



# Myths and misconceptions

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I have wanted to write this article for years, but never have had a suitable venue, or perhaps the nerve. This booklet finally provides that venue. My friends and colleagues have provided the nerve. What I write here is neither pure science nor pure marketing, but a collection of observations made over a period of twenty-five years.

Treating wells with propellants, whether along with perforating or subsequently, should be one of the standard methods in the engineer's bag. That is not to say it should dominate the industry, but that it should be thought of along with conventional perforating, acidization, hydraulic fracturing, and all of the other valid techniques one uses to make a well better. Unfortunately, in the earlier days of propellants, and even continuing until today, too many proponents have succumbed (some unknowingly) to the "snake oil" approach. They have promulgated myths and misconceptions which, instead of growing the industry, have restricted it. Believing in myths leads to results not measuring up to promises, or to downright failures.

That is not to say the purveyors of myths and misconceptions are bad guys. By far, most of them are well-meaning and just trying to promote a technology they believe in, or justify their own



*Myth: "My propellant tool will frac all of these wells in one job!"*

view of the issues. But it is to say that too often, the need for good science and engineering has been replaced with the need to promote.

Let me share some of my observations with you. In all cases, my explanations are based on physical principles, observations, field data, laboratory data, and computer modeling that agrees with both field and laboratory data. My explanations are not guaranteed to be correct, but they surely are better than the unsupported presumptions leading to most of the myths and misconceptions.

## Myth

Propellant tools can create fractures that are hundreds of feet long.

## Reality

Depending on tool, tamp, rock and depth, propellant fracture lengths are generally in the range from a few feet to a maximum, under the very best of conditions, of a few tens of feet.

## Explanation

- \* Some people like to make strong claims.
- \* Others observe some pressure response in nearby wells that are hundreds of feet away and interpret it as a fracture connection. It is common that pulse-like pressure disturbances in liquid reservoirs can create temporary transients in nearby wells. This happens all the time in earthquake-prone regions. It does not mean these wells have been fracture connected, unless a coincidental fault pre-exists.
- \* Overly simplified mathematical models based on elastic fractures use mass balance, complete containment, zero leakoff, and high moduli to show long fractures. These are completely unrealistic because the factors left out have a dominant effect on length, and all tend to reduce length.

### Misconception

Bigger is better. Put the biggest propellant tool possible in the hole.

### Reality

Overly large propellant tools can damage casing and equipment. Even if damage is not done, an overly large tool will simply send most of its energy up and down in the well and not out into the formation.

### Explanation

When a tool burns, energy can go into the formation and up and down in the well, depending on a number of factors such as depth, liquid type, perf area, and formation properties. All of this depends on high-pressure fluid flow rates. If the perms and fracs have reached a limiting flow rate, the release of more burn energy is simply expended in compressing and accelerating liquid in the hole. Bigger is not better. Tool optimization with good design is best.

### Misconception

My propellant makes more gas than yours, therefore, it is better.

### Reality

More gas does not automatically mean better stimulation performance. The trick is to get the energy into the perms and fractures.

### Explanation

See the previous misconception. It is possible with any propellant that you can ignite downhole to provide sufficient energy with adjustment of tool size and other parameters. Propellant energy (per pound) is of secondary importance. Furthermore, some propellants that make more gas are also potentially less stable.

### Myth

All propellants are unreliable. You can't keep them from blowing up the casing or crushing the rock.

### Reality

With quality control and quantitative design based on data, you will not damage casing or crush the rock.

### Explanation

Early experiments with more exotic materials, such as pumpable explosives, highly energetic propellants, exotic ignition systems, and activators caused some problems. It turns out that the extra energy released by these is not needed. The more conventional propellants are well-understood and very controllable. The working range of burn rates that can make fractures and still not damage wells or formations is fairly broad and achievable with good design.



**Misconception**

This propellant looks like a piece of plastic. It can't have enough energy to do anything.

**Reality**

These "pieces of plastic" release nearly as much chemical energy per pound as explosives, but at a lower rate.

