Reducing Methane Emissions from Production Wells: Reduced Emission Completions in Gas Wells; Smart Automation of Gas Well Plunger Lifts

International Workshop on Methane Emissions Reduction Technologies in the Oil and Gas Industry
Lake Louise

14-16 September 2009
Agenda

▪ Reduced Emissions Completions
  – Methane Losses
  – Methane Recovery
  – Is Recovery Profitable?
  – Partner Experience

▪ Plunger Lift and Smart Automation

▪ Discussion

▪ Contacts
Methane Losses During Gas Well Completions

- Gas wells in tight formations and coal beds require hydraulic fracture
- It is necessary to clean out the well bore and formation
  - After new completion
  - After well workovers
- Operators produce to an open pit or tank to collect sand, cuttings, and fluids for disposal
- Vent or flare the natural gas produced
- 67 Bcf\(^1\) (1.9 billion m\(^3\)) of gas is vented or flared from completions and workovers in the U.S. resulting in 27 Bcf (0.8 billion m\(^3\)) of methane emissions

\(^1\) – EPA estimate.
Methane Recovery by Reduced Emission Completions

- Recover natural gas and condensate produced during flow-back following hydraulic fracture
- Portable equipment separates sand and water, processes gas and condensate for sales
- Route recovered gas through dehydrator and meter to sales line, reducing venting and flaring

Portable REC Equipment

Source: Weatherford
Reduced Emission Completions: Preconditions

- Permanent equipment required on site before cleanup
  - Piping from well head to sales line
  - Dehydrator
  - Lease meter
  - Stock tanks for wells producing significant amounts of condensate

- Sales line gas can be used for compressor fuel and/or gas lift in low pressure wells
Reduced Emission Completions: Equipment

- Skid or trailer mounted portable equipment to capture produced gas during cleanup
  - Sand trap
  - Three-phase separator
- Use portable desiccant dehydrator for workovers requiring glycol dehydrator maintenance
Reduced Emission Completions: Low Pressure Wells

- Partners and vendors are perfecting the use of portable compressors when pressure in reservoir is low
  - Artificial gas lift to clear fluids
  - Boost gas to sales line
  - Manage slug flow
  - Adds cost to project
Reduced Emission Completions: Benefits

- Reduced methane emissions during completions and workovers
- Sales revenue from recovered gas and condensate
- Improved relations with government agencies and public neighbors
- Reduced environmental impact
- Improved safety
- Reduced disposal costs
Is Recovery Profitable?

- Partners report recovering 2% - 89% (average of 53%) of total gas produced during well completions and workovers.
- Estimate 7,000 – 12,500 Mcf (200 – 350 thousand m³) of natural gas can be recovered from each cleanup.
  - $50,000 to $85,000 savings at $7/Mcf.
- Estimate 1 – 580 barrels of condensate can be recovered from each cleanup.
  - $50 - $30,000 additional revenue at $50/barrel.
- Incremental contracted cost of typical REC is $700 to $6,500/day for 3 to 10 days of well cleanup.
- Purchase of REC equipment costs $500,000.
  - Payback in 3 to 8 months for 25 well/year drilling program.

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<thead>
<tr>
<th>Gas Price (US$/Mcf)</th>
<th>$3</th>
<th>$5</th>
<th>$7</th>
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<tbody>
<tr>
<td>Payback (year)</td>
<td>3.2</td>
<td>2.2</td>
<td>1.6</td>
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<tr>
<td>NPV (US$)</td>
<td>15,384</td>
<td>68,455</td>
<td>121,526</td>
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REC Partner Experience: BP

- Capital investment of about $500,000 per skid on portable three-phase separators, sand traps, and tanks in the Rocky Mountain Region
- Used Green Completions on 106 wells
- Total natural gas recovered about 350 MMcf/year (10 million m$^3$)
  - 3.3 MMcf (93 thousand m$^3$) per well average
    - Conservative net value of gas saved is $20,000 per well$^1$
- 6,700 barrels/year condensate recovered
- 1.5 year payback based on British Petroleum’s prices for natural gas and condensate

$^1$ Natural gas valued by company to be $7/Mcf
Agenda

- Reduced Emissions Completions
- **Plunger Lift and Smart Automation**
  - Methane Losses
  - Methane Recovery
  - Is Recovery Profitable?
  - Partner Experience
- Discussion
- Contacts
Methane Emissions from Liquid Unloading in Gas Wells

- Completion venting is not the only type of well venting.
- Accumulation of liquid hydrocarbons or water in the well tubing reduces, and can halt, production.
- Operators traditionally blew wells to atmosphere to expel liquids.
- 59 Bcf\(^1\) (1.7 billion m\(^3\)) of methane emissions from liquid unloading in the U.S.

