Baker Hughes

# DeepConnect reservoir-driven perforating charges

## Improve perforating performance and reservoir communication

**DeepConnect™ reservoir-driven perforating charges** from Baker Hughes efficiently penetrate the formation, creating deep perforations into reservoir rock. Through numerical modeling and advanced testing on reservoir rocks in realistic downhole conditions, the DeepConnect shaped charge can achieve up to 50% additional penetration in some of the most challenging reservoir conditions.

Shaped charges have long been used to punch holes in cement and casing to establish flow of hydrocarbons from the reservoir into the wellbore. Traditionally, shaped charges were tested and judged based on their performance in concrete targets when shot at ambient conditions. Unfortunately, most surface testing fails to provide accurate data about how the charge will perform on the job.

At the Pine Island Perforating Technology Center northwest of Houston, Baker Hughes is revolutionizing shaped charge performance by recreating downhole conditions during testing. Advanced performance evaluation that mimics temperatures, pressures, and formation conditions has enabled significant performance and productivity improvements in shaped charge technology.

Modeling and testing for the DeepConnect perforating charge includes shooting into analog rocks at 25,000 psi (1724 bar) in temperatures as high as 350°F (177°C). All testing followed API RP 19B, Section II and Section IV requirements for evaluating charge performance and tunnel geometry. This testing also enabled the Baker Hughes team to make adjustments during development that increased penetration depth and perforating efficiency.

### Reservoir-specific optimization

Built on advanced analysis and job planning data, the Baker Hughes **TerraConnect™ perforating solution** engineered for reservoir conditions accurately simulates and predicts the dynamic conditions that occur during perforating events. These simulations accurately predict transient behavior during lab testing, translating to optimum job designs that improve downhole results and reservoir contact. Using its **PulsFrac™ software**, Baker Hughes optimizes perforation tunnel clean-up with a variety of technologies, including **TerraFORM™ dynamic underbalance optimization services**, **TerraPERM™ propellant perforating optimization services**, and static

### Applications

- Natural and stimulated completions
- Producer and injector wells
- Ultra-HP/HT completions
- Extended-reach and highly-deviated wells
- Tubing-conveyed, wireline, and coiled-tubing-conveyed perforating operations

### Benefits

- Improves reservoir communication
- Outperforms traditional shaped charges
- Overcomes drilling-induced formation damage
- Works with high-temperature explosives required in ultra-deep frontiers
- Leaves clean perforation tunnels for improved reservoir access

underbalance techniques. The TerraConnect perforating solution and PulsFrac software provide a perforating design with fully customized shaped charges and clean-up operations optimized for the target reservoir.

## Increased perforation surface area and productivity

A recent stressed-core perforation test program was conducted at the Baker Hughes Perforating Technology Center to study the effects of proper perforation clean-up strategy and perforating charge selection. This testing utilized API RP-19B Section IV style protocol to simulate downhole conditions, with such factors as overburden pressure, pore pressure and pore fluid rheology, wellbore underbalance pressure, completion fluid type and chemistry, and sandstone core samples.

As a result of proper underbalance clean-up techniques, and using the 7039 DeepConnect perforating charge, the productivity was almost 40% greater than that of previous high-performance perforating charges. This means greater formation connectivity for production, injection, or stimulation.

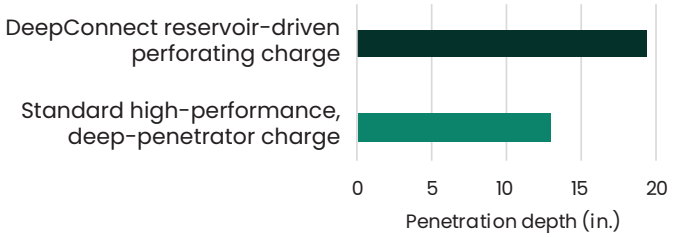
## Accessing ultra-HP/HT reservoirs

When used with the **UltraConnect™ 35K perforating system**, DeepConnect charges offer industry leading performance in ultrahigh-pressure, high-temperature (ultra-HP/HT) conditions, providing access to reservoirs that were previously inaccessible. The ability to combine multiple shot densities and phasing with various gun designs and lengths gives Baker Hughes the versatility to match guns and charges to specific formations and reservoirs, even in the harshest conditions.

## Formation-optimized perforating strategies

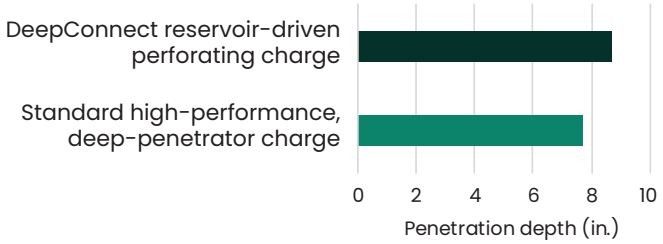
Contact your Baker Hughes representative to learn more about increasing well productivity with perforating science that delivers solutions optimized for your specific formation and reservoir.

**Stressed-rock pentration with 4 1/2-in. gun* (5 shots per foot with 60° phasing)**




*Penetration test performed in carbon tan sandstone at 8,000 psi (552 bar) unconfined compressive strength with in-situ pore, overburden, and wellbore pressures.

**Stressed-rock pentration with 3 3/8-in. gun* (6 shots per foot with 60° phasing)**




*Penetration test performed in nugget sandstone at 12,000 psi (827 bar) unconfined compressive strength with in-situ pore, overburden, and wellbore pressures.

## Application guide

| Typical casing | Gun diameter | Shot density | Charge |
|---|---|---|---|
| 4 1/2-in. | 2 7/8-in. | 6 SPF | 2818 DeepConnect |
| 5-in. | 3 1/8-in. | 6 SPF | 3123 DeepConnect |
| 5 1/2-in. | 3 3/8-in. | 6 SPF | 3123 DeepConnect |
| 7-in. | 4 1/2-in. | 5 SPF | 7039 DeepConnect |
| 7-in. | 4 1/2-in. | 12 SPF | 2818 DeepConnect |
| 7-in. | 4 1/2-in. | 4 SPF XLD | 4539 DeepConnect LD |
| 7-in. | 4 1/2-in. | 4 SPF HOPS XLD | 4539 DeepConnect LD |
| 9 5/8-in. | 7-in. | 12 SPF | 7039 DeepConnect |

NOTES:
"XLD" Extreme Low Debris system provides minimal perforating debris for critical applications.
"HOPS" Horizontal Oriented Perforating System for percise orientation of perforations.

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