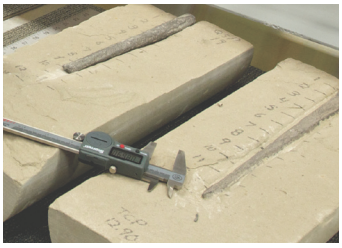
Advanced Perforating Flow Laboratory

MAXIMIZE PRODUCTION, MINIMIZE RISK

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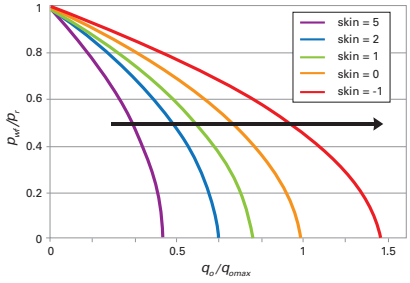
Understand and Optimize Perforating System Performance in Your Well

Evaluate your perforation strategy at full downhole conditions, using the Advanced Perforating Flow Laboratory (APFL) at the Jet Research Center (JRC). Work with our engineers and scientists to design, conduct, and interpret experiments in an environment that accurately mimics your reservoir and wellbore. The APFL can replicate the harshest downhole environments encountered today...and tomorrow.

MAXIMIZE PRODUCTION

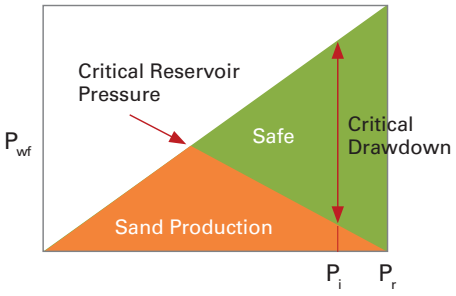
Assess flow efficiency and productivity of your perforations – in the laboratory – before perforating your actual well. This enables operators to confirm or refine well performance estimates and to adjust the perforation strategy if necessary to maximize asset value.

Evaluate the influence of many parameters on inflow performance, including completion fluids, perforating charge design, system configuration, and deployment scenario.



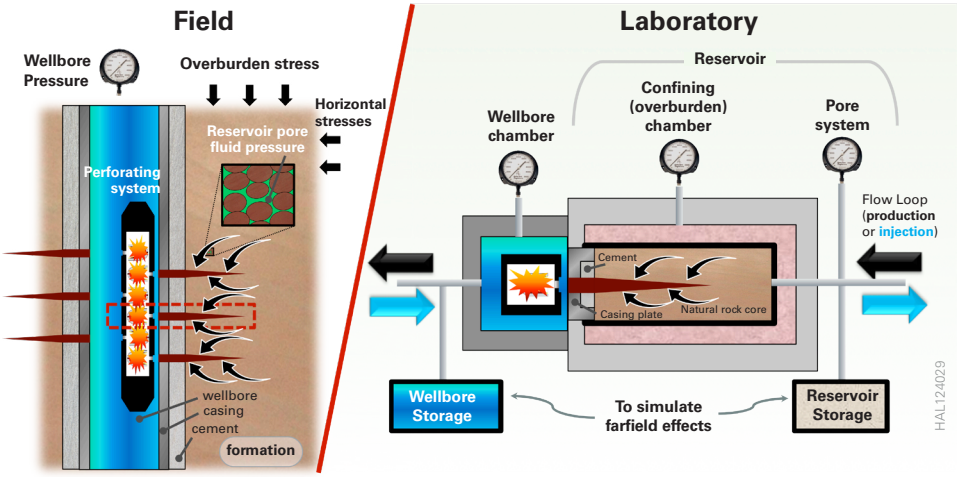
MINIMIZE RISK

Assess the potential for sanding, both early and late in a well's life. Flow tests through actual perforations in the APFL can replicate life-of-well scenarios, including depletion and water cut. This enables operators to identify potential triggers for sand production, and make informed decisions regarding production and/or solids management strategies throughout the life of the asset.



IMPROVE OPERATIONAL EFFICIENCY

Certain operational procedures may be desired for the purpose of improving wellsite efficiency – for example, perforating at static overbalance in order to eliminate the need for surface pressure-control equipment. However, this can influence the perforation design and well inflow performance. Evaluating such techniques in the APFL ahead of time enables operators to optimize the fluids and pressures involved, so that rigsite efficiency and well performance are simultaneously maximized.



