# Consistent Hole Perforators

## All Perforations Are Not Created Equal

**Presented by:** Dan W. Pratt

Core Lab™
RESERVOIR OPTIMIZATION

OWEN OIL TOOLS

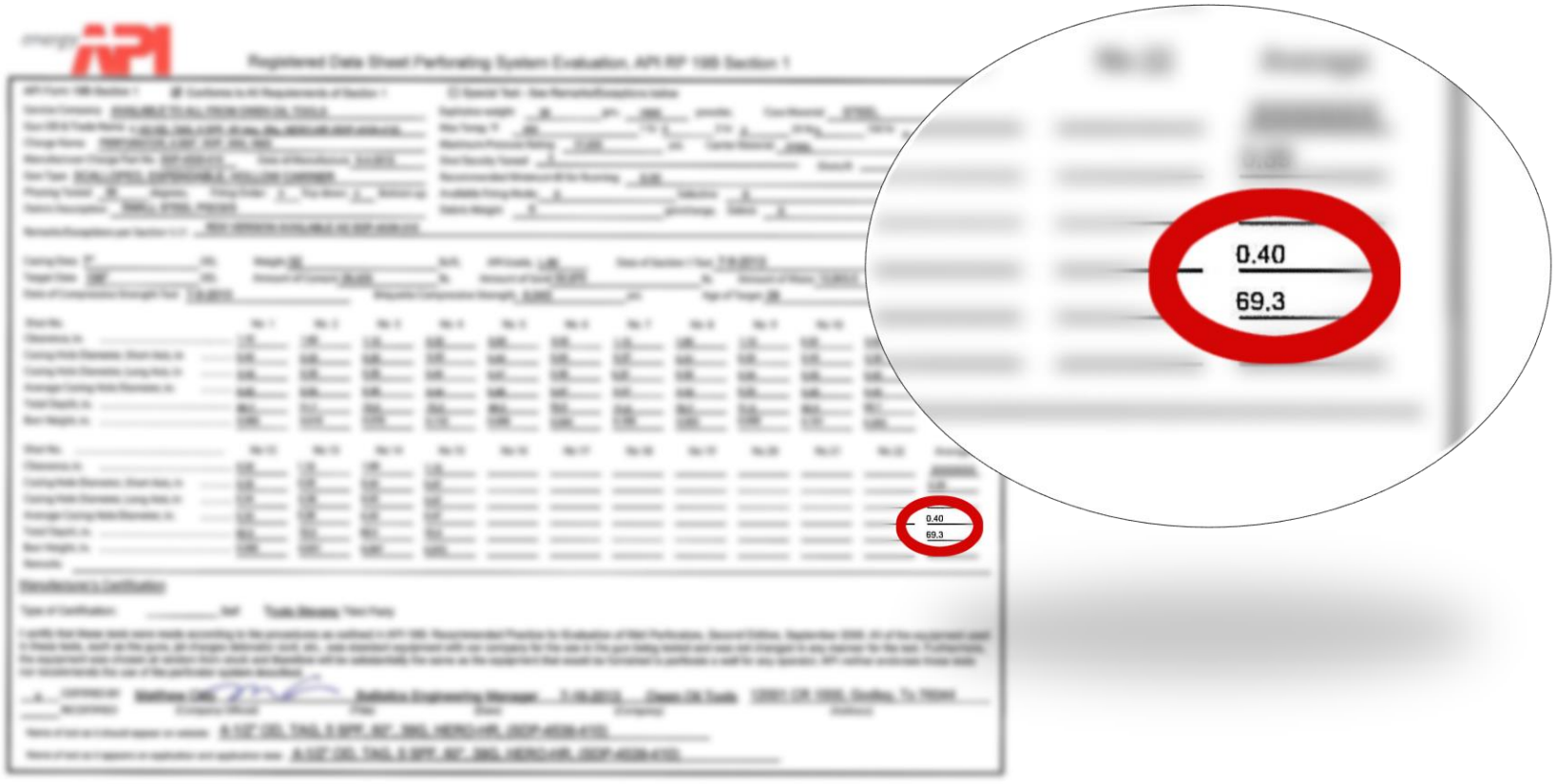
# Why Do We Perforate?

