

# Thinking outside THE FRAC

**Adam Schmidt, The GasGun Inc., USA,  
explains the benefits of solid propellant  
stimulation over hydraulic fracturing.**

In today's world of unconventional reservoirs, and with all the emphasis placed on their importance in bridging the gap of our global thirst for energy, it is no wonder that the vast majority of articles and papers written in the last few years have been about their development. A particular emphasis has been placed on the completions of these complex reservoirs and the resulting environmental impacts. It is no secret that the advances in technology of hydraulic fracturing along with horizontal drilling have changed the landscape of well completions forever. The technical envelope continues to be pushed by the drilling of longer horizontals and the use of larger hydraulic fracs to complete them. The emphasis on unconventional reservoirs and all the technology supporting their development has begun to transition into

*Figure 1. Loaded GasGun tools with a Falcon wireline truck in the background.*



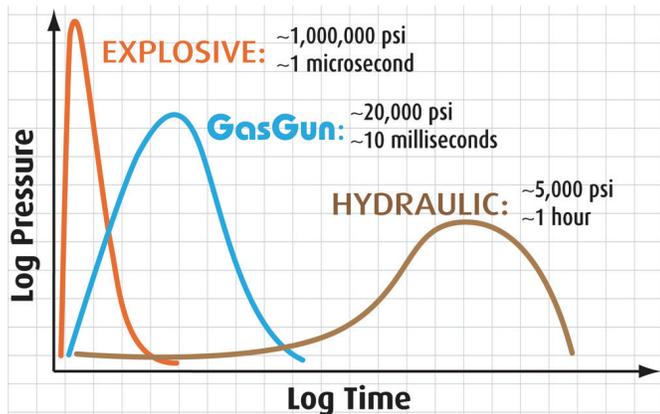


Figure 2. Pressure-time profiles of three stimulation methods.



Figure 3. Map of horizontal well location.

conventional fields as well. Oil and gas operators are taking what they have learned from the unconventional world and are now applying it to conventional reservoirs like sandstones, limestones, dolomites, etc. While there is a lot to be gained from what has been learned from unconventional development, some operators have discovered that what works in those reservoirs does not necessarily translate perfectly to their conventional fields.

Over the last several years there has been a push to increase the fracture surface area in unconventional reservoirs, most notably in the shale plays, by increasing the number of frac stages. Just a few years ago it was common to complete a horizontal shale well with just a few frac stages and now it is commonplace to use 20 or more. This trend has led to a closed-minded approach by many operators in blindly applying this philosophy to their conventional completions without fully

analysing each well. The economics are often very different for conventional reservoirs, and it can be harmful to the bottom line to simply believe that because it worked in one well that it will automatically work in another.

As has been the case throughout the history of oil and gas development, some operators like to challenge conventional wisdom, and apply alternative strategies to their completions. This was the case in May last year when an independent oil and gas operator in Oman decided to use a solid propellant stimulation device, the GasGun®, instead of hydraulically fracturing one of its newly drilled horizontal wells.

### Background on propellant stimulations

Oil and gas wells have been stimulated with high explosives since the late 1800s. This form of stimulation is often referred to as 'well shooting.' Problems of wellbore damage, safety hazards, and unpredictable results have reduced the relative number of wells stimulated with classic high explosives, and this method has largely been replaced by the use of propellants.

Solid propellants deflagrate rather than detonate. Unlike explosives, the burn front in these materials travels slower than the sound speed, and the burn rate can be tailored to fit a wide range of applications. Pressure-time behaviour of propellants differs from explosives in that peak pressures are lower, and burn times are longer. The approximate values of peak pressure and duration for the GasGun are noted in Figure 2. It incorporates advanced design with the use of progressively burning propellants that have been proven by independent research to be more effective in creating fractures and increasing formation permeability.

### Propellant stimulations in horizontal wells

Over the last 40 years oilfield service providers have performed tens of thousands of propellant stimulations for oil and gas companies all across the globe. Despite their widespread use, propellant stimulations account for a small part of the overall fracture stimulation market, and their applications have not been well understood by most operators. Historically, propellant tools have been applied in wells as either a pre-treatment to hydraulic fracturing or in wells where hydraulic fracturing is uneconomical. With advancements in the safety, reliability and design of propellant tools along with the accumulated knowledge from decades of use, oil and gas companies are finding new applications for this maturing technology.