Better Perforations, Better Completions, Better Wells

OPTIMIZE YOUR PERFORATIONS

The API RP 19B – Recommended Practices for Evaluation of Well Perforators – contains two sections involving laboratory testing with stressed rock. Section 2 focuses on penetration depth into a prescribed rock/stress combination, and Section 4 focuses on flow performance of a perforated rock core.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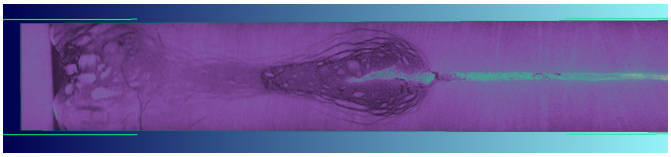
The Advanced Perforating Flow Laboratory routinely conducts experiments in accordance with both Sections 2 and 4, of the API RP19B. Going further, operators often choose to conduct APFL tests at conditions matching their specific downhole environment. These are generally different – and often go well beyond – the standard test conditions.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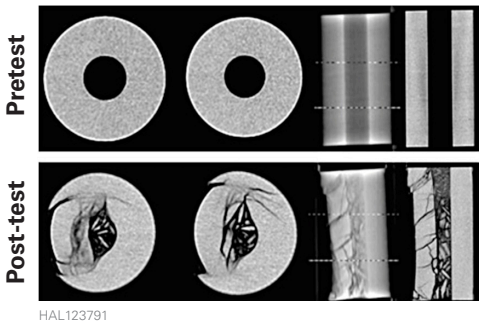
Evaluate charge performance at your reservoir conditions, and use APFL testing to develop optimized charges tailored specifically for your reservoir.

OPTIMIZE YOUR OVERALL COMPLETION

Beyond perforating, experiments in the APFL can help operators assess and optimize their overall completion. Sand control, sand prevention, and stimulation techniques can be evaluated. Experiments can be conducted on extremely large core samples (up to 12 in. in diameter). This is significantly larger than the 1- to 2-in. samples commonly evaluated in stimulation laboratories. This increased core size, combined with extreme pressure capabilities, can make APFL testing an essential part of your overall completion evaluation program. Or investigate acidizing effectiveness – in perforated or unperforated carbonate core samples.



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The Advanced Perforating Flow Laboratory can conduct geomechanics studies that are unique within the industry. Stress-induced or flow-induced sanding and hole stability can be investigated at full downhole conditions, at either slow rates (simulating production) or fast rates (simulating perforation dynamics or surge events).


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Industry-Leading Capability

REPLICATING THE FULL DOWNHOLE ENVIRONMENT

As the industry moves away from testing in concrete and toward testing in rock, the Advanced Perforating Flow Laboratory leads the way. We have pioneered matching the full range of relevant downhole conditions – in addition to the rock itself, matching full downhole pressures (overburden, reservoir, and wellbore), temperatures, pressure dynamics, fluids, and flow regimes.

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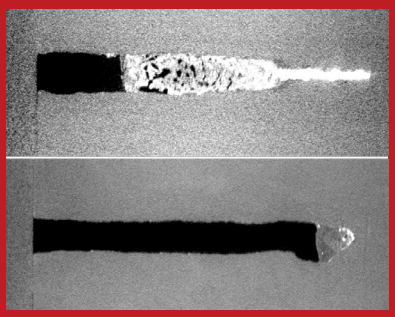
CASE STUDY

Perforating Technique Optimization, Identifies Best Reservoir Inflow at HP/HT Conditions



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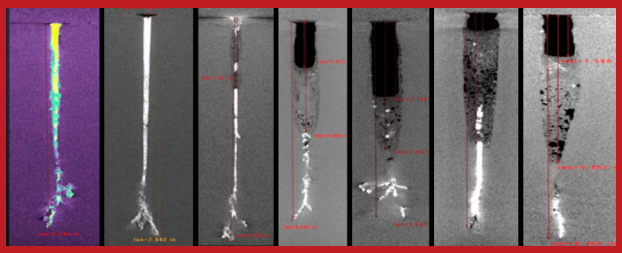
After identifying the operational constraints of one client, a thorough testing program was developed to identify the optimum perforating technique to achieve maximum reservoir contact and inflow of an HP/HT reservoir. The APFL capabilities allowed accurate replication of in-situ reservoir conditions, enabling precise measurement of flow efficiencies with varying drawdown and fluid dynamics. Ultimately, a solution was developed and tested, which significantly improved tunnel geometry through increased perforation tunnel cleanup, providing increased production in the client's HP/HT reservoir.

