Perforating for Shales

Bogota
Julio Lozada
Technical Advisor- TCP Ecuador
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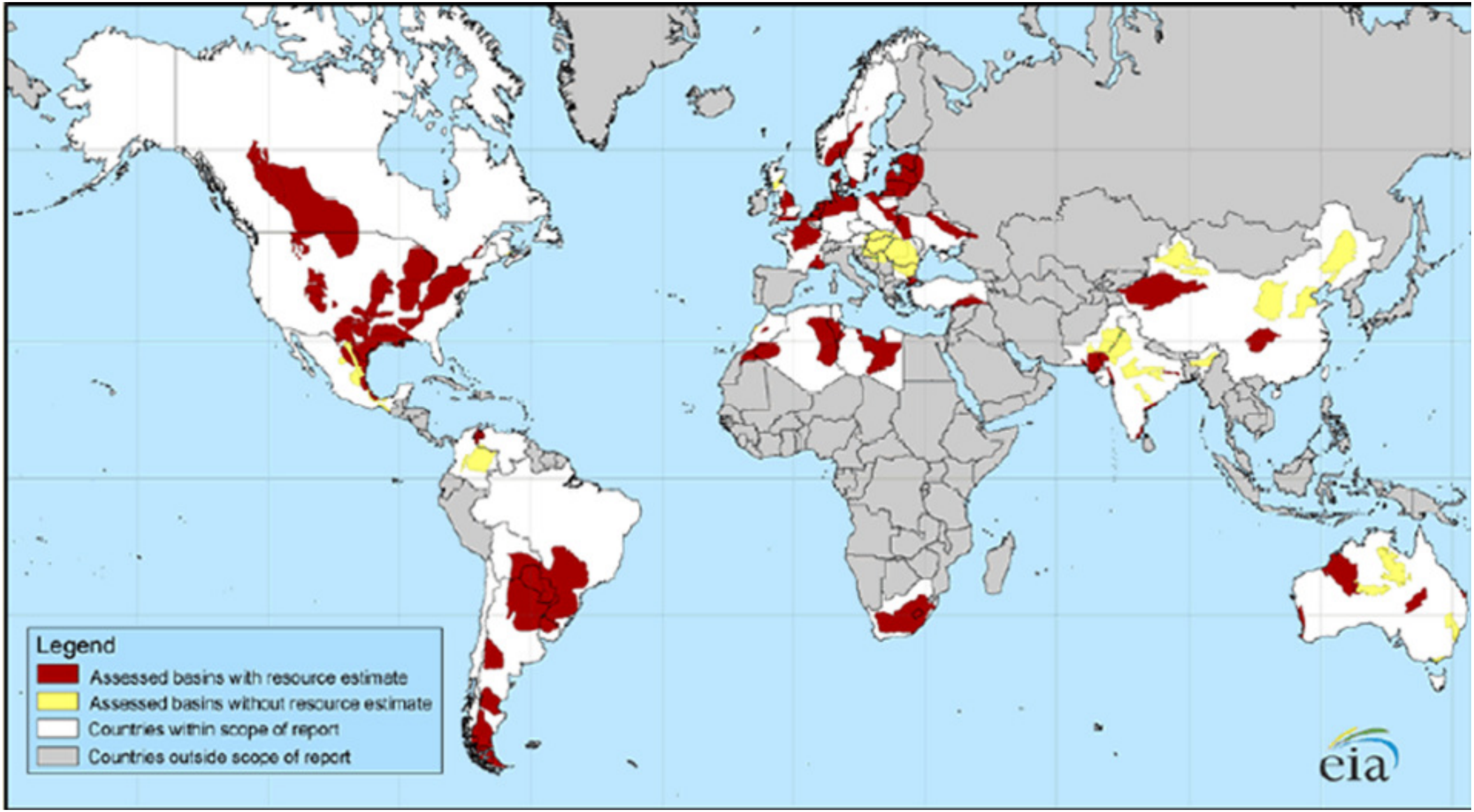
HALLIBURTON

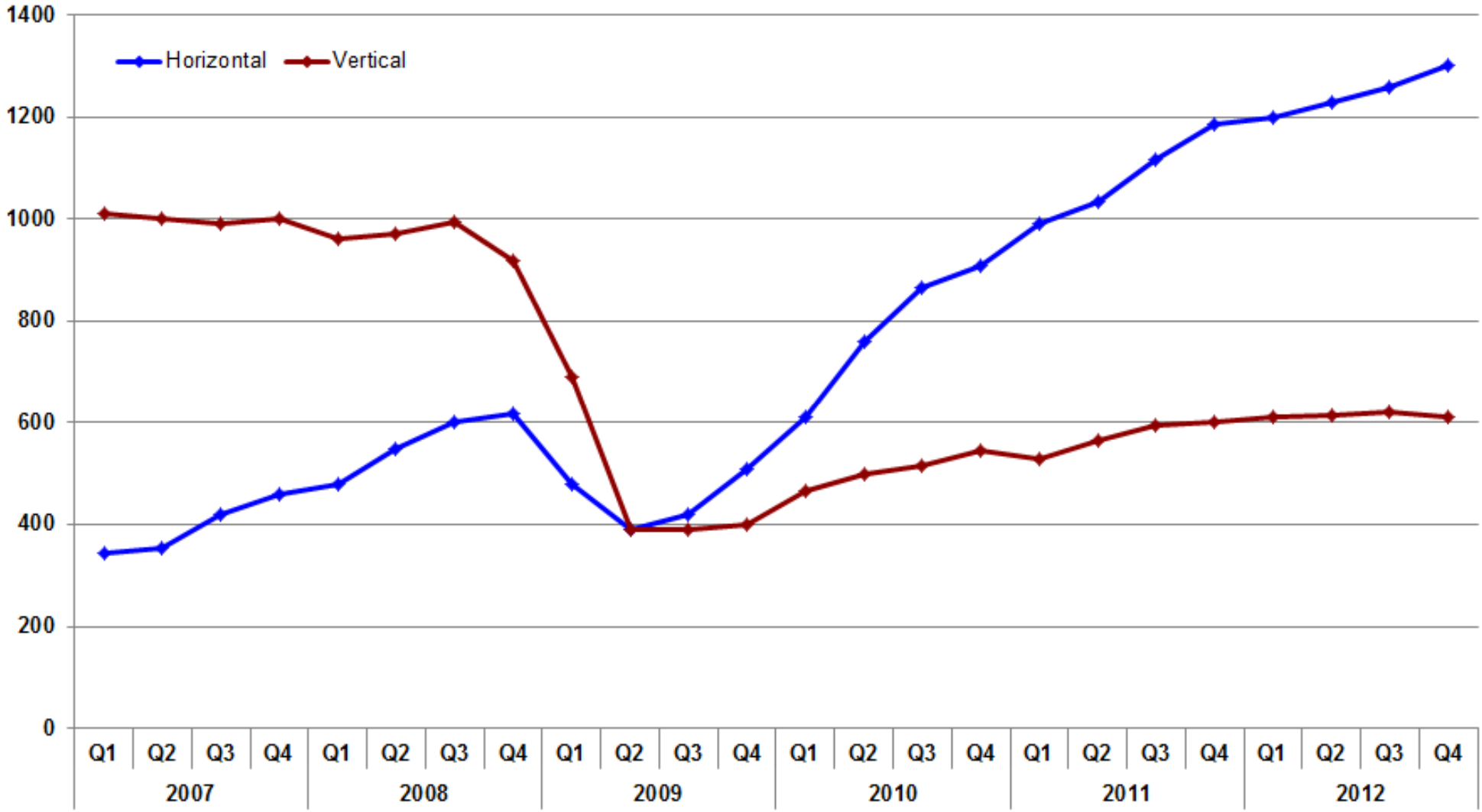
SLAP-29

Multi-Stage Multi-Well Completion

Estimated 187 Trillion m^3 (Energy Information Administration 2011)