- To establish effective communication between the wellbore and the formation
  - There are 2 components to the perforating result
    - Thru hole in the tubular and cement sheath
    - Perforating tunnel into formation

# Where Does Hole Size Come From?

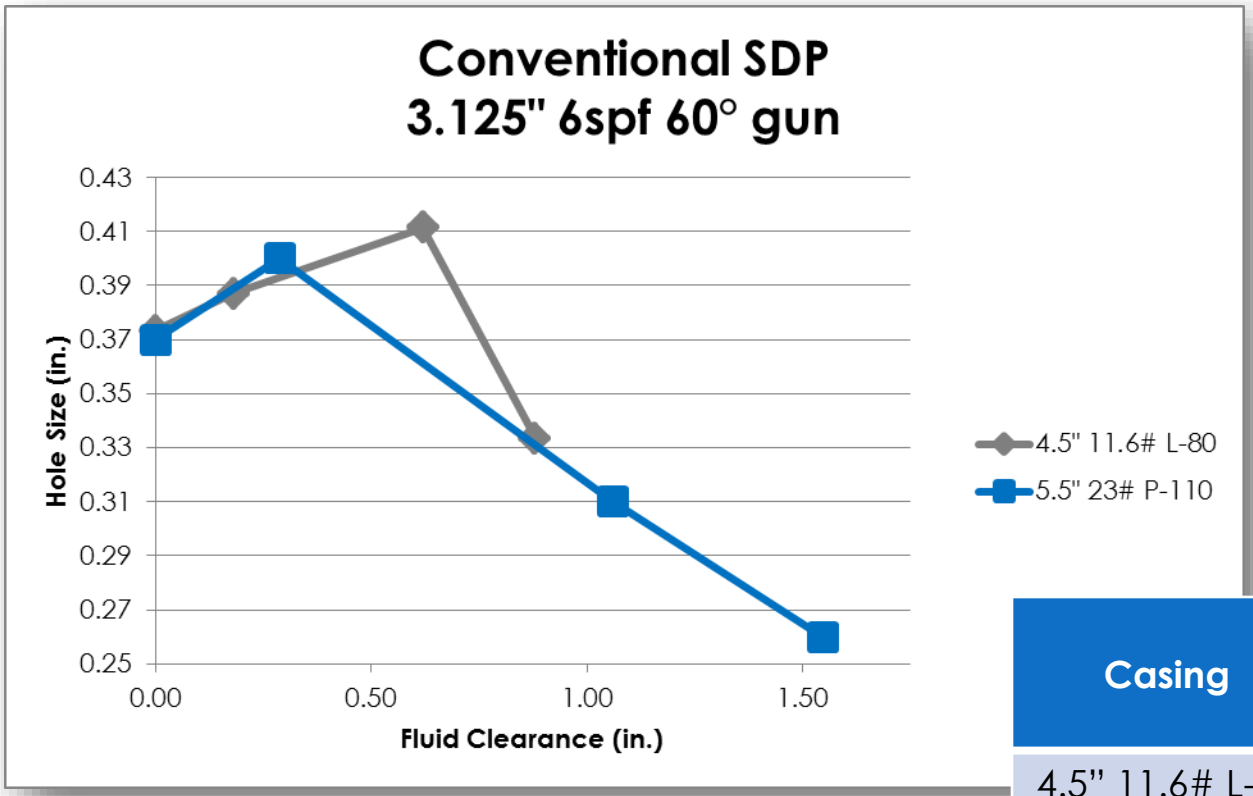
- Full System Testing
  - API RP-19B Section 1
  - Tests in Actual Well Tubulars
- Single Charge Testing
  - QC charge test
  - API RP-19B Section 2
  - API RP-19B Section 4
- Simulations

