Optimizing Treating Pressure Through Implementation of Consistent Through Hole Charge

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Authors: Tim Golian, Bill Collins, Chris Sokolove, James Cole
Presented by Josh Howk

Overview

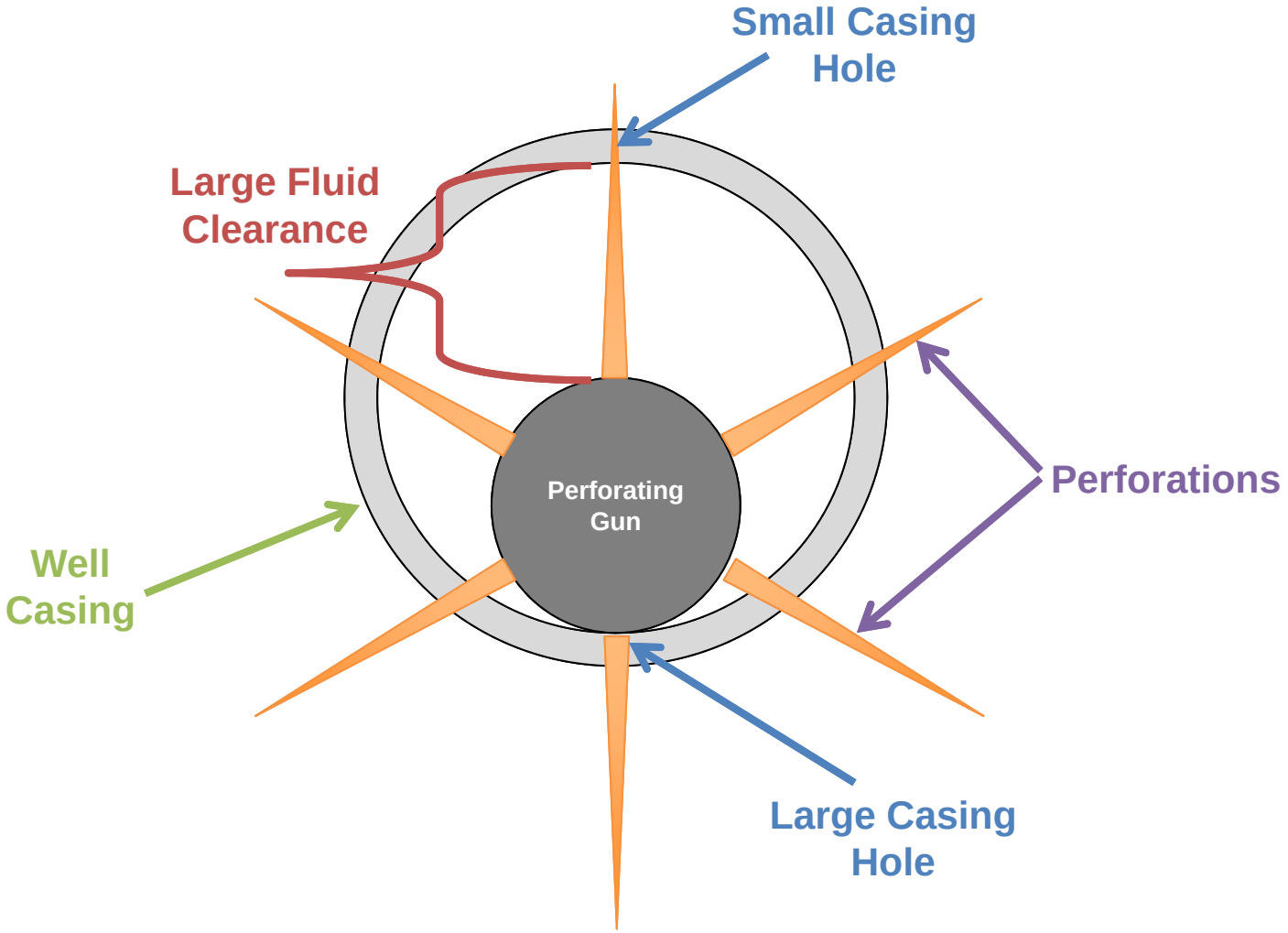
- Casing hole size effects with conventional shaped charges
- Well-stimulation effects due to hole size variation
- Overcoming hole size variation with consistent through hole charge
- Optimizing treating pressure with consistent hole size

The Client Request

- The objective is to provide a new Shape charge for :
  3-3/8”, 6SPF, 60 degree gun decentralized in 5.5”, 23#, P-110 casing run
  in the horizontal.
- The requirements were to produce a consistent hole of 5% or less standard deviation
  without use of centralization.