Land Drilling Activity by Type



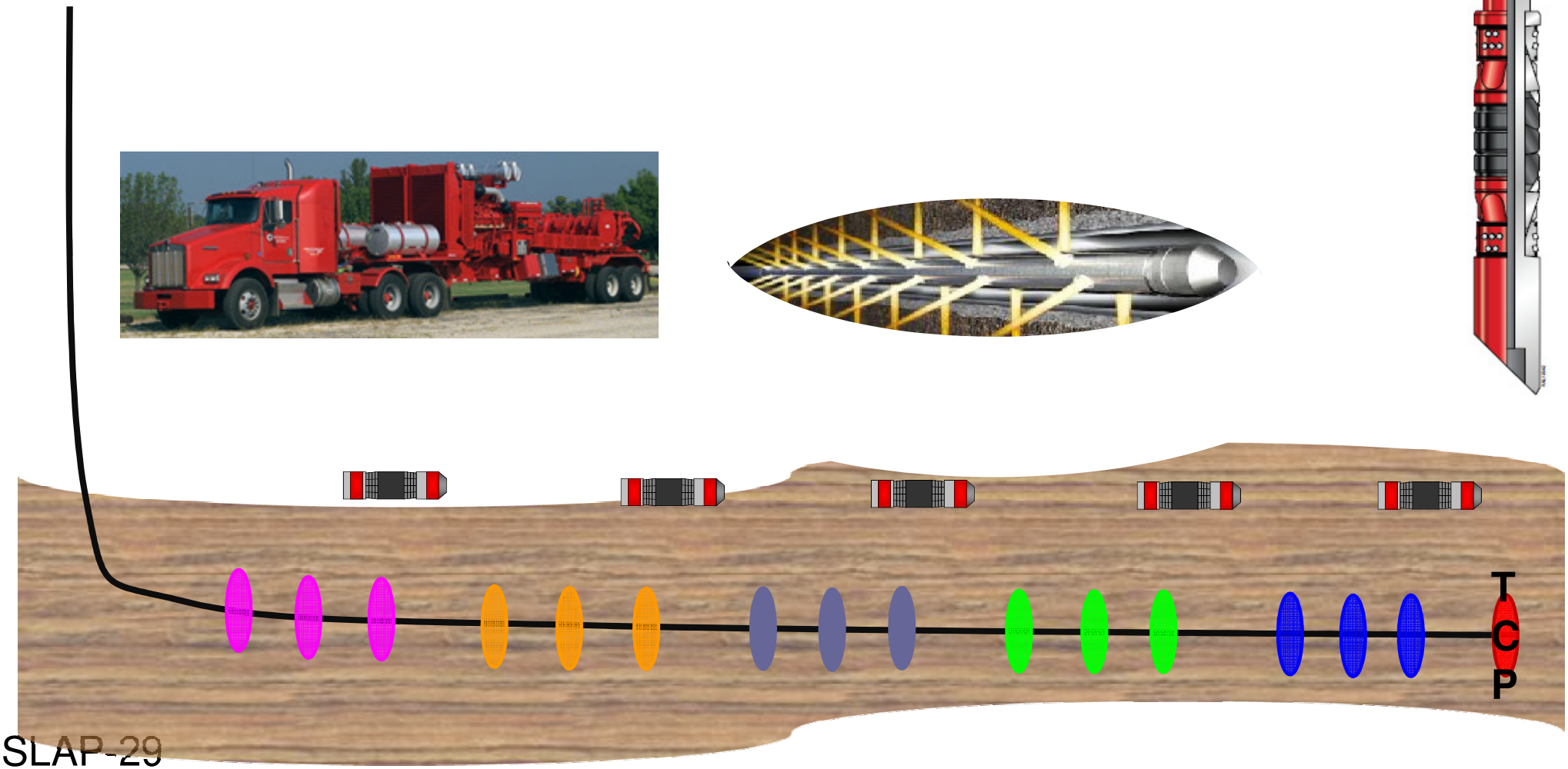
From Spears & Associates, Inc

Horizontal Multi-Stage Perforating

- Pump Down Services (PDS) offers quick, efficient and cost effective deployment of multi-gun/plug runs for multiple stage completions
- PDS is a common deployment method used in horizontal unconventional wells primarily for guns and plugs but also for other e-line services (pipe recovery, logging, etc)
- Efficient PDS now allow up to 5 stages per 24 hour day
- A typical single E-Line stage consists of
  - Multiple guns (3 foot - 6 spf carriers) ((Selective Perforating))
  - Explosive setting tool
  - Composite plug