# API Section 1



# Where Does Hole Size Come From?

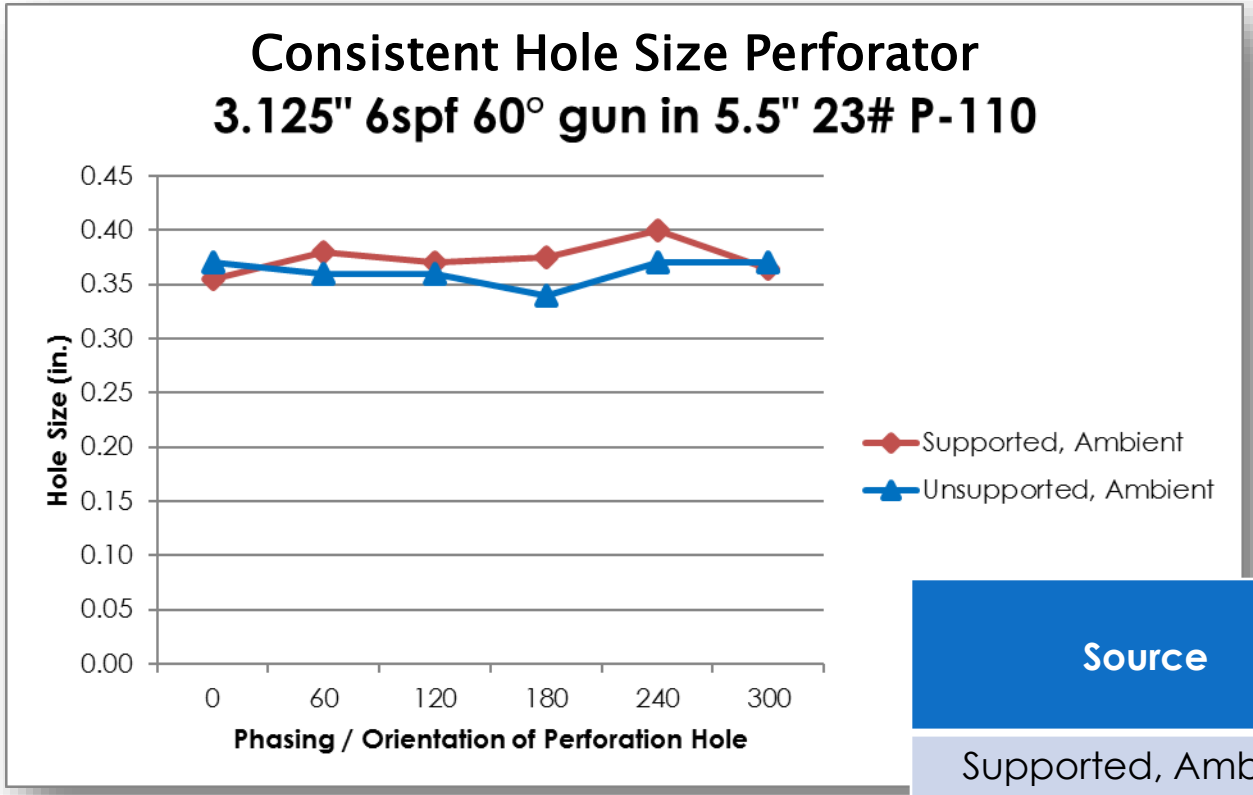
- Full System Testing




| Casing | Avg. Hole Size |
|---|---|
| 4.5" 11.6# L-80 | 0.39" |
| 5.5" 23# P-110 | 0.34" |

# Where Does Hole Size Come From?

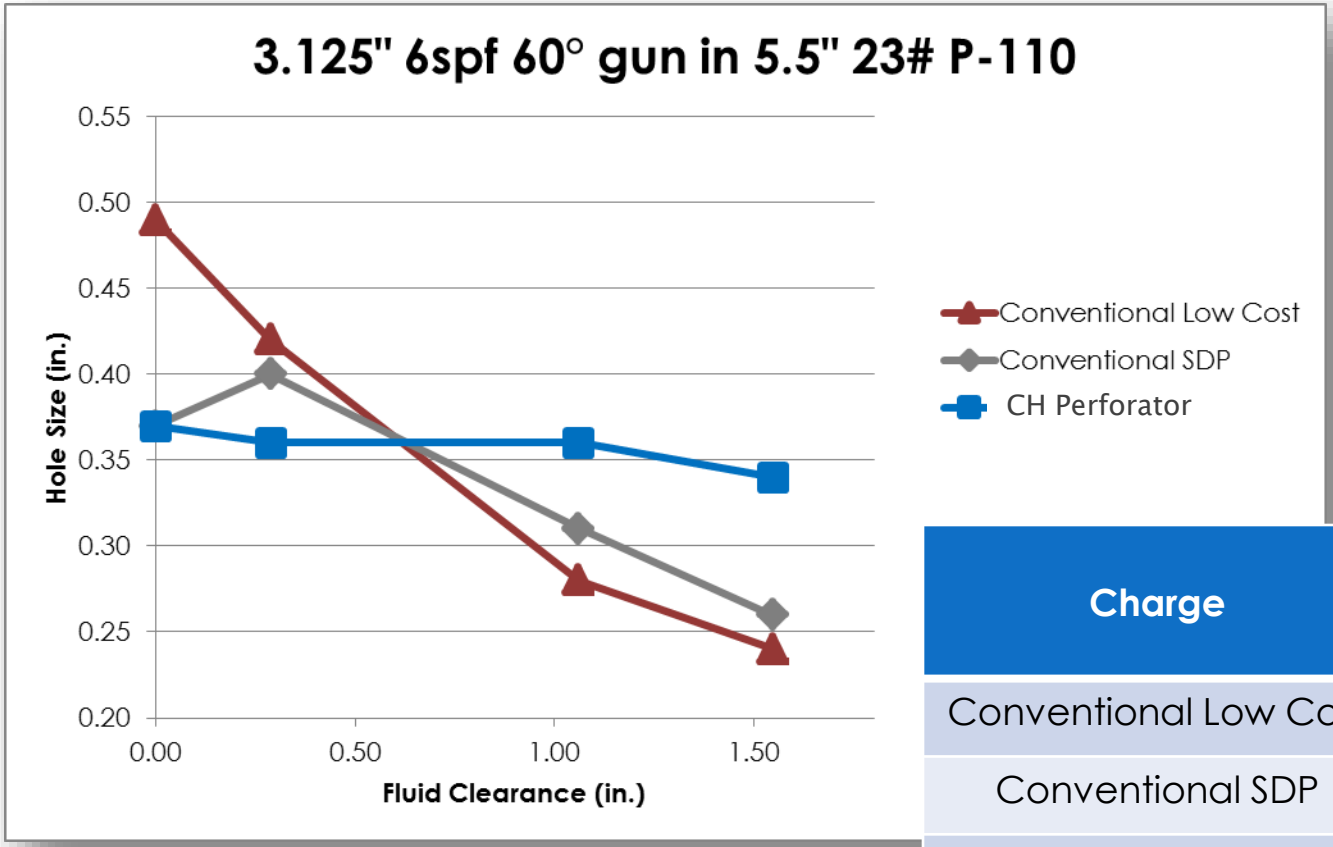
- Supported Casing vs. Unsupported Casing