Perforating with Conventional Shaped Charges

Non-centralized Perforating Gun



Standard 3-3/8” Gun, 23gm Charge in 5-1/2” 23# P-110

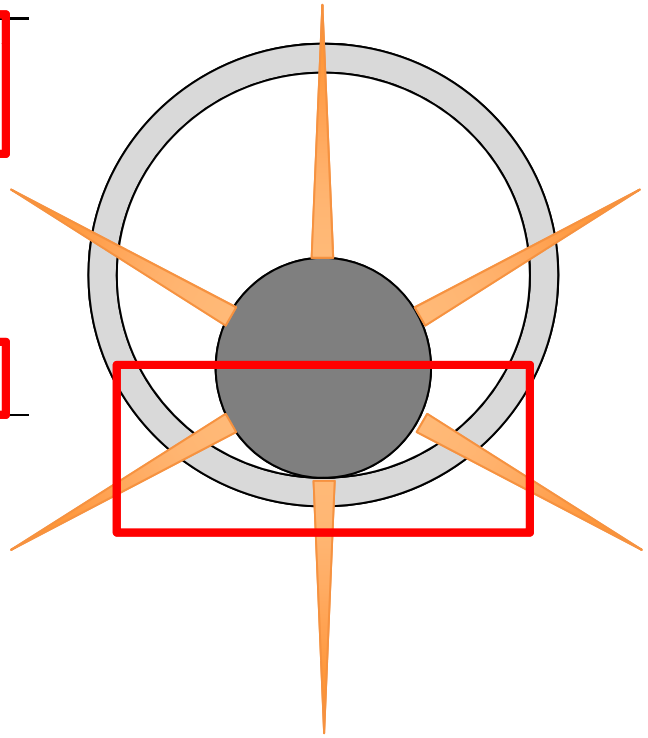
		Planned		Actual	
Phase [Deg.]	Fluid Gap [inches]	Avg. Hole Dia. [inches]	Flow Area [cubic inches]	Avg. Hole Dia. [inches]	Flow Area [cubic inches]
0	0	0.36	0.10	0.52	0.21
60	0.29	0.36	0.10	0.46	0.17
120	0.90	0.36	0.10	0.25	0.05
180	1.29	0.36	0.10	0.24	0.05
240	0.90	0.36	0.10	0.25	0.05
300	0.29	0.36	0.10	0.46	0.17

	Avg.	Total	Avg.	Total
	0.36	0.61	0.36	0.69
Variation	0.0%	0.0%	**35.7%**	**10.9%**

Standard 3-3/8” Gun, 23gm Charge in 5-1/2” 23# P-110

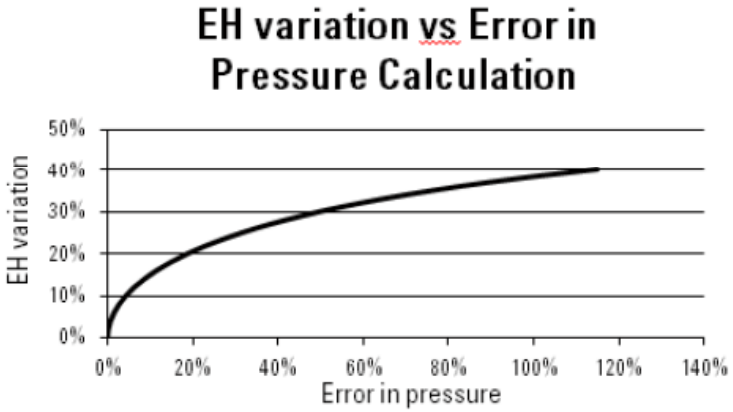
80% of Flow Area comes from 50% of perforations

