CT's Role In Refracs

An Open & Shut Case

Image Courtesy Of Calfrac

Eric G. Schmelzl

VP Strategic Business

NCS Multistage

CT's Role In Refracs

A Case Of Open And Shut

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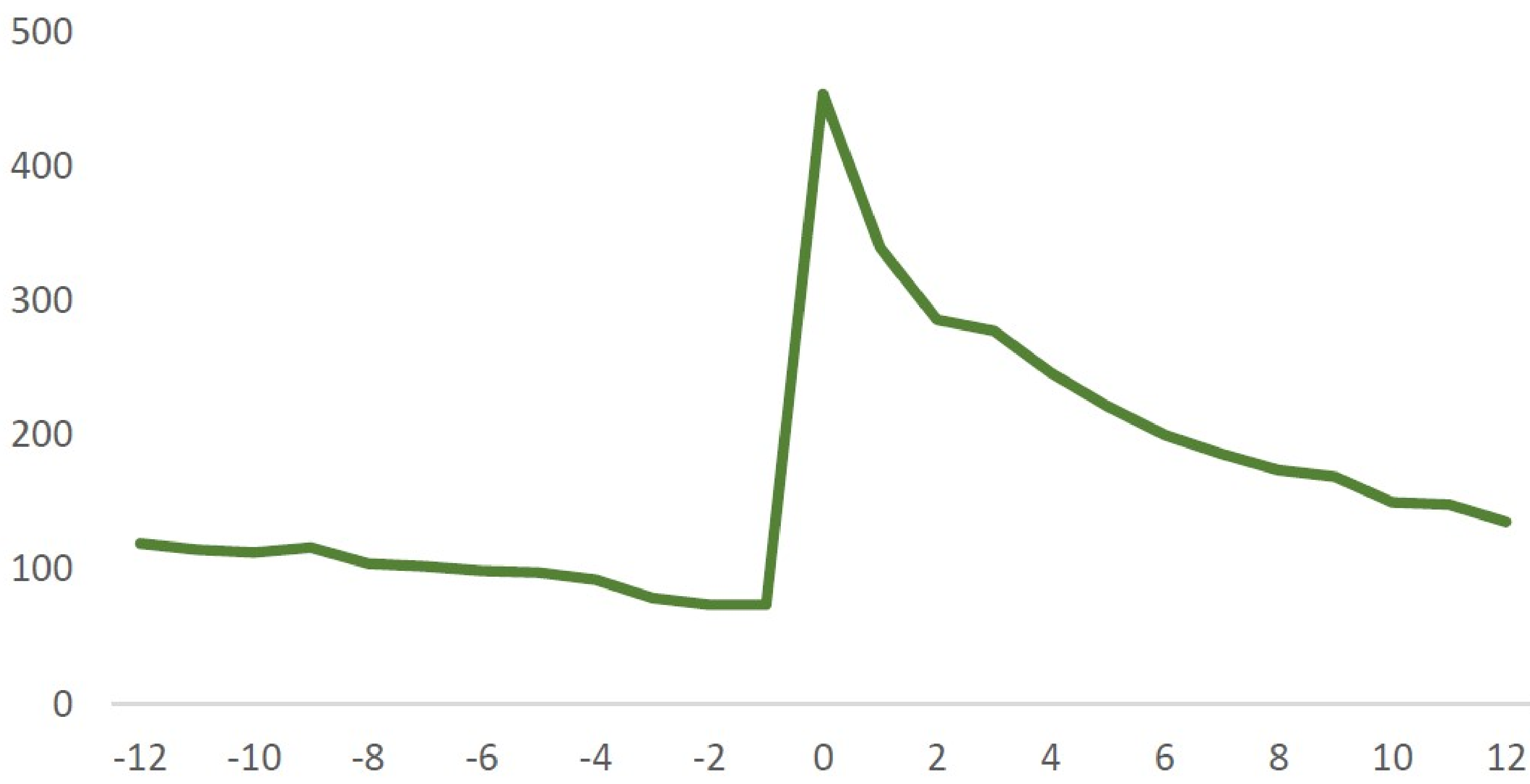
OUTLINE

- Refrac Challenges
- The “IDEAL” Refrac
- Frac Sleeves & Refracs
- Field Applications

Hydraulic fracturing operations in the Montney Canada. Calfrac Well Services Photo.