| Source | Avg. Hole Size |
|---|---|
| Supported, Ambient | 0.37" |
| Unsupported, Ambient | 0.36" |

# Where Does Hole Size Come From?

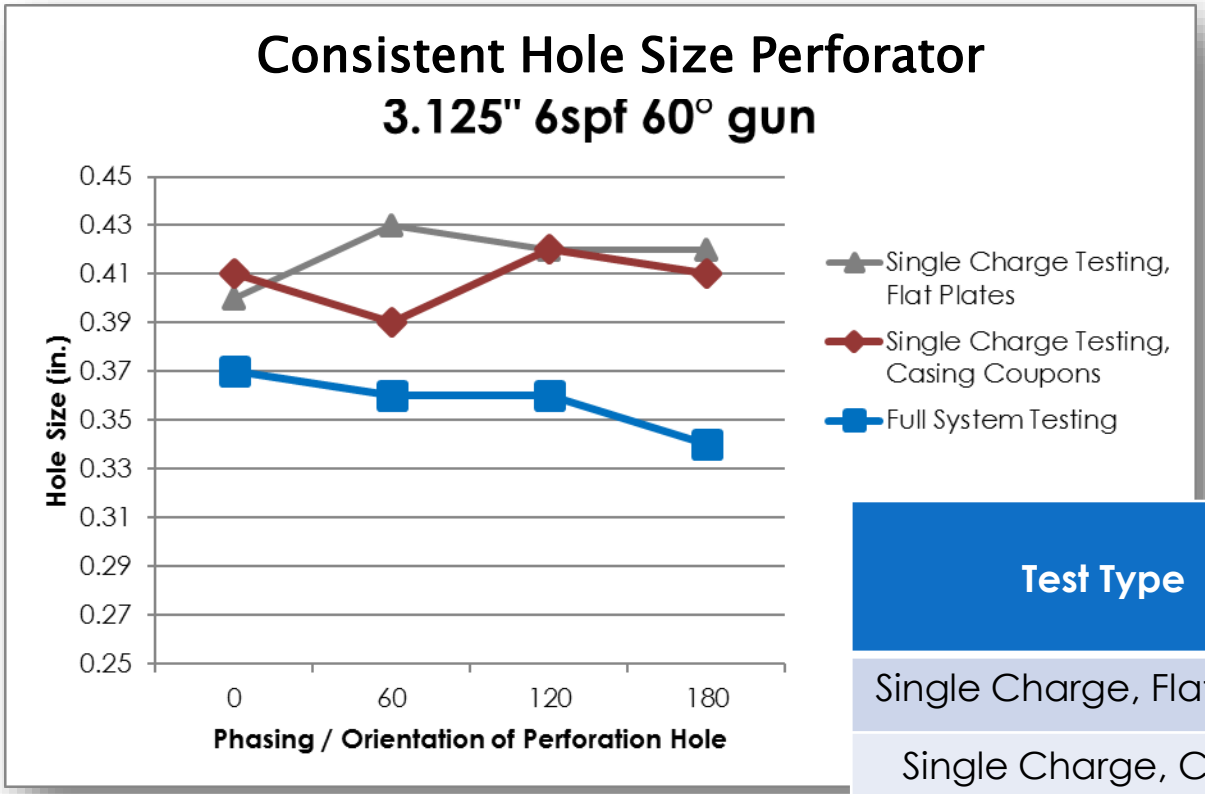
- The Effect of Fluid Clearance on Hole Size




