



Perforating for Shales

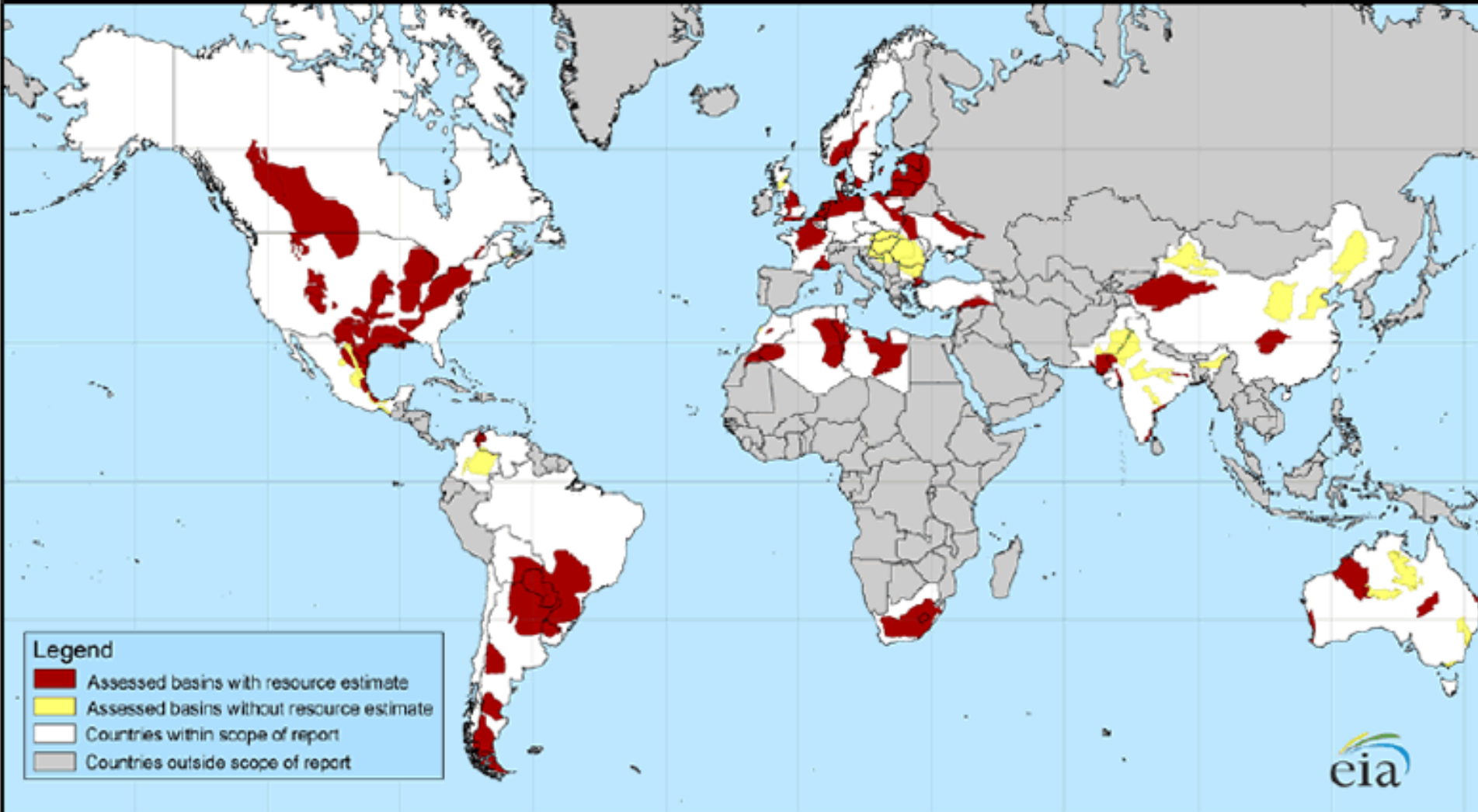
**Amsterdam
Cole White
Technical Advisor- TCP
November 2012**