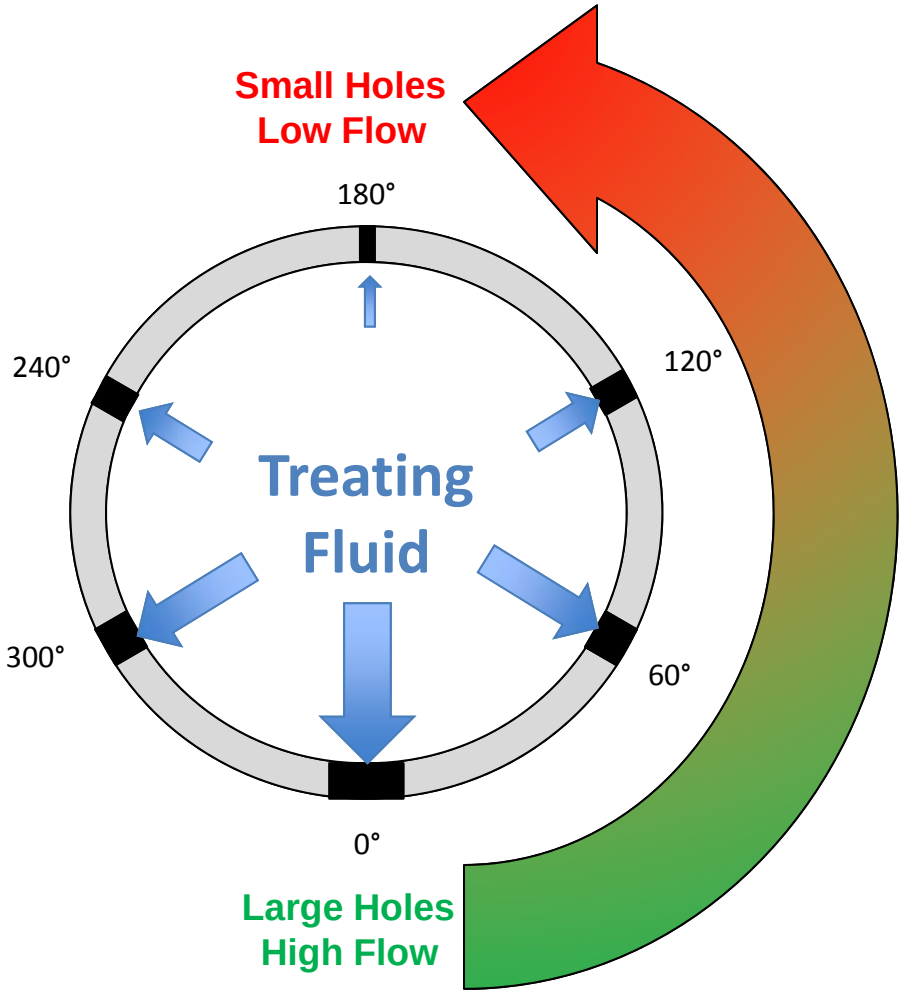
		Actual (Standard Charge)	
Phase [Deg.]	Fluid Gap	Avg. Hole Dia. [inches]	Flow Area [cubic inches]
0	0	0.52	0.21
60	0.29	0.46	0.17
120	0.90	0.25	0.05
180	1.29	0.24	0.05
240	0.90	0.25	0.05
300	0.29	0.46	0.17



Effects of Hole Size Variation: Poor Treating Fluid Distribution

- Preferential fluid flow to large holes
- Leads to erosion & slotting of holes
- Not all perforations utilized