| Charge | Avg. Hole Size |
|---|---|
| Conventional Low Cost | 0.36" |
| Conventional SDP | 0.34" |
| CH Perforator | 0.36" |

# Where Does Hole Size Come From?

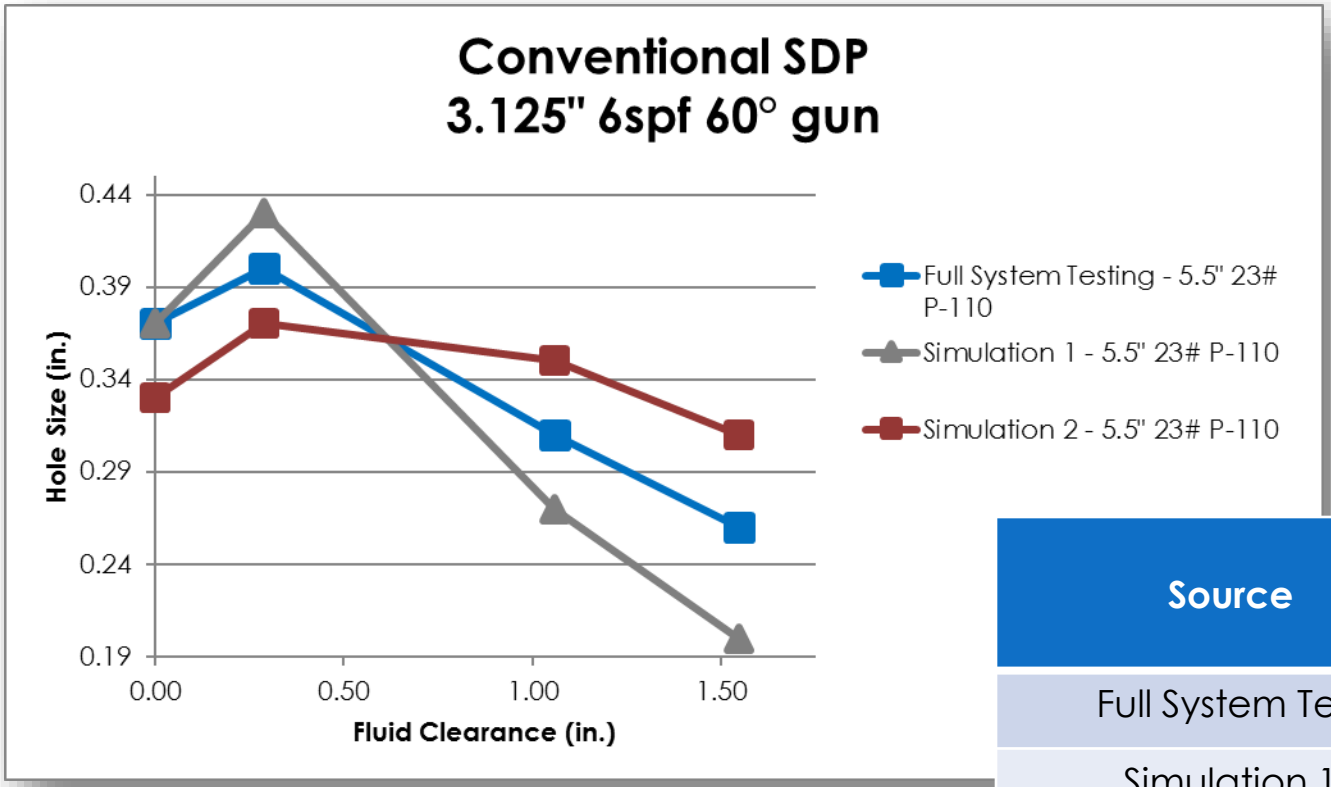
- Single Charge Testing




| Test Type | Avg. Hole Size |
|---|---|
| Single Charge, Flat Plates | 0.42" |
| Single Charge, Casing | 0.41" |
| Full System | 0.36" |