HALLIBURTON

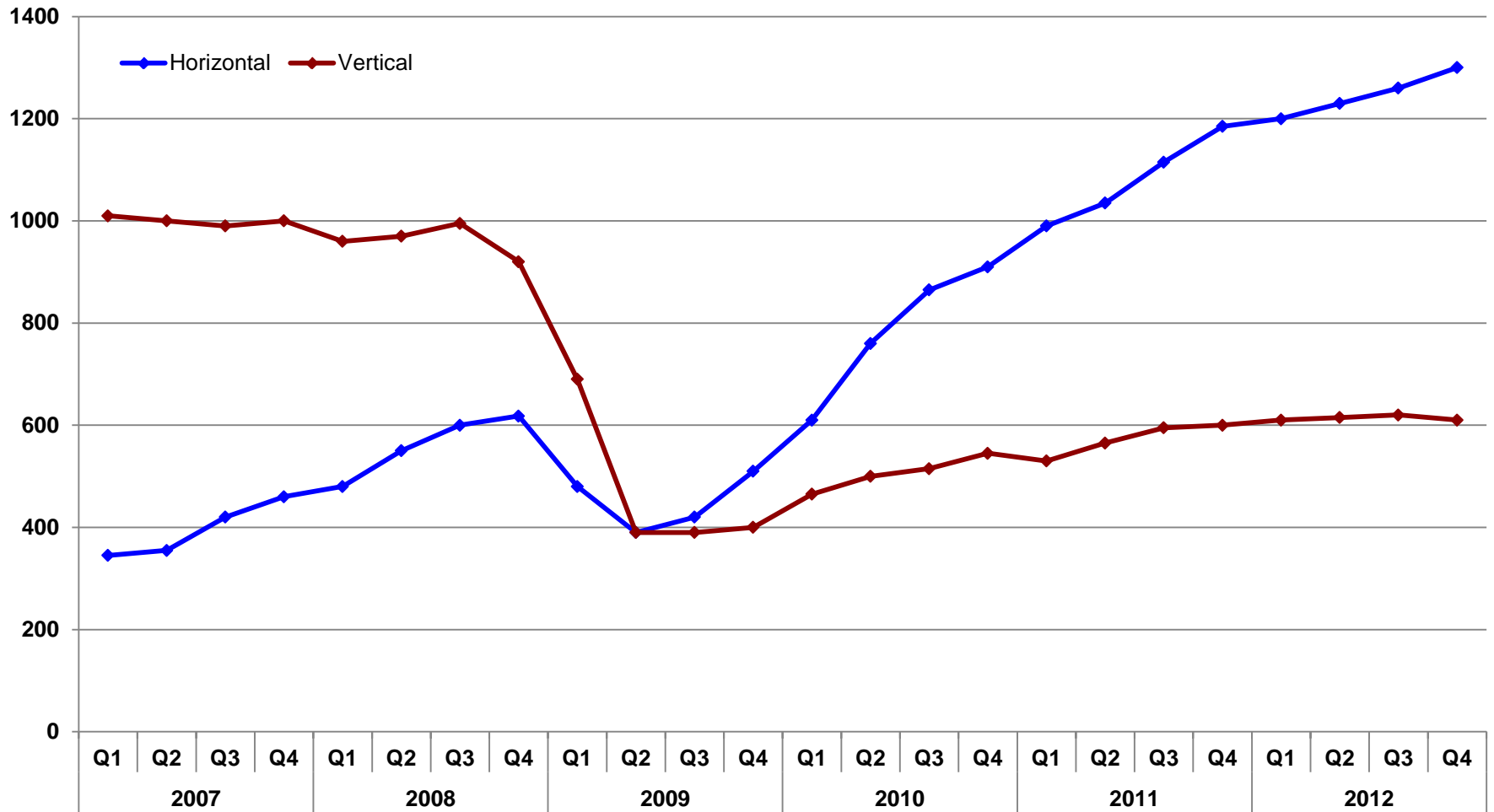
Multi-Stage Multi-Well Completion



Estimated 187 Trillion m³ (Energy Information Administration 2011)