Horizontal Multi-Stage Perforating- Pump Down Service

Most PDS completions are perforated in a geometrical spacing

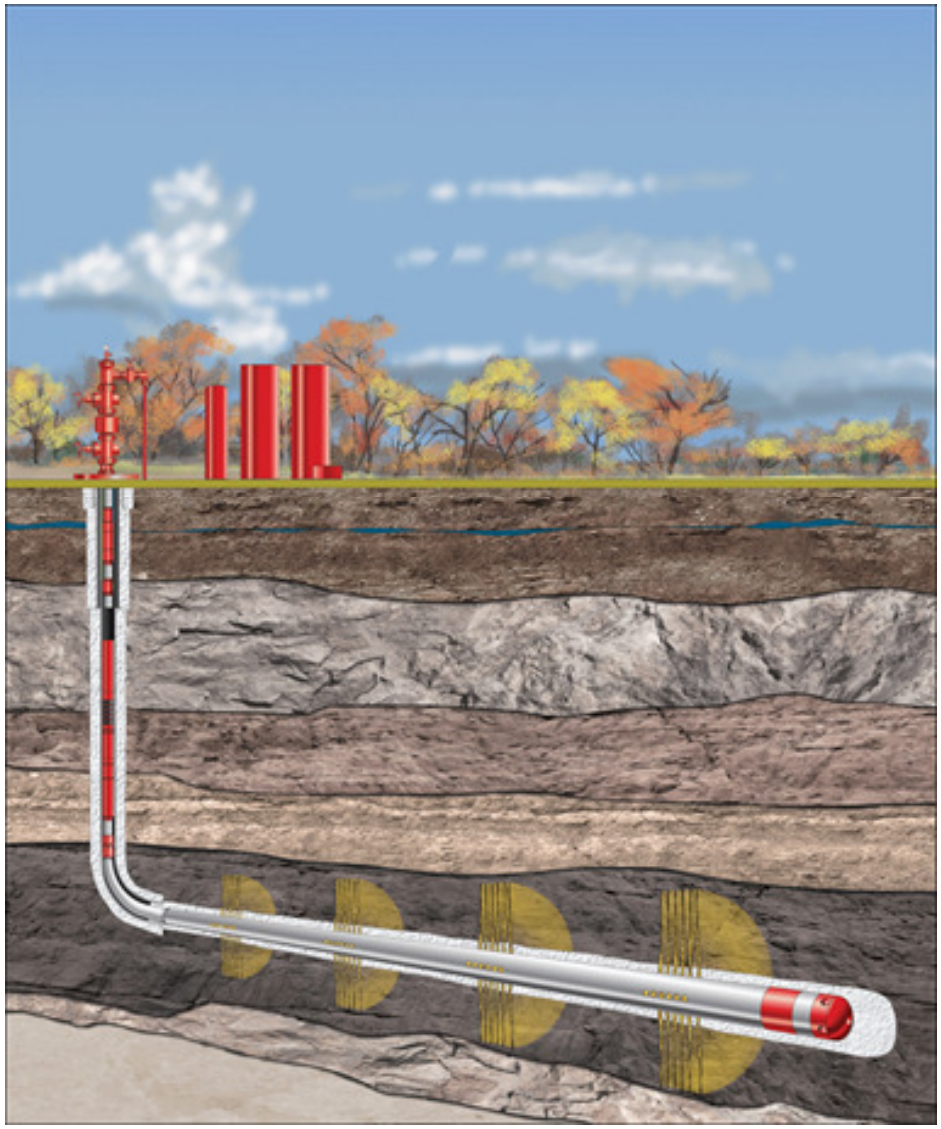


Perforating Objective

- Create a conduit between the wellbore and reservoir
- Choices to be made:
  - Size of gun and charge
  - Type of shaped charge
  - Shot density and phasing
  - Perforation interval

Perforating for Stimulation

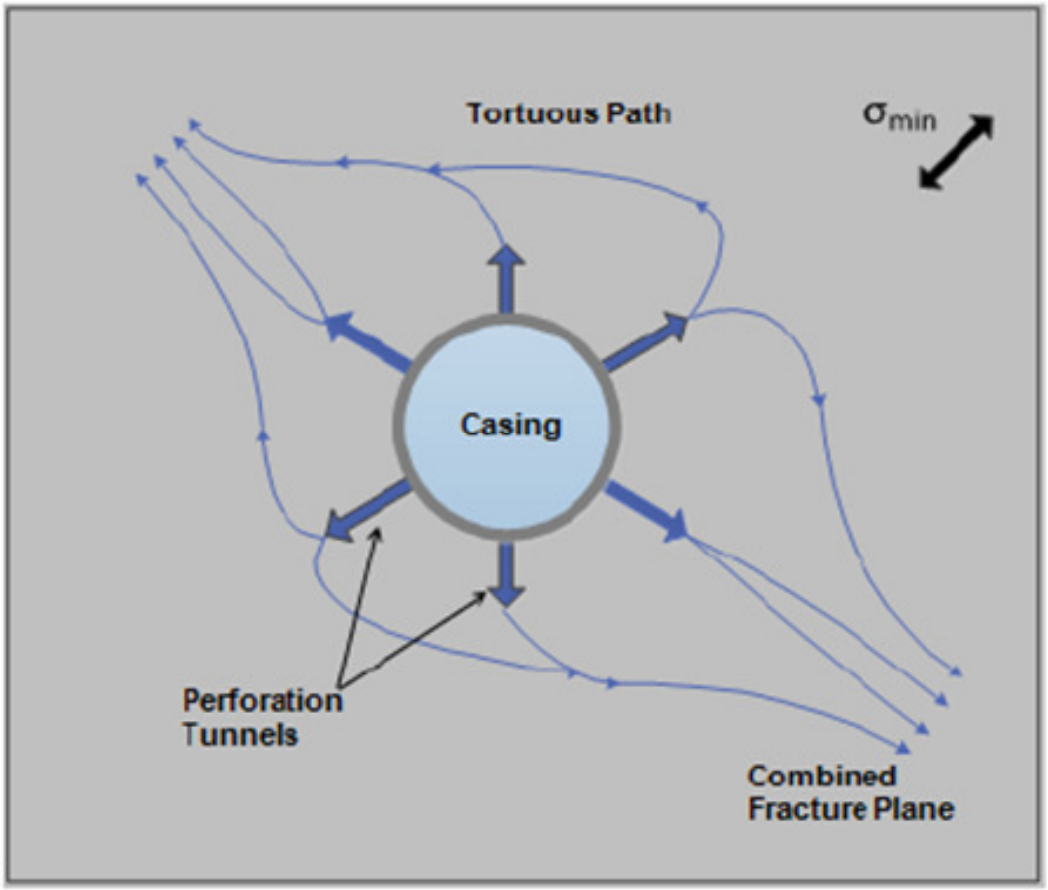
- Interval
  - Stage Length
  - Perforation Spacing
- Orientation
  - Phasing
- Charge Selection
  - DP, GH or FRAC