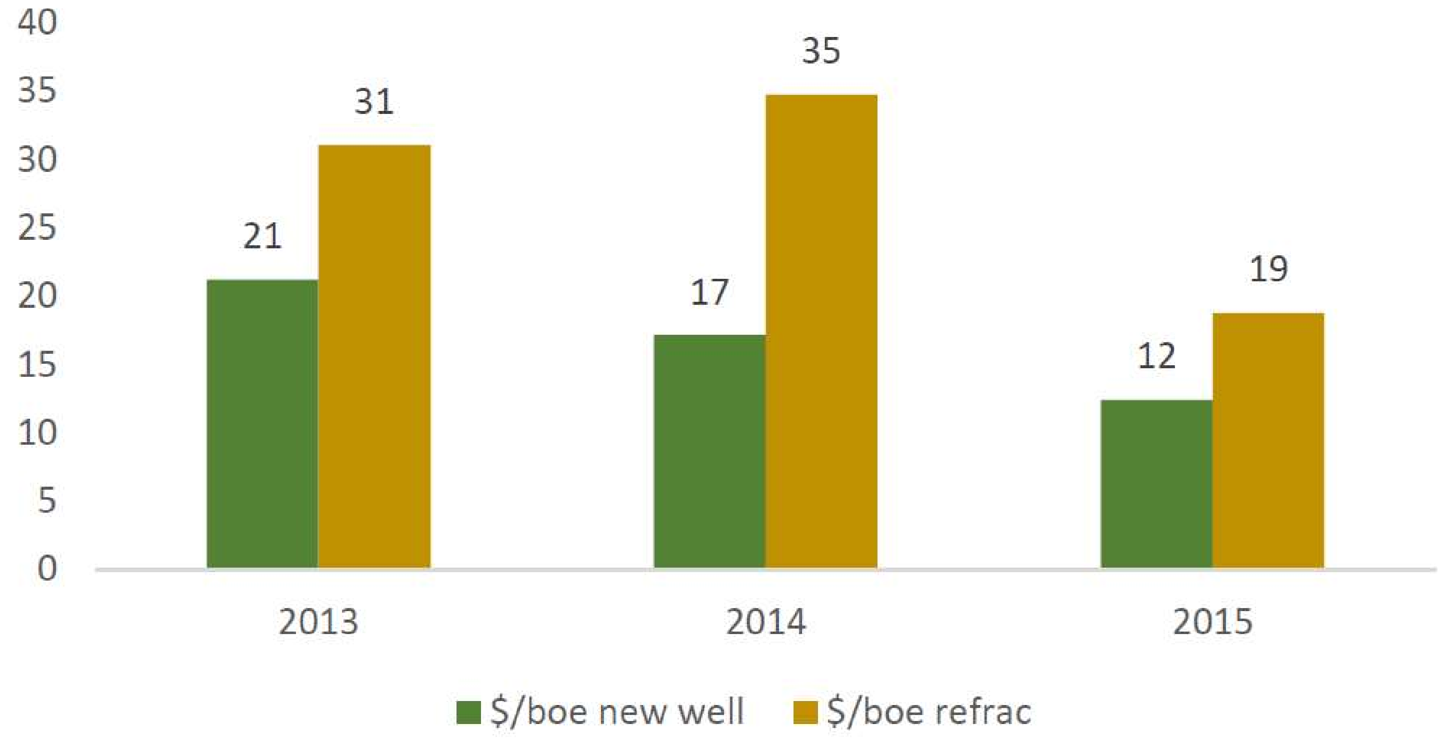
WHY REFRAC?



Average daily production (boe/d) for Bakken wells refracked in 2014 and 2015.

Rystad Energy NASWellData and Rystad Energy analysis.

WHY REFRAC?

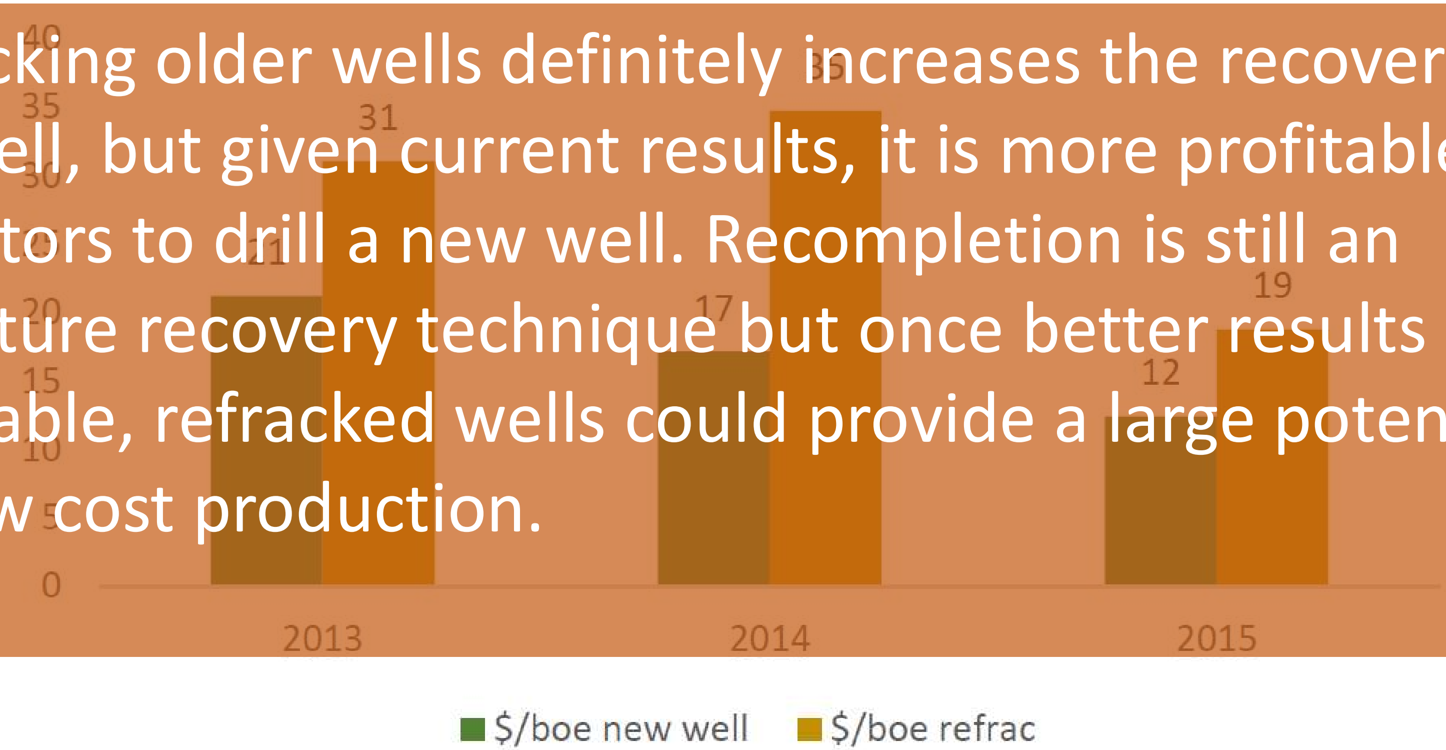


Development cost per boe for Bakken wells compared to refrack wells in each year.

Rystad Energy NASWellData and Rystad Energy analysis.

WHY REFRAC?