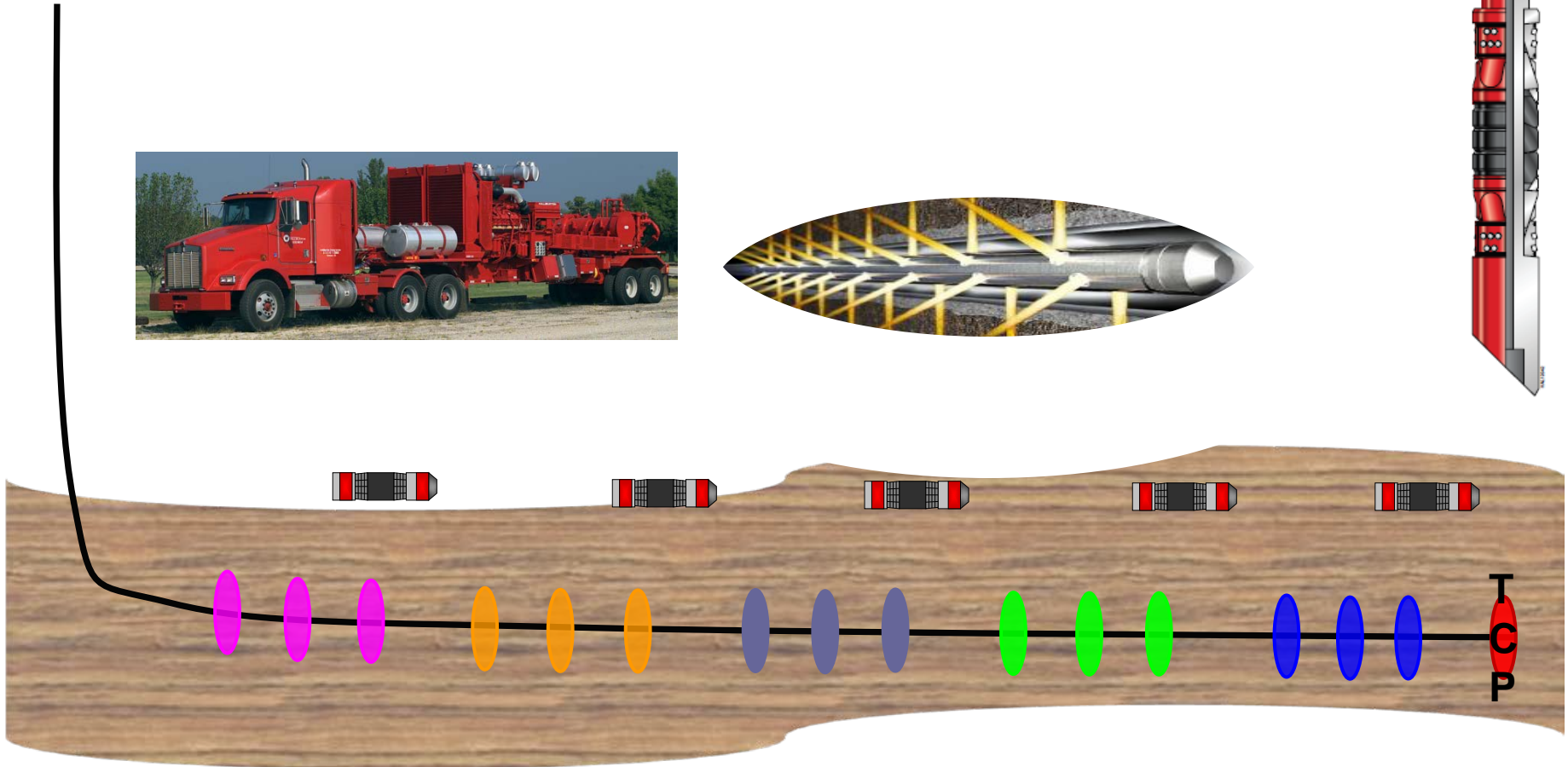
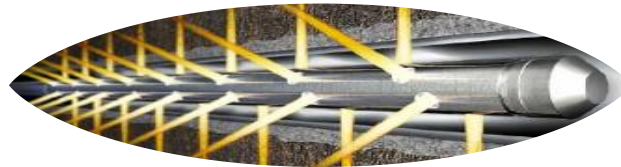
Land Drilling Activity by Type



From Spears & Associates, Inc

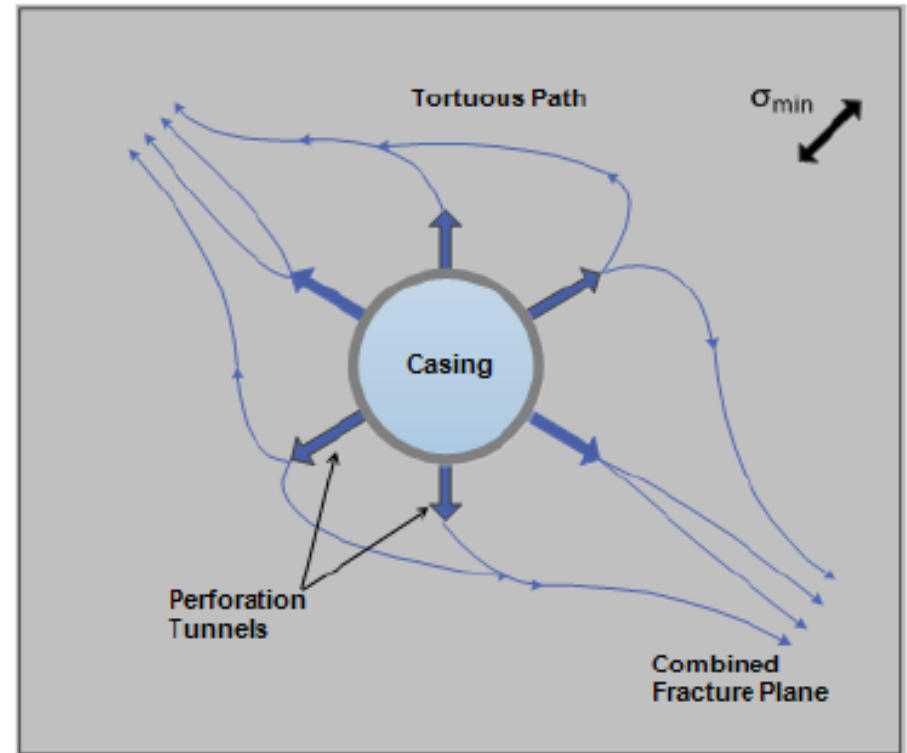
Horizontal Multi-Stage Perforating- Pump Down Service