**Explanation**

This is the opposite of the previous myth. Propellant energies are known and measured. The additional good news is that despite the high energy content, most propellants are very difficult to light up and burn at a dangerous rate under surface conditions. They are therefore somewhat safer than explosives (although they should always be handled with appropriate care).

**Misconception**

I tried some propellant in my well and it didn't help. Therefore, propellants don't work.

**Reality**

This is the common fallacy of generalization.

**Explanation**

There are some applications in which propellants will not help. You cannot use one misapplication to judge an entire technology, and yet this has been done.

**Misconception**

Propellants make multiple radial fractures. I have heard that these kinds of fractures are bad for hydraulic fracturing. Therefore I would not consider using a propellant prior to my frac job.

**Reality**

Yes, propellants make multiple radial fractures, although the bi-wing that is stress-preferred is longest. However, the most important thing that propellants do prior to hydraulic fracturing is to break down the majority of perforations and make the most preferred able to accept fracture fluids earlier in the job. Propellants help, not hurt hydraulic fracturing.

**Explanation**

"Tortuosity" is a catch-all term used to describe near-wellbore restrictions that create high fracturing pressures, poor flow, and premature sandouts. One of the host of things that is used to describe possible tortuosity creation is "radial fractures." Multiple fracturings with convoluted near-wellbore geometry, that all accept flow equally (and poorly) are certainly not good. Propellants, which can pre-create cleanly broken down perms, can return the well to the condition best for hydraulic fracturing. If almost all perms are broken down, then the best, most ideally oriented perms will take fracture fluid first. Propellants, therefore, are tortuosity reducers, not tortuosity increasers.



### Misconception

A given propellant tool burns at a given peak pressure. When the pressure begins to decline the burn is done.

### Reality

Peak pressure is the result of a coincidence of several factors. Burn can continue well after peak pressure is reached.

### Explanation

Peak pressure is determined by a balance of burn gas creation, fluid acceptance by the perfs/formation, and compression and motion of wellbore fluids. If the formation accepts burn products, pressure can decline while burn continues. These phenomena emphasize the need for design calculations supported by prior data to predict peak pressure burn durations and tool effectiveness.

### Misconception

I have been told that four perf shots per foot are adequate for all propellant treatments.

### Reality

There is a minimum acceptable perf area for all treatments. It depends on hole size as well as hole density. It depends to a lesser extent on penetration, but penetration is not completely unimportant. In a few cases, two shots per foot may be enough. Often, four shots per foot are adequate. Frequently, six shots per foot are best.

### Explanation

Because of the balance of burn, flow, compression, and fracturing, a single perf geometry is not always best. With design and experience in a given area, the optimum can be determined.

### Misconception

Since hydraulic fractures can initiate from the microannulus and not necessarily from a perf, improving perf tunnel breakdown will not help my frac job. I don't need propellants.

### Reality

Pre-treatment with propellants have improved the initiation of many, many fracture jobs. In fact, this is one of the most common successes of the technology. If the misconception were true, propellants would never create improvement in hydraulic fracturing.

### Explanation

Good laboratory research has demonstrated that the microannulus effect exists for the slow flow regime at the inception of a conventional hydrofrac. However, propellants create a very fast flow regime in which the microannulus cannot accept fluids rapidly enough to dominate the flow. Therefore, the propellant effectively pressurizes the perf tunnel until breakdown. A propellant-generated perf breakdown looks more like the ideal situation – a relatively clean fracture emanating from the perf tunnel face. This in turn can accept the subsequent fracture fluid flow instead of the microannulus because it is already broken down and is the route that requires less work for fracture entry or subsequent extension.



### Misconception

Who cares if proppants make fractures? Since they are not propped they will soon heal and become ineffective.

### Reality

Many proppant jobs have shown sustained skin reductions and production increases for periods of years. Furthermore, some applications, such as perf breakdown prior to subsequent fracture or acid treatment, do not require that fracs remain open for extended periods.