# Where Does Hole Size Come From?

- Simulations



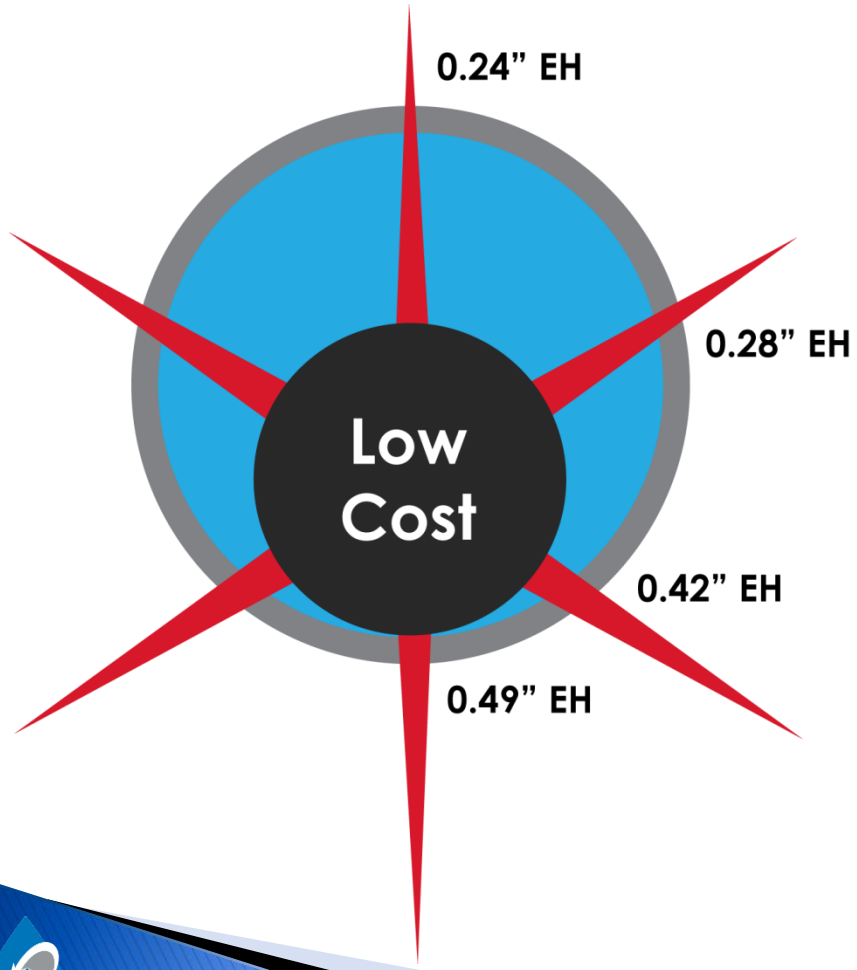

| Source | Avg. Hole Size |
|---|---|
| Full System Test | 0.34" |
| Simulation 1 | 0.32" |
| Simulation 2 | 0.34" |

# Hole Size Variation

- 3.125" 6spf 60° gun in 5.5" 23# P-110

| | Conventional Low Cost | Conventional SDP | CH Perforator |
|---|---|---|---|
| Average Hole Size (in.) | 0.36 | 0.34 | 0.36 |
| Minimum Hole Size (in.) | 0.24 | 0.26 | 0.34 |
| Maximum Hole Size (in.) | 0.49 | 0.40 | 0.37 |