Most PDS completions are performed in a geometrical spacing

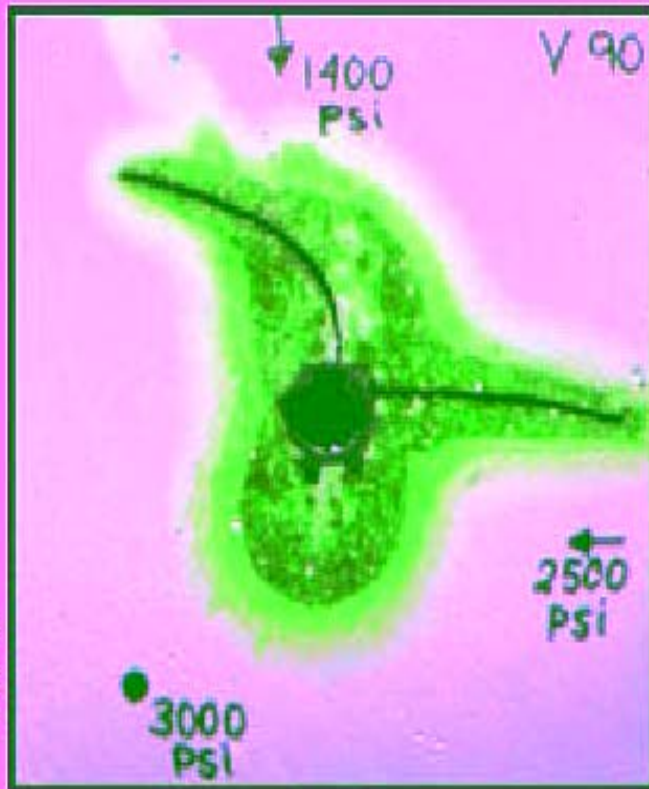


Perforation Phasing

- 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

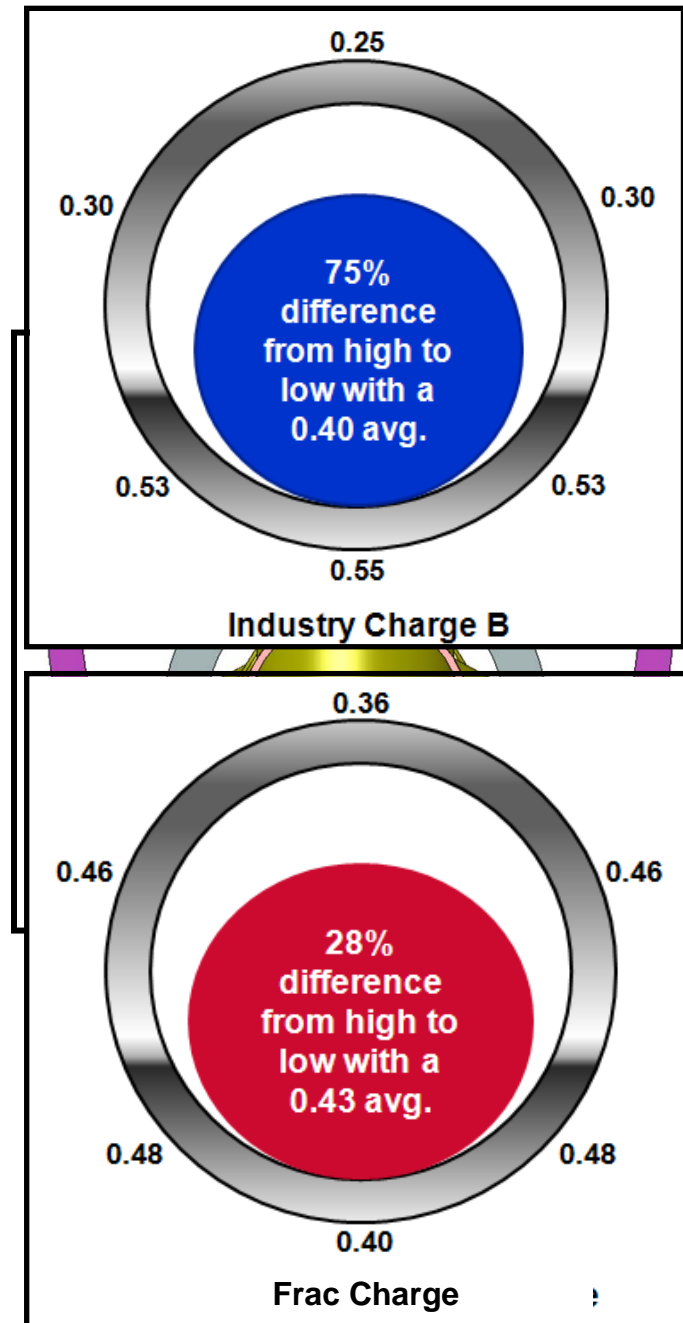
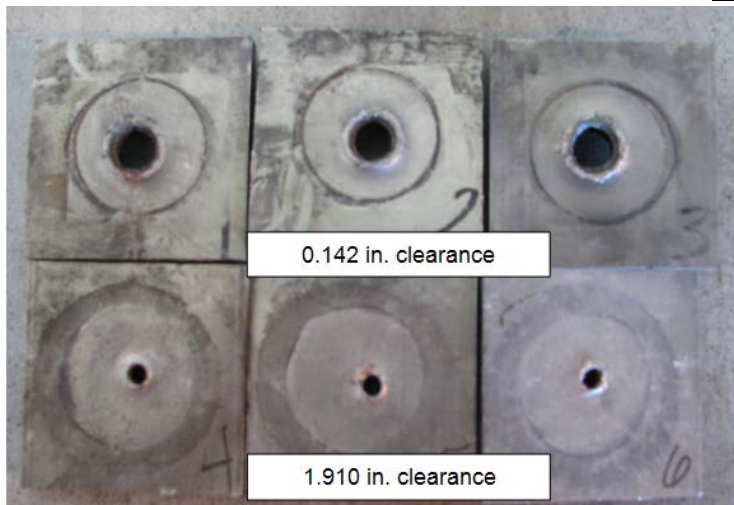