Source: BP

1 – EPA estimate.
Methane Reductions from Plunger Lifts

- Plunger lifts automatically produce liquids without blowing the well to the atmosphere
- Shut-in gas pressure stored in the casing annulus periodically pushes the plunger and liquid load from the well bottom to surface separator
- Wells with the right combination of shut-in pressure, depth and liquid accumulation are kept productive with less operator attention

Source: Weatherford
Plunger Lift Applications

- Plunger lifts are a long term solution
- Common plunger lift applications include
  - Wells with gas-to-liquid ratios of 400 scf/bbl (11.33 m³/bbl) per 1,000 feet of depth
  - Wells with shut-in pressure that is 1.5 times the sales line pressure
  - Gas wells with coiled tubing
  - Wells in need of paraffin and scale control
The Real Benefit is Increased Production
Plunger Lift: Benefits

- Continuous production
- Lower maintenance
- Increased efficiency
- Reduced methane emissions
Is Recovery Profitable?

- Partners report annual gas savings of $90,000 to $130,000\(^1\) per well by the installation of plunger lifts.
- Estimate 4,700 – 18,250 Mcf (130 – 520 thousand m\(^3\)) per well of natural gas can be recovered by the installation of plunger lifts:
  - $32,900 to $127,750 savings at $7/Mcf
- Benefits from both increased gas production and emissions savings are well and reservoir specific and will vary considerably.
- Cost of implementation ranges from $2,591 to $10,363 per well.
- Purchase of plunger lifts costs $7,772\(^1\):
  - Payback in 2 to 14 months for incremental gas production ranging from 30 Mcf/day (850 m\(^3\)/day) to 3 Mcf/day (85 m\(^3\)/day).

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<td>Payback (months)</td>
<td>2.8</td>
<td>1.9</td>
<td>1.5</td>
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<tr>
<td>NPV (US$)</td>
<td>120,630</td>
<td>176,157</td>
<td>231,684</td>
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1 - EPA Lessons Learned 2006, “Installing plunger lift systems in gas wells.”
Smart Automation: Continuous improvement on plunger lifts

- Plunger lifts are an improvement over blowing down wells to unload liquids, but there are limitations to conventional plunger lifts:
  - Fixed timer in conventional plunger lifts requires manual adjustments of the plunger cycle time
  - Manual adjustments are not performed regularly
  - Do not account for gathering line pressure fluctuations, declining well performance, plunger wear

- Results in manual venting to atmosphere when plunger lift is overloaded and production loss when liquids are not unloaded efficiently

Source: BP
Smart Automation Well Venting

- Automation can enhance the performance of plunger lifts by monitoring wellhead parameters
  - Tubing and casing pressure
  - Reservoir pressure recovery time
  - Sales line pressure
  - Flow rate
  - Plunger travel time

- Using this information, the system is able to optimize plunger operations
  - To minimize well venting to atmosphere
  - Recover more gas
  - Further reduce methane emissions
Smart Automation: Methane Savings

- Methane emissions savings is a secondary benefit
- Optimized plunger cycling to remove liquids increases well production by 10 to 20%\(^1\)
  - Additional 1%\(^1\) production from avoided venting
  - Conventional plunger lift reduces venting by 50%
  - Smart Automation recovers another 25 - 40% of vent gas
- 6,300 Mcf/year (180 thousand m\(^3\)/year) methane emissions savings for average U.S. well venting 9,400 Mcf/year (270 thousand m\(^3\)/year)

\(^1\) Reported by Weatherford

Source: BP
Smart Automation: Other Benefits

- Reduced manpower cost per well
- Continuously optimized production conditions
- Remotely identify potential unsafe operating conditions
- Monitor and log other well site equipment
  - Glycol dehydrator
  - Compressor
  - Stock Tank
  - Vapor Recovery Unit

Source: BP
Is Recovery Profitable?

- Estimate 6,260 – 24,300 Mcf (177 – 688 thousand m³) per well of natural gas can be recovered by the installation of smart automation
  - $44,000 to $170,000 savings at $7/Mcf
- Benefits from significant reductions in gas venting volumes along with production improvements
- Automation System can be installed at a cost of less than $12,000 per well
  - Payback in 1 to 3 years

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<td>Payback (months)</td>
<td>16</td>
<td>10</td>
<td>7</td>
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<tr>
<td>NPV (US$)</td>
<td>40,548</td>
<td>82,247</td>
<td>123,945</td>
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Smart Automation Partner Experience: BP

- BP’s first automation project designed and funded in 2000
- Pilot installations and testing in 2000
  - Installed plunger lifts with automated control systems on ~2,200 wells
  - ~$15,000 per well Remote Terminal Unit (RTU) installment cost
  - $50,000 - $750,000 host system installment cost
- Achieved roughly 50% reduction in venting from 2000 to 2004
Smart Automation Partner Experience: BP

Source: BP
Smart Automation Partner Experience: BP

- BP designed two pilot studies in 2006 to further improve well scientific control
  - Interviewed control room staff and worked closely with the field automation team leader
  - Established a new procedure based on plunger lift expertise and pilot well analysis
- In mid 2006, “smarter” automation was applied to wells
  - 1,424 Mcf (40 thousand m³) reported annual savings per well
Smart Automation Partner Experience: BP

Asset Vent Volume

Source: BP
Discussion

- Industry experience applying these technologies and practices
- Limitations on application of these technologies and practices
- Actual costs and benefits
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