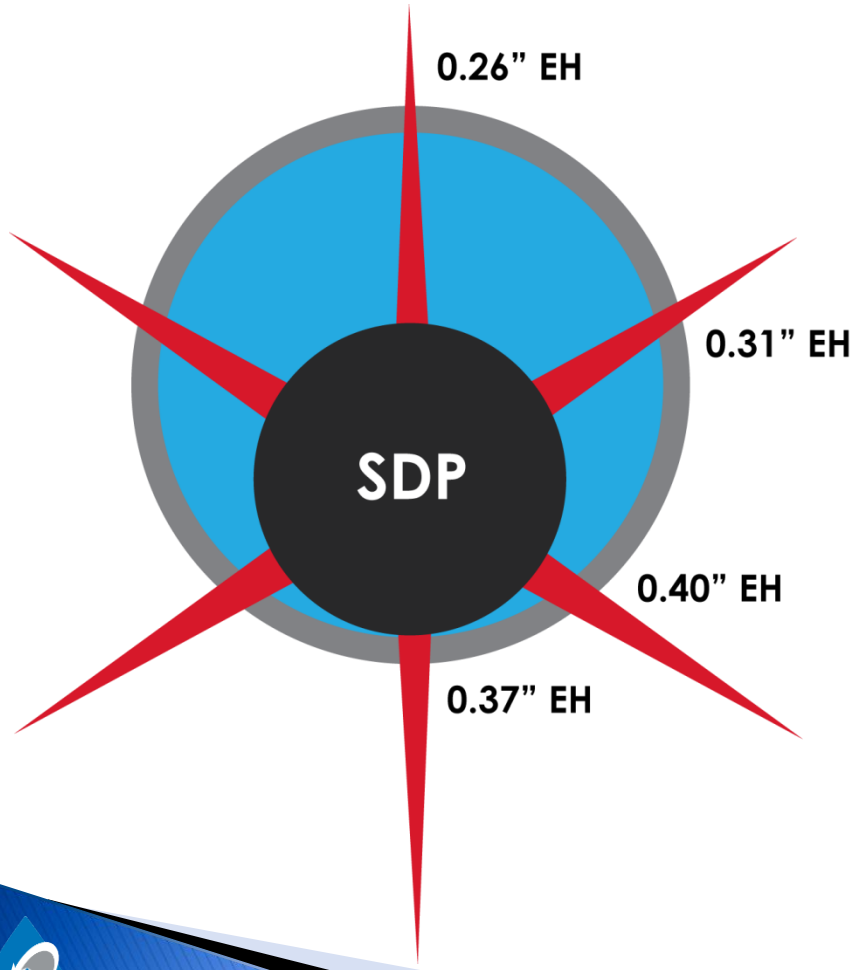
# Hole Size vs. Clearance
# Conventional Low Cost Charge




**Conventional Low Cost** charge in 3.125" 6spf 60° gun in 5.5" 23# P-110

- Avg. Hole Size = 0.36"
- Diff. from Min. to Max. Hole Size = 0.25"
- **28.5% std dev**
- Significant Difference in Hole Size
- Penetration in Concrete: 21.60"

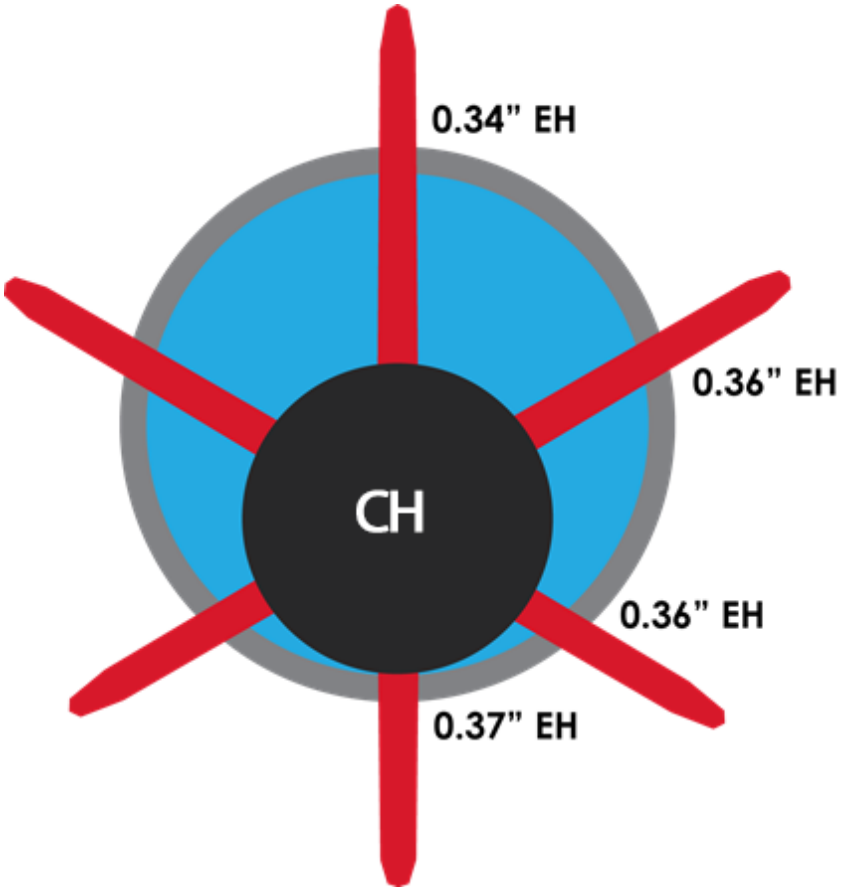
# Hole Size vs. Clearance
# Conventional SDP Charge