From 'Oriented Perforations – A Rock Mechanics View' SPE 28555

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

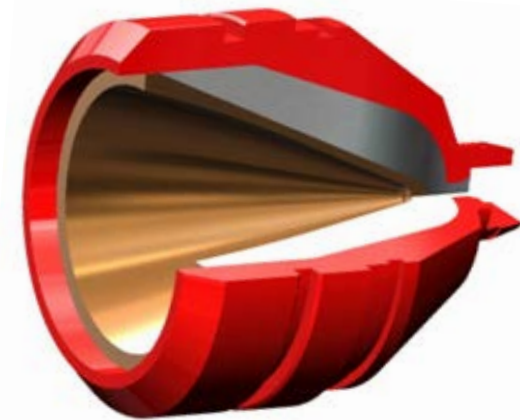


Why hole size matters

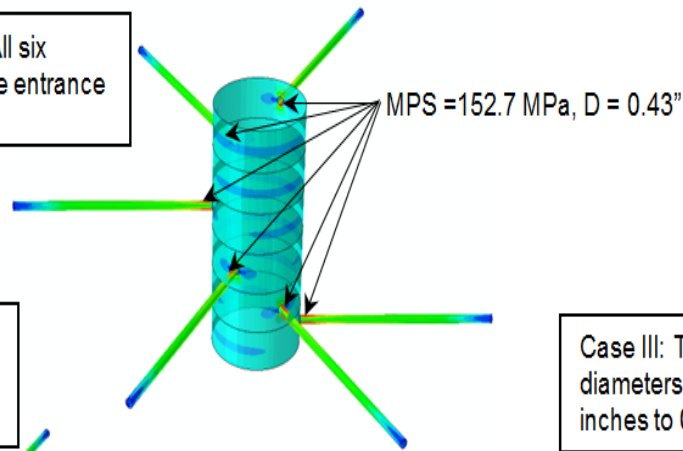
$$\sigma_1 = T_{fail}$$

$$\sigma_1 = Kp$$