CASE STUDY

Optimizing Wellbore Pressure Dynamics Produces More Productive Perforation



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The strategy of improving gas production by removing perforation debris from perforation tunnels with dynamic underbalance (DUB), even in an overbalanced (OB) wellbore setting, was advanced by conducting a series of perforation tests. Based on API RP 19B (2014) Section 4, perforation tests were conducted matching well configurations and conditions in a high-pressure gas field to help improve production. These tests and early field indicators show that despite perforating at a high-static OB, optimizing DUB effects improves perforation cleanup, resulting in productive perforations.

Industry-Leading Experience

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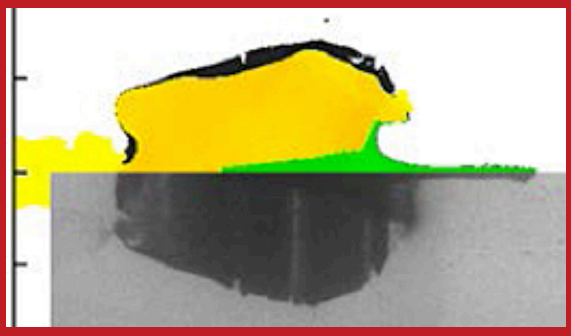
CASE STUDY

Increased Production in Mature Well – Operator's Largest Producing Field in the World

In the Caspian Sea, perforation and completion techniques damaged productivity in an operator's largest field. In response, Jet Research Center developed a specialized shaped charge that could maximize downhole penetration specific to the reservoir and wellbore environment. After testing at the Advanced Perforating Flow Lab, the charge resulted in a 41% increase in clean perforation tunnels and a 34% increase in total core penetration depth.



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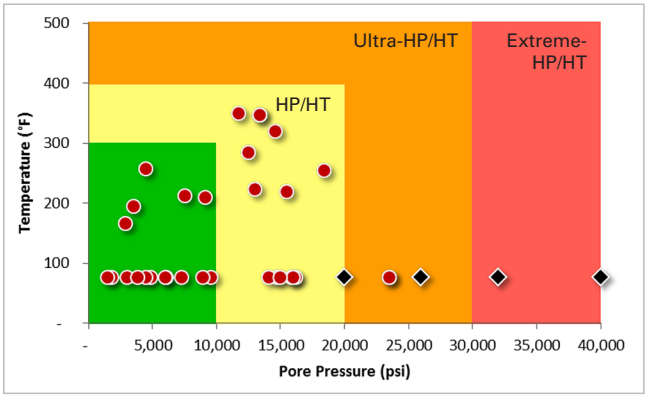

Conditions matched in APFL test programs.

Jet Research Center's Advanced Perforating Flow Laboratory (APFL) was awarded the *Hart Energy's* Meritorious Award for Engineering Innovation.

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Unmatched Capabilities, Matched to Your Asset

YOUR RESERVOIR, YOUR WELLBORE


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Matching your reservoir starts with the rock. The ideal laboratory target is an actual core sample from your reservoir. But when these aren't available in the required size, quarried outcrop rock is used as an analog. The Advanced Perforating Flow Laboratory has access to many different varieties of natural sandstones, carbonates, and shales, and features a full onsite coring facility to extract cores directly from large blocks of anything a quarry can deliver. Cores are fully prepared onsite – including vacuum saturation with desired fluids. Core strength, porosity, and permeability are precisely measured onsite.


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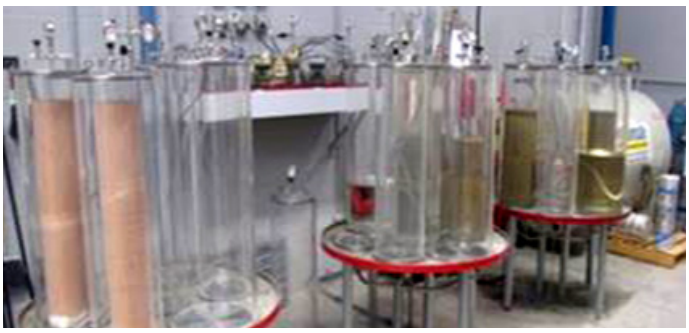
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The APFL uses a wide variety of fluids to simulate your reservoir and wellbore environment. Oil- or water-based liquids, or gas, can be used to match your formation and wellbore fluids.