**Conventional SDP** charge in 3.125" 6spf 60° gun in 5.5" 23# P-110

- Avg. Hole Size = 0.34"
- Diff. from Min. to Max. Hole Size = 0.14"
- **15.9% std dev**
- Significant difference in Hole Size
- 44.40" Penetration in Concrete
- 14.50" Penetration in Stressed Berea

# Hole Size vs. Clearance
# CH Perforator Charge



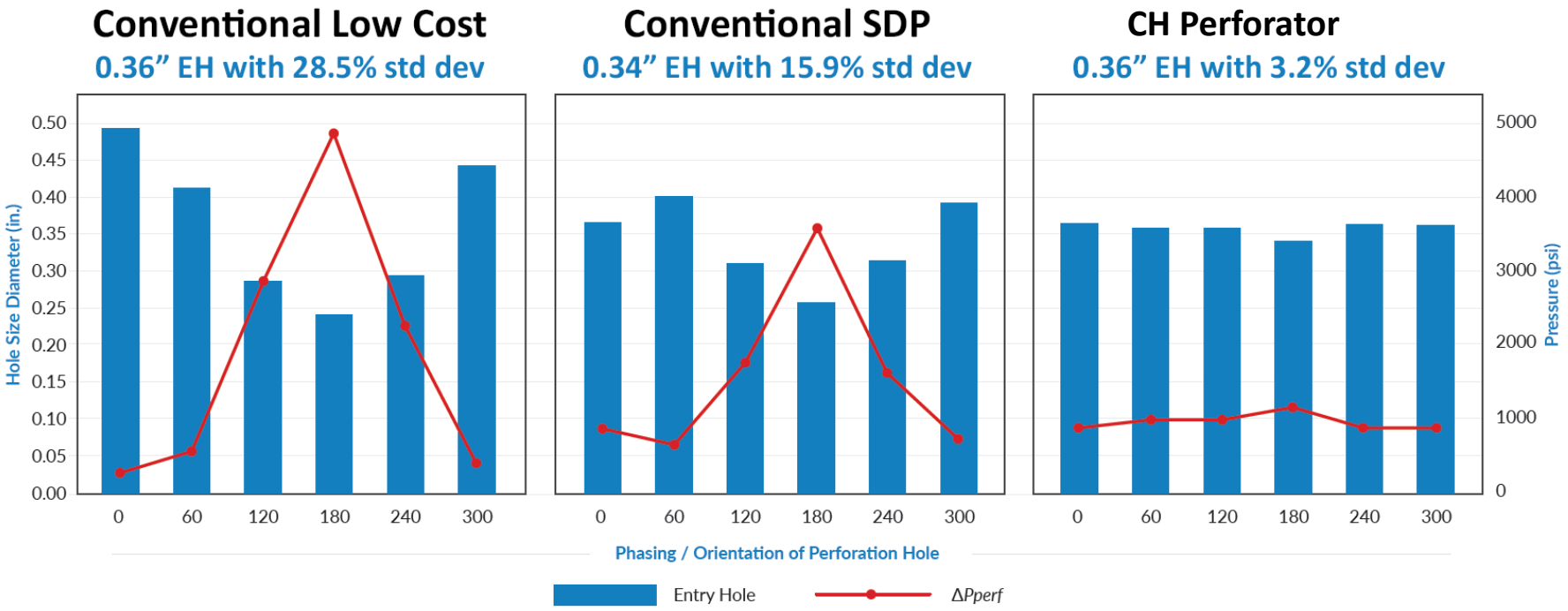

***CH Perforator*** charge in 3.125" 6spf 60° gun in 5.5" 23# P-110

- Avg. Hole Size = 0.36"
- Diff. from Min. to Max. Hole Size = 0.03"
- **3.2% std dev**
- 31.10" Penetration in Concrete
- 9.63" Penetration in Stressed Berea
- 6.50" Penetration in Stressed Shale

# Perforations for Hydraulic Fracturing Operations

- **Consistent Hole Size is Critical!**
  - Minimizes the effects of tortuosity
  - Maximizes cluster efficiency and increases SRV (Stimulated Reservoir Volume)
  - No special hardware required - uses industry standard hardware

# Perforations for Hydraulic Fracturing Operations




The charts above were generated using the following equation where:

- ρ = 8.33 ppg
- Q = 2 BPM/perf
- D = average hole size of each phasing
- C = 0.7

$$\Delta P_{perf} = \frac{.237\rho Q^2}{D^4 C^2}$$