Refracking older wells definitely increases the recovery of the well, but given current results, it is more profitable for operators to drill a new well. Recompletion is still an immature recovery technique but once better results are replicable, refracked wells could provide a large potential for low cost production.



Development cost per boe for Bakken wells compared to refrack wells in each year.

Rystad Energy NASWellData and Rystad Energy analysis.

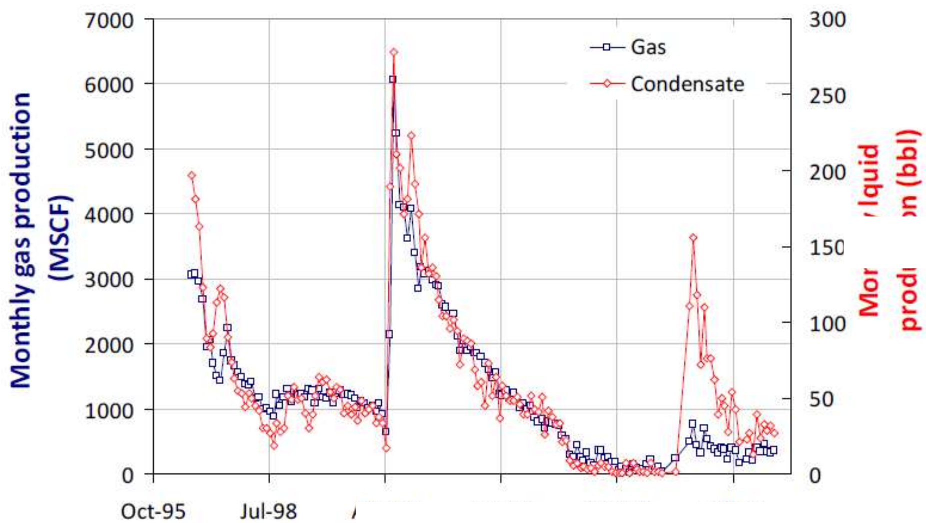
OPPORTUNITIES FOR IMPROVEMENT

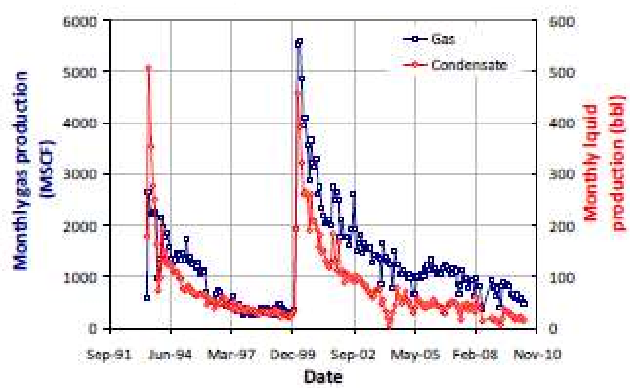
….. 40% to 60% of stages produce little or no hydrocarbons, while 30% of the stages represent 80% of a well’s entire production. Baker Hughes estimates that ineffective stages have come at an annual cost upward of USD 40 billion.

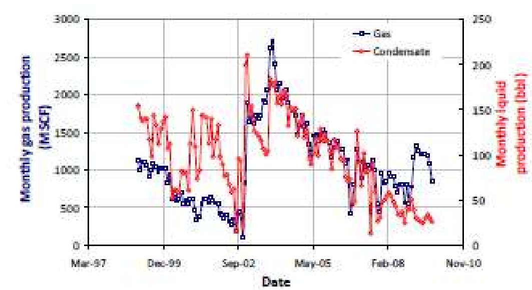
Trent Jacobs, JPT

SUCCESSFUL REFRACS

1. Increase EUR &/or
2. Provide Rate Acceleration







Ref: RPSEA Report
M. Sharma

EXTENSIVE REFRAC LITERATURE


26 SPE 134330

References noted in paper text (additional references in Appendix)

Asadi, M. et al, 2002: Monitoring Fracturing Fluid Flowback with Chemical Tracers: A Field Case Study. SPE 77750 presented at the 2002 Annual Technical Conference, San Antonio TX, Sept 29-Oct 2.

SPE 134330 27

28 SPE 134330

SPE 134330 29

FROM SPE 134330

"The efforts of many researchers have already cast much darkness on the subject, and it is likely that if they continue, we will soon know nothing about it at all."

Mark Twain

SOME "TYPICAL" OBSERVATIONS

- "Initial completions exhibit inconsistent proppant coverage across the perforated interval." – SPE-174979, Leonard, Moore, Woodruff, Senters
- Wells employing (refrac) diversion techniques … are not consistently contacting new rock. - SPE 174979
- " The biggest challenge in re-stimulating old wells is how to handle the existing perforations." - SPE 174979
- "…the variation in (refrac) outcomes is too wide for refracturing to be adopted on a large scale today." – SPE 174951, Indras, Blankenship
- "… Can we design wells that can be easily isolated and refractured?" – SPE 136757, M. Vincent

REFRACS CAN ONLY

1. RESTORE FRACTURE CONDUCTIVITY
   (Re-Touch "Old" Rock, Add Complexity)
2. STIMULATE "NEW" ROCK
   - Add Frac Stages (Reduce Stage Spacing)
   - Diversion / Extension

- APPLY NEW LEARNINGS
  (Fluids, Proppants, Chemistry etc)
- PROVIDE FRAC-HIT "PROTECTION"

