Reduced Emission Completions in DJ Basin and Natural Buttes

Producers Technology Transfer Workshop
May 1, 2008
Rock Springs, Wyoming

Topics of Discussion

- Anadarko’s areas of tight gas production
- Conventional completion emissions
- Reduced emission completions
  - Best Management Practices “BMP”
  - Breco skids
- Environmental and economic benefit
- Future plans
Anadarko’s Areas of Tight Gas Production

- Wyoming
- Utah
- Colorado
- Wamsutter
- Granger
- Natural Buttes
- DJ Basin

Conventional DJ Gas Well Completion

- Pressure test of well
- Perforation of well casing and cement in production zones
- Fracture of reservoir to enhance production
  - Fracture media and proppant dependent on reservoir
- Flow back well until well pressure safe to rig up
  - Possibility of lasting weeks
  - Gas vented to atmosphere
- Run production tubing
- Connect to production equipment and gathering system
- Operate well
### Conventional DJ Completion CH₄ Emissions

<table>
<thead>
<tr>
<th>Year</th>
<th>Wells Frac’d</th>
<th>Avg Vent Time</th>
<th>Estimated Gas Lost</th>
<th>Revenue Lost¹</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Days</td>
<td>MMSCF</td>
<td>MM$</td>
<td></td>
</tr>
<tr>
<td>1998</td>
<td>281</td>
<td>8</td>
<td>899.2</td>
<td>2.7</td>
</tr>
<tr>
<td>1999</td>
<td>374</td>
<td>8</td>
<td>1196.8</td>
<td>3.6</td>
</tr>
<tr>
<td>2000</td>
<td>387</td>
<td>11</td>
<td>1702.8</td>
<td>5.1</td>
</tr>
<tr>
<td>2001</td>
<td>491</td>
<td>13</td>
<td>2553.2</td>
<td>7.7</td>
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<tr>
<td>2002</td>
<td>538</td>
<td>14</td>
<td>3012.8</td>
<td>9.0</td>
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<tr>
<td>2003</td>
<td>447</td>
<td>16</td>
<td>2860.8</td>
<td>8.6</td>
</tr>
<tr>
<td>2004</td>
<td>379</td>
<td>15</td>
<td>2274.0</td>
<td>6.8</td>
</tr>
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<td>2005</td>
<td>473</td>
<td>11</td>
<td>2081.2</td>
<td>6.2</td>
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<td>Average</td>
<td>421</td>
<td>12</td>
<td>2072.6</td>
<td>6.2</td>
</tr>
</tbody>
</table>

¹ Based on EPA STAR $3 gas

### Reduced DJ Emission Completions

- Pressure test of well
- Perforation of well casing and cement in production zones
- Fracture of reservoir to enhance production
  - Fracture media and proppant dependent on reservoir
- **Well flows back until gas cut**
- Well shut-in and tied to production equipment
  - Basin specific due to reservoir and gathering system parameters
- Flow back well to separation equipment until well pressure safe to rig up
  - Possibility of lasting weeks
  - Gas directed to sales
  - Liquids collected in tank
- Run production tubing
- Operate well
### Reduced DJ Emission Completion CH$_4$ Emissions

<table>
<thead>
<tr>
<th>Year</th>
<th>Wells Frac’d</th>
<th>Average Vent Time</th>
<th>Estimated Gas Lost</th>
<th>Revenue Lost$^1$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Days</td>
<td>MMSCF</td>
<td>M$</td>
</tr>
<tr>
<td>2006</td>
<td>590</td>
<td>0.08</td>
<td>19.7</td>
<td>137.7</td>
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<td>2007</td>
<td>636</td>
<td>0.08</td>
<td>21.2</td>
<td>148.4</td>
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<td>2008</td>
<td>310</td>
<td>0.08</td>
<td>10.3</td>
<td>72.3</td>
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<tr>
<td>Average$^2$</td>
<td>613</td>
<td>0.08</td>
<td>20.5</td>
<td>143.1</td>
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</table>

1. Based on EPA STAR $7$ gas
2. 2006 and 2007

### Average DJ Economic Benefit

<table>
<thead>
<tr>
<th>Completion Method</th>
<th>Wells Frac’d</th>
<th>Average Vent Time</th>
<th>Estimated Gas Vented</th>
<th>Revenue Lost</th>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Days/well</td>
<td>MMSCF</td>
<td></td>
</tr>
<tr>
<td>Conventional</td>
<td>421</td>
<td>12</td>
<td>2072.6</td>
<td>$6.2 MM</td>
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<tr>
<td>Green</td>
<td>613</td>
<td>0.08</td>
<td>20.5</td>
<td>$143.1 M</td>
</tr>
<tr>
<td>Comparison G vs. C</td>
<td>+192</td>
<td>-2052.1</td>
<td>+$6.1 MM</td>
<td></td>
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</tbody>
</table>
Natural Buttes Reduced Emission Completions

- Began using Breco skid late 2005 through 3rd quarter 2006
- Designed internal system which is currently used
- Fracture materials separated from gas stream
- Gas stream directed to gathering system

Natural Buttes Completion Benefit

<table>
<thead>
<tr>
<th>Wells Completed</th>
<th>Flow Time Through Breco</th>
<th>Cumulative Gas</th>
<th>Breco Cost</th>
<th>Gas Saved Revenue¹</th>
<th>Difference</th>
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</thead>
<tbody>
<tr>
<td>138</td>
<td>80</td>
<td>3.9</td>
<td>$6,341</td>
<td>$25,710</td>
<td>$19,369</td>
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</tbody>
</table>

¹ Based on traded gas price
Environmental Benefits

- Reduction of vented VOCs and HAPs
- Reduction of GHG compounds
  - CH$_4$ 21 times more potent than CO$_2$
- Possibility of recycling stimulation fluids
- Reduces combustion byproducts

Reduced Emission Completion Restrictions

- Methodology employed dependent on reservoir characteristics
- Areas where nitrogen or carbon dioxide are used to enhance fracture fluid
  - Sales gas specifications
  - Flaring utilized
- Gathering system pressure
  - Gas compression may be required
Future Plans

- Continue to utilize green completion practices
- Evaluate new green completion techniques and production methods

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Questions or Comments?