Gas-Well De-Watering Method Field Study

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Outline

• Definition of Liquid Loading
• Method Description, Goals, Highlights
• Case Studies with De-Watering Method
• Differences Between Case Studies
• Additional Field Statistics
• Lessons Learned / Future Plans
What is Liquid Loading

- Formation GLR falls below unloading rate
- Gradual build-up of well-bore fluid in well
- Well-bore perforations covered, become saturated
- Low-Producing Gas Wells
- Low SBHP
- Long Perforated Intervals
Liquid Loading Example

Pressure survey to determine liquid loading

Pressure

Depth

Gas gradient above liquid

Liquid level

Water gradient below liquid
Some gas may bubble up through liquid column
Liquid Loading Well Behavior

Decline curve as indicator of liquid loading rate

Smooth decline curve indicates no liquid

Liquid loading problems are indicated by erratic decline curve and lower production
De-Watering Method
Description

• Tail-pipe beneath production packer
• Carrier sub(s) spaced along tail-pipe
• Regulating device inside each sub
• Trapped gas pushes liquid level down
• Gas reaches carrier sub / Enters tail-pipe
• Continues down-hole as more gas comes in
De-Watering Method Goals

- Decrease the critical unloading rate
- Minimize fluid build-up across the perforations
- Maximize reservoir draw-down
- De-hydrate near well-bore area
- Maximize net gas production in well
Operational Highlights of Method

• No surface control / Driven by Reservoir
• Can allow well to flow longer on its own
• Regulators can be slick-line retrievable
Case Study #1

- Deep Gas Well in Rockies (flowing natural)
- Perforations = 12,321’ to 13,740’
- Casing = 7”, 32 #; No Production Tubing
- Well-Test Evaluation Date = 9/24/04
- H2O = 0 BPD, Oil = 0 BPD, Gas = 489 MCF
Case Study #1 Optimization

Plan

• Conventional gas-lift design w/ 3-1/2” tubing
• Production packer set at +/- 12,200’
• Install de-watering method beneath packer
• 2-7/8” Tail-pipe, 2 Regulators, EOT = 12,900’
• Date of Installation – October 2004
Case Study #1 Well-Bore Sketch

Sand Perfs
TCP perfs 120 deg phasing
12321'-333', 12341'-371', 12400'-404', 12511'-529', 12536'-650', 12669'-590', 12619'-440', 12685'-750', 12704'-792', 12810'-825', 12840'-860', 12920'-930', 12950'-1300', 13033'-1058', 13062'-140', 13152'-295', 13276'-296', 13369'-350', 13396'-440', 13510'-580', 13610'-586', 13708'-740'

7" Production Casing @ 13,519'
7" 20# & 32# N-55 & L-80 LF66 & FL45 casing
Primary cement: 500 cc 50/50 pose & 400 cc G

#1 GLV @ 5000
#2 GLV @ 6500
#3 GLV @ 10000
#4 GLV @ 10000
#5 GLV @ 11000
#6 GLV @ 11600
#7 GLV @ 12000
Case Study #1 Method Results

- Flowing Press/Temp Log on 11/1/2004
- Gas gradient from surface down to EOT
- Water level found below EOT
- Temp cooling noted across regulators
- H2O = 22 BPD, Oil = 10 BPD, Gas = 2 MMCFD
- Injection Gas = 1 MMCFD
Case Study #1 Final Press/Temp Profile

TUBING OVERVIEW

- Flowing Profile
- 0.05 psia/ft Average Gradient
- Lifting Point

COMPLETION OVERVIEW

- Flowing Completion Profile
- 0.07 PSIA/FT
- Fluid Level @ 12900' MD
- 0.39 PSIA/FT
- 0.46 PSIA/FT

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Case Study #1 Expanded Flowing Profile

Expanded Completion Profile

0.07 PSIA/FT

Gas Production
Case Study #1 Production History

Case Study #1 Production History Plot

- Net Gas
- Gas-Lift
- Water Rate
- Oil Rate

Date

Gas Rate (MCFPD)

BBL/Day

8/1/04 9/5/05 10/10/06 11/14/07 12/18/08 1/22/10
Case Study #2

- Deep Gas Well in Rockies on Gas-Lift
- Perforations = 12,528’ to 13,487’
- Casing = 7” , 32 #; Tubing = 4-1/2” 12.6 #
- No Initial Well-Test Evaluation Performed
- H2O = 225 BPD, Oil = 0 BPD, Gas = 75MCFD
- Injection Gas = 1200 MCFD
Case Study #2 Optimization

Plan

- Conventional gas-lift design w/ 2-7/8” tubing
- Production packer set at +/- 12,490’
- Install de-watering method beneath packer
- 2-7/8” Tail-pipe, 3 Regulators, EOT = 13,350’
- Date of Installation – April 2006
Case Study #2 Well-Bore Sketch
Case Study #2 Method Results

- Light gradient from surface to +/- 12,450’
- Water level below injection point to bottom
- Minimal temp cooling noted across regulators
- Water = 156 BPD, Oil = 0 BPD, Gas = 0 MMCFD
- Injection Gas = 858 MCFD
Case Study #2 Press/Temp Profile
Case Study #2 – Next Course of Action

• Well shut-in due to lack of production
• Opened back 1/16/08 for Well-Test Evaluation
• Method was evaluated again w/ similar results
• Recommendation to try annular gas-lift system
Case Study #2 Annular-Flow Results

- Annular gas-lift system installed 2/19/09
- One gas-lift orifice set at EOT = 13,500’
- H2O = 625 BPD, Oil = 0 BPD, Gas = 0 MCF
- Injection Gas = 2300 MCFD
Differences Between Case Studies

- Initial pre-install well-test analysis was obtained for Case Study #1
- EOT for Case Study #1 was strategically set
- Hydrocarbon potential was pre-identified for Case Study #1
Additional Example Deep Gas #1
Additional Example Deep Gas #2
Additional Field Statistics

- Deep gas field in Texas
- Average well depth = +/- 10,000’ to 11,000’
- Average perforated interval = +/- 150 feet
- Casing = 5-1/2”, 4-1/2”, Tubing = 2-3/8” 4.7#
- No pre-install well-test or reservoir data available
- 29 wells installed with method (2006 – 2009)
- 20 wells flowing naturally (Rates = 250 MCF, 30 to 50 BWPD)
Lessons Learned

- Important to understand well and potential
- Importance of EOT depth selection
- Well must have hydrocarbon potential
- Using lessons learned to select candidates
Future Plans for Method

• Develop a program to identify design criteria
  – Determine optimal number and depths regulators
  – Estimate gas passage to properly size regulators
• Develop a regulator with closing capabilities
  – Give system the ability to work deeper as possible
    • Maximize reservoir draw-down
    • Maximize production rates
References


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