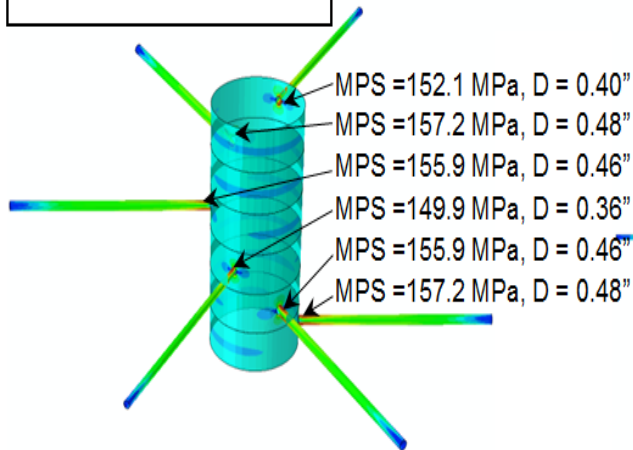
$$p_{bd} = T_{fail}/K$$



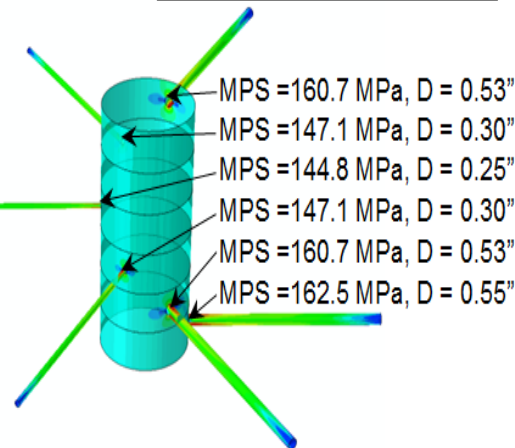
Case I: (Ideal Case) All six tunnels have the same entrance hole diameter.



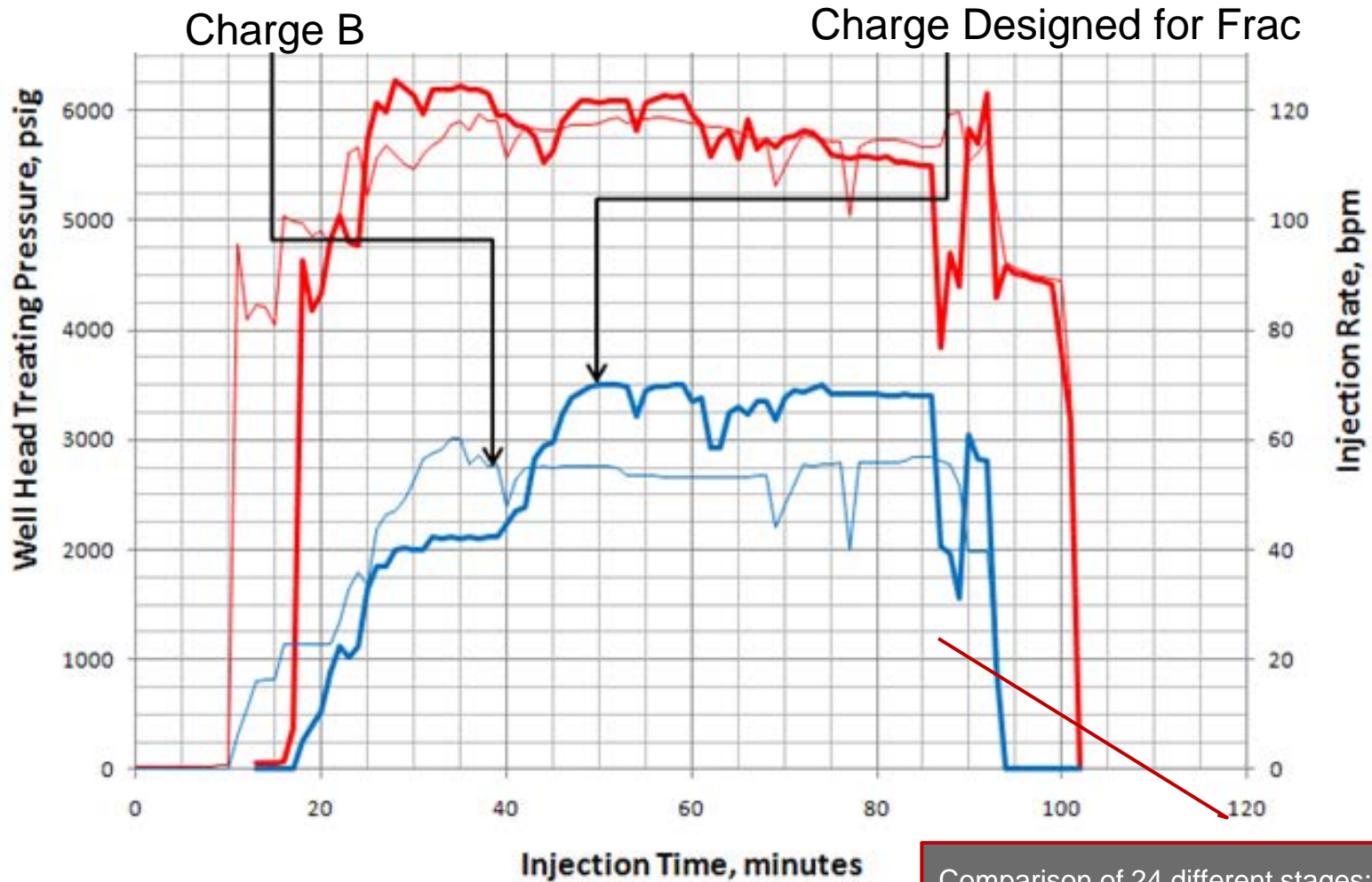
Case II: The entrance hole diameters vary from 0.36 inches to 0.48 inches.