Refrac Derailers

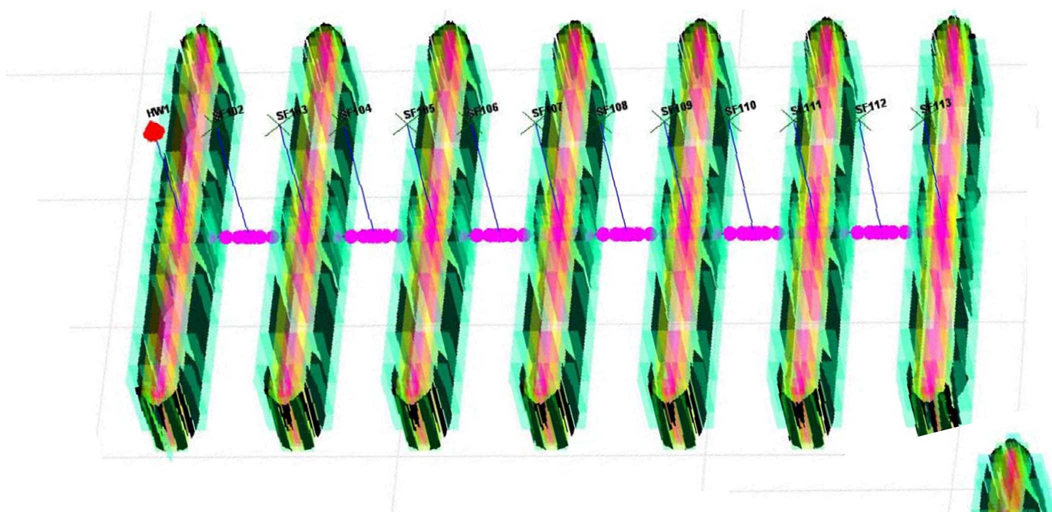
- Remaining Resource (Recovery Factor)
  - Where Is It & How Do We Target It

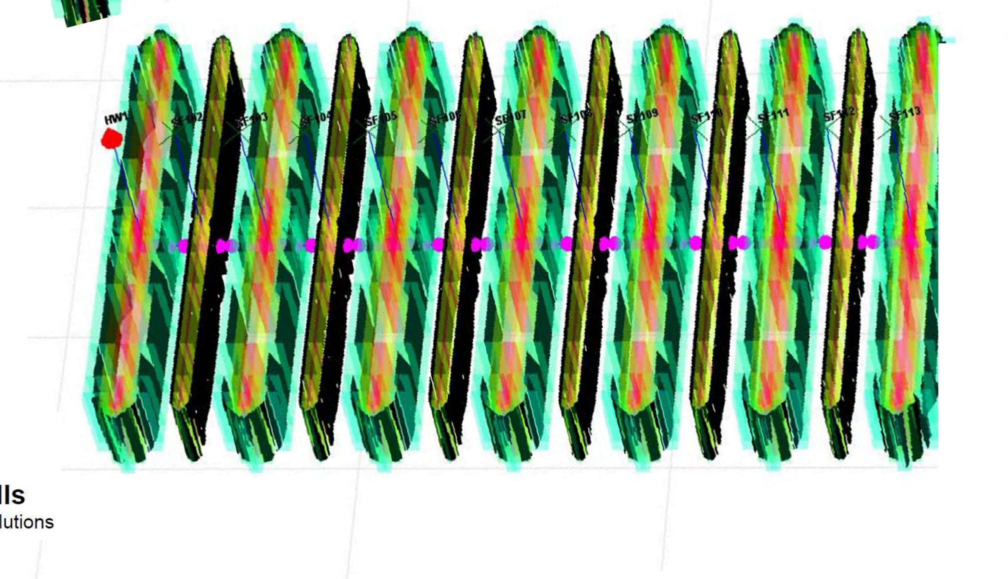
- WELL CONFIGURATION
  - Balls/Perfs/Ports/Baffles/Plugs/Debris

- WELL INTEGRITY & HYDRAULIC ISOLATION
  - Casing Size, Weight, Erosion, Corrosion, Cement Integrity, External Packers, Casing Deformation etc.

- Existing Fractures
  - Conductivity, Location, Dimensions, Inter-well Communication

