Reservoir Productivity

Unmatched Perforating Capabilities
Reach into Reservoirs in Ways Never Before Possible

EXPANDING YOUR CAPABILITIES AND OPTIONS

Halliburton has long been known for the breadth of its perforating technologies. Introducing new ultra-deep penetrating MaxForce® shaped charges, an ultra high-pressure gun system rated to 30,000 psi, and an electronic firing head that operates with a full suite of safety features, even under extreme pressures. In addition, we can provide solutions for more demanding environments than ever.

Optimum Solutions from Broad Portfolio

The breadth of our perforating capabilities and experience enables us to understand your reservoir and prescribe the optimum perforating solution. We design our own equipment and charges, and they are manufactured using stringent Six Sigma processes to ensure quality control and repeatable performance.

Just One Chance to Do it Right

With perforating, you only get one chance to do it right. That's why we do everything possible to ensure operational and service excellence. Halliburton pioneered the shaped charge for perforating. Reliability and safety are paramount. That's why we rigorously test each batch of charges during manufacturing. That's also why we continuously train our perforating professionals in the industry's newest techniques and equipment.

As Close as You Can Get to Real-World Conditions

The Advanced Perforating Flow Lab helps us understand how a perforator actually performs under extreme downhole conditions. It can provide real-world answers that account for overburden stress, reservoir pore pressure, wellbore pressure, and reservoir and wellbore response. The Advanced Perforating Flow Lab can also help identify the optimum solution to connect the wellbore and reservoir.
Perforation Quality
New MaxForce® Charges, Software and Perforating Techniques Deliver Unmatched Performance

ACHIEVING HIGHER FLOW RATES REQUIRES A NEW APPROACH TO PERFORATING THAT PRODUCES DEEP AND CLEAN TUNNELS

New, Higher Levels of Performance
New MaxForce® charges are our deepest-penetrating charges ever. MaxForce charges use an improved liner geometry, proprietary liner composition, and patented case technology. We manufacture them in our own facilities to stringent specifications that minimize performance variation and test them to ensure consistent, repeatable downhole results.

Accelerating Production
Using MaxForce charges with Halliburton's SurgePro™ service produces even better results. SurgePro software accurately simulates peak pressures and surge effects created by different charges, guns, and conveyances. It helps identify the optimal combination in your conditions, and is essential in designing effective dynamic underbalanced perforating programs that maximize perf clean up.

A Charge for Any Environment
Halliburton ballistic engineers at our Jet Research Center continue to develop and manufacture perforating systems for virtually any reservoir environment or intervention technique.

Custom Design
We can also develop custom charges to maximize effective penetration into specific reservoirs.

CASE STUDY
Dominator® Charge Gives 21% Greater Penetration in Challenging North Sea Field

A major operator asked Halliburton to optimize its gun system for use in a marginal gas condensate field in the North Sea. Tests at the Advanced Perforating Flow Lab helped tailor charges to specific rock characteristics and reservoir conditions, providing deeper penetration and efficient tunnel cleanup for the operator’s specific underbalance condition. These combined effects led to a 21% increase in rock penetration and a 12% productivity increase over benchmark conventional charges.
Flow is also impeded by rock debris in the crush zone surrounding the perf tunnel. Such clogs can reduce long-term production.

Advances in Perforating

Clean and deep perforations can lead to higher real-world production.

Reduction Debris Improves Well Performance
Keeping perf tunnels and wellbores free of debris can increase flow rates and decrease completion costs. Selected MaxForce shaped charges use a patented twist-lock feature within the charge case and charge tube holder. This eliminates the need for bend tabs to hold the charges in place. These tabs were a major source of debris. Halliburton’s specialized zinc-cased charges also provide an additional means of low-debris perforating.

MAXIMUM FORCE
New MaxForce® charges generate optimal force for creating conductive pathways into your reservoir. They combine excellent penetration and hole diameter with minimum debris.

MaxForce charges used with our SurgePro service produce clean, deep tunnels.

A portion of this tunnel’s depth is clogged with detonation material from older-style charges.

