAS ALLOCATION
  - DEPTH OF INJECTION FROM SIMULATION AND TEST RATE
TEST DURATION

◆ TIME NEEDED:
  • TO ATTAIN RATE STABILITY
  • TO REMOVE EFFECT OF PRIOR TEST
  • TEST OF WELL AND ITS SPECIAL PROBLEMS, SUCH AS FREEZING

INJECTION GAS RATE

◆ Monitor compressor availability
◆ Detect gas hydrate problems
◆ Evaluate gas allocation
◆ Simulate the depth of lift when coupled to the gas pressure on the casing and the last production test
WELLBORE GRADIENTS AND PRODUCTION TESTING

- Computer simulation, flowing gradients, and production tests can be used in combination to improve the quality of data for each well.
- Testing data can be used to estimate point of injection.
- Correlation selection and PVT data adjustment requires flowing survey data.
- Guides for gradient surveys and for production testing can improve the quality of the data.

MODELING AND ANALYSIS

- PVT data is the most important item affecting accurate simulation with computer models. The data can come from PVT reports or from field data.
- PVT data should be adjusted using flowing pressure surveys and a computer model.
- Wellhead pressure delivery curves are used to predict natural flow rates and the conditions when natural flow ceases.
- Production rate versus injection gas delivery curves can be used to select rates, generate gradient curves.