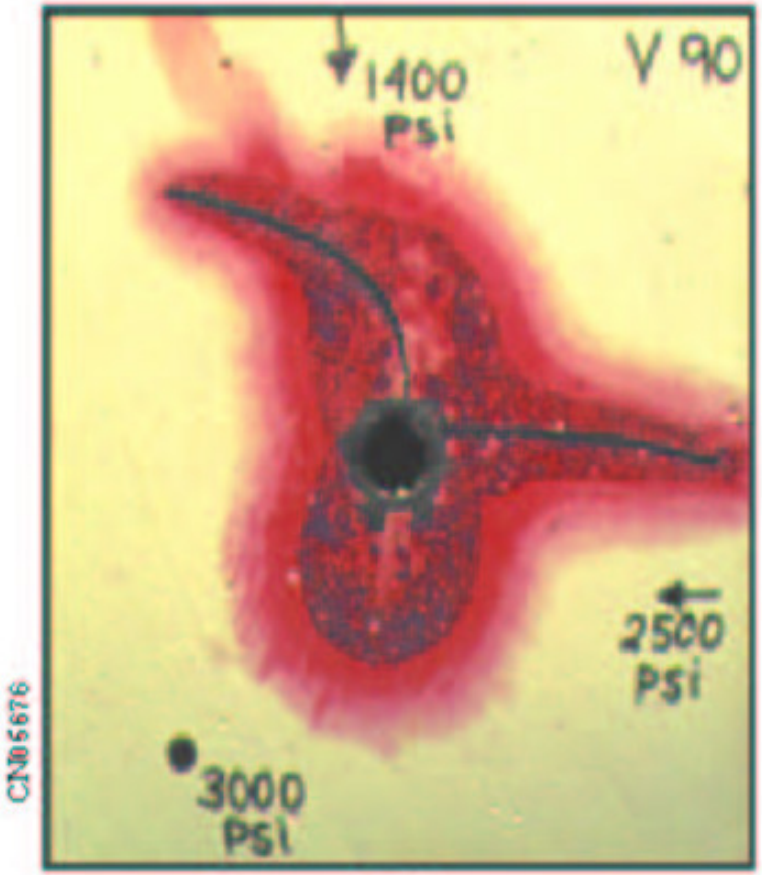
Perforation Phasing

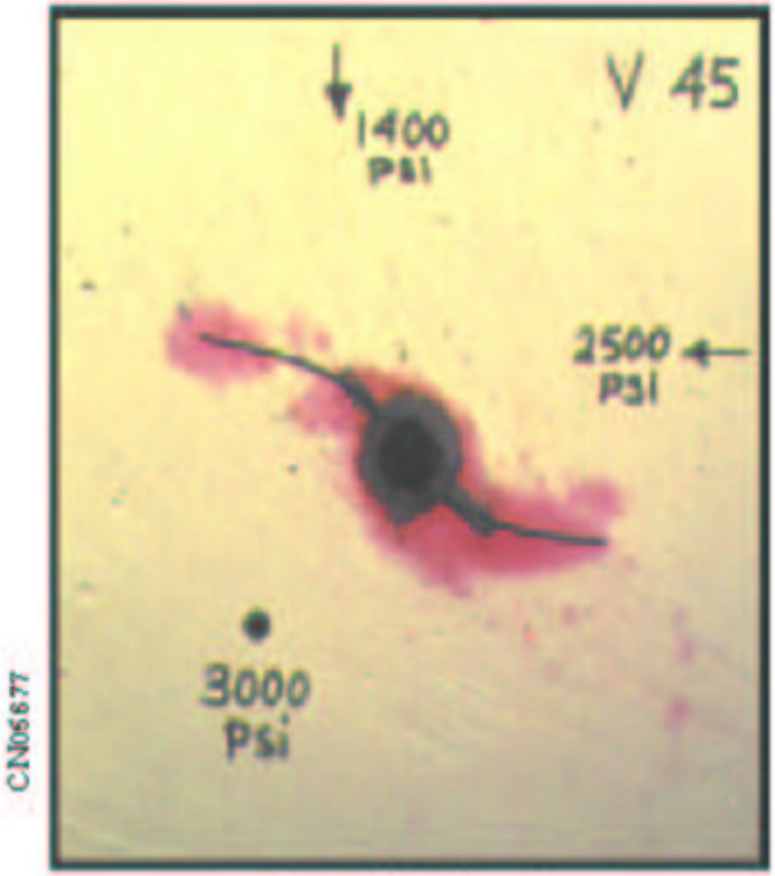
- Perforation phasing reduces near wellbore tortuosity. (SPE 24823 & 39453)

- Run in conjunction with FRAC charges, a measurable improvement in stimulation treatments is observed. (SPE 159085)



Perforation Phasing Test



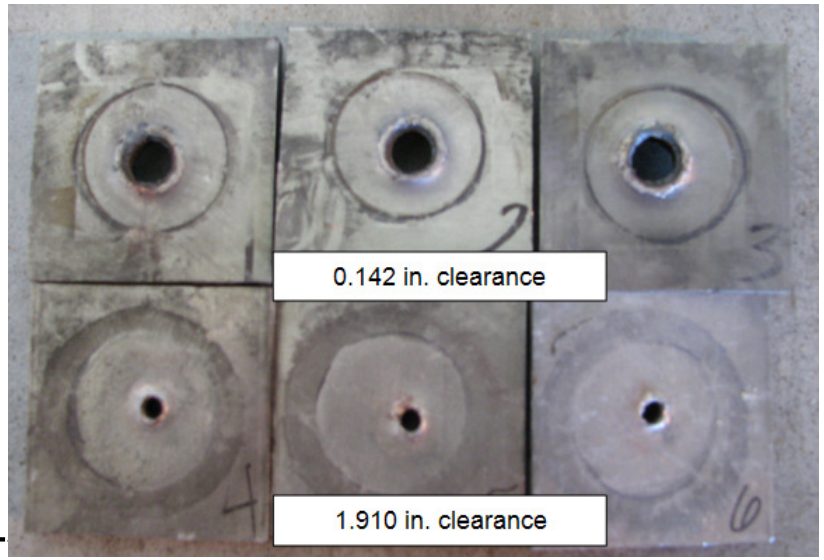


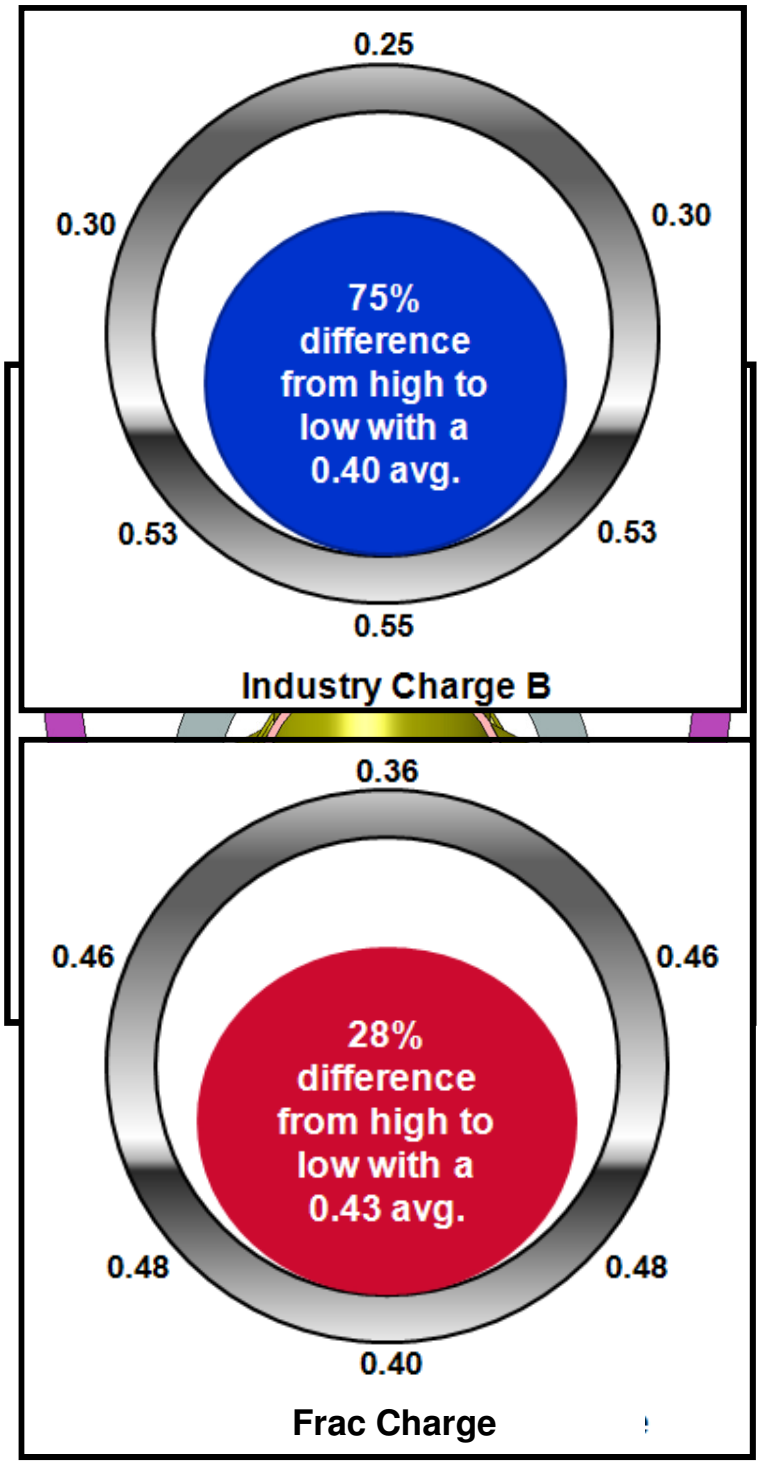
From ‘Oriented Perforations – A Rock Mechanics View’ SPE 28555

What role do perforations play?