Case III: The entrance hole diameters vary from 0.25 inches to 0.55 inches.



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	

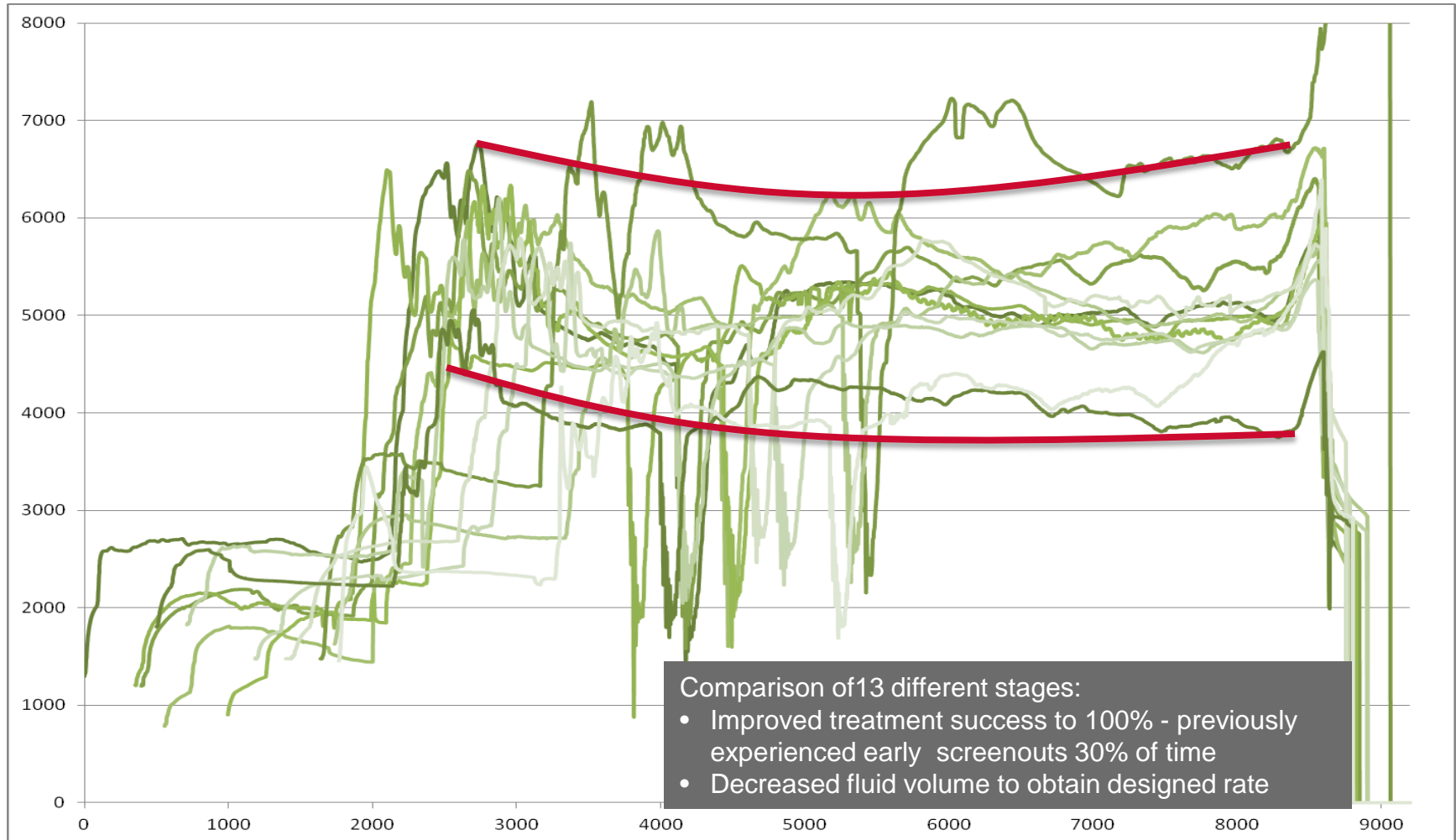
- Faster time to rate

TABLE 6—COMPARISON OF STAGE #6, FIELD TRIAL 4.