Flow is also impeded by rock debris in the crush zone surrounding the perf tunnel. Such clogs can reduce long-term production.
Pressure

Introducing the World’s First 7-Inch Perforating Gun Rated to 30,000 psi

HIGH-PRESSURE WELLS NEED A RELIABLE PERFORATING SYSTEM. NOW THEY HAVE ONE.

Reach Deeper into the Earth
As operators explore more-challenging environments, they are reaching the operational limits of today’s perforating technology. To bring home the oil and gas from these reservoirs, operators need new technologies capable of handling the extreme pressures found beyond 20,000 and 25,000 psi (138 and 172 MPa).

Ultra HP Gun Improves Safety Margin
Halliburton’s 30,000 psi (207 MPa) HP Gun System can withstand industry-leading pressures. It functions reliably, thanks to a proprietary design, custom manufacturing techniques and specialized metallurgy.

G-Force® Precision-Oriented Perforating System
Historically, oriented perforating required devices and weights outside the gun. These created friction as guns moved down the casing, compromising accuracy and effective shot density. They also hung up in doglegs.

To solve these issues, Halliburton placed its orienting system inside the guns so they could pivot in any direction without friction. Our G-Force® system can squeeze through restrictions not possible with older systems. It can run through tubing and orient in casing for wells of 25 degrees deviation and greater with an accuracy of ± 5 degrees. The absence of external weight bars also means there are no lost shots.

DrillGun™ System
Halliburton’s all-aluminum DrillGun™ system provides one-trip bridge-plug placement, perforating, and cementing on tubing. This makes it the perfect choice for plugging and abandoning wells, sealing off zones, creating sidetracks, or performing blocksqueeze cementing jobs in underbalanced conditions.

We make the gun and firing mechanism from lightweight materials that can be drilled out if necessary. It uses standard, high-performance perforating charges and operates reliably in pressures up to 14,500 psi (100 MPa). Guns may be combined for longer intervals.

Low-Swell Gas Gun
Thailand’s unique monobore completions often have a restriction of 2.313 inches. Using newer, high-performing charges made existing 2-inch scalloped guns impractical because of gun swell. Halliburton developed a new 2-inch, low-swell design to meet the needs of our customer. It has a maximum OD after detonation of just 2.193 inches using the ultra-deep penetrating MaxForce charges. As a result, the client signed Halliburton to a five-year contract.
Like all of Halliburton perforating solutions, our new Ultra HP Gun can be conveyed on tubing, wireline or slickline. This conveyance flexibility can save clients time, money and space on cramped offshore rigs.

**SUCCESS STORY**

**AutoLatch™ System Enables Successful Perforation in Producing HPHT Wells**

A client asked Halliburton to perforate 12 wells in a hostile HPHT environment – without killing the wells. Temperature and pressure exceeded 400°F (204°C) and 16,000 psi (110 MPa) at 18,000 ft (5,500 m).

Our unique AutoLatch™ connector system enabled multiple guns to be injected through the BOP using coiled tubing under live well conditions with full control. We created a string long enough to perforate entire intervals in a single run without killing each well, and risking damage to the formation or loss of production.

Engineered for high-pressure and low-debris conventional scallops (A) use a short radius. Our new design (B) uses a larger radius at the bottom of the scallop. This minimizes the scallop hole, thus improving debris retention. It also enables the gun to withstand higher pressures.
Performance Under Pressure
Halliburton’s new electronic firing head reduces actuating pressures while increasing performance and reliability.

The Dilemma of High-Pressure Wells
Traditional-pressure firing heads operating near the limit of their performance envelopes created a dilemma during completion:

- Increasing actuation pressure risked harming downhole equipment
- Reducing actuation pressure interfered with additional downhole tools and processes

Actuated by Unique Sequence of Events
To solve this dilemma, Halliburton developed a new TCP electronic firing head—the 40,000-psi (276-MPa) MaxFire™ tool. A special pressure transducer senses a sequence of pressure cycles to activate the firing head. This effectively lowers the pressure activation window.

Once a series of programmable conditions are met (a unique, user-defined number of cycles of different durations at different intervals at different pressures), the gun will fire instantly or after a preprogrammed delay.

210 MaxForce®-FRAC Charge
Perforating charges traditionally have been designed for natural completions, which focus on depth of penetration with little regard to hole size and consistency. Oil and gas reservoirs, including unconventional, that require stimulation to be productive, benefit from consistent hole size to improve fracture placement.