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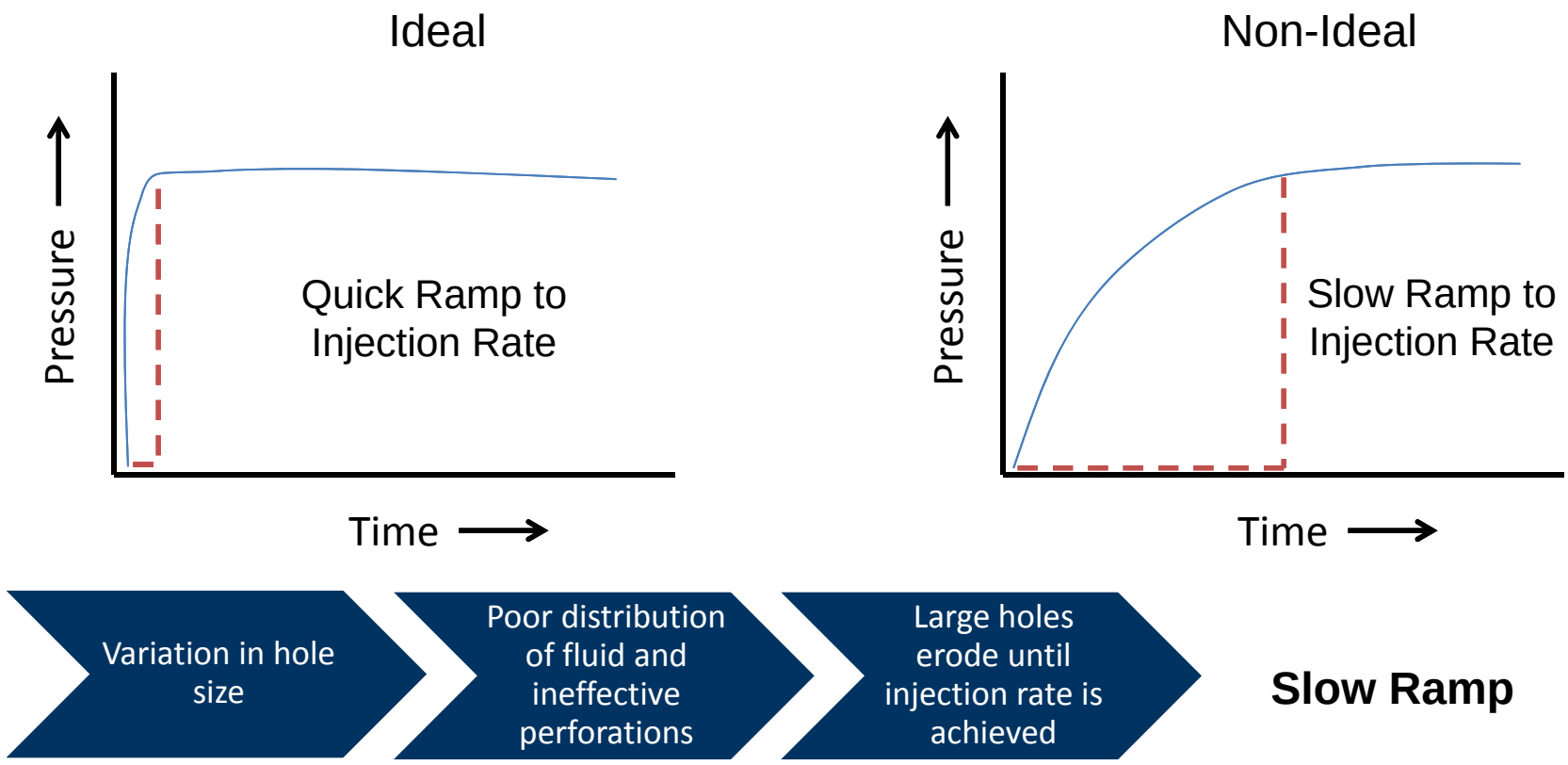
Effects of Hole Size Variation: Erosion to Injection Rate



Effects of Hole Size Variation: Planning

Planned

- *Minimal Variation* in hole size
- *Equal* area open to flow between perforations
- *Equal* use of each perforation
- *Uniform* treating fluid flow through perforations
- *Quick* ramp to injection rate
- *Ideal* well-stimulation

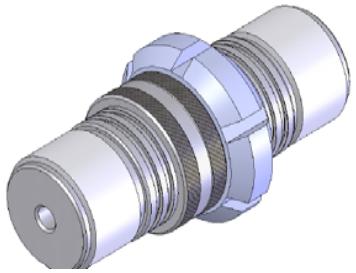
Actual

- *Large Variation* in hole size
- *Unequal* area open to flow between perforations
- *Unequal* use of each perforation
- *Non-Uniform* treating fluid flow through perforations
- *Slow* ramp to injection rate
- *Non-ideal* well-stimulation

Issue

Perforation hole size must be consistent for planned well-stimulation to match actual well-stimulation and allow for optimization.