The Key Component; Frac Placement Control



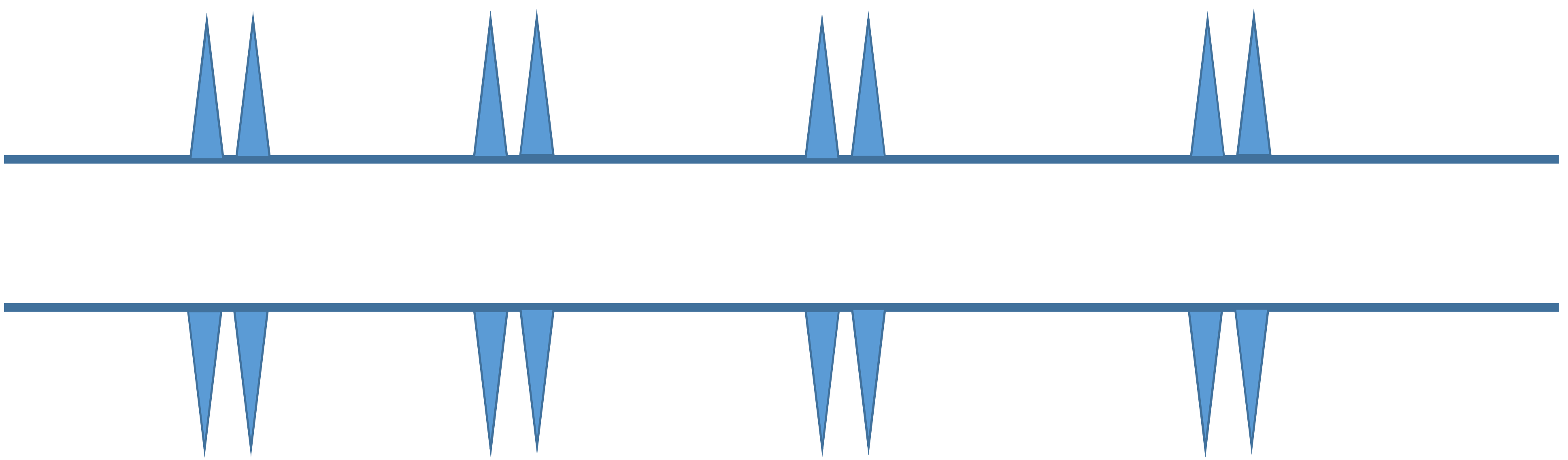


SPE 154669

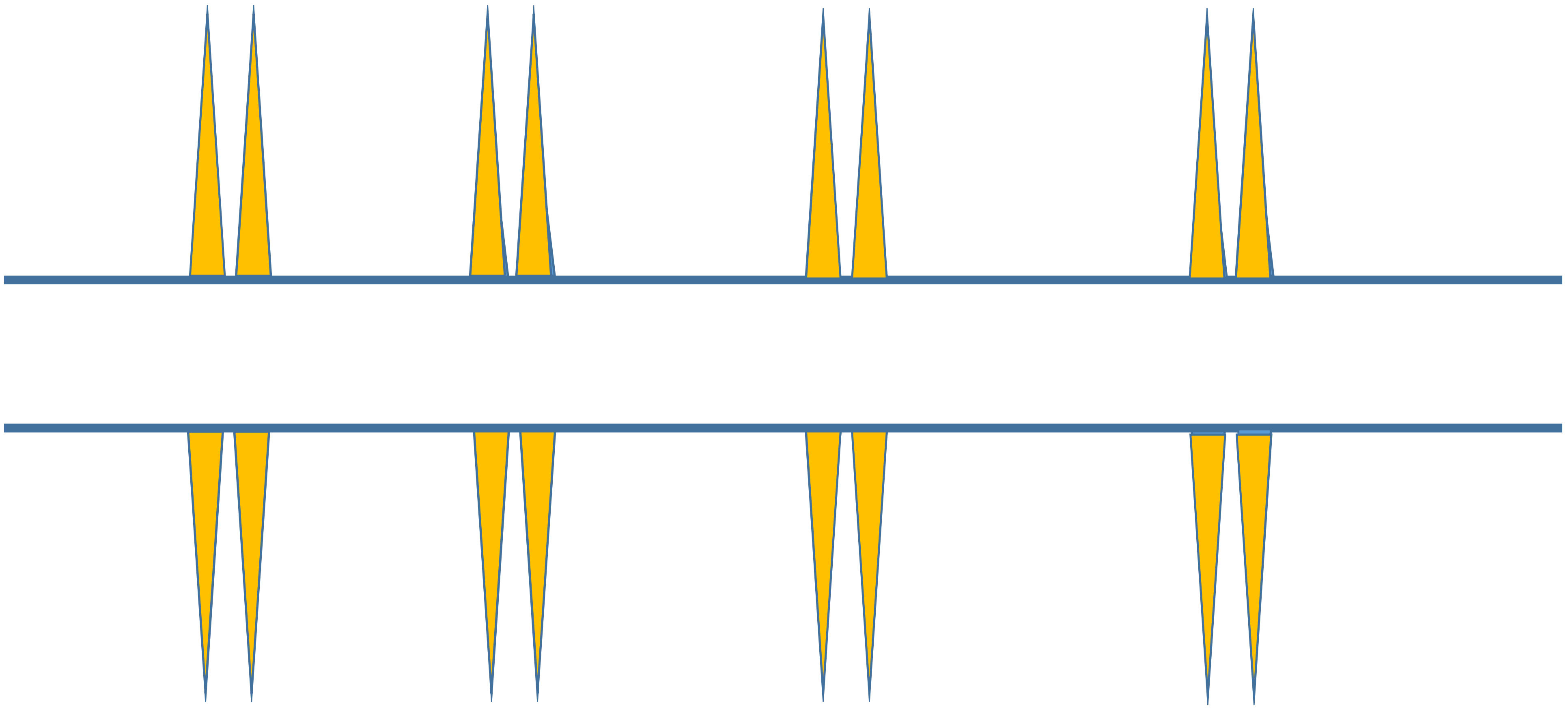
Barnett Shale Horizontal Restimulations: A Case Study of 13 Wells

Mark Craig, SPE, and Steve Wendte, SPE, Devon Energy Corp; Jim Buchwalter, SPE, Gemini Solutions