One of these new applications is horizontal well stimulations. As discussed earlier, most horizontal wells are stimulated via multi-stage hydraulic fracturing. This is certainly the case for the vast majority of shale wells, which have very low permeability and require massive fracture treatments to make them flow at commercial rates. It is becoming more common to apply this same technology to wells drilled horizontally in conventional reservoirs. However, these wells may not necessarily exhibit the same permeability limitations. Conventional reservoirs usually have superior permeability relative to unconventional reservoirs. It then becomes a very complex problem to understand the economics of each well so that operators can maximise the return on their investment.



**Figure 4.** *Drill rig in Oman used to convey GasGun tools.*

Propellant stimulations are often considered a low cost alternative to hydraulic fracturing in reservoirs with moderate to good permeability. They have been used in countless vertical wells, all over the world in a wide variety of applications. Despite this fact there have been very few operators willing to apply propellant stimulation technology to their horizontal well completions.

### **First application in a multi-stage horizontal well**

In November 2010, The GasGun, Inc. was commissioned by an independent oil and gas operator in Oman to investigate the possibility of stimulating a multi-stage open hole horizontal well. The well was located in Block 3 Farha South, which lies in the eastern part of Oman (see Figure 3 for the well location). The operator launched a drilling programme in 2009 and an Early Production System (EPS) in 2010 as part of the ongoing long term production test of the Farha South trend. The operator was set to drill an appraisal well designed to evaluate the Lower Al Bashair formation. The well was to be drilled into the moderately tight sandstone formation to a total measured depth of 2900 m of which approximately 860 m would be the horizontal leg.

Due to the very high cost of hydraulic fracturing and because this is only an appraisal well, the operator thought this would be a good opportunity to try a more cost-effective method of stimulation.

The operator had virtually no experience with the use of propellant tools, so in February 2011 three of its engineers travelled to West Texas from the Middle East to witness a solid propellant stimulation being conducted for a large independent operator in the Permian Basin. The engineers were impressed by the service and requested a proposal for solid propellant stimulation treatments in both their vertical and horizontal wells.

The company had only shot a handful of horizontal wells previously, which were limited to a few runs on tubing with single 3 m tools. The operator requested that a propellant stimulation

system be designed to stimulate eight stages of the open hole lateral covering a total of 859 m. Based on the open hole logs it was decided that each stage would consist of several 3 m GasGun tools separated by 6 m blanks. Several fielding options were considered including tubing conveyed, coil tubing, drill pipe and a wireline conveyed well tractor. The drilling operation of the well was scheduled to reach TD by the end of April 2011, so if a system could be designed, manufactured, and exported to Oman in eight weeks or less it made the most sense to convey the tools via drill pipe immediately after drilling the well.

On 1 May the first stage of tools was assembled with a ball-activated differential-pressure firing head on top of the 14 m string and lowered into the well on drill pipe to a measured depth of 2898 m in the open hole lateral. The ball was dropped, pressure increased, and the tool string ignited. Pipe was tripped out of the hole, and the GasGun carriers were inspected for evidence of proper ignition and burn. The system had performed as designed. The remaining seven stages were all fired and retrieved successfully over the following seven days with as many as eight 3 m tools in a single stage for a total of 33 3 m tools. The operating company has requested that the results be kept confidential, but they immediately ordered more equipment for future stimulations. Since then the operator has stimulated an additional horizontal well and several vertical wells.

### **Future outlook for propellant stimulations in horizontal wells**

Successful completion of this project was a vital step towards the future of propellant stimulations in horizontal wellbores. All of the uncertainties about whether a propellant tool was a viable option for stimulating relatively long and complex lateral wells were answered. It also served as a launch pad for solid propellant stimulations in the Middle East with several pilot projects scheduled this year. Additional horizontal wells have been stimulated with this specific design since the first successful completion in May last year, and future wells have already been scheduled for the remainder of this year. These additional stimulations will move horizontal propellant stimulations beyond the research and development phase so the company can begin to build a dataset of case histories and learn how to best apply this technology to future wells.

Over the next few years, horizontal well completions with propellant stimulation tools will likely gain in popularity as operators continue to look for alternatives to hydraulic fracturing for a variety of reasons. Propellant tools have become a staple for many independent oil and gas companies throughout the US and abroad. They are used every day in a wide variety of other applications including:

- Close water contact: stimulate wells successfully that are known to produce water when hydraulically fractured.
  - Pre acid: create fracture network first to allow acid to etch new channels into the formation.
  - Naturally fractured reservoirs: connect wellbore to existing fracture network.
  - Nearbore damage: remove damage caused by perforators, cement, drilling fines, acid, polymer gels, etc.
  - Pre frac: break down a formation first to reduce treating pressures during fracturing.
  - Injection wells: increase injection rates in waste disposal, waterflood and gas storage wells. **U T**
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