Option 1



Centralize Perforating Gun

- Not always possible to use centralizing hardware
- Not truly centered, only improved
- Additional hardware on the tool string
- Non uniformed outside tool diameter

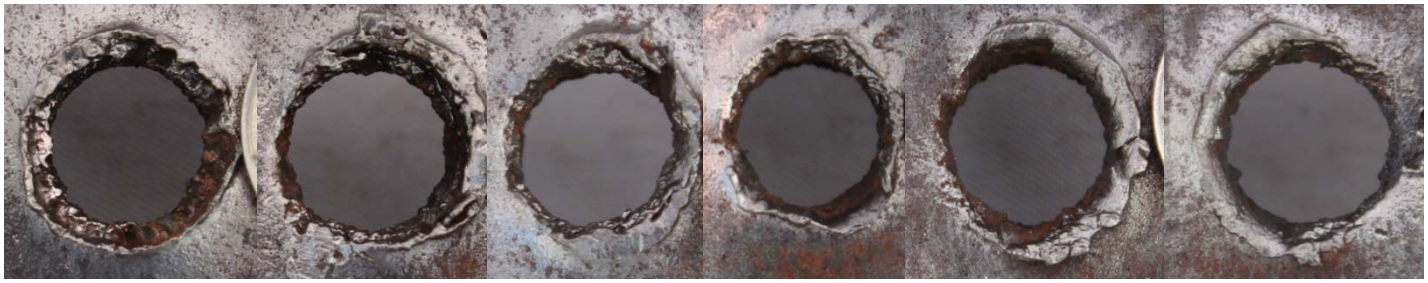
Option 2

Utilize Consistent Through Hole Charge

- Single charge optimized for performance across all fluid clearances
- No need for centralizing perforating gun