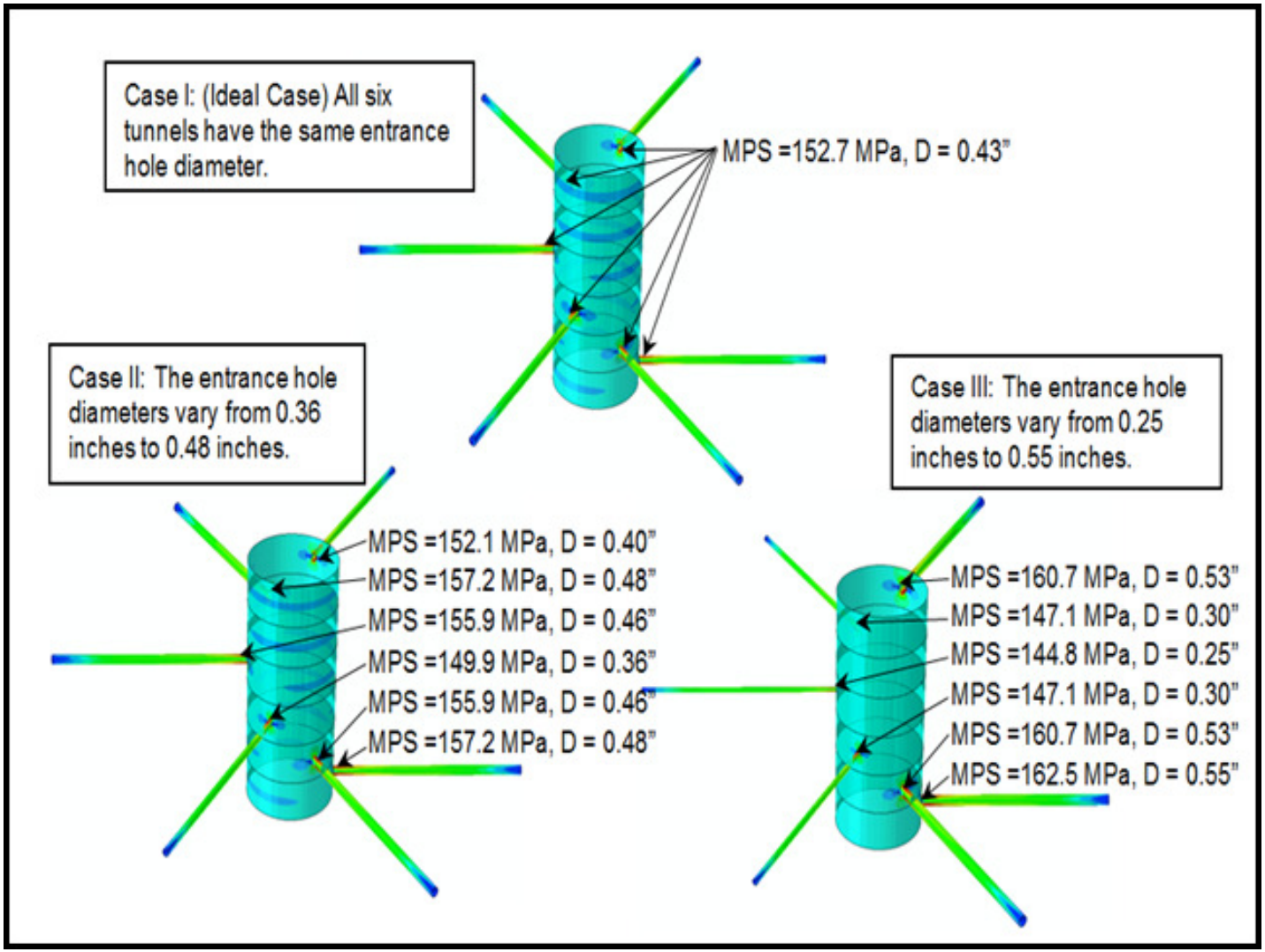
"Unless a perforating gun is centralized, the perforation casing hole diameters are a function of gun phasing. This means that the ***injection rate is different for different perforation diameters***. "