### Explanation

Proppant-induced fractures can be partially propped and opened due to erosion, ablation debris deposition, and shear offset. Indirect evidence indicates that this happens. However, the magnitude of these effects remains unmeasured, and this is an area where more research is required in order to make quantitative predictions of permanent fracture widths created by proppant fractures. ✨

# Benefits of using high-speed gauge data to obtain rock properties

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Minifrac are used to assist with the main hydraulic fracture design by generating estimates of fluid efficiency, closure pressure, fracture geometry, and leak-off coefficient prior to the main treatment.

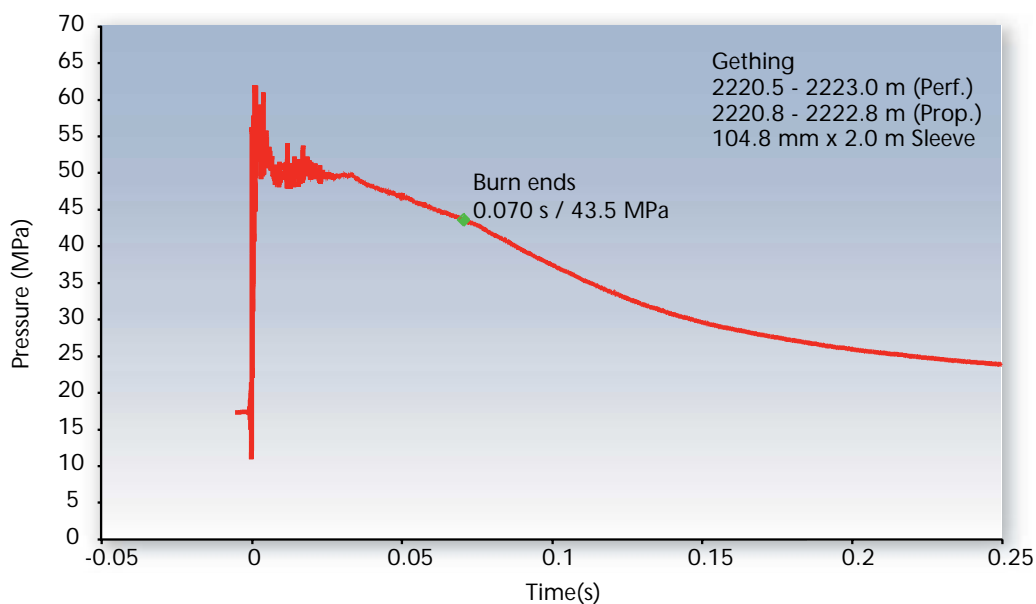
Closure stress or minimum horizontal stress is frequently determined by analyzing the pressure leak-off response after pump shut-down using a Nolte-G function analysis plot. Comparison of the measured data with the dimensionless Nolte-G time indicates closure when used in combination with the derivative and pressure superposition derivative.

The use of a high-speed digital pressure data recorder during well perforating/propellant treatments provides a new field technique to determine closure stress using the G-function and associated methods. By using a high-speed digital pressure data gauge, the fall-off pressure from the event, although lasting only a few hundred milliseconds, has been shown in special cases to provide sufficient closure information. Results have been consistent with other methods and this new technique can give a quick estimate of closure stress prior to hydraulic fracturing while equipment is in place in the field.

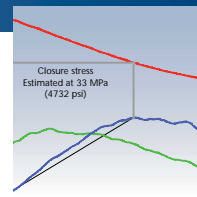
## Method

Propellant stimulation devices are routinely used for near-wellbore cleanup and enhancement. One of the primary applications is for perforation breakdown and fracture initiation. Propellant initiates formation breakdown, allowing successful fracturing at lowered initiation pressures. As the propellant rapidly burns, high-pressure combustion gases are generated. These gases exert a pressure load on the formation, which can exceed the tensile strength of the rock resulting in fracture initiation. Fracture growth is maintained by continued gas generation from the tool burn. Once the tool is spent, the driving force for fracture growth is removed and the pressure response is strictly related to gas leak-off (Figure 1). As gas pressure decreases, energy sustaining the fracture reduces to the point at which the fracture closes. The change in geometry or flow area results in a change in the rate of leak-off (Figure 2).