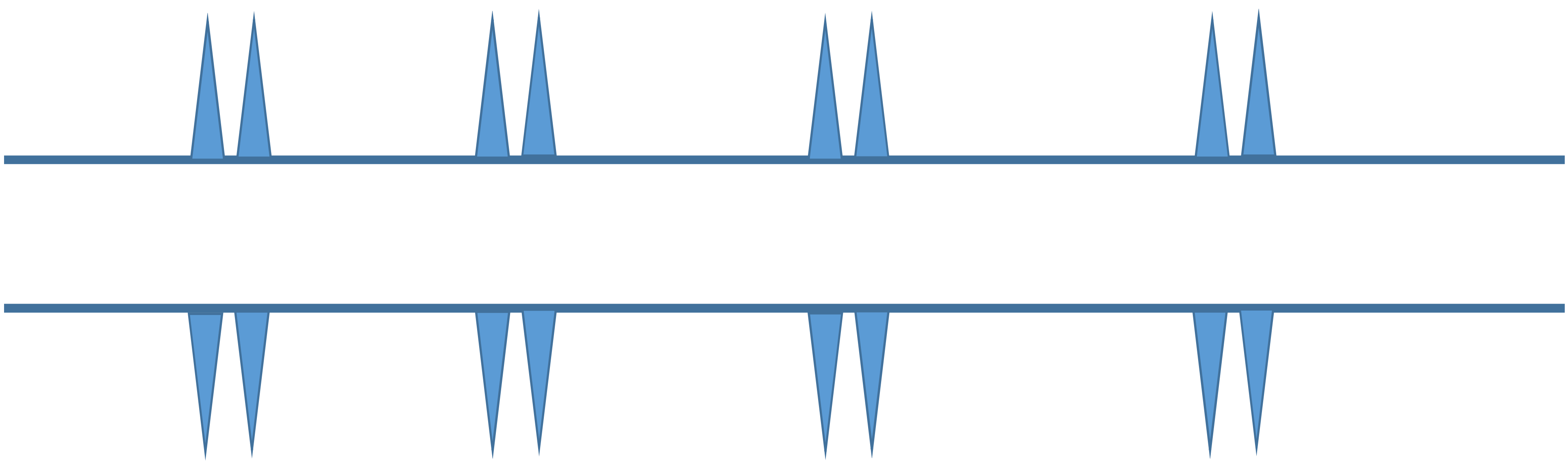
Mechanical ReFrac Systems



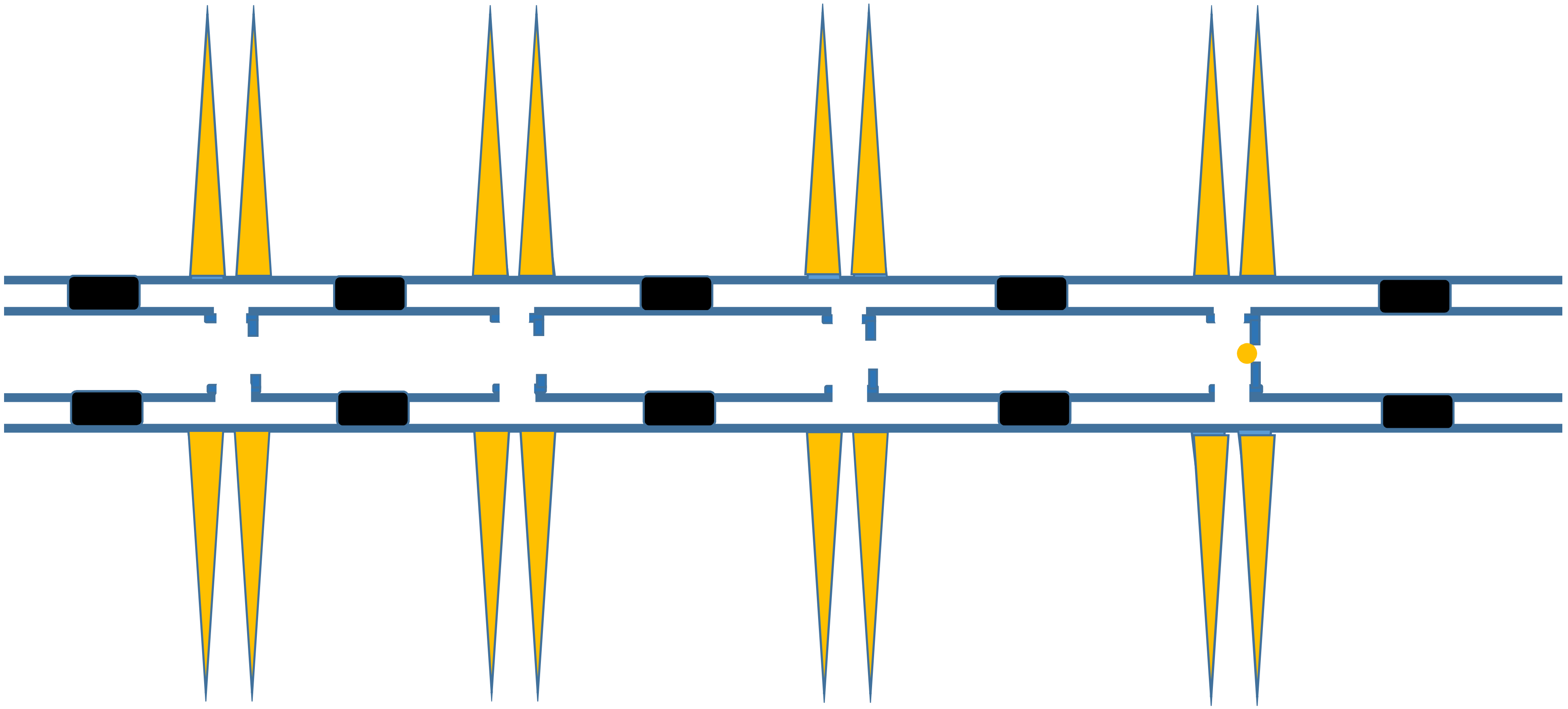
Mechanical ReFrac Systems



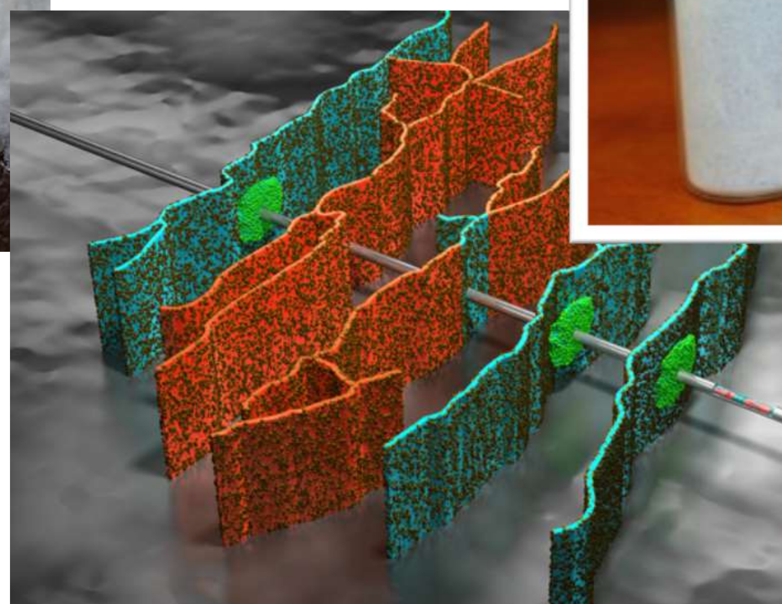
Mechanical ReFrac Systems

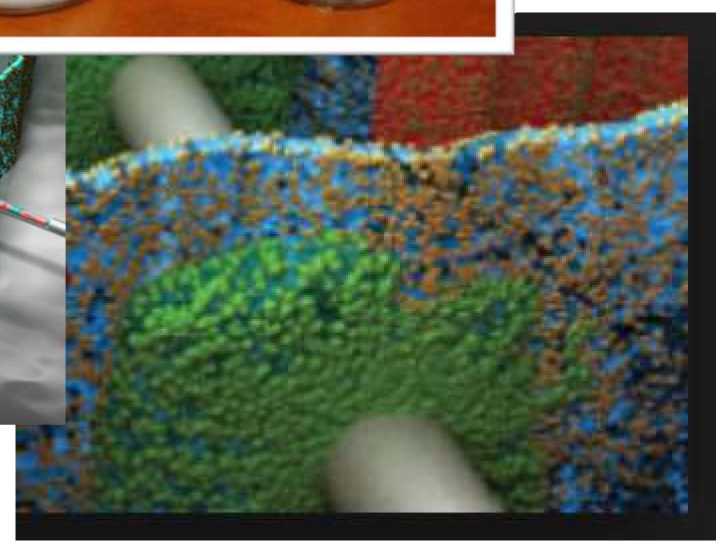


Mechanical ReFrac Systems



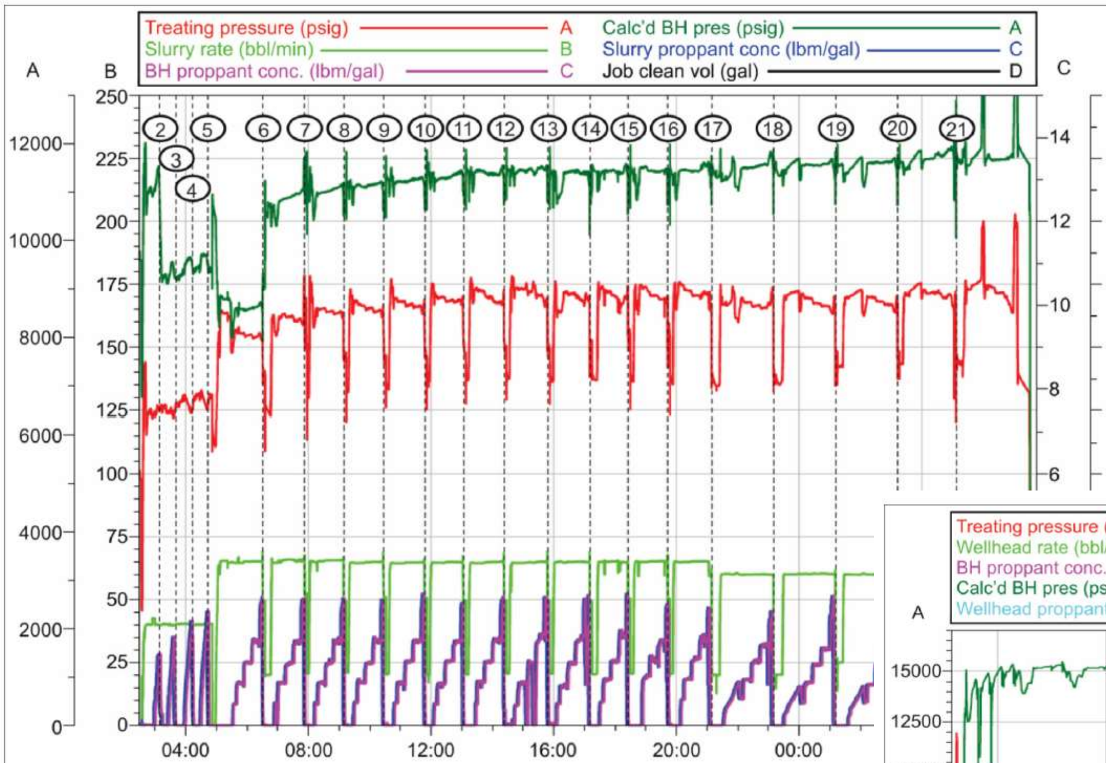
DEFAULT TO DIVERSION





Images By Halliburton

“CONTROL” OF FRAC PLACEMENT?



SPE-177306-MS

Refracturing Design for Underperforming Unconventional Horizontal Reservoirs

J. T. Krenger, J. Fraser, and A. J. Gibson, Devon Energy; A. Whitsett, J. Melcher, and S. Persac, Halliburton

WHAT MIGHT AN "IDEAL" REFRAC LOOK LIKE ??

- FLUID & PROPPANT PLACEMENT CONTROL
- REDUCED RISK OF WELL BASHING
- REFRAC EXISTING STAGES
- CAPACITY TO ADD NEW STAGES
- MULTIPLE REFRACS OVER WELL LIFE
- LOWEST POSSIBLE OPERATIONAL RISK
- PRODUCTION MANAGEMENT
- MAXIMUM SRV

START WITH THE END IN MIND:

START WITH THE END IN MIND:
RE-CLOSABLE FRAC SLEEVES

START WITH THE END IN MIND:
<u>RE-CLOSABLE FRAC SLEEVES</u>

- MEETS ALL “IDEAL” REFRAC CRITERION

- A POTENTIAL STEP-CHANGE IMPROVEMENT
  - Uniformity Of Proppant Distribution
  - Refrac Capabilities
  - Production Control
  - “Other” Benefits

1st CASE HISTORY

1. SLEEVES OPENED & ACIDIZED (Individually)
2. PRODUCED FOR SEVERAL WEEKS
3. SLEEVES CLOSED & PRESSURE TESTED
4. SLEEVES FRACTURED INDIVIDUALLY
5. WELL PLACED ON PRODUCTION