The Halliburton MaxForce®-FRAC engineered charge addresses perforating for stimulation. The charge is designed to maximize hole-size performance while maintaining entry-hole consistency in the casing, regardless of the gun’s azimuth orientation and standoff.

Sample results from FEA model. Ideally, the average hole size that is published would be the result at every phase of the gun, but in the real world, it varies significantly. The local maximum principal stress is always on the surface of the perforation tunnel near the entrance, so the entrance hole diameter is the dominant parameter in fracture initiation, not the tunnel length.
Actuated by unique, user-defined sequence of events
The sequence can combine a unique number of pressure cycles at different intervals and durations.

Only after all programmable conditions are met, will Halliburton’s MaxFire™ tool fire the gun.
Delivering the Well
Halliburton Delivers Unmatched Perforating Capabilities

HALLIBURTON OFFERS A WIDE VARIETY OF INDUSTRY-LEADING PERFORATING TECHNOLOGIES, LIKE THOSE SHOWN IN THIS BROCHURE. BUT THE WAY WE DELIVER OUR SERVICE TRULY SETS US APART.

The Attitude Advantage
We go to great lengths to collaborate with clients. For instance:

- Our unique AutoLatch™ connector system (see page 5) was developed in weeks in collaboration with a client to respond to a specific need. If we don’t have a solution that meets your needs, we’ll develop one.
- We manufacture and test our own charges to ensure their reliability and repeatability.
- Our innovative Advanced Perforating Flow Lab allows accurate simulation of downhole events under pressure at the surface to help ensure your results.

Raising the Bar
Our new MaxForce charges, electronic firing head, and high-pressure gun are just three examples of our commitment to continuous innovation and quality improvement. Each year, we introduce new tools and techniques that raise the bar for the industry while raising your production.

Service Integration Advantage
We fully integrate our services and those from other parts of Halliburton to enhance efficiency, accuracy, and results while reducing NPT and risk.

Operational Excellence
Operational excellence has always been a hallmark of Halliburton. That’s why our market share is increasing. That’s why few companies in the world work on as many wells as we do. And most important, that’s why clients give us such high ratings for:

- Lack of delays due to tool performance
- Lack of delays due to operator error
- Reduction of NPT
- Problem resolution

When we do encounter problems, resolution can usually be measured in minutes, not hours or days. Give us a chance to show you how quickly we can resolve your reservoir issues.
FLOW LAB SIMULATES DOWNHOLE CONDITIONS
The unique Halliburton Perforating Flow Laboratory simulates actual well conditions and pressures to address deficiencies in surface tests. The lab provides insight into physical phenomena occurring in the reservoir during complicated perforating and multiphase flow events.

This provides operators with information needed to design perforation systems and solutions that optimize a well’s production.

The lab includes a pressure chamber, a wellbore section mounted against one face of the core, and a flow loop. The flow loop applies pore and wellbore pressure to core samples. After detonation, flow-loop pressures can be changed to induce flow from or into the perforation.

The laboratory can quantify the impact of different perforation design variables on well productivity and completion efficiency. These variables include conveyance (tubing vs. wireline); charge size and type; under- vs. overbalanced; fluid type and skin source. When linked with reservoir characterization analysis, the perforating system and well-completion design can be tailored for specific reservoirs.

ADVANCED FLOW VESSELS RAISE THE BAR
Our facilities include three new testing vessels that do more than any other facility in the industry. They include:

- 50,000-psi (345-MPa) vessel — Allows Halliburton to conduct tests at pressures higher than any other testing facility in the industry.
- 25,000-psi (172-MPa) vessel — Can rotate up to 180 degrees, enabling Halliburton to perform gravity-related sanding studies to better understand the effects of perforating and fracturing in horizontal wells. No other testing facility can simulate these conditions.
- 25,000-psi (172-MPa) high-temperature vessel — This vessel can flow at temperatures reaching 400°F (204°C) enabling us to test perforating capabilities in high temperatures.
Sales of Halliburton products and services will be in accord solely with the terms and conditions contained in the contract between Halliburton and the customer that is applicable to the sale.