Since a small fracture is normally generated during the stimulation operation, information about the formation is captured as subtle variations in the pressure response measured by a high-speed pressure recorder. This data can be used in a similar manner to



**Figure 1 –**  
*Propellant  
pressure vs. time  
curve*



minifrac data to assist with formation mechanics determination using the G-function method. Using the superposition derivative magnifies the subtle slope changes in pressure response assisting the location of the point of closure, which is related to the minimum horizontal stress.

**Benefit**

An estimate of closure stress is important for proper hydraulic fracturing design. The ultimate advantage of obtaining closure stress at the time of perforating/propellant stimulation is a significant cost savings because the data can be obtained in the normal course of the completion operation.

**Example**

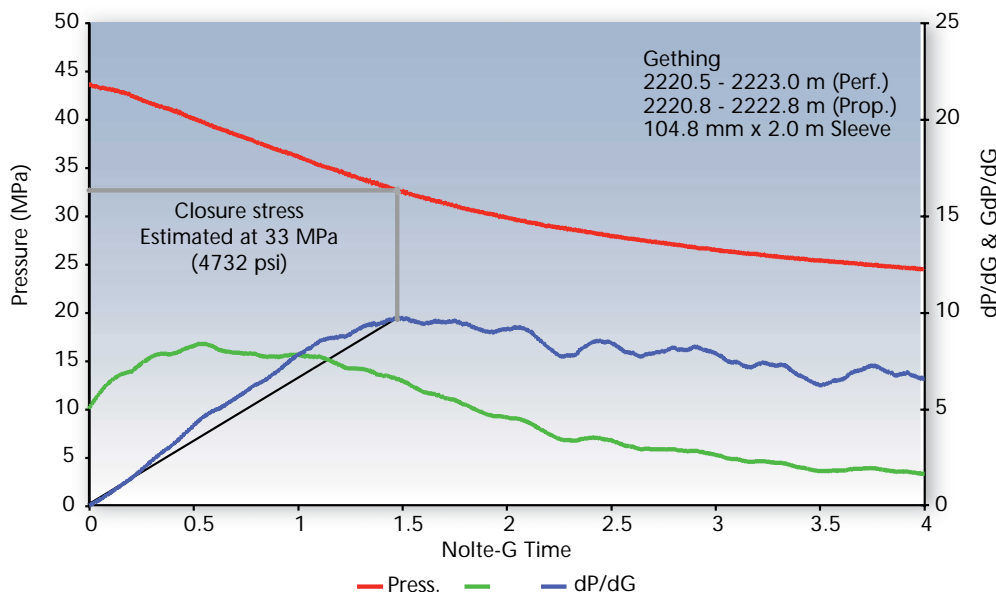
A StimGun™ assembly was used to assist hydraulic fracture breakdown. The well was deviated, and experience in the area indicated that this normally contributed to higher hydraulic fracturing breakdown pressures. Normally observed breakdown pressures range from 6900 to 7250 psi (47,000 to 50,000 kPa). Propellant-assisted perforating was used to clear the perforations and lower the breakdown pressure. A subsequent gelled hydrocarbon fracture broke down at 6200 psi (42,700 kPa) – a substantial reduction

from previous field experience. Pressure recorder data indicated that this was a good candidate for determination of the formation closure stress.

**“The high-speed data from propellant breakdown looks equivalent to a normal hydraulic fracturing G-function.”**

*– John Gilbert*

- \* A superposition derivative of the G-function was applied to the data to make the determination of closure stress. Closure is determined as the point at which the superposition derivative (GdP/dG) drops off after completion of the propellant tool burn.
- \* From this plot closure (Figure 2) stress is estimated to be 4728 psi (33 MPa).
- \* Based on the depth of the well, and applying a minimum horizontal stress gradient estimate of 0.65 psi/ft (1.4 kPa/m), closure pressure is estimated at 4734 psi (33 MPa) at downhole conditions. ✶



**Figure 2 – Nolte-G function plot of Figure 1 data showing fracture closure.**



# New product and technology development

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The goals of Propellant Technology Development Group are to not only to manufacture, supply, and support the existing products, but also to devote resources to the following:

- \* Product optimization
- \* New product development
- \* Innovation in dynamic stimulation methodology

To achieve these goals, we must constantly maintain awareness of licensee and industry needs, review manufacturing and distribution procedures, test products in the laboratory and in the field, and improve hardware and software to keep it state-of-the-art.