– SPE 39453





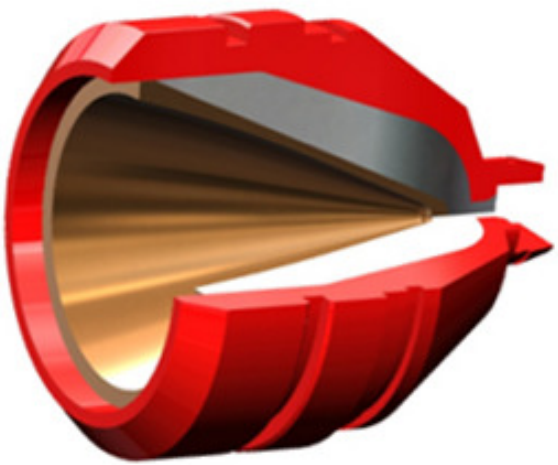
Why hole size matters



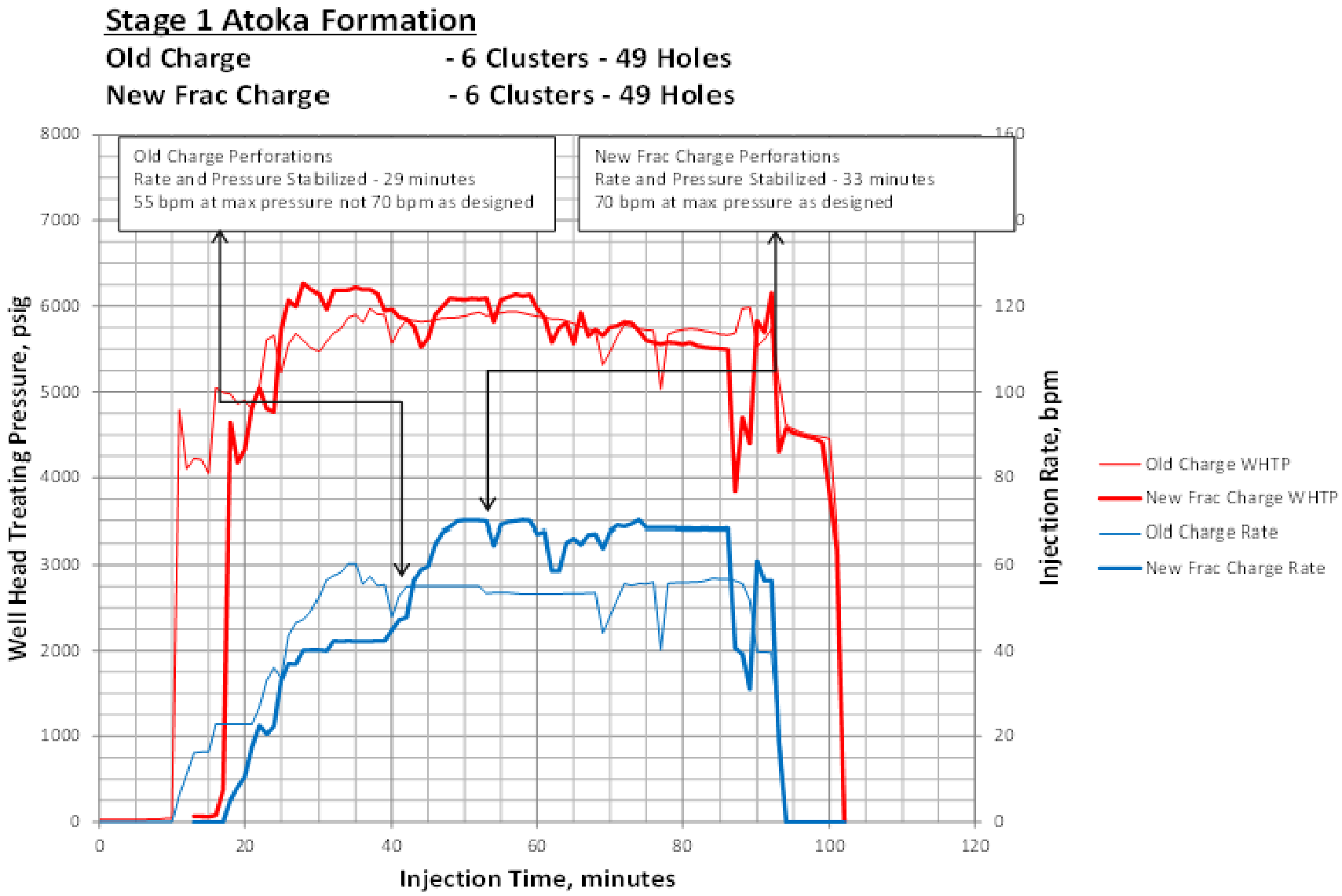
$$\sigma_1 = T_{fail}.$$

$$\sigma_1 = Kp$$

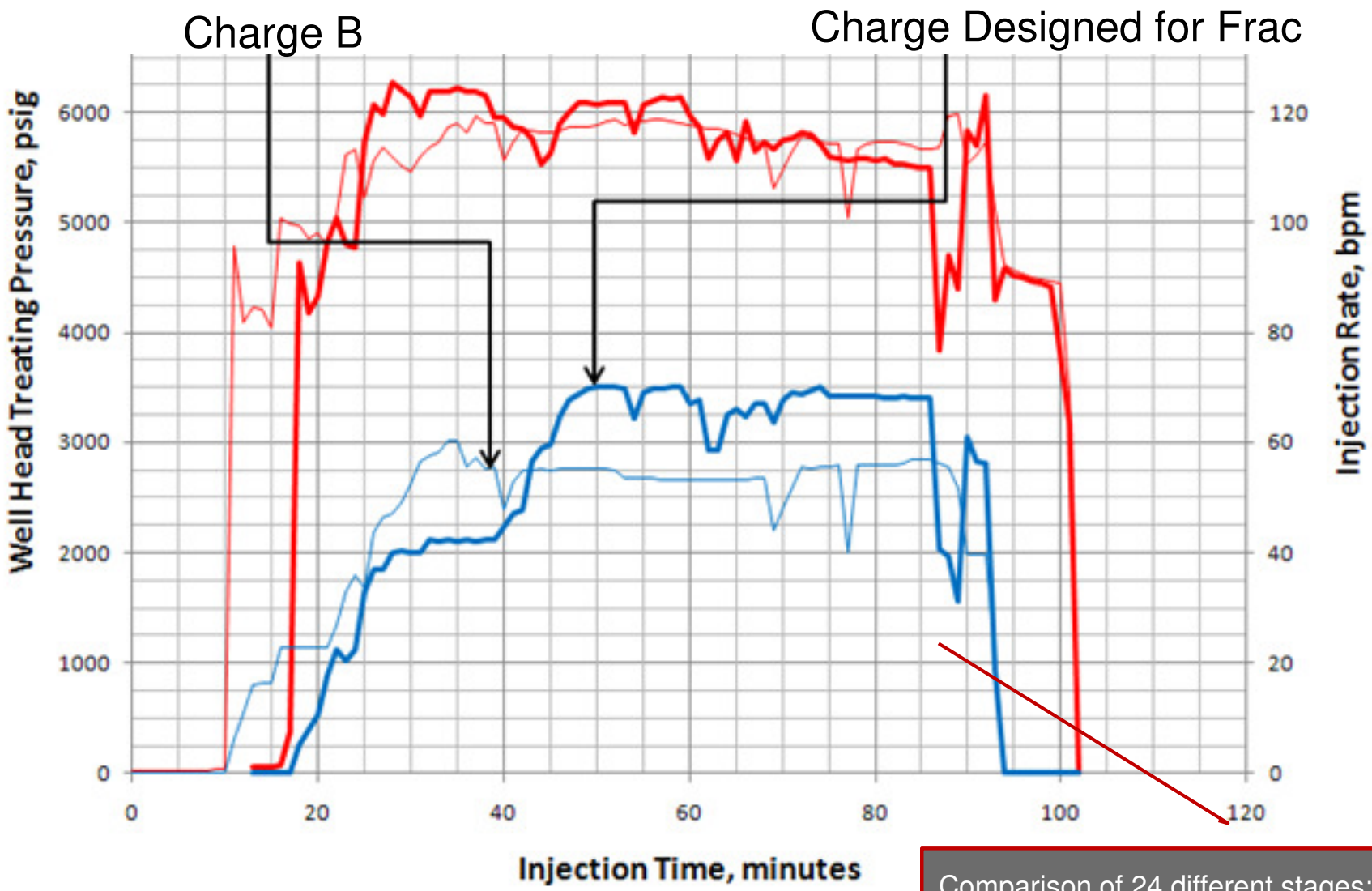
$$p_{bd} = T_{fail}/K$$



Studies demonstrate a **difference.**



Frac Charge Results



Comparison of 24 different stages:
- Increased injection rate by 27%
- Lowered treating pressures 500-1,000psi

Additional Efficiencies

TABLE 4—COMPARISON OF STAGE #5, FIELD TRIAL 2.			
	Old Charge	New Frac Charge	
Clusters	6	5	
Holes	57	48	
Time to Rate	3	3	
Rate	65	60	
Pressure	2,212	2,175	
ISIP	1,004	1,013	