2nd Case History

- New Step-out Well, No prior history in area
- 114.3 mm casing
- 25 CT enabled MC frac sleeves cemented in place
- TVD = 769 m, TMD = 2229 m
- HZ length ~ 1200m

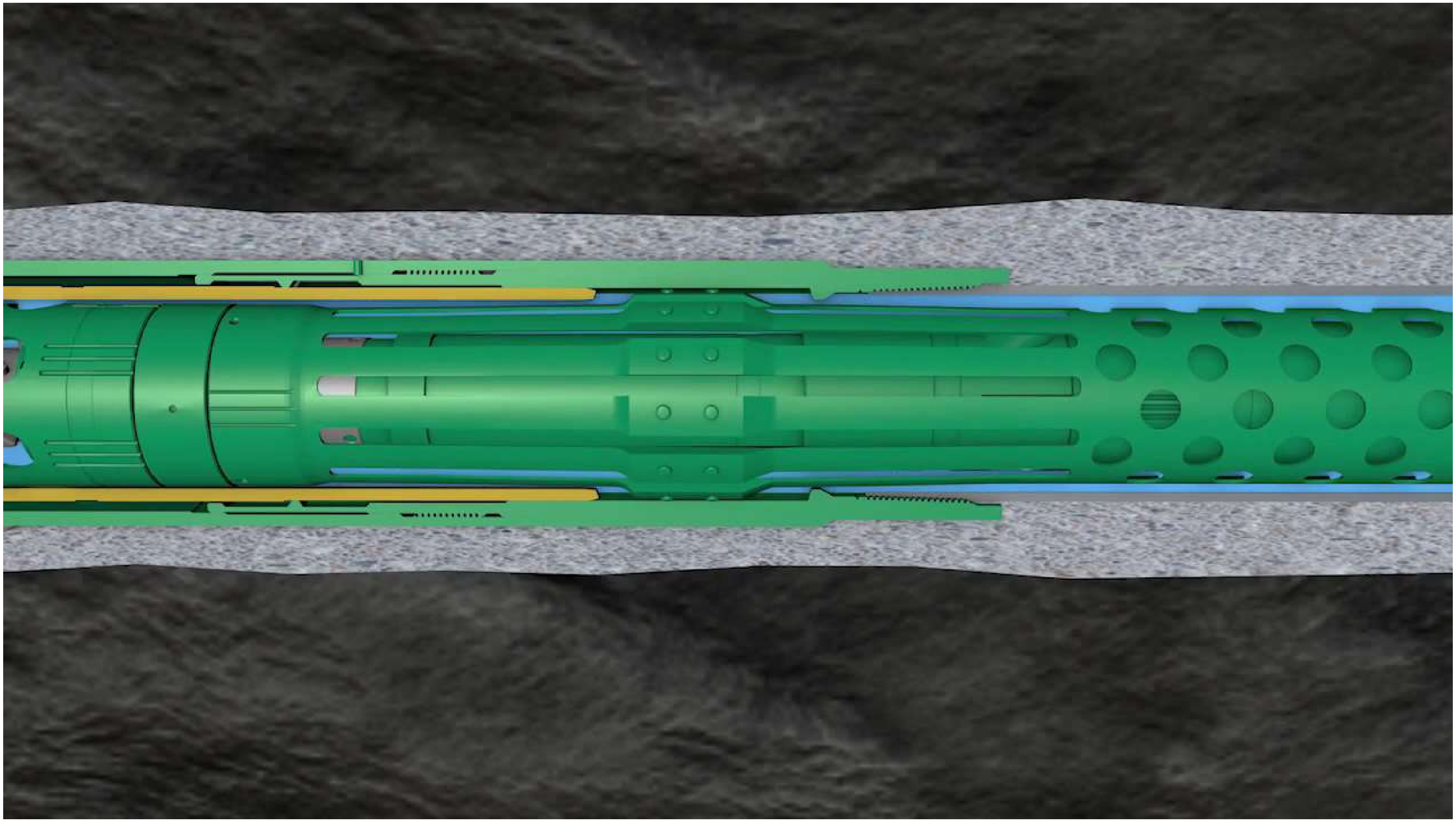
Original Completion

- Each interval fractured down CT using:
  - 10t of 20/40 sand
  - 0.5 m3/min rate
  - Slickwater (SW) fluid
  - Sand concentration ~ 650 kg/m3
  - acid spearheads(~ 0.5 m3)
- Total operation took ~ 56 hours to complete
- Disappointing results

SFC Process

- CT BHA locates the sleeve and shifts it open
- Interval is fractured
- Sleeve is immediately closed
- Process is repeated until well is fully completed (moving from toe to heel, although any desired stage sequence is viable)
- CT is moved back down hole to re-open all the sleeves from toe-to-heel
- Well is placed on production

SFC OPERATION



Re-Frac Operations

1. All Sleeves Shifted To CLOSED Position
2. Well Successfully Pressure-Tested
3. Refrac Executed (SFC)
4. Well Successfully Pressure-Tested
5. All Sleeves Shifted To OPEN Position

Re-Frac Details

- Each interval fractured down CT/CSG annulus using:
  - 15t of 20/40 sand
  - 3.0 m3/min rate
  - Hybrid system (SW followed by cross-linked fluid)
  - Sand concentration ~ 1000 kg/m3
  - acid spearheads(~ 0.5 m3)
- Shift-Frac-Close sequence used on all stages
- No sand cleanout necessary after both original and re-frac completion
- Total operation took ~ 38 operating hours to complete

Conclusions

- Initial completion designs play a significant role In the potential for refrac execution
- Coiled tubing actuated Multi-Cycle sleeves provide a unique operational environment for refrac applications
- The worlds first propped refrac completion operation utilizing Multi-Cycle Sleeves has been executed successfully, providing precision, time and cost savings as compared to other methods available

Post Script: A Recent SPE Luncheon