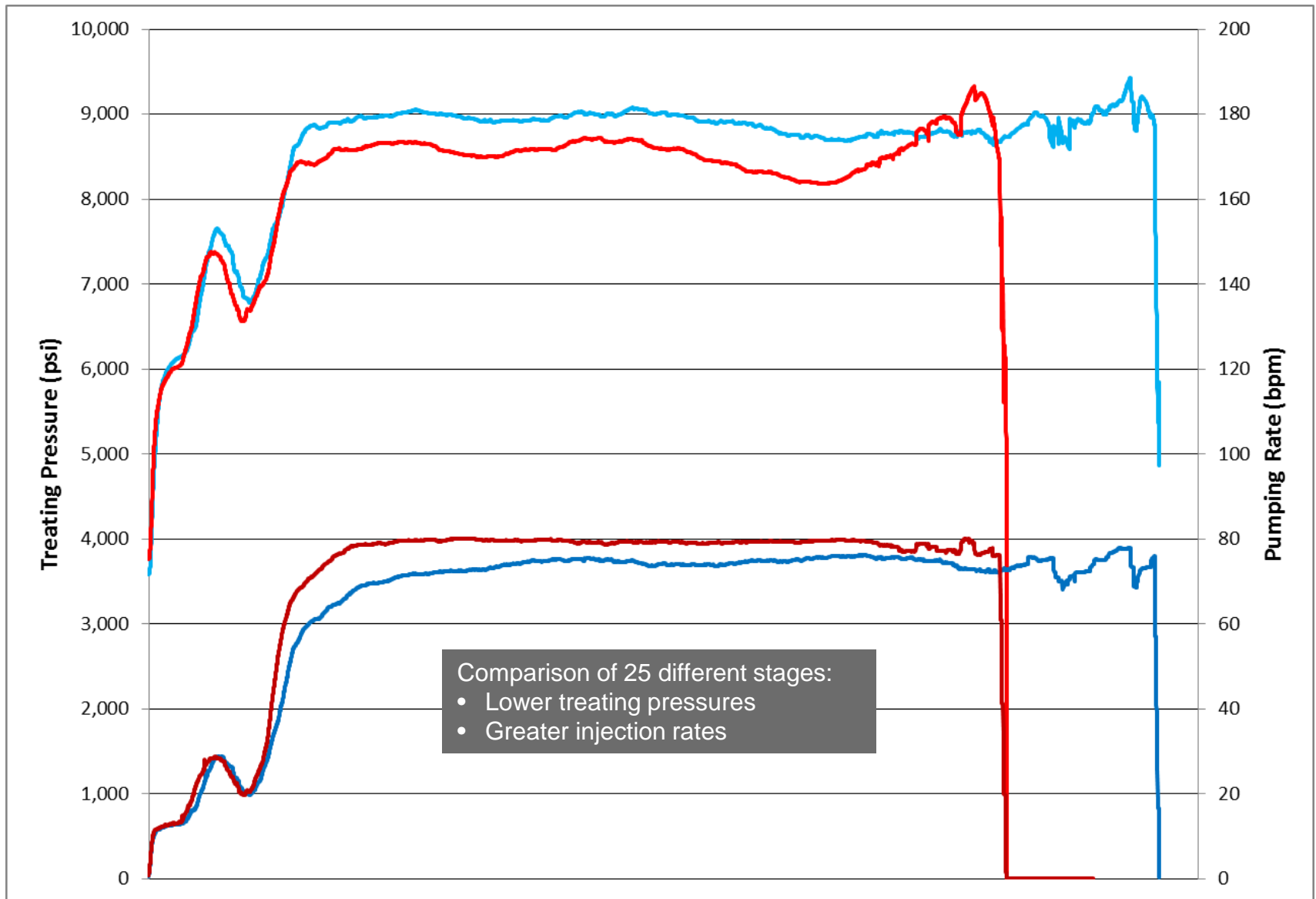
	Old Charge	New Frac Charge	
Clusters	5	6	
Holes	52	52	
Time to Rate	5	3	
Rate	60	65	
Pressure	1,952	2,075	
ISIP	507	611	

- More rate
- Faster time to rate

Offset Well (Identical Completion & Pump Schedule)



Studies demonstrate a difference.



THANK YOU