## New dynamic testing facility

While developing, testing, and deploying products, and with the assistance of licensees, the group has realized that almost no industry-standard testing methods exist for the evaluation of high-speed (dynamic) stimulation tools. There is a need for such

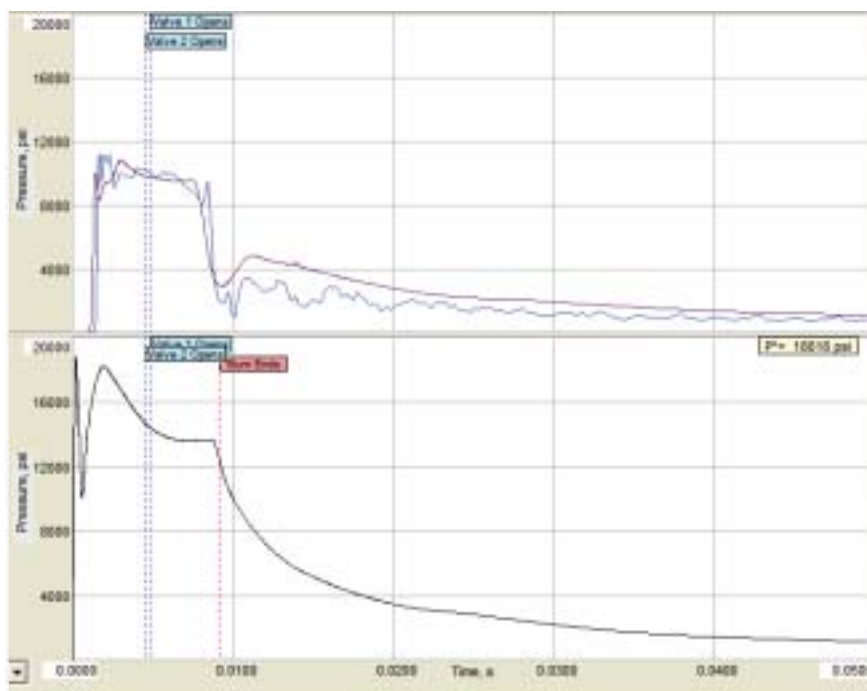
methods because dynamic tools, with their high loading rates and peak pressures (but low-time durations) affect wellbore equipment, tubular hardware, cement, and producing formations differently than low-speed quasi-static industry methods. For example, we know that good-condition casing can withstand significantly higher differential pressures than handbook burst values when only loaded for 10 ms. We are not exactly sure what the increased dynamic strength is and how it is affected by load duration and other factors.

To address this need, the group has embarked upon a program to develop a surface dynamic testing facility. The conceptual design of this facility has been completed and several tests have been run in prototype configurations. The basic concept of the facility is to allow tools and hardware (such as casing and packers) to be tested at the differential pressures and for the time durations (in the range 10 to 100 ms) they

would see in dynamic field operations. An integral part of the facility will be the ability to measure pressures and deformations (strains) in this time range. Special computer code methods will allow data and results to be compared and findings extrapolated to a wide variety of downhole conditions.

Some of the specific planned activities for this facility are:

- \* Establish dynamic ratings for casing, packers, plugs, etc.
- \* Develop methods for pressure wave control to reduce equipment impact.
- \* Develop methods of dynamic fluid flow modification to improve tool performance and reduce tool motion.
- \* Evaluate new products and components to improve performance and/or reduce costs.



**Figure 1** – Pressure vs. time for a 2 in. (51 mm) StimTube™ tool at surface in 4½ in. (114.3 mm) casing. Blue line in upper graph is data at pressure gauge port compared with computer simulation in red. Black line in lower graph is computer simulation at tool center.