3-3/8" Gun, 23gm Charge in 5-1/2" 23# P-110 Casing

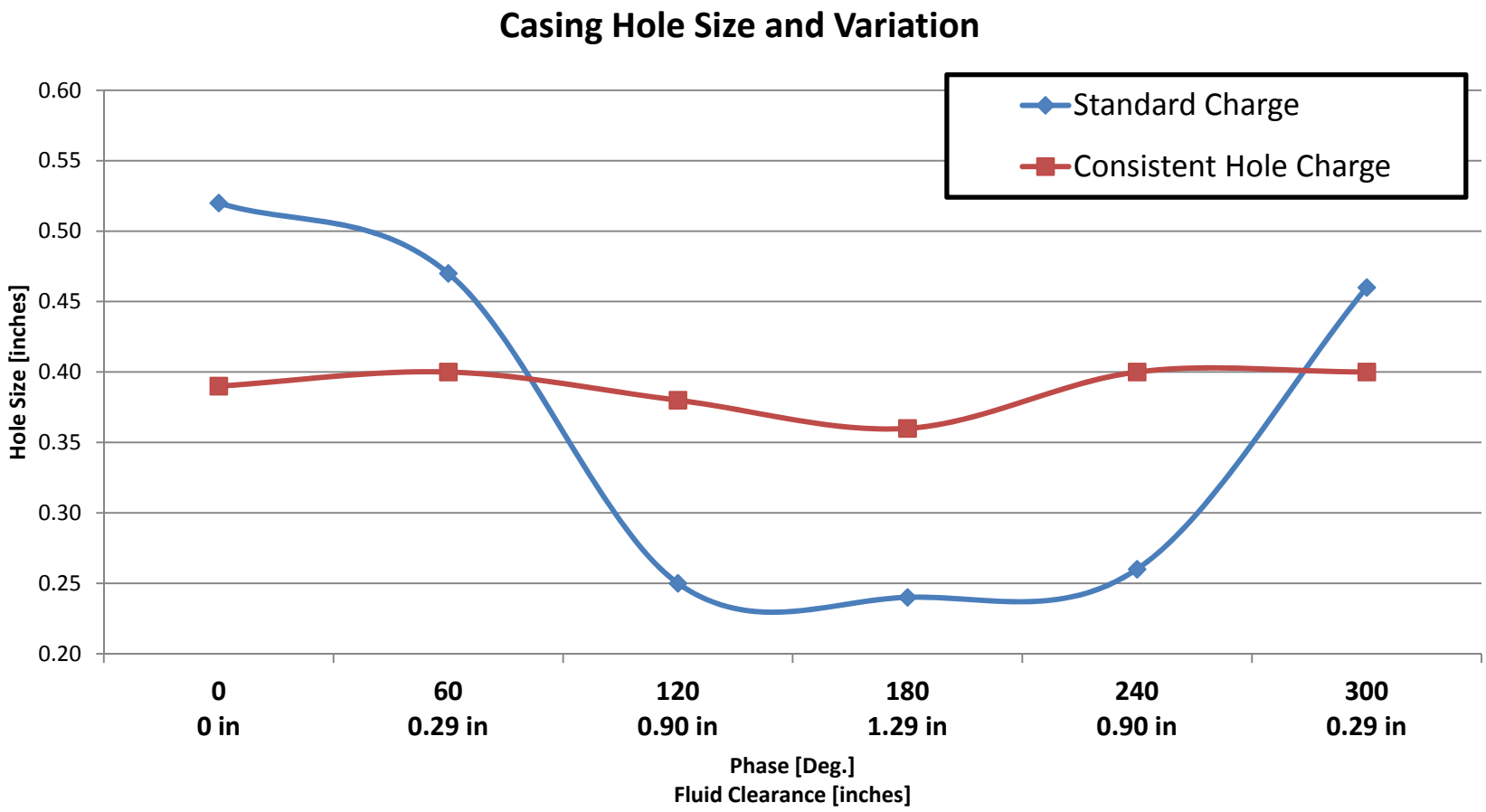
Consistent Through Hole Charge



Phase	0°	60°	120°	180°	240°	300°
Clearance	0 in	0.26 in	0.90 in	1.29 in	0.90 in	0.26 in

Industry Standard Charge

3-3/8" Gun, 23gm Charge in 5-1/2" 23# P-110 Casing



3-3/8" Gun, 23gm Charge in 5-1/2" 23# P-110 Casing

		Standard Charge		Consistent Hole Charge	
Phase [Deg.]	Fluid Gap [inches]	Avg. Hole Dia. [inches]	Area [cubic inches]	Avg. Hole Dia. [inches]	Area [cubic inches]
0	0	0.52	0.21	0.4	0.13
60	0.29	0.46	0.17	0.39	0.12
120	0.90	0.25	0.05	0.38	0.11
180	1.29	0.24	0.05	0.36	0.10
240	0.90	0.25	0.05	0.4	0.13
300	0.29	0.46	0.17	0.4	0.13

	Avg.	Total	Avg.	Total
	0.36	0.69	0.39	0.71
Variation	35.7%	10.9%	4.1%	1.3%

Optimizing Treating Pressures with Consistent Hole Technology

- Actual well-stimulation reflect planned well-stimulation
- Effective use of each perforation
- Uniform distribution of treating fluids
- Quick ramp up to injection rate based on preliminary well tests
- Equal treatment of each perforation

Designed Application

- Decentralized perforating guns
- Horizontal well completion

Consistent Though Hole Charge

- 3-1/8” and 3-3/8” perforating guns
- 0, 60 and 180 degree phasing
- Up to 6 SPF

Next Steps

Test well studies comparing standard and consistent hole charges to include:

- Comparison of pump pressures
- Production information
- Down hole images of erosion and perforation hole geometries

References

- IPS-2014 Schlumberger Fracture Initiation from Perforations. (A. Martin/ H. Williams)
- SPE 114173 Stimulating Unconventional Reservoirs: Maximizing Network Growth and Optimizing Fracture Conductivity (N.R. Warpinski)
- SPE 127986 Optimizing Fracture Spacing and Sequencing in Horizontal-Well Fracturing (N. Roussel)
- SPE 138425 Improving Production in the Eagle Ford Shale with Fracturing Modeling, Increased Conductivity and optimized Stage and Cluster Spacing Along the Horizontal Wellbore (L. Bazan)
- MENAPS 13-02 Perforating Carbonates (A. Martin)
- SPE 152596 Hydraulic Fracturing 101: What Every Representative, Environmentalist, Regulator, Reporter, Investor, University Researcher, Neighbor and Engineer Should know About Estimating Frac Risk and Improving Frac Performance in Unconventional Gas and Oil Wells (G.King)

Questions

- If the charge helps optimize the treating pressure during the stimulation will it make a more effective frac?
- With the efficiency of the pre-job plan now versus what it would be in the future will it cut cost for the completion of the well?
- What other changes should we look at with this type of technology?