- Fewer holes
- More rate per perforation

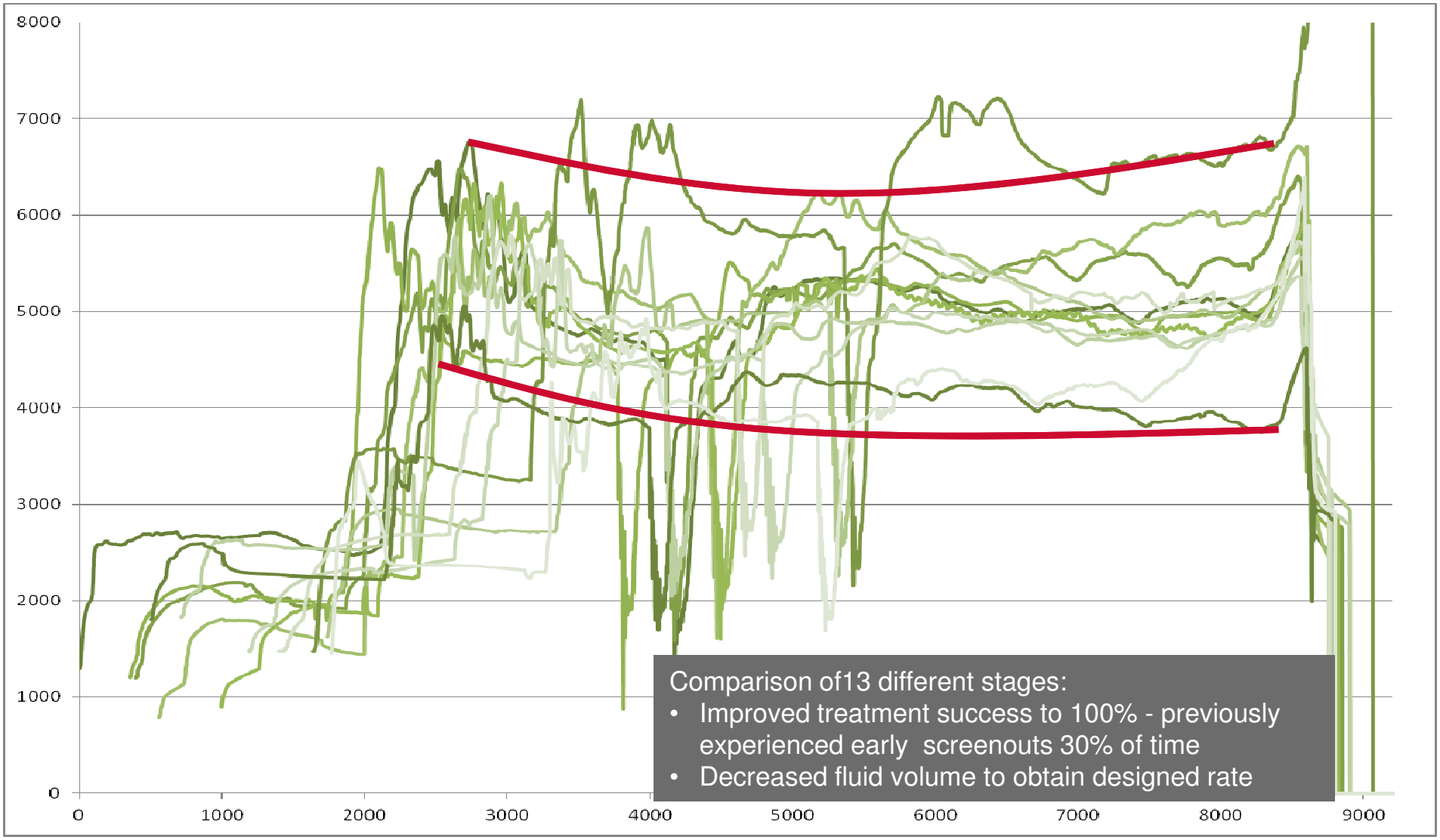
TABLE 5—COMPARISON OF STAGE #8, FIELD TRIAL 3.			
	Old Charge	New Frac Charge	
Clusters	6	6	
Holes	58	52	
Time to Rate	4	2	
Rate	65	65	
Pressure	1,812	1,800	
ISIP	719	745	

- Faster time to rate

TABLE 6—COMPARISON OF STAGE #6, FIELD TRIAL 4.			
	Old Charge	New Frac Charge	
Clusters	5	6	
Holes	52	52	
Time to Rate	5	3	
Rate	60	65	
Pressure	1,952	2,075	
ISIP	507	611	

- More rate
- Faster time to rate

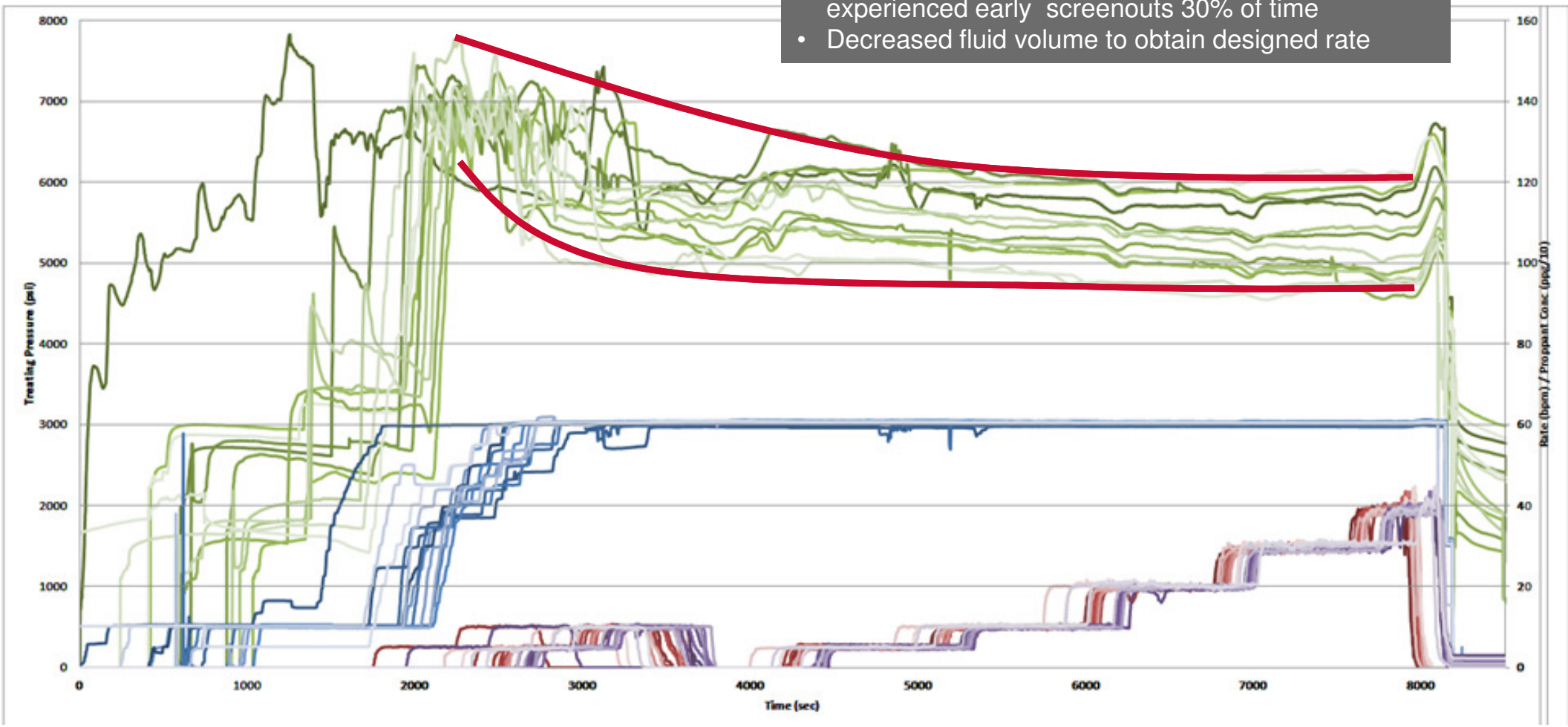
Offset Well (Identical Completion & Pump Schedule)



13 Stage Comparison

Comparison of13 different stages:

- Improved treatment success to 100% - previously experienced early screenouts 30% of time
- Decreased fluid volume to obtain designed rate