## Dynamic Casing Ratings

As part of the prototype facility development, the initial instrumented tests have been successfully conducted to develop a dynamic pressure burst rating for casing. Figure 1 shows the pressure versus time record and computer simulations for a 2 in. (51 mm) OD x 36 in. (.91 m) length StimTube™ tool in water-filled 4½ in. (114.3 mm) N-80 casing. Casing burst was exceeded by a factor of 1.6 for about 10 ms and failure did not occur.

Tests in this series will continue to fully develop the facility and to create a series of dynamic casing test evaluations that can be used for job design.

## Pressure wave control

Several methods are being evaluated of controlling and attenuating pressure waves that have the potential of adversely damaging packers, plugs and other equipment. Figure 2 shows a small pressure vessel (chamber) is opened up by a perforating charge that does not penetrate the outer casing. Rapid fluid flow into the chamber results in a temporary pressure reduction lasting about 15 ms.

This effect can be used to reduce operational problems as well as create dynamic underbalance in an otherwise balanced or overbalanced situation.

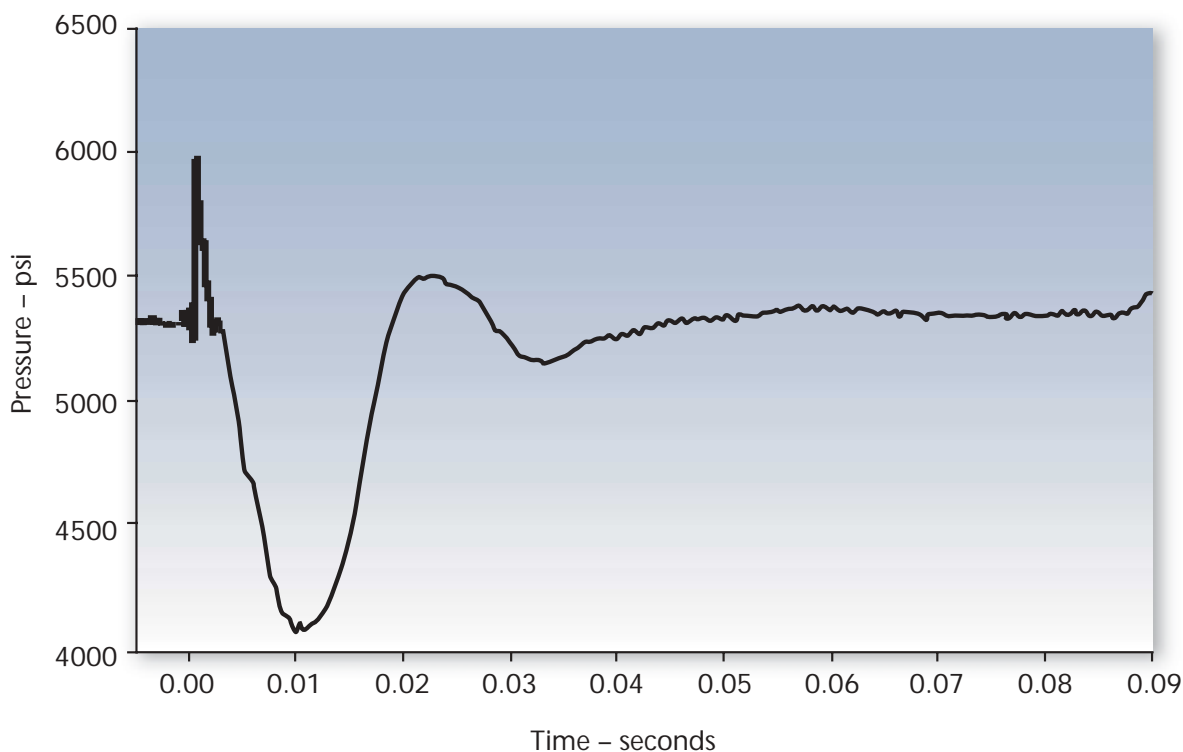
## Dynamic flow modification

Several methods will be investigated of modifying the dynamic flow near to a tool to improve performance and reduce the potential of operational problems. These include the use of special diverters and reflectors.