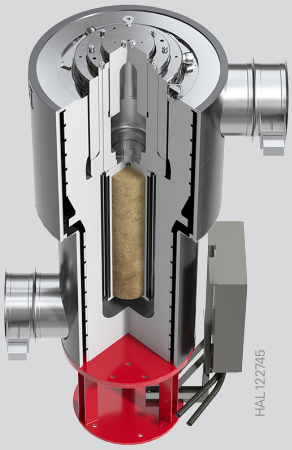
Oil | Brine | Completion Fluids* | Gas

*Oil-based or water-based fluids

Vessel	HP/HT	UHP	Rotating
Overburden stress (psi)	25,000	50,000	10,000
Reservoir Pressure (psi)	20,000	40,000	5,000
Wellbore pressure (psi)	20,000	40,000	5,000
Temperature (˚F)	400		
Rotation			+/-90

Your Flow Conditions

Flow oil, water, brine, gas, or mixtures. High-rate, high-capacity continuous delivery systems enable operators to assess flow performance through perforations at actual in-situ rates. Evaluate production, injection, or both.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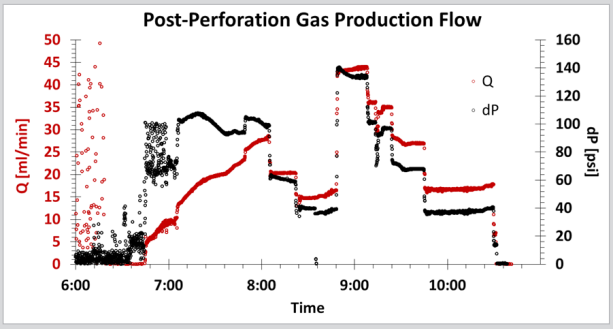
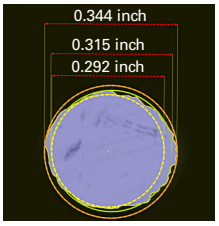
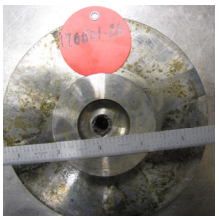


Advanced Diagnostics and Interpretation

ONSITE CT SCANNER AND OPTICAL COMPARATOR

The APFL features the industry's most comprehensive analysis laboratory for post-test evaluation. Our onsite CT scanner enables detailed nondestructive characterization of perforation tunnels and interior features of the core. Recent laboratory enhancements include an advanced optical comparator. Using this latest technology, the APFL delivers the most accurate, precise, and reliable measurements of casing hole sizes in the industry.





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Leverage the Full Range of Halliburton Expertise

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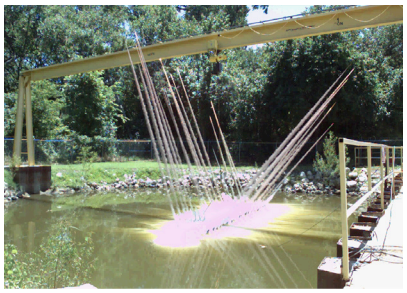

The Advanced Perforating Flow Laboratory is a focal point of the Jet Research Center in Texas. JRC is a fully integrated research, engineering, and manufacturing site dedicated to delivering advanced perforating technologies to the industry.

REGIONAL OPERATIONS

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The APFL is closely connected with the Halliburton global network of operations experts. Operators testing in the laboratory benefit from this deep knowledge of local environments and field practices.

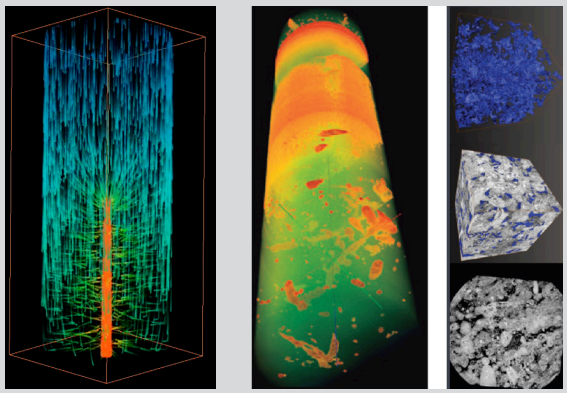
Deeper Insight into Your Reservoir and Your Perforations

The laboratory works closely with the world's preeminent core analysis experts – INGRAIN.

We also routinely collaborate with Halliburton experts in the fields of geomechanics, well completions, and stimulation.

INGRAIN
A HALLIBURTON SERVICE

- Advanced core imaging and diagnostics
- Pore-scale reconstruction
- Inflow simulation and perforation damage assessment



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Take Charge of Your Reservoir

Use the Advanced Perforating Flow Laboratory at Jet Research Center

PRODUCT SALES, RESEARCH, TESTING, AND MANUFACTURING FACILITY

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