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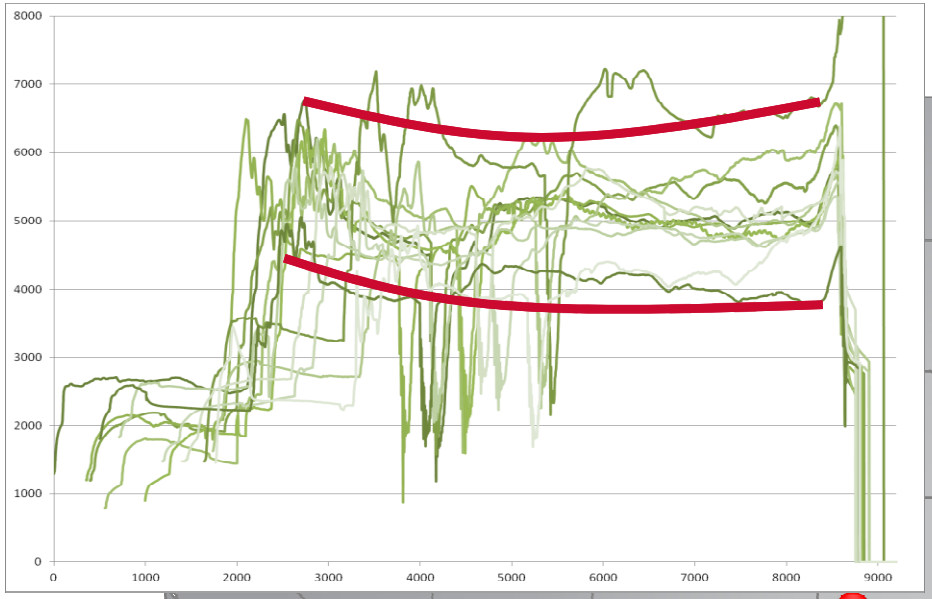

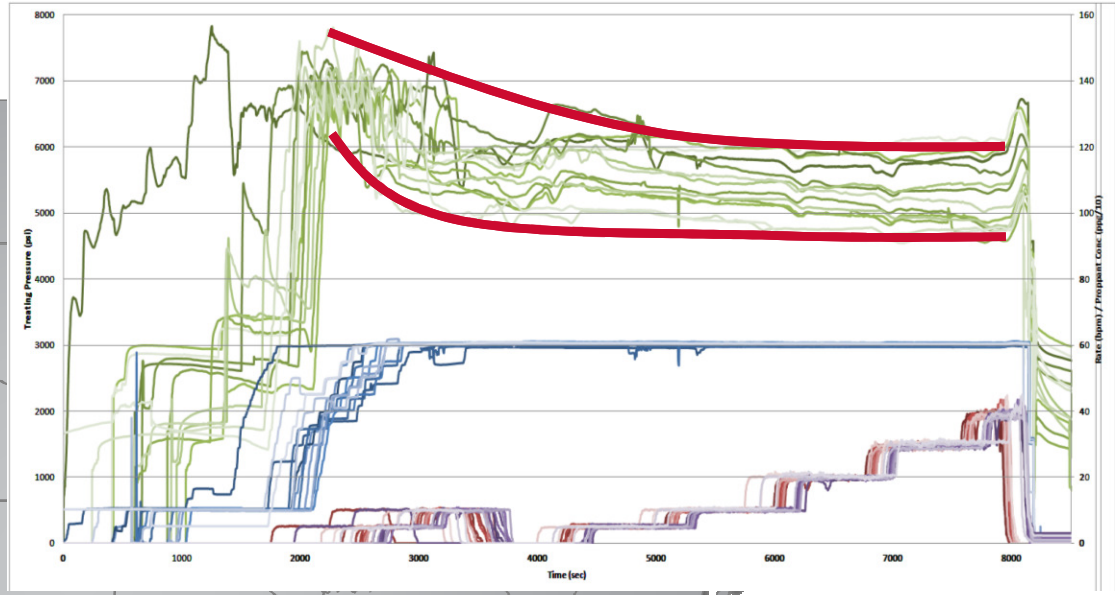

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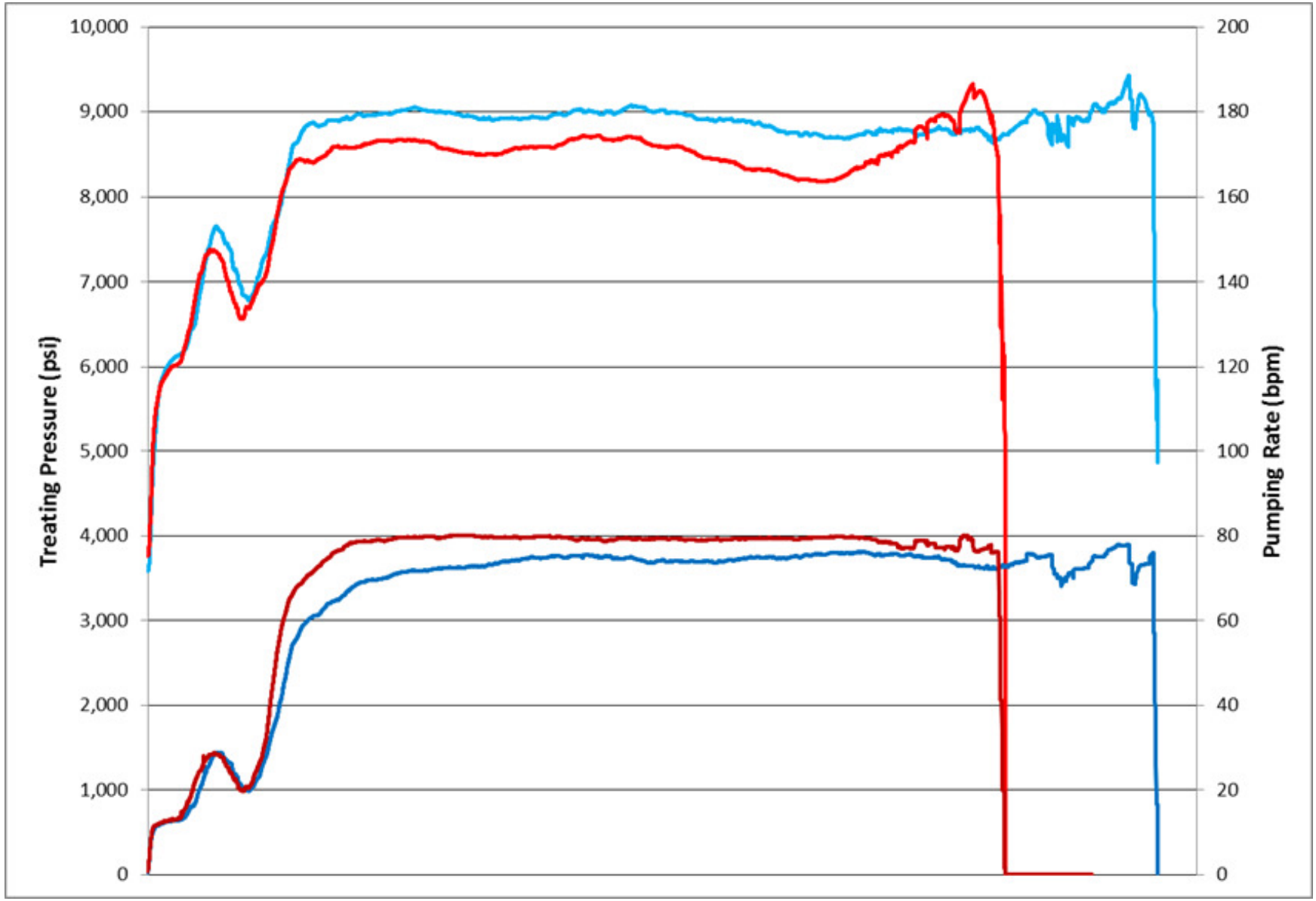

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THANK YOU