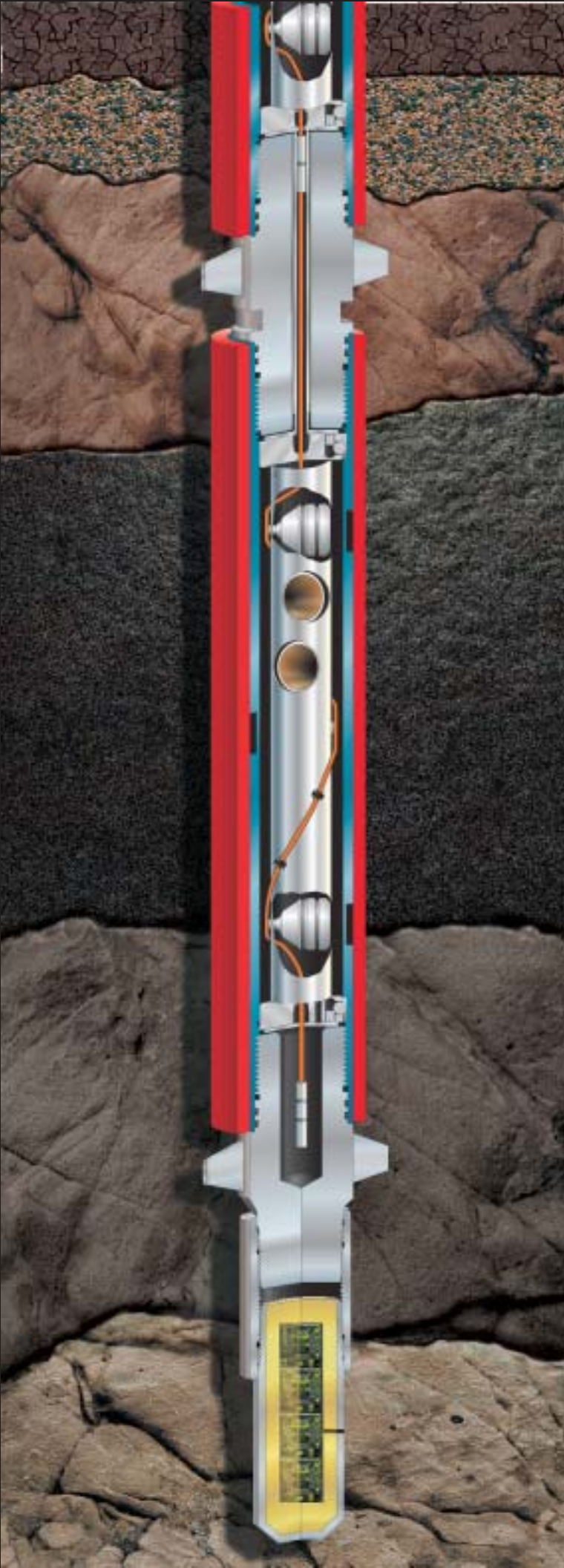
## Product and component development

Work in this area will include:

- \* New tool sizes
- \* Propellant formulations requiring minimal liquid tamp
- \* Novel use of proppants
- \* Tools containing tracers
- \* Internal sleeve StimGun™ assemblies
- \* Novel tool geometries and types for long horizontal holes and tubing-size limited work \*



**Figure 2** – Dynamic pressure decrease resulting from the rapid opening of a chamber inhole. In the example, the pressure decreases by more than 1000 psi for about 15 ms.



The StimGun technology has been a collaborative effort of a multitude of companies and people. The perspectives and input from these various sources continues to improve the overall portfolio. The authors of this publication hope the readers will consider incorporating StimGun technology in well completions.

While “Mission Statements” have certainly decreased in popularity over the past few years, this group’s statement has always remained the same:

- \* *“Develop successful applications for the propellant technology in the oil and gas industry.*
- \* *Maintain safety as the highest priority.*
- \* *Establish a high trust relationship with the industry, our customers, and each other.*
- \* *Build a profitable business opportunities for the stakeholders of the technology.”*